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# Design of information and technology tools to support the process of creativity and innovation

Pedro Chávez Barrios

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**UNIVERSITÉ  
DE LORRAINE**

**SIMPPÉ**



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L'ÉNERGIE

**ERPI Laboratory**

Equipe de Recherche sur les processus Innovatifs

**Conception d'outils d'information et de technologie pour  
soutenir le processus de créativité et d'innovation.**

**By Pedro Chávez Barrios**

**Thesis defended September 5, 2019.**

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Dedicated to my sons Pedro and José Eduardo,

And

To my wife Irma.

To my mother Rosa Barrios.

To my sisters Elizabeth and Irma Rosa.

To my brothers Guerrero, Esteban, Juan Manuel, Salvador and my uncle Pedro.

To my beloved grandparents Lola and Lolo.

My family, my motivation.

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# Introduction

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## Topics of the Introduction

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- 2. Research Laboratories Incorporation** ..... Error! Bookmark not defined.
- 3. The problematic of the thesis and its hypothesis** ..... Error! Bookmark not defined.
- 4. Objectives, originality and novelty of the thesis**..... Error! Bookmark not defined.

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# General Introduction of the Thesis

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## 1. General Context

The scientific study of innovation and creativity is increasing. Governments, industry and educative centers from different countries and cultures focus in both concepts due to the needs that emerge in countries from different continents in the world. Creativity has to be developing to improve innovation. The creativity and innovation are applied in some diverse fields such as production, health, environment, transport, communication, poverty, technology, education, linguistic, etc. *The effects of creativity and innovation are not limited to the world of business and the development of non-profit organizations such as hospitals (Mumford, Hester, and Robledo, 2012).*

Innovation and creativity are important topics to study. They have been studied since last century to cover problems and nowadays these concepts must strongly appear at every place and in every single person in the world: *creativity isn't magical! It's an aspect of normal human intelligence, not a special faculty granted to a tiny elite (Boden 2009).* Individual creativity is used to generate ideas, but actually, with the explosion of information and specialization, *the development of innovation will require group, and interaction in their process. Thus, organizations and teams need diverse skills a knowledge (Paulus and Nijstad, 2003).* At this moment, organizations as educative centers and companies concern in the countries' needs: they start creativity workshops to solve or cover these needs. The University of Lorraine in France, as an educative center, is also focus on these topics. The work is carries out at ERPI laboratory in the École Nationale Supérieure en Génie des Systèmes et de L'Innovation (ENSGSI) with the "creativity workshop 48H", where thousands of ideas are generated in a divergence phase, and others as possible solutions with a convergence phase.

This wave of ideas generates an immense quantity of information. However, with this problem some interesting, modern and technological topics appear with the question: "How to manage these information, documents and knowledge?". First, we need to propose a semantic approach to compare ideas. Second, a multi-agent system must be proposed to define the agent model, service model and acquaintance model. Third, we need to create an ontology. Therefore, the artificial intelligence with the concept of "multi-agent" and "semantic web" with the concept of "ontology" are very interesting fields in our study. In addition, the "semantic approach" could impulse the number of possible solutions to innovate.

## 2. Research Laboratories Incorporation

This thesis research is a product of the collaborative work of two important laboratories and several educative organizations The ENSGSI at ERPI laboratory worries about industrial problems performs every year a creativity workshop (CWS) called 48 hours (48H) of creativity. The organization of the CWS 48H integrates several industries, educative centers, institutes, universities, professors from several countries and continents.



Focusing in our thesis, a collaborative work between ERPI laboratory and Lorraine Research Laboratory in Computer Science and its Applications (Loria) laboratory in the University de Lorraine and Inria (Grand-Est) by mean of the professors help us with their advice and guide.

### 3. The problematic of the thesis and its hypothesis

#### *Research Context*

For many years, scientists have been wondering if they can build new technical and innovative systems that can emulate a valuable human behavior consisting of visualizing and giving life to their ideas. This approach is creativity and involves many concepts such as discovery, creation, sociability, refinement and communication. Creativity can be achieved combining ideas, exploring some characteristics about the subject, and transforming these ideas (Boden 2009); creativity can be also defined as the generation of new and useful/valuable ideas for products, services, processes and procedures by individuals or groups in a specific organizational context (Martins and Terblanche, 2003).

The work's mission is to design by informatics and technological tools to support creativity and innovation process. In consequence, there are several objectives to achieve during the time requested for this research.

In this research reflection, we can state our problematic as follows:

**“How can we assist the participants of a creativity workshop to manage their ideas and knowledge?”.**

In this logical order, we can describe our working hypotheses in terms of scientific challenges as follows:

#### Scientific Challenge n° 1:

**The first scientific issue** is How to identify the knowledge and ideas created during the creativity workshops? To face this issue, we wish *“To propose an **organizational model to understand creativity workshop**”*. We consider a creativity workshop as a human organization where participants work together to generate ideas and also share their experiences and knowledge. We wish to model this organization to highlight knowledge and to understand the process to create ideas.

#### Objective One:

The **first objective** consists to understand the knowledge sharing during a creativity workshop; to study the human organization in a creativity workshop and its general process. Particularly, we study the event 48 Hours of creativity (48H), where ideas are the final product that is performed in Nancy, France at The University of Lorraine (ERPI Laboratory). In addition, we compare creativity workshops from different countries and cultures in order to know the differences among them such as actors, duration, countries, ideas, problems, activities to generate ideas. The necessity to define clearly the organizational structure, processes, collaborative activities and roles to highlight knowledge is a primordial goal.

### Scientific Challenge n° 2:

*“To propose an **intelligent system** to assist participant of the creativity workshops to manage their ideas”.*

### Objective Two:

The **second objective** is to design an intelligent system based on multi-agent system (MAS) and to develop an annotation system. With respect to the design of an intelligent system: **first**, we need to analyze the actors, roles and the interactions of them during the creativity workshop, and second, to design the multi-agent system. The creativity workshop is the environment where actors are sharing their knowledge; without forget that this knowledge is created and is evaluated in a dynamic way, these actors might represent the agents.

The collaboration among these actors is physically distant and their interactions could be asynchrony or synchrony; so, we can say that the process is distributed. The nature of the information is heterogeneous (ideas, experiences, schema, etc.) and is distributed.

In addition to that, to develop an annotation system, with the purpose of representing the creativity workshop, the organizational model and the multi-agent system in a way that the machine can understand them. The computer must comprehend the relationships among the concepts generated. Having our ontology, we might integrate it to the global semantic web.

### Scientific Challenge n° 3:

Face to the huge quantity of ideas generated during the creativity workshops, how to compare, cluster and evaluate the ideas during the creativity workshop?

*To face this issue, we wish “To propose a **semantic approach** (system) to compare **idea cards** and **the global design system**”.*

### Objective Three:

The **third objective** is proposing a semantic approach to manage ideas and the global design system. This objective has several secondary objectives. In the aspect of the semantic approach.

- **First:** to achieve it, we need to create and use a methodology that consist in three steps: 1- to organize the content of idea cards, 2- to compare idea cards in a semantic way and 3- to annotate as a process of knowledge organization.
- **Second:** to organize the content of the ideas, we are going to use a semantic lexical tool; to compare the idea cards, we need some requirements to execute the comparative process such as corpus, representation of concepts, elements from semantic lexical relation and semantic lexical relational database to define an algorithm that compares ideas. To apply the new algorithm and to analyze the results obtained, the algorithm compares different idea cards from the corpus.
- **Third:** to apply a semantic process and to compare ideas, it consist in six steps: 1- select a group of idea cards from corpus; 2- extract all concepts from every idea card; 3- obtain semantic concepts; 4- path and depth using a semantic lexical database; 5- create a list of synonyms, hyponyms, hypernym, identic concepts and the list of inherited hypernym to obtain the semantic distance and graph of the

idea card to make the comparatives; 6- to match concepts from different idea cards and finally to analyze the results.

To describe the global design system, it is necessary to create the object model and interface model, next the creativity support system, the semantic approach system and from knowledge to annotation system.

## 4. Objectives, originality and novelty of the thesis

The mission of the thesis is “to design by informatics and technological tools to support creativity and innovation”.

The objectives are:

**a)** To propose an organizational model to understand a creativity workshop.

The organizational model to understand creativity workshops has a principal goal to highlight knowledge in a complex environment with different countries, different students, during the creativity workshop. Each team receives new topics about industry’s needs; every participant and group will use creativity to produce novel ideas using collaborative activities; these activities have necessarily divergence activities to produce many ideas and convergence activities to create idea cards with a specific focus. Inside of the creative collaborative activities appear roles, creative techniques, roles and ways to generate ideas.

As results, this model produces a description about:

- Organizational Structure that describes the organization identity with missions, goals and procedures, and organization actions with processes;
- Process of Collaboration and Creation, its shows inputs, outputs, activities, roles and responsibilities, we could remark that the final output are idea cards as possible solutions to the industrial problem;
- Activities and results generated, here roles, knowledge, deliverable name, generated knowledge, general competences and general actions; and
- Role and Its characteristics that are to describe main mission, competences, knowledge and interaction fields.

**b)** To propose an intelligent system and annotation (ontology).

To propose an intelligent system and to develop an annotation system, it is not a simple job. there are several goals to achieve: first, to present a specification of multi-agent system that shows the characteristics of the analysis and design model of the multi-agent systems. Second, clear descriptions of the roles model, interaction model, agent model, services model and acquaintance model. Besides, to use an ontology that represent knowledge (knowledge model), to define concepts, relations to define our adequate ontology.

As results, we need to develop: data model, annotation model, semantic model to obtain a system of architecture and the organization of reactive agents and definition of ontology graphe, table of concepts and table of relations.

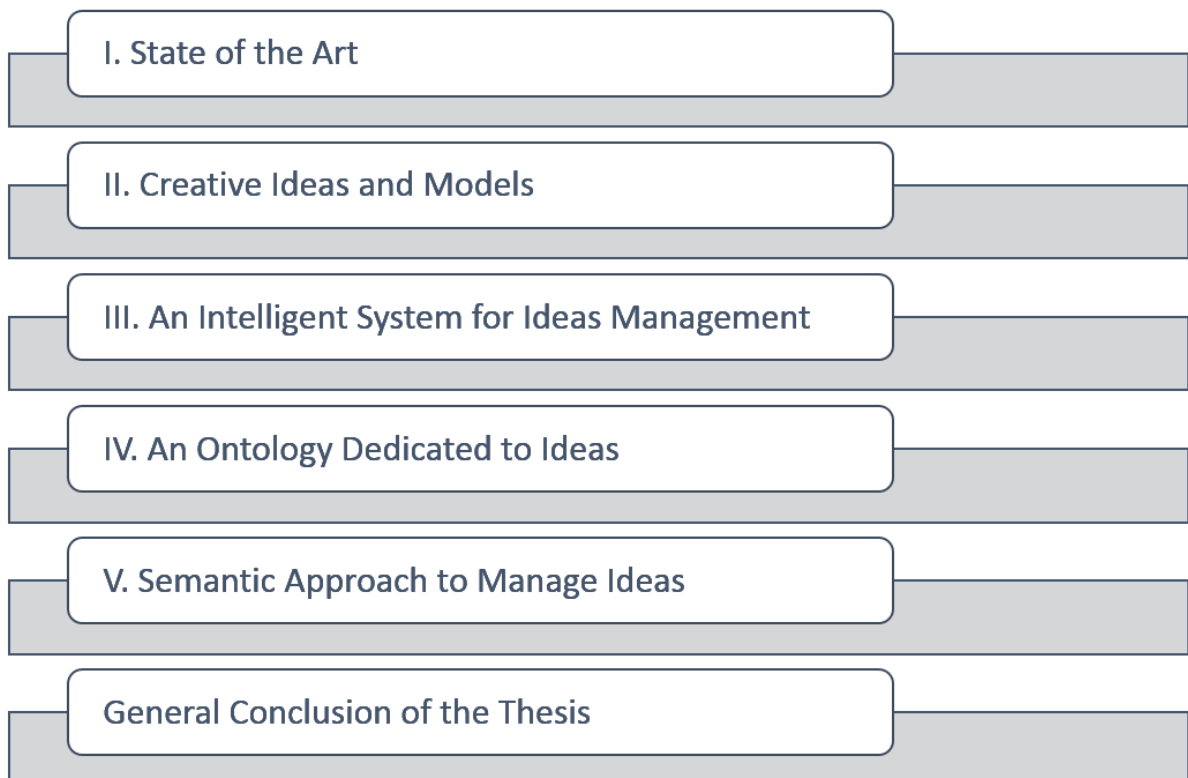
c) To propose a semantic approach to compare ideas and experimentations.

To propose a semantic approach as a complex objective, the goal is to manage all ideas that are produced during the collaborative creative activities. To manage imply several steps to create ideas using convergence after divergence, to capture, to save, to retrieve, to classify, to evaluate, to enhance, to select the idea cards to deliver possible solutions to innovate. Every step has a hard challenge that many creative support system has been developed to help in this creative way. Inside the semantic approach, a semantic process is located, it is a difficult challenge process where all idea cards are kept and saved in a corpus; next, we can select the idea cards, to apply the semantic process and to obtain results. This Semantic process has four important stages: 1- corpus, 2- representation of concepts, 3- model knowledge and 4- graphic representation.

As results, we need to develop a methodology to compare ideas that has a description of the three steps that belong to the approach applied, to organize the content of Idea Cards, to compare Idea Cards in a semantic way and to annotate. Requirement for the comparative process, Algorithm, representation of elements, finally the semantic process to achieve results.

According to our objectives, which are presented in the form of scientific challenges and with the focus to answering the proposed problematic, our work presents the following chapters which will allow the reader to assimilate: 1- the complexities related to this research work, 2- the associated treatments to align theoretical and practical solutions, and 3- to propose concrete achievements in response to the difficulties addressed.

In this resolution, chapters of this research thesis are:



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## **Extended Abstract**

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# Extended Abstract

## Résumé élargi

### **Conception d'outils d'information et de technologie pour soutenir le processus de créativité et d'innovation.**

Cette thèse de recherche aborde les champs de la créativité, de l'innovation, du processus créatif collaboratif et de systèmes multi-agents. Il est nécessaire de construire de nouveaux systèmes techniques et innovants qui peuvent imiter le comportement humain précieux consistant à visualiser et à donner vie à leurs idées. Cette approche fait appel à la créativité et implique, en tant que processus, de nombreux concepts tels que la découverte, la création, la sociabilité, le raffinement et la communication.

Introduction générale de la thèse, en tant que contexte, l'étude scientifique de l'innovation et de la créativité se développe. Les gouvernements, l'industrie et les centres éducatifs de différents pays et cultures se concentrent dans les deux concepts en raison des besoins qui se font jour dans des pays de différents continents. La créativité doit se développer pour améliorer l'innovation. La créativité et l'innovation s'appliquent dans divers domaines tels que la production, la santé, l'environnement, les transports, la communication, la pauvreté, la technologie, l'éducation, la linguistique.

L'innovation et la créativité sont des sujets importants à étudier. Ils ont été étudiés depuis le siècle dernier pour couvrir des problèmes et, de nos jours, ces concepts doivent fortement apparaître dans chaque lieu et chez chaque individu dans le monde. À l'heure actuelle, les organisations en tant que centres éducatifs et les entreprises s'intéressent aux besoins des pays: elles organisent des ateliers de créativité pour répondre à ces besoins. L'Université de Lorraine en France, en tant que centre éducatif, se concentre également sur ces sujets. Le travail est effectué au laboratoire ERPI de l'ENSGSI avec «l'atelier de créativité 48H», où des milliers d'idées sont générées dans une phase de divergence, et d'autres solutions possibles avec une phase de convergence.

Cette vague d'idées génère une immense quantité d'informations. Cependant, avec ce problème, certains sujets intéressants, modernes et technologiques apparaissent avec la question: "Comment gérer ces informations, documents et connaissances?". Premièrement, nous devons proposer une approche sémantique pour comparer les idées. Deuxièmement, un système multi-agents doit être proposé pour définir le modèle d'agent, le modèle de service et le modèle de connaissance. Troisièmement, nous devons créer une ontologie. Par conséquent, l'intelligence artificielle avec le concept de «multi-agent» et «Web sémantique» avec le concept d'ontologie sont des domaines très intéressants dans notre étude. De plus, «l'approche sémantique» pourrait impulser le nombre de solutions possibles pour innover.

#### *Problématique et hypothèse*

Depuis de nombreuses années, les scientifiques se demandent s'ils peuvent construire de nouveaux systèmes techniques innovants capables d'imiter un comportement humain précieux consistant à visualiser et à donner vie à leurs idées. Cette approche est la créativité et implique de nombreux concepts tels que découverte, création, sociabilité, raffinement et communication.

L'œuvre a pour mission de concevoir par l'informatique et par des outils technologiques l'appui à la créativité et au processus d'innovation. En conséquence, plusieurs objectifs doivent être atteints dans cette recherche.

Dans cette réflexion de recherche, nous pouvons énoncer notre problématique comme suit: «Comment pouvons-nous aider les participants d'un atelier de créativité à gérer leurs idées et leurs connaissances?». Dans un ordre logique, nous pouvons décrire nos hypothèses de travail en termes de défis scientifiques comme suit :

Défi scientifique n° 1:

Le premier problème scientifique est Comment identifier les connaissances et les idées créées lors des ateliers de créativité? Pour faire face à ce problème, nous souhaitons "proposer un modèle d'organisation pour comprendre l'atelier de créativité". Nous considérons un atelier de créativité comme une organisation humaine dans laquelle les participants travaillent ensemble pour générer des idées et partager leurs expériences et leurs connaissances. Nous souhaitons modéliser cette organisation pour mettre en évidence les connaissances et comprendre le processus de création d'idées.

Premier objectif:

Le premier objectif consiste à comprendre le partage des connaissances lors d'un atelier de créativité ; étudier l'organisation humaine dans un atelier de créativité et son processus général. De plus, nous comparons des ateliers de créativité de différents pays et cultures afin de connaître leurs différences : acteurs, durée, pays, idées, problèmes, activités pour générer des idées. La nécessité de définir clairement la structure organisationnelle, les processus, les activités collaboratives et les rôles pour mettre en valeur les connaissances est un objectif primordial.

Défi scientifique n° 2:

“Proposer un système intelligent pour aider les participants aux ateliers de créativité à gérer leurs idées”.

Deuxième objectif:

Le deuxième objectif est de concevoir un système intelligent basé sur un système multi-agent (MAS) et de développer un système d'annotation. En ce qui concerne la conception d'un système intelligent : nous devons d'abord analyser les acteurs, les rôles et leurs interactions au cours de l'atelier de créativité, et ensuite, concevoir le système multi-agents. L'atelier de créativité est l'environnement dans lequel les acteurs partagent leurs connaissances. sans oublier que ces connaissances sont créées et évaluées de manière dynamique, ces acteurs pourraient représenter les agents.

La collaboration entre ces acteurs est physiquement distante et leurs interactions pourraient être asynchrones ou synchrones ; alors, on peut dire que le processus est distribué. La nature des informations est hétérogène et distribuée. En plus de cela, développer un système d'annotation, dans le but de représenter l'atelier de créativité, le modèle d'organisation et le système multi-agents de manière à ce que la machine puisse les comprendre. L'ordinateur doit comprendre les relations entre les concepts générés. Ayant notre ontologie, nous pourrions l'intégrer au Web sémantique global.

Défi scientifique n° 3:

Face à l'énorme quantité d'idées générées lors des ateliers de créativité, comment comparer, regrouper et évaluer les idées au cours de l'atelier de créativité?

Pour faire face à ce problème, nous souhaitons "proposer une approche sémantique (système) permettant de comparer les cartes d'idées et le système de conception global".

### Troisième objectif:

Le troisième objectif propose une approche sémantique de la gestion des idées et du système de design global. Cet objectif a plusieurs objectifs secondaires. Dans l'aspect de l'approche sémantique.

- Premièrement : pour y parvenir, nous devons créer et utiliser une méthodologie en trois étapes : 1- organiser le contenu des cartes d'idées, 2- comparer les cartes d'idées de manière sémantique et 3- annoter en tant que processus d'organisation du savoir.

- Deuxièmement : pour organiser le contenu des idées, nous allons utiliser un outil lexical sémantique. Pour comparer les cartes d'idées, nous avons besoin d'exigences pour exécuter le processus comparatif, telles que corpus, représentation de concepts, éléments de relations lexicales sémantiques et base de données relationnelle lexicale sémantique pour définir un algorithme de comparaison d'idées. Pour appliquer le nouvel algorithme et analyser les résultats obtenus, l'algorithme compare différentes cartes d'idées du corpus.

- Troisièmement: pour appliquer un processus sémantique et comparer des idées, il comporte six étapes: 1- sélectionner un groupe de cartes d'idées à partir d'un corpus; 2- extraire tous les concepts de chaque carte d'idée; 3- obtenir des concepts sémantiques; 4- chemin et profondeur en utilisant une base de données lexicale sémantique; 5- créer une liste de synonymes, d'hyponymes, d'hypernymes, de concepts identiques et la liste d'hypernymes hérités pour obtenir la distance sémantique et le graphe de la carte d'idée pour effectuer les comparatifs; 6- faire correspondre les concepts de différentes cartes d'idées et enfin analyser les résultats.

Pour décrire le système de conception global, il est nécessaire de créer le modèle d'objet et le modèle d'interface, puis le système d'aide à la créativité, le système d'approche sémantique et du système de connaissances au système d'annotation.

Dans cette résolution, les chapitres de cette thèse de recherche sont : I État de l'art, II idées et modèles créatifs, III système intelligent de gestion des idées, IV Une ontologie dédiée aux idées, V approche sémantique de la gestion des idées et conclusion générale de la thèse.

### **I Etat de l'art**

Créativité et innovation, les deux concepts fonctionnent ensemble à un ou plusieurs niveaux pour assurer le succès au sein de toute organisation. Au premier niveau, la créativité produit des idées mentales ; au niveau du travail d'équipe, les personnes travaillent avec des activités créatives collaboratives ; au niveau organisationnel, les meilleures idées créatives arrivent et l'innovation peut commencer. L'innovation dépend de la créativité lors de tous les processus de l'atelier de créativité. Dans tout atelier de créativité, il est impossible de séparer créativité et innovation. L'innovation a besoin de créativité et la créativité aide l'innovation avec des idées créatives.

Cette recherche commence par une nécessité ou un problème ; ce sera la racine pour impulser la créativité individuelle, puisque chaque personne peut aider à la solution en utilisant son intelligence. Certaines activités de collaboration avec confiance et coopération apparaîtront grâce à ces activités de collaboration une fois que les idées seront présentées comme des solutions à des problèmes industriels complexes. Cependant, la quantité et la qualité des idées individuelles créées sont minimales comparées au nombre d'idées produites ayant un processus de créativité collective. La collaboration créative est la base de toutes les activités créatives du processus.



## II Idées créatives et modèles

Ce chapitre apporte une représentation des ateliers de créativité et de l'évolution des idées. Nous avons choisi «de modéliser les ateliers de créativité avec une approche organisationnelle pour mettre en valeur les connaissances » comme des idées et des concepts créés lors de l'interaction entre les différents rôles des acteurs professionnels dans le processus de créativité. En effet, les modèles d'organisation ont pour objectif de mettre en évidence la structure organisationnelle d'une équipe ou d'un groupe et de décrire les informations et les connaissances utilisées et partagées au sein de ces organisations. Ce chapitre présente également le processus de créativité, l'évolution des idées, un modèle organisationnel pour comprendre un atelier de créativité. Il présente également quelques ateliers de créativité permettant de comparer les différentes caractéristiques entre eux et notre atelier de créativité, le modèle organisationnel de quarante-huit heures (48H).

Au cours de l'atelier de créativité, les capacités individuelles et les émotions des participants au solveur sont la base pour produire une pensée divergente et soutenir une organisation créative. L'atelier de créativité 48H de l'ENSGSI regroupe toutes les caractéristiques mentionnées, telles que les activités, les méthodes de création en collaboration et une organisation. Pendant deux jours, différentes institutions éducatives, industries et parties prenantes travailleront en collaboration. À la fin de cet atelier de créativité, des milliers d'idées ont évolué pour devenir des cartes d'idées et elles seront les solutions possibles pour innover.

### *Un modèle d'organisation pour comprendre l'atelier de créativité*

Nous avons choisi de modéliser les ateliers de créativité avec une approche organisationnelle mettant en évidence les connaissances (idées et concepts) créés lors de l'interaction entre les différents rôles des acteurs professionnels dans le processus de créativité. En effet, les modèles d'organisation ont pour objectif de mettre en évidence la structure organisationnelle d'une équipe ou d'un groupe et de décrire les informations et les connaissances utilisées et partagées au sein de ces organisations. Afin de modéliser le CWS, nous avons utilisé le modèle organisationnel de réutilisation des connaissances appelé KROM (Girodon, Monticolo, Bonjour, et al. 2015), qui permet de modéliser les missions, objectifs, processus, activités, compétences, connaissances, agents et responsabilités des utilisateurs. une organisation.

Au cours de l'atelier de créativité, les capacités individuelles et les émotions des participants au solveur sont la base pour produire une pensée divergente et soutenir une créativité au sein d'une organisation. Ensuite, dans la phase de divergence, les équipes formées par le solveur participant agissent dans la phase de convergence, où elles génèrent des cartes d'idées créatives collaboratives, puis la phase d'évaluation améliore le contenu des cartes d'idées. Nous observons différents rôles au cours de l'atelier de créativité.

L'organisateur a plusieurs objectifs : exiger de l'acteur qu'il s'inscrive pour donner son lieu de travail et son rôle à tous les acteurs, attribuer des sites à un événement, fournir une équipe et une industrie aux participants, aux experts en création et aux experts techniques.

Expert créatif, initialement en tant qu'acteur, fournit des données personnelles et une institution. Deux actions pertinentes de la créativité sont en charge de l'expert créatif. Ce rôle propose une activité, offre également une méthode de création collaborative à l'équipe de participants au solutionneur, dans le but de générer des idées individuelles et des fiches d'idées.

Le rôle du solveur est le rôle le plus important de l'atelier de créativité. Il a pour but de fournir des détails pour l'inscription, de sélectionner une activité, de réfléchir, d'écrire et de partager des idées, de choisir une méthode de création collaborative, d'écrire, de partager et d'améliorer les cartes d'idées. d'envoyer 2 cartes d'idées comme solutions possibles et enfin de présenter les solutions possibles.

L'expert technique est chargé de stimuler la créativité de l'équipe de participants, il offre de nombreuses caractéristiques d'une solution possible au problème et les participants, experts techniques et solveurs, s'emploient à améliorer la carte d'idée. L'objectif initial est de fournir des données personnelles pour l'inscription et l'objectif principal est d'aider les participants au solveur à améliorer la carte d'idée.

Directeur industriel est la racine de l'atelier de créativité. Il propose un problème industriel et reçoit de nombreuses solutions possibles.

Certains de ces rôles créent l'environnement requis qui permet à d'autres rôles d'échanger des idées. Il est primordial d'impulser la créativité individuelle dans chaque groupe créatif collaboratif formé au cours de cet atelier ; les participants réalisent plusieurs séquences créatives afin de générer une quantité énorme d'idées en utilisant des activités faisant toutes partie de la phase de divergence. Selon la phase de convergence, les solveurs-participants formalisent, décrivent, écrivent et représentent leurs idées et leurs cartes d'idées à l'aide de notes autocollantes, de cartons, d'images, de sons, de vidéos et de méthodes créatives. Les deux phases, divergence et convergence, sont au cœur de la créativité collaborative au sein de toute organisation.

L'événement 48H a six phases de créativité ; ces étapes font du vélo dans le but de les améliorer. Certains éléments comme Idées (I), les cartes d'idées (IC), qui sont une excellente source pour trouver les solutions possibles (PS), sont également améliorés. Les phases de la créativité sont les suivantes : 1 Description du problème, 2 Idées de divergence, 3 Convergence des cartes d'idées, 4 Évaluation, 5 Enregistrement et 6 Solutions possibles.

### **III Mise en œuvre d'un système intelligent de gestion des idées**

Ce chapitre décrit un système intelligent prenant en charge la gestion des idées. Pour expliquer la conception du système intelligent, il est nécessaire de prendre en compte les chapitres précédents où les activités de créativité et les différents rôles du participant ont été expliqués. L'atelier de créativité est un environnement où les acteurs partagent leurs connaissances. De plus, ces connaissances sont créées et évaluées de manière dynamique. La collaboration entre ces acteurs est physiquement distante et leurs interactions pourraient être asynchrones ou synchrones afin que nous puissions dire que le processus est distribué. La nature des informations est hétérogène (idées, expériences, schémas, etc.) et également distribuée. Pour ces raisons, nous avons choisi d'utiliser une approche système multi-agents car ces systèmes prouvent déjà leur efficacité pour gérer des informations distribuées et hétérogènes (Dignum et al. 2005).

Pour construire un outil pour ce genre d'événement créatif, nous avons besoin d'étudier comment prendre en compte le modèle humain de partage des connaissances et comment un système proposé peut développer une approche sémantique pour comparer les cartes d'idées dans un atelier de créativité de 48 heures. Les principaux objectifs de cette recherche sont de comprendre le partage des connaissances lors d'un atelier de créativité et d'étudier l'organisation humaine dans un atelier de créativité et son processus général, en

particulier. Nous étudions l'événement 48 Heures de créativité (48H) comme un processus créatif et innovant où l'idée est le produit final.

#### **IV Ontologie**

Nous avons modélisé l'atelier de créativité dans le chapitre deux pour mettre en évidence les connaissances et les idées utilisées et créées par les participants. Le modèle décrit la structure organisationnelle, les idées, les processus, les activités, les acteurs, les rôles, les méthodes, les cartes d'idées et les n solutions possibles. Tous ces concepts composaient les connaissances créées lors d'un atelier de créativité. Nous proposons dans ce chapitre de construire une ontologie pour structurer et représenter la connaissance des ateliers de créativité. Cette ontologie sera utilisée par le système multi-agents décrit dans le chapitre trois afin d'annoter la carte d'idées et de faciliter la gestion des idées.

#### **V Approche sémantique pour gérer les idées**

Ce chapitre décrit notre approche sémantique pour gérer les idées lors d'un atelier de créativité. L'approche sémantique s'applique aux quatre étapes de l'atelier de créativité (besoins, idées, créativité et innovation).

Le mot sémantique a deux significations importantes : la sémantique (informatique) concerne l'étude mathématique des langages de programmation comme l'écrit Bossi (Bossi et al. 1994) et la sémantique (linguistique) est le sous-champ consacré à l'étude du sens, comme inhérent au niveau des mots, des phrases, des phrases et des unités de discours plus larges (appelées textes ou récits). Dans certains exemples particuliers, un problème courant dans l'étude de la sémantique consiste à calculer la similarité sémantique entre deux mots (Li, Bandar et McLean, 2003) ou à évaluer la relation sémantique à l'aide de représentations en réseau (Resnik, 1995). Les autres problèmes sont: La désambiguïsation du sens des mots, où Resnik utilise un algorithme qui tire parti de la similarité taxonomique pour résoudre les ambiguïtés syntaxiques et sémantiques (Resnik 1999). Détection et correction des fautes d'orthographe (malapropismes) (Budanitsky et Hirst, 2001). Cohérence, le schéma de segmentation du texte fournit le cadre permettant de reconnaître une structure de texte cohérente (Kozima, 1993).

Nous présentons également dans cette section notre approche sémantique pour gérer et annoter des idées. Nous décrivons l'approche sémantique pour comparer des cartes d'idées dans l'atelier de créativité 48H. Pour réaliser cette proposition, nous présentons une méthodologie en trois étapes «1- organiser le contenu des cartes d'idées », «2- comparer les cartes d'idées de manière sémantique » et «3- annoter les cartes d'idées» en tant que processus de connaissance. Organisation.

Conclusion générale de la thèse

Ce chapitre décrit les contributions et les perspectives de la thèse.

#### **Mots-clés**

Créativité, Atelier de créativité organisationnelle, Approche sémantique, Ontologie, Systèmes multi-agents.

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## **Chapter 1: State of the Art**

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## Topics of the State of the Art

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## I. Innovation and Creativity

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## I.1. Chapter Introduction

Creativity and Innovation both concepts work together in one or more level to assure the success inside any organization. At the first level, creativity produces mental ideas; at the level of work team people work avec collaborative creative activities; at the organizational level, the best creative ideas arrive, and innovation could start. Innovation depends of creativity during all the creativity workshop (CWS) processes. *Creativity and innovation can appear at the level of individual, work team, organization, or at more than one of these levels of analysis combined, with clear benefits (Anderson, Potocnik, and Zhou 2012)*. Inside any creativity workshop is impossible to separate creativity and innovation; innovation needs creativity and creativity helps innovation with creative ideas. Nevertheless, an explanation, about what is, where, when, and how creativity and innovation appear in a CWS as an organization, is presented in definitions and in the chapter of contribution.

This research starts with a necessity or problem; it will be the root to impulse the individual creativity, since every single person can help in the solution using his intelligence. Some collaborative activities with confidence and cooperation will appear thanks to these collaborative activities after ideas are going to be presented as solutions for industrial, complex problems. *Creativity is not magical, it is an aspect of normal intelligence, not special faculty granted to a tiny elite (Boden 2009)*. However, the quantity and the quality of individual ideas created is minimal compared with the number of ideas produced having a collective creativity process. Creative collaboration is the base in every creative activity inside the process.

This chapter presents some definitions about innovation, creativity, our position, but also the explanation of some types of creativity that are inherent to it such as individual creativity, collective creativity, individual creativity processes and collaborative creativity process; at the end of this chapter the conclusion and the synthesis will be presented.

## I.2. Definitions

### I.2.1. Innovation

The word innovation has multiples definitions, with the purpose to understand the concept and to compare with creativity some definitions are given. First, inside an organization ready for changing. *Innovation is a development of new ideas within an organization, usually implies change, (Dougherty and Dunne 2012)*; the second definitions is about project management of innovative teams; *in many organizations, innovation occurs in a working team within a project management structures (Paletz 2012)*; however, creativity and innovation have simple but important differences with respect to novelty and utility. *Creativity is related to novelty, while innovation requires some demonstrated value or utility (Bhowmik et al. 2014)*. Next definition is about process in creativity and in innovation; *Creativity is seen as an exploration process in which one considers alternatives, whereas innovation is more of an exploitation process in which one tries to effectively implement an idea (Paulus, Dzindolet, and Kohn 2012)*. Innovation and creativity have important linked concepts as ideas, organization, change, team, project, novelty, utility, process, alternatives, and implementation. Innovation is part of an organizational process; this organizational process generates creative and novelty ideas or alternatives to implement them and obtain

some utility and change. Therefore, innovation is clearly different of creativity although they work together during a process.

There are some innovation's relations; innovation has close relation with idea that is the result of creativity also prosperity is a result of innovation inside companies; *inside an organization, there exist the vision to innovate with ideas generated by individuals and teams (West and Sacramento 2012)*. Moreover, innovation has its own process to generate, select and implement ideas with this process changes and prosperity are the goal for it, although creativity is located inside this innovation process in consequence of collaborative activity in generation and selection of ideas. *Innovation is the use of creative ideas that permit changes in product or services and the use of a process to produce these previous changes; what we are going to change and the process of change itself (Bessant and Tidd 2007)*.

Innovation has as purposes solve problems with several processed ideas in the collaborative creativity activities. *Innovation correspond to the implementation of ideas towards better procedures, practices, or products (Anderson et al. 2012)*. Innovation is also seen as knowledge-based process, *knowledge is a primordial input inside process and process is elemental in innovation; in a procedural point of view, innovation is the knowledge treatment (Tidd, Bessant, and Pavitt 2005)*.

There exist several ways to achieve innovation, the steps to innovate could be lightly different for some authors but they always have an essential step to manage ideas. The innovation process could change according to the author or necessities, this process could be linear or cyclic and this process always will have the phase of ideation; *all innovation project has four phases: collection of information, ideation and selection, realization of the idea and finally diffusion of the product (Pizelle et al. 2014)*. The innovation process described as general process of design that means four stages: exploration, ideation, co-creation and experimentation; *Innovators use design thinking to move through three general phases inspiration, ideation and implementation (Brown and Katz 2011)*. The process of innovation has different steps, activities stages according the necessity or characteristics of the problem however, ideation or generation of ideas are an essential part of them. *This process of innovation integrates the notion of idea generation that is one base activity of the innovation process with the activity of management of ideas (Murah et al. 2013)*.

The most innovation has a lot of important results in the progress in the organizations, companies, countries and in the world, we have to put attention to the development of new technologies and learn from every field and domain to contribute inside of our society. *Far from being a simple mode, innovation reveals a deep change, the contemporary innovation wants the invention of new identities for the objects, a necessary activity to know how to break the rules of design of all orders, new values, new business models, new functions, new technologies, new architectures and new ecosystems (Burguer-Helmchen, Thierry, Hussler, Caroline, and Cohendet 2016)*.

All process follows to implement something useful to the society, something that is very relevant and opportune, innovation must be in exact time to cause a big change that is a hard job but also innovation is not alone. There is a partner that motivate, impulse, accelerate their goals during the process, it is creativity; the real formula to progress in any field, domain and discipline is a couple or basic team created by innovation and creativity. This concept is extremely relevant; of course, in our work, creativity is not an exception.

### 1.2.2. Creativity

The literature presents some definitions of creativity, it is perceived in a positive way and the variety and complexity of its meaning make us think in a valuable and rich concept; *creativity can be defined as the ability to generate novel, useful, and valuable, ideas (Boden 2009), (Sternberg 2005), (Stein 1953)*. Nevertheless, the development and the generation of ideas and innovation are concepts completely different with respect to creativity. *The “useful” aspect of a creative idea or product is a reference to innovation, and the development and the generation process is separate (Amabile 1986), (Amabile 1983)*. Creativity shows some different views according to process, person or product; *psychologist have a long history of disagreement with the definition of creativity, variously defining it in terms of the creative process, the creative person or the creative product (Amabile 1983)*. Even these differences, creativity is the source of solutions expressed by individuals and society to cover needs. *Creativity enables the individual to take greater benefit from opportunities (Soriano de Alencar 2012)* and also creativity is basic to innovate and is the result of the generation process; *creativity is intimately connected with innovation, and innovations are of great importance to organizational effectiveness and survival (De Dreu, Baas, and Nijstad 2012)*.

People with creative abilities and free time takes long time in creative process, many positives characteristics and skills can be given, but the principal characteristics to impulse creativity could be decision, background, environment, motivation, support and direction; *creativity refers to the constellation of personality and intellectual traits shown by individuals (Findlay and Lumsden 1988)*. Some positives individual characteristic such as domain of the topic, confidence and the capacity to collaborate, keep easy the production of ideas and in consequence the solution of problems; *the cognitive capacities comprise the easy way to manage open problems (Gabriel 2016), (Sternberg 2005)*.

Creativity and innovation shared a space in the progress with respect to the time, creativity is necessarily a first condition to innovate and finally obtain progress although some definitions are in disagreement. *The implementation of creative ideas in an organization is the innovation, creativity is an initial point to innovate but it is not an enough condition, to consider an idea as creative, this idea must be different to the previous ideas (Amabile 1988)*. At the end of collaborative creative process in an organization, participants present several and different ideas as possible ideas to innovate. *The nature of an idea must be heuristic, different alternatives have to be tested until find an acceptable solution (T. Amabile 1992)*.

The motivation that produces the evaluation of an excellent idea that has the conditions to be a solution, impulse the confidence of individuals and increase the collaborative creativity inside the group. *The nature heuristic of the creative task has consequences in the factors to increase or decrease creativity, specially on individuals (Burguer-Helmchen, Thierry et al. 2016)*.

The risk to reach progress and to face challenges to have better processes to get new technology are supported by creativity in all their aspects such individual creativity, collaborative creativity, collaborative creativity process and supported too by innovation to develop the ideas produced in collaborative creative process. Both concepts create a strength to manage knowledge in this era of information, communication, ontology, agents, architectures, information systems and artificial intelligence.



### 1.2.3. Scientific challenges: positioning

Last century, communications and information technologies didn't have the strength and the coverage to transmit the social problems in the world and the novel solutions were spread in a slow and limited way as health, economical, countries-relations problems.

The actual century has a modern society but with some specific characteristics like many and diverse necessities in different domains and disciplines, complex problems and requirements. Now this society could express easily these characteristics to another societies, however, there are a big austere society and other poor society with minimal or null contact or use of the new technologies. Unfortunately, the difficulties in society are transmitted to our more elemental resources such as air, water, soil, energy. These three types of societies have the same problems with respect to the elemental resources, nevertheless, they face the necessities, problems and requirements in a different way mainly with organizations to confront them. Consequently, organizations like industries; companies are getting bigger due to innovation in novel products, services, and processes that improve the relations and the quality of life. Due to these demand, novel, creative and innovation contests are taking place in countries, organizations, educative centers taking in account the great importance individual creativity and collaborative creativity inside organizations in order to solve complex industrial problems.

For the previous reasons, the importance of creativity and innovation in countries in our changing world is immense; therefore, both words are basic in the development of our planet. Creativity and innovation have been deeply analyzed from the middle of the last century to today; it is important that we express the importance of creativity and innovation to real-world organizations. For example, today's rapidly changing environment provides a unique context in which creativity occurs (Csikzentmihályi, 1999), a context which needs to be considered for future research (Robledo et al. 2012).

## 1.3. Individual and collective creativity

### 1.3.1. Individual creativity

There are several definitions to individual creativity. It is an ability to create ideas to solve problems, besides it has two important elements the person and the domain of the person such as the knowledge or experience that individual has to create, share or deliver ideas; individual creativity impulses organizations by mean of collective creativity however some positive conditions like motivation and confidence are necessary to achieve a set of better ideas. *Individual creativity is essential in organizations, any approach, process, or characteristic that enhances individual creativity should also have positive effects on team creativity* (Paulus et al. 2012), (West and Sacramento 2012). Leaders and colleagues are factors to affect or to impulse directly to the results of individual creativity, the relation among individuals also cause effects in the individual creativity. *Organization impulses individual creativity with mechanisms for enhancing creativity but these mechanisms could sometimes affect in their performance* (Agars et al. 2012), (De Dreu et al. 2012).

Individual creativity has as primordial objective to create ideas, we could use some activities or techniques to provoke the participation, collaboration, creation of many ideas; these ideas will be evaluated and enhanced to feed innovation. *There is a close relation*

*between individual creativity and organizational innovation, this relation is based in the production of something new, without creative ideas, there is nothing to implement (Amabile and Pratt 2016). Individual creativity is part essential in any creativity workshop process, every individual collaborate in the solution of the problem with an idea that could be combined with another ideas or transformed by another individual, at the end of the creative process the individual creativity helps to the team and consequently helps to the whole organization with collaboration. The model of creativity has five stages, 1. Identifying the problem, 2. To build knowledge, 3. Possibilities to solve the problem, 4. Evaluation and 5. Outcome assessment (Amabile and Pratt 2016).*

### I.3.2. Collective creativity

Individual creativity forms collective creativity by mean of creative activities. In latest century and during this century collective creativity has more elements that help in the solution of problems, these elements are technological devices such as computers, mobile phones, servers and also services as internet, communications that support data, voice, video and software. Initially, *creativity and especially the collective aspect of creativity in the organization are undervalued, though most of the work in the organization needs the expertise and creativity of many employees (Parjanen 2012). All gadgets or electronic devices that help in creativity such as laptops, tablets, cellphones belong to the group of collective creativity as humans; much of our intelligence and creativity results from the collective memory of communities of practice and of the artifacts and technology surrounding them --- what we call collective creativity (Nakakoji, Yamamoto, and Ohira 1999).*

The diversity of disciplines and the collectivity among the individuals from each discipline help to find better and more variety of solutions for complex problems, collective creativity is wide and impulses the development in all scientific directions. *Science is not more a solitary work, solutions do not stem from a unique discipline or a unique person (Veilleroy and Hoogstoel 2012). In recent years, collective creativity is used in particular complex problems, for example: problems co-design as collective creativity in eHealth interventions with children and young people (Thabrew et al. 2018); a global collective creativity to solve complex problem of our planet (Family 2003).*

People inside collaboration have a common goal, on the contrary inside collective creativity have not. Collective belong to collaboration that is most complex concept. *Collective creativity can be very powerful and can lead to more culturally relevant results than individual creativity does, this is what happens with really good collaboration based on teamwork (Sanders 2001). With the new informatics applications and asking people about any problem by mean of simple questions, we can obtain huge quantities of ideas to solve problems using individual creativity, the complexity is to stablish a team to maintain the communication and feedback. the logic behind this approach is to use humans to perform small task that can be easily done by humans but cannot easily by computers (Girotto 2016);*

### I.3.3. Process for individual and collective creativity

The importance to produce ideas to cover needs is increasing. Early work on creativity focused largely on the importance of the individual to the creativity process and the production of creative products (Barron & Harrington, 1981; Ford & Gioia, 1995; Galton, 1869; Reuter, Panksepp, Schnabel, Kellerhoff, & Hennig, 2005). As an example, there are two

processes, in the first place *The creative process is structural, inspirational and situational* (Shneiderman 2007) In the second place, other classifications about processes are done like combinational, explorational and transformational (Boden 2009). The detail of these combinational processes have been explained and used by other authors *The combinational process produces new ideas from two or more ideas, the explorational and transformational processes apply some rules or alter the ideas; by exploring a conceptual space* (Goldschmidt and Tassa 2005).

During the individual creativity process, participants as individuals receive the problem and they produce ideas in an individual manner. These ideas are in their minds and the collective collaborative process will start in the next level where activities as brainstorming and problem solving will appear. *The creativity and its process have different perspectives of analysis individual, collective and organizational* (Mumford 2012), the individual perspective is cognitive. *The individual process is a nonlinear process to generate knowledge considering different mechanism* (Gero and Kannengiesser 2004). In the individual creative process appears the divergent thinking to help in the production of ideas as an ability, we could develop this ability with the purpose to increase the quantity of ideas. *Divergent thinking is a complex ability, influenced by task type, knowledge, experience, personality, and attitudes* (Mumford 2012). *Divergent thinking is the most important ability in the process of generation of ideas to solve a problem* (Acar and Runco 2012).

The inspiration is one creative process that happen on individuals, they have an instant of creativity which is produced by anything, good, bad, ugly, pretty many adjectives also helps on this inspirational process, however inside a group or an organization, would the creative process work similar? Perhaps is not the moment neither the job to answer this question. The collaborative creativity and organizational creativity process being bigger as individual creativity process with respect to the quantity could influence in the production of ideas with another similar creative process such as structural, situational, combinational, exploratory and transformational. However, we have to know, these concepts for our job that happen inside a creativity workshop: collaborative creativity and organizational creativity.

#### 1.3.4. Collective creativity process

Creative process and collective creative process are topics that define actions to get a product; but the collective creative process has stronger effect in the production due to the collaboration of individuals. The creative process was earlier studied since the middle of the last century; *A creative process is the succession of thoughts and actions that leads to an original and adaptive production, (a) preparation, (b) incubation, (c) illumination, and (d) verification* (Guilford 1950). However, this creative process has been modified according to the needs; *Empirical research suggest that the basic 4-stage model may be revised and replaced* (Lubart 2001). Some adaptation to the creative process has been done in nineties and during this century; *the creative process has three component intuition, incubation and insight – the phenomenological hallmarks of human creative thought* (Shames and Kihstrom 1994), *but evaluation is essential in the creative process* (Boden 2004).

Collective creativity process appears with the interaction of individuals in the production of ideas this concept is new in relation with “creative process”. *Collective creative process, which emerges through both individual work and collaboration between the designer and the programmer, the model used has the following four facets collection, representation,*

*interaction and reflection (Nakakoji, Yamamoto, and Aoki 2002). On the contrary to creative process, collective creative process defined as a process during which different individuals have to collaborate, has not been investigated as much as the individual one (Peilloux and Botella 2016). Some collective creative process from animals could be adapted in our human collective process as the appearance of "higher order" from the actions of a group of relatively simple agents following local rules such as flocks or ants (McDonald 2009).*

The difference among collective creative process with organizational and collaborative creative process is in the goal of the group of individuals, since individuals from collective creative process doesn't have a common goal as in organizational a collaborative creative process.

## I.4. Organizational and collaborative creativity

### I.4.1. Organizational creative process

Since the last century, creativity has been studied in an individual point of view but nowadays the perspective collective or collaborative creativity process are more important. *An analysis of 45 years of scientific productions confirm that augmentation in collaboration (Sawyer 2012).* Due to complex issues in a variety of domains cause the intervention of expertise working in collaboration.

Organization has in its environment activities creativity and innovation. *The collective creativity considers the social interaction, to produce different ideas. This is the case of brainstorming and creative solving problem (Osborn 1953) while organizational creativity needs qualified employees to implement change; such a change. The creativity process has four steps (cf. Figure I.1), beginning with problem finding, then cycling through problem defining and solving and solution implementing according to (Basadur, Basadur, and Licina 2012). This creative activity in the organization help us in our work to understand the general creative process during a creativity workshop, where a problem represents industrial needs. Four iterative stages represent the creative process: analysis of the problem, idea generation, idea evaluation and implementation/communication (Howard et al., 2008). Other author presents more detailed the creative problem with the concepts of the problem, resources, information analysis, evaluation and selection, communicating and evolving (Olszak, Bartuś, and Lorek 2017).*

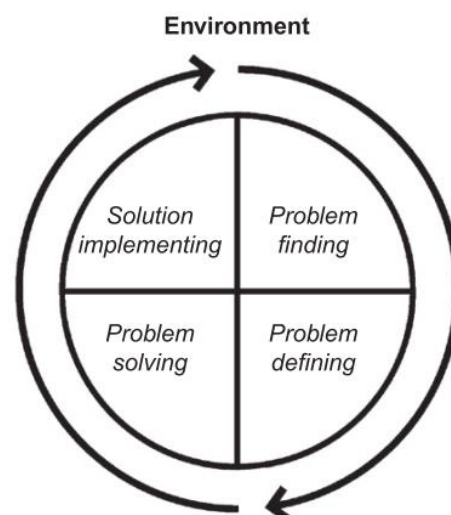


Figure I.1: Creative activity in an organization.

A positive and crucial characteristic in collaborative creativity are the heterogeneous groups with individual's domain and leadership. *These different types of groups in domain, knowledge, discipline stimulate the creative collaboration with diversity in ideas; this characteristic helps in all creativity levels individual, collaborative an organizational; creativity is multilevel (Drown 2012), (Marion 2012) heterogeneous groups are more productive (Simonton 2012).* Today, the collaborative creativity solves complex problems based in work team, information technology and communication; *a single individual does not possess all the knowledge necessary to solve these problems, and teams have been viewed as the solution to this problem (Reiter-Palmon, Wigert, and De Vreede 2012).*

The University of Lorraine, Nancy France, in the ENSGSI at ERPI laboratory has an annual contest of creativity. It is a creativity workshop 48H. This complex challenge involves different organizations, cultures and countries that work with creative ideas to produce collaborative creative ideas with the purpose of give some ideas as solutions to an industrial problem but also as possible solutions to innovate. *An important point to recognize, given the significance of creativity to organizations, is that encouragement and management of creative efforts are not easy endeavors (Robledo et al. 2012).*

#### I.4.2. Collaborative creative process

Collaboration means work together and share knowledge also we can add that collaboration is carried out by individuals that have a common problem; these individuals form a group to talk about ideas to solve problems or similar situations, this group spends time together until they achieve one or several solutions. *Collaboration means work with others, it is a way of cooperation if all individuals have a common goal (Boughzala 2007).* Inside the collaborative work must exist confidence, cooperation, help and a common language to express concepts, difficulties, characteristics and ideas; *the notion of collaboration is larger than cooperation (Boughzala 2007).*

The collaborative creative process could have as a final product "a conversation" which is an idea too; *interaction flow is a mode of interaction in which (a) participants' non-verbal signals express a joint heightened involvement in the conversation, (b) participants build on one another's contributions through reflective reframing, and (c) turn-taking dynamics among participants intensify (Oortmerssen, Woerkum, and Aarts 2015).*

There are creative process and techniques that helps in the collaborative creative processes, concepts such as foster, improving, interaction, ideation and evaluation are presents in a collaborative creative technique. *Some collaborative creative techniques in an adequate environment appears to impulse the production of ideas (Marion 2012);* When collaborative creative process is not enough to cause changes the organizational development interventions is used; *Organizational development is a continuous process of finding and solving problems and implementing solutions (Basadur et al. 2012).* During a collaborative creative process the social interaction must appear; *Collaborative processes are those that involve some degree of interaction and coordination (Paulus et al. 2012).* There are more process to help collaborative creative process; *they are several alternative processes that can be viewed as creative designing processes because they have the capacity to introduce new variables into the design (Gero 2000).*

Convergence and divergence are important steps in a collaborative creative process. Convergence support innovation and collaborative creative ideas support divergence. As a process, collaborative creative has some stages: *fact finding, problem defining, idea finding, solution finding and acceptance finding with divergent (ideation) and convergent (evaluation) thought in each step; there exist distinct stages of an organizational creativity process (Osborn 1953). Divergence and convergence skills (cf. Figure 1.2) are needed in a short process of ideation and evaluation (Basadur & Finkbeiner, 1985), (Basadur et al. 2012).* Both steps are important in our general creative process that is present in the stages of 48h's creativity workshop. In our general creative process, the active divergence will happen first in the stage of ideas where participants have their ideas in mind, active convergence is in the creativity stage where collaborative activities appear to produce and evaluate idea cards.

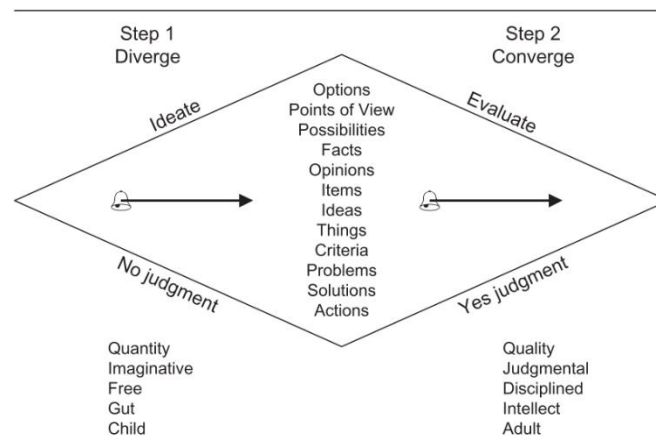


Figure 1.2 : Ideation evaluation: A sequential creative thinking mini process.

Besides creativity process, techniques also help in the idea evaluation process, techniques are skills necessary for creative work; *for individual are styles of thinking, working, approaching the world and for organizational are skills in innovation management, conception development and implementation of ideas (Amabile 1988).* Another complex techniques is parallel thinking, *this technique bases in that idea has six imaginary vision color hats (De Bono 2000).* The generation of ideas through activities could be achieved by *individual or group activities; typology of idea generation activities (VanGundy 2005).* Other complex techniques achieve the generation of ideas; *a mature theoretical framework for solving contradictory problems creatively (Chen, Jia, and Xiao 2015).*

## 1.5. Research context on creativity

### 1.5.1. Introduction

Today, all organizations present the importance of innovation and creativity. Although they have been studied since the last century, new creative and complex ideas, collaborative activities, processes, collaborative tools still appear nowadays with more intensity than ever. *Domain differences between innovation and creativity were examined in the 1930s (e.g., Patrick, 1935, 1937, 1938), and social criteria of creativity relying on consensual agreement go back at least to 1953 (Stein 1953).* Creativity has some specific characteristics to be adequate in an organizational process or in the scientific method, *it is collaborative, original, effective and it has to be present in individual, group and organizational level; the standard*

*definition is bipartite: Creativity requires both originality and effectiveness (Runco and Jaeger 2012).*

Creativity is a way to solve problems and cover needs by mean of creative ideas generated in an individual, group or organizational processes. For this reason, educative centers teach and train creativity with the purpose to develop it and enhance it. Creativity workshop, creative support system, ideas management system, creative collaborative process and tools to support creativity are topics immerse in this research where creativity is used to produce thousand ideas with collaborative creative activities.

This chapter's section presents some research works in the domain of innovation and creativity.

### 1.5.2. Creativity Workshops

The creative workshop described in the literature are used in different domains like education, industry or entrepreneurial, for example, workshop in creative education (Barry and Kanematsu 2007) and creative problem solving (Camacho et al. 2016). CWS have three similar and important characteristics "Creative Techniques", "Role Solver-Participant" and "Role Creative Expert" and all integrate the concept of "creative thinking" to solve problems, these *creative thinking are mental processes such as retrieval association, synthesis, transformation, analogical transfer and categorical reduction (Sternberg 2005).*

#### A. The 48 Hours to generate ideas challenge:

For almost one decade, in the Engineering School of Innovation (ENSGSI) of the University of Lorraine organizes an important event is happening and it will be keep happening. The "48 hours generating ideas" (48H) offers, every year, a creativity workshop to generate ideas with the purpose of solve industrial problems. The key to do it is to use Creativity, Collaborative Creative Techniques in order to generate a big quantity of ideas. The collaborators inside this CWS are industrial partners, and the participants are students from Universities from different countries and with different cultures.

During the creativity challenge 48H, the students have the role of solver participant, so they are the responsible for solving industrial problems. Organizers will deliver material, agenda, a room to organize the teams, instructions, and directions to follow the event. Creative expert helps students to apply creative methods to generate ideas. Technical experts give some advises about the industrial problem to the solver participants; Industrial managers deliver the problem. All stakeholders work in collaboration inside this organization with the purpose to achieve the missions and goals of the organization.

At individual level, solver participants have to present by himself or herself, after they think in possible solutions for the problem. They use creative methods to generate ideas such as brainstorming, write storming or other creative activities to generate ideas; next, the creative expert helps to the group with a creative and collaborative method or technique in order to generate a big quantity of ideas and select creative ideas. In that moment, the group level appears; the organizational level will appear when every group, with the same industrial problem, shares the two best ideas. After that, the participant has to evaluate two ideas in order to obtain and score, participant have to remember that every idea is important and the high or low score just represent a comparative among different idea cards

which is important for all participants. During this CWS every solver participant and in consequence each group of solver participants has all the conditions to generate ideas such as time (48 hours), room space, the industrial problem, materials, support staff, communications and a web platform to share ideas online.

### B. Workshops in Creative Education for Students and Teachers:

This workshop in creative education, led by Barry and Kanematsu (Barry and Kanematsu 2007), includes the preparation and use of innovative teaching techniques and tools. It is sponsored by the Northern New York section of the American Chemical Society and Suzuka National College of Technology in Japan. The program's main goals are to turn students onto science/engineering and to prepare them to be creative problem solvers.

The international program created to develop student's creative thinking skills in science and engineering is carry out through workshops, using three creative teaching techniques developed by the authors. The Multisensory Teaching Approach takes advantage of students' senses and it is designed to meet individual student's needs. The method Science Fair Projects allows students to creatively solve and share the results of their exciting investigations. To develop critical thinking and problem-solving skills by reading stories and solving mysteries.

The total number of students from USA and Japan Organizations are 207; they belong to Clarkson University (US), Edwards-Knox High School (US), Canton High School (US), Suzuka National College of Technology (Japan), Takada High School (Japan), Kanbe High School (Japan).

### C. Creative Problem Solving Builds Entrepreneurial Mindset:

Students in various disciplines from the Pennsylvania State University- Berks Campus (USA) served as mentors for a primarily middle school and high-school group of students and teachers during the service-learning workshops conducted in the rural municipality of San José de Cusmapa (Nicaragua).

These workshop series were developed as part of the Penn State Berks Creativity, Entrepreneurship, and Economic Development (CEED) Center's initiative to expand students' global and social entrepreneurial mindset.

Participants, four students majoring in various disciplines (Business, Information Sciences and Technology, and Global Studies), enrolled in ENTR 497A- Creativity and Innovation Workshops course to develop strategies to instruct and serve as student mentors during the week-long service-learning trip workshops in San José de Cusmapa, Nicaragua.

The Nicaraguan workshop participants first worked on various creative problem-solving activities, then learned to develop a business model and came up with their innovative idea, and finally presented their business models at the end of the week. The total number of workshops participants was of 20 students (11 females and 9 males) and 5 teachers (1 female and 4 males).

There are seven characteristics inside this comparative table showed above, clearly, 48H has a notable quantity of countries participants in contrast to the other CWS with just two countries (*cf.* Table I.1). The roles created in 48H are specialized, but the mentors, in workshop III, applies a lot of creative techniques, so the quantity of ideas is huge. In the other workshops (II educational and III entrepreneurial), the number of techniques is minimum, but the participant produces a very important quantity of ideas too. The



workshops II and III are achieved by children from elementary, middle and college schools who are by definition, more creative than adults are.

CREATIVE WORKSHOPS						
Number and Name	Country (ies)	Roles	Techniques	Level of students	Objective (s)	Days
I The 48H	France, Canada, Chile, Argentina, Bahrain, Morocco, Tunis, and Algeria	1 Solver-participants, 2 Industrial stakeholder/ Decision makers, 3 Technical expert, 4 Organizers, 5 Creative experts,	Every creative expert selected a technique in a meeting several weeks before that the 48H starts	Students inside all the universities, schools or institute, these students must be registered in the system of 48H	To enroll students to the event of 48H.  To generate, write, share, evaluate and select ideas in order to solve problems	2
II Workshops in Creative Education for Students and Teachers	USA and Japan	1 Creativity thinker, 2 Teachers	1 Multisensory Teaching Approach, 2 Science Fair Projects, 3 Reading stories and solving mysteries	Elementary students, middle school students, college students, and teachers	Turning students onto science and engineering, and to preparing them to be creative problem solvers	1
III Creative Problem Solving Builds Entrepreneurial Mindset	Nicaragua and USA	1 Mentors from USA, 2 students and teachers from Nicaragua	The business model canvas, I. The 20 Circles Challenge II. The Nine Dots Problem III. The Ball and Pipe Problem IV. The Newspaper Tower	K-12 students and Teachers	Fostering the development of creative thinking	4

Table I.1 Characteristics in three creative workshops.

The CWS “48H” is given in 2 days and the “Workshop in Creative Education for Students and Teachers” is given in one day. In contrast with the workshop “Creative Problem-Solving Builds Entrepreneurial Mindset” that was given during four days in Fabretto’s Education Center in San José de Cusmapa, Nicaragua. To ensure an enjoyable and active learning environment, a balanced combination of hands-on and creative problem-solving activities, in addition to the introduction of important business concepts, were implemented. Because a successful entrepreneurial venture is usually initiated by an idea aiming to solve an important problem, understanding how to generate ideas, solving problems creatively, and overcoming the negative influences that obstruct creativity through various practical activities were the early steps of the concept development process and the central topics of the first day workshop. The second day was focused on the development of the components that make a business work properly using the business model. The last two days were

centered on the financial aspects (revenue streams and cost structures) of the business model while continuing with more creative problem-solving activities to supplement the discussion of the business components.

When an idea is created, this is the result of the creative techniques that allow to participant to share their experiences and knowledge to generate new concepts; the knowledge shared and created linked to as idea has to be formalized in order to build intelligent creative support systems. Knowledge management shows this formalization of knowledge inside an organization; *knowledge is the principal resource in any process, method or activity creative; an organizational process which consists in identifying, preserving, valorizing, updating and managing the crucial knowledge (Grundstein 2000), (Hassen, Turki, and Gargouri n.d.)*. According to that, the organization 48H works every year in this subject and for this reason, we find knowledge and at the same time understand the CWS.

In the next section, we will present different creative technics used in the CWS.

### 1.5.3. Creativity support systems (brainstorms, writestorms)

From nineties until recent years, creativity support systems on idea generation have been analyzed in different fields and in different ways to generate valuables ideas but also hypothesis inside the organizations; *creativity support applications significantly enhance the creative performance of individual users (Massetti 1996), (Hayama, Hayashi, and Kondo 2017)*.

Each creativity workshop performs a creativity process under the coaching of creative expert other actors are included too; these are creativity participants and stakeholders. The creative expert domains the creative process where participants must have preferentially strong abilities about styles of thinking as activities to generate ideas and a positive attitude, but also collaborative working abilities such as parallel thinking, brainstorming, write storming. *However, these systems are not always useful for not professionals, system story (Kuraya, 2016). Even in computer software with several techniques to generate ideas in teams, the background knowledge is significantly (Viriyayudhakorn and Kunifuji 2012)*.

#### A. Ideas management system:

The collaborative activities belong to process but also belong to an organizational creativity process that produces ideas in several steps. This process has initial point, needs, after selection, evaluation, improvement, save, and get possible solution to the innovation stage. The issue is how to manage this enormous quantity of ideas that are generated by collaborative creative activities. We have to take in account that manage covers actions as **capture, classify, storage, retrieval, compare, evaluate, select and produce** better ideas; *Manage system based on the knowledge process of organizations, as social collectives and knowledge systems (Leidner 2001), (Holzner and Fisher 1979); Pentland 1995)*. The goal of such systems is to organize the input, assess it and produce a list of best ideas that will potentially deliver benefit to the organization. Separating good ideas from bad is the core reason for existence of idea management.

After having knowledge, the necessity to represent them ontologically must be done before to classify, store, evaluate so on; *the ontology management is the basis to even start talking about linked data in the context of idea management (Westerski and Iglesias 2011)*.

All steps are important however the evaluation step must include the quantity and quality of knowledge and the results of knowledge, *necessarily a step of evaluation will improve the ideas (Taghi and Moghaddam 2006)*. Actually, there are some systems that help in the management of knowledge transforming data into information after information into knowledge, next they use a *data warehouse to store and retrieving and finally to describe and present the information, using Data mining, known as knowledge-discovery in databases (KDD), (Hrin, Anghel, and David 2016)*.

The ideas management system constitutes several steps such as creation, selection, save, evaluation, improvement of ideas produced in an organization by mean of collaborative activities. Every step has a width opportunity to develop a helpful system in the field of ideas management. *Some information systems manage people's data and also create another action according to the people's information like external alarm in hospital (Fan and Li 2004)*.

## B. Tools to support creativity:

Creative support systems are created to support creativity and planning in all the process of ideas management, the computer tools help in any part of the management process and logically in the production of creative ideas with divergence. These tools cold help creativity in several fields and disciplines such as design, literature, technics to improve creativity, informatic, health. *In the field of design, computer tools help in the creation of difficult design and to spend less time on it, in speech production to impulse creativity, in brainstorming networks by mean of wikis or social networks, in card games that boost creativity; (Miyata 2012), (Unoki and Nishimoto 2012), (Villanueva et al. 2009), (Hasebe et al. 2013)*. There are infinite numbers of possibilities to apply tools to support creativity. With respect to innovation, it is necessary to spend more time to be creative and as a result of that innovation will increase. *Innovation is a creative activity, thus in order to improve product innovation, we must support people in being more creative (El-sharkawy, Grube, and Schmid 2009)*.

Inside organizations a general creative process supports creative collaborative activities that are carry out by actors. In addition, something very important is being generated, passed, stored, recover, processed, represented, so on, it is called knowledge. In fact, knowledge management represent a lot of our work, due to the importance of this subject, next section is dedicated to it. Topics about it are presented such as what is knowledge?, knowledge process, knowledge representation, knowledge sharing, knowledge management and collaborative work, knowledge management ontology and finally knowledge management system.

## I.6. Emergence of knowledge:

Our society is every day more modern and technological but also more complicated, as a result of that the actual problems are sophisticated and complexes, the solutions of these problems must be found using all the elements able to work in collaboration and solve the problems, these elements could be creativity, innovation, collaboration, agents, processes, organization and knowledge. With respect to knowledge, which is our topic, there are varieties of possibilities to highlight, create, process, treat, represent and manage knowledge adding to all this the knowledge sharing, organizational knowledge and

knowledge management systems. *The concept of coding, storing, and transmitting knowledge in organizations is not new—training and employee development programs, organizational policies, routines, procedures, reports, and manuals have served this function for years (Alavi 1999).*

The concept of knowledge must be well defined due to the constant development of information systems during this century; knowledge sometimes is perceived as information, but they are different, to explain the difference we have to add the concept of data and definitions from different domains. *To formalize knowledge and information is a desperate need (Hilbert 2016).* From the business knowledge management literature, information, knowledge and understanding help us in efficiency where knowledge answers how to questions, intelligence is the ability to increase efficiency and wisdom is the ability to increase efficiency (Ackoff 1999), also in information theory, information is defined in terms of data, knowledge in terms of information (Rowley 2007).

What is knowledge, we could say this concept represent the reality of the information; but there are some other definitions that together could or might complete a good but maybe not complete definition. *Knowledge may be viewed from several perspectives (1) a state of mind, (2) an object. (3) a process. (4) a condition of having access to information, or (5) a capability. (Leidner 2001); According to the knowledge based theory of the firms, knowledge is the organizational asset (Alavi 1999). The assumption seems to be that if knowledge is not something that is different from data or information, then there is nothing new or interesting about knowledge management (Fahey and Prusak 1998). Knowledge is factual authenticated information (Dretske 1981).*

In early jobs, Knowledge has an order to get it, recently a new order appears, and this order change the direction. It is very important to know the meaning of data, information and knowledge, the order and their difference although the context could complicate the job but it could help us to get a different perspective to develop an information system. *The hierarchical order is from data to knowledge, although the order is inverse: knowledge must exist before information can be formulated and before data can be measured to form information; the conventional view on the knowledge hierarchy consist in unfiltered data, patterns information, predictability knowledge, choice intelligence and compassion wisdom; (Tuomi 1999).*

To highlight knowledge is hard in the area of information systems (IS), it implies to describe the organization, processes and collaborative activities, and roles. Knowledge highlighted can be used, *however using knowledge to take decision is not always used to find answer to solve problems at least in social science research(Weiss 1980).* To highlight knowledge, we will use a model that help us however there are other techniques to create and highlight knowledge. *The creation of knowledge consisting of three elements: (i) the Socialization process, knowledge creation through the conversion of tacit and explicit knowledge; (ii) 'ba', the shared context for knowledge creation; and (iii) knowledge assets, the inputs, outputs and moderators of the knowledge-creating process (Nonaka, Toyama, and Konno 2000).*

### **Process of knowledge**

The knowledge is a resource inside organizations, knowledge as any resource as oil, fruit, mineral, water and so on have to be located, preserved, shared and take care, this process is

deeply detailed with respect to knowledge by specialist in management. The problem to capitalize knowledge can be determined by a cycle *which consists in identifying, preserving, disseminating, updating in general, managing the crucial knowledge* (Grundstein 2000). The collaborative work has also a process that contains several activities to achieve and highlight knowledge, these activities are focused to produce ideas, highlight knowledge, identify competences and roles. *A work process can be considered as a general process to coordinated activities of production, support or evaluation as well as the collaboration cycle is formed with co-analysis, co-definition, co-realization and co-evaluation* (Boughzala 2007). Both processes knowledge process and collaborative process helps in knowledge management inside organizations.

### **Knowledge representation**

There are several and different topics where knowledge can be represented to develop better information systems; the huge quantities of data travelling and sharing through the world by mean of distinct ways to communicate. These topics could be artificial intelligence, languages, learning so we need to understand and know the topic or domain to solve the problems that appear; nowadays not only text is represented, heterogeneous data must be represented from text to video (text, image, video, audio, maps). *Hypermedia represents a new medium to developing instructional programs with immediate access to multimedia resources and a new communication medium in its own right, people will communicate in real time over the network. Hypermedia CALL application thus constitute a realistic part of the future of communications* (Pennington 1996). The computer assisted language learning (CALL) is proposed initially, in nineties, in the second language learning, it was focus in the development cyclic process; *the nature of theory-driven CALL, particularly as it relates to the development process* (Levy 1997). CALL uses the new technologies to collaborate and interchange ideas in addition CALL is now better perceived as a hybrid field of study on different disciplines; *New technologies and new pedagogies using collaboration through blogging, podcast, mobile technologies and e-mail tandem* (Levy, Blin, Françoise, Bradin Siskin, and Takeuchi 2011).

Other field where knowledge representation acts is artificial intelligence: *reasoning (KR-R) is a field of artificial intelligence, KR is dedicated towards representing information about the domain that can be utilized in path planning. Ontology based knowledge representation and reasoning techniques provide sophisticated knowledge about the environment for processing tasks or methods* (Gayathri and Uma 2018). Research on knowledge representations of second language acquisition. *Implicit knowledge is usually described as the tacit, intuitive, and procedural knowledge that is mainly responsible for automatic language processing, whereas explicit knowledge is the conscious, declarative knowledge of language rules and categories* (Gutiérrez 2011).

### **Knowledge Sharing**

Knowledge Sharing helps organizations in their projects, the motivation among the individuals, good relations, and confidence helps to achieve this important activity moreover the modern technologies impulse in sharing. Knowledge sharing among different groups with different culture countries and persons is a complex problem. *Knowledge sharing is referred to as activities aimed at transferring or disseminating knowledge from one person or*

group to another (Lee, 2001). Knowledge sharing is crucial because it enables people to capitalize on existing knowledge bases residing within and outside the organization, thus enhancing their capacity to come up with creative solutions (Carmeli, Gelbard, and Reiter-Palmon 2012). As an explicit example of knowledge sharing is on how teacher-students contribute to the group's collaborative knowledge construction and use each other's ideas and tools as an affordance for their jointly evolving cognitive systems (Näykki and Järvelä 2014).

Feelings are important factor to share knowledge, another factors such as shared goals, social relational embeddedness, and influence strategy (Chen, Lin, and Yen 2014). Findings indicate that team members share their knowledge when they trust their partners and when they feel dependent. Feelings of dependence and trust are influenced by the communication frequency, perceived similarity of the project's value, and the perceived expertise (Park and Lee 2014). There are five areas of emphasis of knowledge sharing research: organizational literature review we developed a framework for understanding knowledge sharing research, the framework identifies five areas of emphasis of knowledge sharing research: organizational context, interpersonal and team characteristics, cultural characteristics, individual characteristics, and motivational factors (Wang and Noe 2010).

### **Knowledge Management and collaborative work**

Knowledge could be well defined, but knowledge management must be focus in knowledge's actions such as creation, sharing, saving, uses although sometimes is focus in modern concept as communication and internet. The definition of knowledge with respect to a dictionary, *Knowledge are facts, information and skills acquired through experience or education; the theoretical or practical understanding of a subject; (i) the sum of what is known; (ii) information held on a computer system; (iii) true, justified belief; certain understanding, as opposed to opinion* (Anon 2018). In the other side, knowledge management has several important definitions, as a discipline *Knowledge management (KM), which emerged as a separate scientific discipline in the last decade of the 20th century, takes a specific point of view on knowledge, investigating it as a resource for enterprises (realized by companies, organizations and individuals)*(Garbacz et al. 2017).

Nowadays, due to the development of communication and informatics technologies, we could use information technologies to manage knowledge such as internet, intranets, browsers, data warehouses, data mining techniques and agents (Leidner 2001). As a result of these technological development inside organizations that use this process is the success, *Knowledge management is a prerequisite for the successful organization and what knowledge management needs are tools and techniques that are more oriented towards knowledge – its creation, mapping, transfer and use* (Yang 2009). Knowledge management can be represented according to services of the organization, *it could be defined as the conscious, coordinated and operational management of all the information, knowledge and how-to of the member of an organization serving this organization* (Tisseyre 1999).

Now, talking about collaborative work, groups inside of it are sharing knowledge, competences, difficulties, differences, strength, confidence and cooperation; as a result of these ingredients in the group will be strong an able to create ideas that could be probably solutions for complex problems. *One of the challenges of knowledge management is to foster collaborative and even cooperative work to move from individual intelligence to collective intelligence* (Boughzala 2007). With the collaborative work, the individuals

increase their knowledge, security and self-esteem; with all these positive characteristics, the solution of problems could be attacked with collaborative work and knowledge management.

### **Knowledge Management Ontology**

There exist works that used ontology to support the knowledge management; knowledge management appears in the twenty century while ontology during the actual century, ontology takes a great impulse in the development of computer systems and helps in knowledge management. Some representative jobs about knowledge management and ontology are, first, *Formal Knowledge Management Ontology FKMO* which presents the ideas, expressed in natural language, in a formal way, *it is consistent and prove its usefulness by defining the logical schema of a database based on the theory* (Garbacz et al. 2017). And second, *a new type of knowledge database system to manage and obtain the distributed knowledge resources based on ontology theory* (Yan-hao et al. 2014).

In early years of this century, ontology and knowledge management help us to understand the topic or domain eliminating ambiguity and represent knowledge. *Ontology is a new object of artificial intelligence AI that recently came to maturity and a powerful conceptual tool of Knowledge Modeling, it is used to improve knowledge management* (Gandon 2002). The concept of Artificial intelligence emerges as a new and modern field and with ontology cover the relation among people, knowledge and the whole organization.

Ontology is used in a semantic approach to represent concepts from the corpus before of the general creative process but also for innovation management to support the idea life cycle. *Ontology is used to represent ideas with additional benefits like semantic reasoning and automatic analysis become available. Ontology provides a common language to foster interoperability between tools and to support the idea life cycle* (Riedl et al. 2009).

Ontology is a mirror of the reality; it has the definition of all concepts to avoid ambiguity among collaborators inside an organization. *Ontology is the study of existence, of all the kinds of entities—abstract and concrete—that make up the world...The two sources of ontological categories are observation and reasoning...A choice of ontological categories is the first step in designing a database, a knowledge base, or an object-oriented system* (Sowa 1999).

### **Knowledge management system, Information systems and Multi-Agent Systems**

In first place, we want to define an information system (IS). During seventies, last century of course, the system of information can be defined according to individual-decision-representation, *all information system concerns an individual that confront a decisional precise problem inside a determined organization, with elements of decision and a way to represent*, (Richard and Ian 1973). The SI was defined in the first years of this century, its definition was with respect to enterprises, *the information system of the enterprise is the part of the reality that consist of organized information of events having an effect on this information and of actors that act with respect to this information or on the basis of this information, according to a process aimed at a purpose of management and using information technologies* (Berthier, Morley, and Maurice-Demourieux 2005). A third definition of Information System, in this decade, is with respect to technological aspect that

*identify three main dimensions and their resources; the notion of an information system has three dimensions defined, informatic, technologic and organization (Reix et al. 2016).*

The resources in an information system are actors, data, materials and software on the contrary the resource in a knowledge management system is knowledge from data to wisdom (data, information, knowledge, how-to, intelligence and wisdom); sometimes there is a confusion but knowledge management system is focus in knowledge, creativity, innovation processes and collaboration. Due to data belongs to resources of information system and resources of knowledge management system, some resources from information system helps in the design of our informatic technological tool. *The different resources of an information system are actors (staff, executives, leaders, clients, analysts, programmers); data ( data, text, image, sound, video), material and software (terminals, networks, programs); working practices, the real practices of travail individual and collectives; and objectives of the system (Reix et al. 2016).*

The difference between the target and the purpose of knowledge management system inside organizations is minimal, both try to improve collaboration and share knowledge; the creation of knowledge management system has as a target to capture, distribute, save and reuse knowledge inside organizations; *many organizations are developing information systems designed specifically to facilitate the sharing and integration of knowledge. Such systems are referred to as Knowledge Management System (KMS) (Alavi 1999).* The concept of knowledge inside the organization, knowledge management correspond to all activities that permit to acquire, to keep, to communicate knowledge with the purpose to improve the efficacy of the action inside the organization (Reix et al. 2016).

The objectives in the knowledge management system is to improve the efficacy of the action inside an organization or to facilitate the sharing and integration of knowledge, whereas information system has as objectives to organize and control resources like data, actors, software, activities; however an important definition about the objectives of an enterprise is based in the human feelings. *One of the objectives of an organization is to achieve the enterprise of the future where every actor will give their time, competences and motivation in exchange of money, quality of life, the feeling to belong to a team and collaborate with respect and values (Reix et al. 2016).* Knowledge-based system shows data, information and knowledge helped by knowledge engineering that is looking for process to generate knowledge, keep, distribute and sharing knowledge. *Knowledge Engineering is the aspect of systems engineering which addresses uncertain process requirements by emphasizing the acquisition of knowledge about a process and representing this knowledge in a Knowledge-based System (Yang 2009).*

Collaboration and exchange ideas with the new technologies and gadgets is the new and future way to present ideas in the solution of industrial problems also in the process inside the knowledge management system such as all the activities to capture, keep, reuse, share knowledge. *The new development through the support of New Technologies, New Pedagogies, Developing Language Skills through Technology, Materials design and Development, Learner Training and Teacher Education (Levy et al. 2011).*

Multi-agent systems started in eighties under the name of Artificial Intelligence (AI), in this early century is called artificial life (Alife), the concept is young but the numbers of papers contributed to this volume suggests the potential of this concept for engineered systems (Weyns, Parurak, and Michel 2004). The multi-agent systems (MAS) describes the interaction



among individual agents, they could be people or animals like ants or bees, that interaction is carry out by mean of messages inside an environment. *Environment is essential for multi-agent systems, environments that can be divided in two classes: concerns related to the structure of the environment, and concerns related to the activity in the environment* (Weyns, Parurak, Michel, et al. 2004).

There are some studies about environment MAS and environments with organizations, these studies propose several models for environments in the last decade. *The relation between an intelligent agent and its environment, where agents interact with the environment through sensors, the agents perceive the environment and produce actions toward that environment with effectors; the description of the environment is primordial in the MAS by Russell and Norving. Second the modelling of environments by Ferber. AGR (Agent-Group- Role) organizational model, called AGRE (AGR + Environment), which includes physical (or simply geometrical) environments (Ferber, Michel, and Baez 2004).* The description of agent, groups, roles, missions, goals procedures, collaborative activities, definition of reactive agents, cognitive agents, the ontology and the semantic approach inside an organization create the conditions to realize the design of an informatics technologic tool.

## 1.7. Conclusion and synthesis

Innovation as a part of a process has the solution or solutions of a singular problem, these solutions are obtained in previous steps of this process using creativity in their three levels individual, collaborative and organizational. Creativity is a positive ability, it is used to create ideas in an individual manner, moreover, there exist collaborative activities that permit to produce big quantities of ideas using different collaborative creative techniques; thus, individual and collaborative creativity impulse organizational creativity. In the creativity workshop 48H thousands of ideas are produced using creativity in all its levels with the clear purpose to innovate the several ideas solutions using convergence that are presented to the industrials.

Creativity workshop is a complex environment (individual, group, organizational, process complex); In a general process inside an organization is a difficult task to set the limits among them. First we have to know the difference between creativity and innovation, they are concepts linked but completely different. Second, to understand the three levels inside an organization, individual creativity, group creativity and organizational creativity; the individual creativity will be in group activity and in organizational creativity. Third, it is complex to define the stages in an organizational creativity workshop something the divergence in ideas could produce many ideas but the path to arrive to the convergence and to do it is difficult. Fourth, to produce knowledge through an organizational model (organizational structure, processes and collaborative activities and roles) is not a simple task.

The main result of the creativity workshop is knowledge, at first, needs appear and immediately ideas are created in individual and in collaborative creative activities, after an evaluation and feedback is done, next thousands of idea cards are produced as solutions, initial innovation is arrived; this brief process has knowledge. The process to generate idea cards solutions in particular or any process in general have in their interior a principal

element, the human element, human being or group of them execute the whole general creative process to create idea cards or produce new and useful things or services.

Inside 48H creativity workshop, natural language is used to create idea cards as problem solutions. Human beings or actors produces these idea cards; Actors play a role or roles during this process. Every single idea card produced content several heterogeneous fields majorly of them use natural language, another use picture or photo, date and consecutive number. Inside our project the fields industrial problem and description. How to manage this quantity of idea cards, create, store, delete, evaluate, modify, select that are done by actors.

With the purpose to manage ideas, initially a corpus is created to store idea cards; the idea card's information would be represented (ontology) in some way that any informatics machine could manage these idea cards. This representation helps us to store the ideas in the corpus. The field name of idea and description are taking in account to modelling the creative idea cards.

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# Chapter 2: Creative Ideas and Models

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## Topics of Creative Ideas and Models

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## **II. Creative Ideas and Models**

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### **II.1. Chapter introduction**

In the previous chapter, we present a state of the art about creativity and innovation. This chapter brings a representation of the creativity workshops and the evolution of the ideas. We chose “to model the creativity workshops with an organizational approach to highlight knowledge” (ideas, concepts) created during the interaction between the different roles of the professional actors inside the creativity process. Indeed, the purpose of organizational models is to highlight the organizational structure of a team or a group and to describe the information and knowledge used and share inside those organizations. This chapter also

presents the creativity process, the evolution of the ideas, an organizational model to understand a creativity workshops, furthermore, it presents some creativity workshops to contrast the different characteristics among them and our creativity workshop forty-eight hours (48H) organizational model.

A creativity workshop is a group that works together to apply individual activities and collaborative creative methods to generate ideas. The creativity workshop is a complex organization due to the different participants who work in a collaborative way to apply collaborative creative methods (Drown et al. 2012) and activities (Dean Keith Simonton 2012) to generate a maximum of ideas.

During the creativity workshop, the individual ability and emotions of the solver participants are the base to produce a divergent thinking and support a creative organization. Acar in (Acar and Runco 2012) highlights the importance of the divergent thinking: "creative ability is a broad label and category; there is one notable kind of creative ability, namely divergent thinking ability."

The creativity workshop 48H at the ENSGSI (École Nationale Supérieure en Génie des Systèmes et de L'Innovation) brings together all the mentioned characteristics such as activities, collaborative creative methods, and an organization. During two days, different educative institutions, industries and stakeholders will work in collaboration, using activities and collaborative creative methods to generate ideas in an individual way. At the end of this creativity workshop, thousands of ideas evolved to become idea cards and they will be the possible solutions to innovate.

### **An organizational model to understand creativity workshop**

We chose to model the creativity workshops with an organizational approach to highlight knowledge (ideas and concepts) created during the interaction between the different roles of the professional actors inside the creativity process. Indeed, the purpose of organizational models is to highlight the organizational structure of a team or a group and to describe the information and knowledge used and shared inside those organizations. In order to model the CWS, we have used *The Knowledge Reuse Organizational Model called KROM* (Girodon, Monticolo, Bonjour, et al. 2015) which allow to model the missions, goals, processes, activities, competences, knowledge, agents and responsibilities of an organization.

During the creativity workshop, the individual ability and emotions of the solver participants are the base to produce a divergent thinking and support a creativity inside an organization. After, in the phase of divergence, teams formed by solver participant act in the convergence phase where they generate collaborative creative idea cards next the phase of evaluation improves the content of idea cards. the phase of divergence is recommended by Selcuk Acar and Carsten, they highlight the importance of the divergent thinking: "creative ability is a broad label and category, there is one notable kind of creative ability, namely divergent thinking ability" (Acar and Runco 2012), (Carsten K.W. De Dreu, Matthijs Baas 2012). The creativity workshop is a complex organization due to its creative characteristics such as the individual abilities, the use of individual activities, the use of collaborative creative methods to cover the problems inside an organization, the organizational characteristics to impulse leadership, and the work realized by heterogeneous groups inside the organization (Simonton, 2004a, 2010), (Dean Keith Simonton 2012), (Drown 2012). The

phase of divergence is primordial with respect to creativity, here, solver participants carry out activities to produce individual ideas that impulse the creation of other novel ideas.

In the creativity workshop 48H, the organizer presents a new topic, subject or problem to solve. After discovering the problem, the participants use different creativity ways to produce novel ideas:

- Combinational: combination among other ideas produces new ideas, (Bhowmik et al. 2014).
- Exploration: ideas with some rules (Gero 2000).
- Transformation: ideas with some alteration; (Boden 2009).

After the problem discovery activity, a creative coach explains the different collaborative-creative methods to the participants and creates a trust atmosphere by using team-building games. The trust in the creative groups is an important condition to facilitate the ideas creation. *At the organizational level, creativity is the creation of a valuable, useful product, service, idea, procedure, or process by individuals working together in a complex social system (Damanpour and Aravind 2012).* In order to reach this creation of value, we observe different roles during the creativity workshop.

Organizer has several purposes, they are to require details from the actor for inscription, to provides site of work and role to all actors, to assign sites to an event, to provides team and industry to the roles solver participant, creative expert and technical expert, at the end of the event to watch the presentation of possible solutions and awards.

Creative expert, initially as an actor, provides personal data and institution. Two relevant action of creativity is in charge of creative expert. This role offers an activity, also offers a collaborative creative method to the team of solver participants, both with the purpose to generate individual ideas and idea cards.

Solver participant is the most important role during the creativity workshop, his purposes are to provide details for inscription, to select an activity, to think, write and sharing individual ideas, to select collaborative creative method, to write, share and improve idea cards, to send 2 idea cards as possible solutions and finally to present the possible solutions.

Technical expert is in charge to boost the creativity in the team of participants, he offers many characteristics of a possible solution to the problem and both technical expert and solver participants work to improve the idea card. The initial purpose is to provide personal data for inscription and the main purpose is to help solver participants to improve the idea card.

Industrial manager is the root of the creativity workshop. He offers an industrial problem and receives many possible solutions.

Some of these roles create the required environment that permits to other roles to exchange ideas. *These ideas are as knowledge that nurture the exploratory, combinational and transformational creativity of individuals located in the same place that are solving the problem (Benkhelifa, Tiwari, and Pipe 2010) and (Ruiz et al. 2015).*

It is primordial to impulse the individual creativity in every collaborative creative group formed during this CW; *organizational creativity is influenced by many things some are social others are brought to the organization by the individuals who comprise it. To a certain degree, then, organizational creativity depends on the abilities of the individuals within it (Acar and Runco 2012)* , it are also explained in the handbook of organizational creativity

(Mumford 2012). De facto, organize and execute a creative workshop require knowledge about the creative process, the context of the problem, the field of the problem, the individuals involved in order to permit to participants to solve the issue; the group of solver-participants has all the conditions to generate probably something new and unexpected. *It is considered a desirable property and characteristic of intelligent human beings* (Gero and Maher 1993).

The participants achieve several creative sequences to generate a huge quantity of ideas using activities all these as part of the divergence phase. According to the convergence phase, with the collaborative and creative methods solver-participants formalize, describe, write and represent their ideas and idea cards by using sticky notes, paperboards, images, pictures, sounds and videos. Both phases, divergence and convergence are the heart of the collaborative creativity inside any organization.

### **Phases of the creativity inside the 48H.**

The event 48H has six phases of creativity (*cf.* Figure II.3); these stages are cycling with the purpose to improve them. Some elements like Ideas (I), idea cards (IC) which is an excellent source to find the possible solutions (PS) are enhance too.

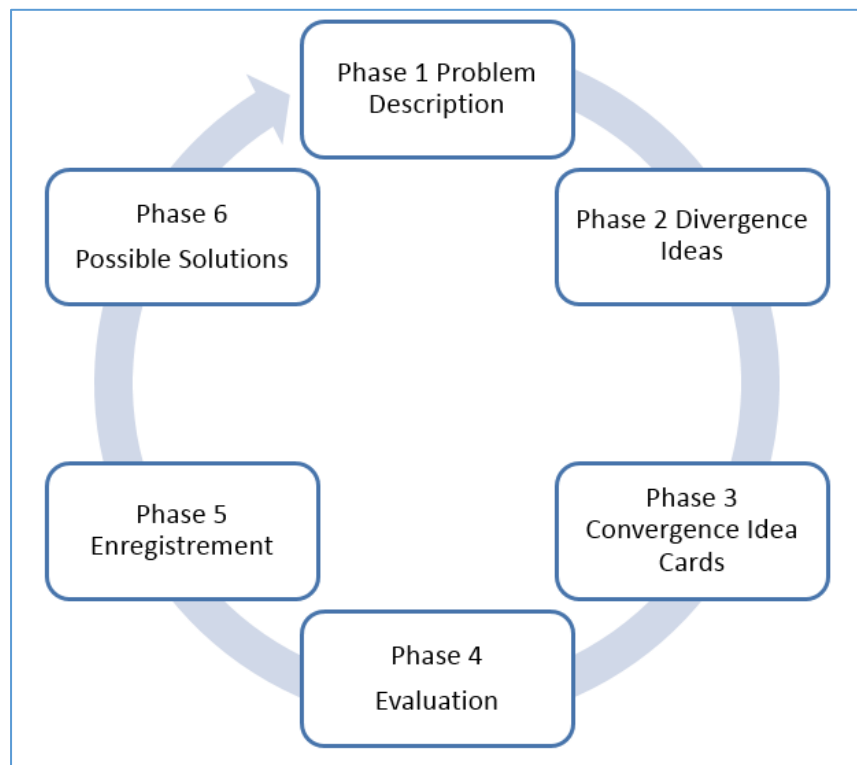


Figure II.3: The creativity Phases in the 48H.

The phases of Creativity:

#### Phase 1 Problem description,

The *first phase “problem”* sets a group of industrial problems, the organizer and industrial works in collaboration to describe the industrial problem and present them to the teams of participant. A technical expert will help the team by answering the question about the problem during the 48H. These problems could be a development, progress, question,

problem, proposition, improvement or a challenge. For example, last here a sport brand company proposed the following problem “how to run safety?”

### Phase 2 Divergence Ideas

This phase starts logically at the end of the problem description immediately the creative expert starts his work by generating a trust environment in the team of solver participant by applying team-building games.

During the *second phase, “Divergence Ideas”*, the creative expert offers individual and group activities to produce ideas. Solver participants and creative experts begin to work in collaboration to apply creativity technics like brain purge (Arthur B. VanGundy 2005), inverse reasoning, analogy thinking (Holyoak and Morrison 2005), etc. The possible solutions in the primary development appear as ideas (I); many of these ideas are in the mind of the creative participant.

### Phase 3 Convergence Idea Cards

In the convergence phase, the stakeholders have to generate many idea cards. The creative expert offers some collaborative creative methods like Pass the Buck, The Name Game, Greeting Cards (Arthur B. VanGundy 2005), Six Thinking Hats (De Bono 2000), etc. In order to improve the idea cards, the technical expert helps teams with advises like characteristics of the possible artifacts, product, or idea card. The organizational environment has full motivation, trust, and confidence as factors to impulse the individual creativity and the collaborative creativity.

### Phase 4. Evaluation

The team of solver participants evaluate their idea cards and choose the two better idea cards. Two groups of students working on the same industrial problem exchange their ideas after each group must improve, complete, make better their own ideas; then, each group displays their two ideas cards on the 48H platform, finally, all solver participants vote for the idea cards (by mean of five colored stars) but they couldn't vote for their own idea cards.

### Phase 5. Enregistrement

The solver participants capture their idea cards in a Web site created for the 48H workshop. The solver participants have access to the whole idea cards generated during the 48H and can evaluate them by giving a “like”.

### Phase 6. Possible Solutions

During this phase, the teams present possible solutions to the stakeholders and mainly to the industrial managers.

An Idea Card (IC) is the result of a collaborative and creative process” which have several actions such as “Domain discovery and meeting group”, “group activities and collaborative and creative methods with individual”, “To write Idea Cards”, “To share Idea Cards” and “To select innovative idea cards”. During this process the roles creative expert, solver participant and technical expert interact with each other. These activities define the input and outputs data and the roles that interact in its.

The quantity of idea cards creates a creativity corpus. These idea cards might be the possible solutions to innovate. However, the huge quantity of ideas makes difficult the possibility of analysis the ideas for innovation. In the next section, we describe our approach to support the management of ideas during the creativity workshop.



## II.2. An approach to support creativity and innovation

### II.2.1. Research context and position

To deal with the huge quantity of created ideas, we propose an approach to support creativity and innovation (*cf.* Figure II.4) based on three parts:

- To build a model to highlight knowledge and ideas during creativity workshops,
- To design an intelligent system to assist the actors during a creativity challenge, and annotation system.
- To propose a semantic approach to manage ideas.

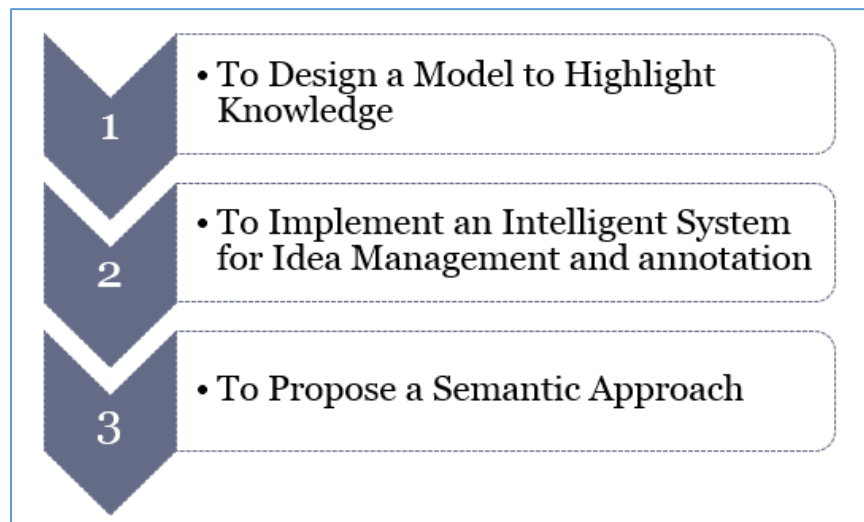


Figure II.4: Scientific Approach

This chapter describes our organizational model to highlight knowledge during creativity workshops. To build the organizational model we have observed and analyzed the “48H to generate ideas” creativity workshop. The first step was to define an organizational structure of this workshop, the second step was to describe the expertise management of the actors, and the last step is to highlight knowledge for each expertise.

### II.2.2. Context of the creativity workshop

For almost one decade, the University of Lorraine organizes a creativity challenge called “48 hours generating ideas” (48H). The aim of this workshop is to use creativity methods to generate a maximum of ideas in order to solve an industrial problem. During this, the participants use different rules, information sources, processes, creativity methods, and ways to generate ideas. The ENSGSI engineering school and the ERPI laboratory at the University of Lorraine in Nancy organize annually the 48H. Several French universities, and abroad universities from different countries of the world such as Canada, Chile, Argentina, Bahrein, Morocco, Tunis and Algeria, participate at the event. Since decades, this workshop implies more than 1500 students from various backgrounds, about fifty professors supporting students and help them to apply creativity methods, activities and collaborative approach to generate ideas, and tens of industries propose a variety of subjects or problems to solve.

In the creative workshops 48H, the participants work in collaboration using individual skill inside groups. They apply organizational creativity methods (Benkhelifa et al.

2010)(Bhowmik et al. 2014)(Ruiz et al. 2015) such as combinational, exploration and transformational (Boden 2009) with the purpose of solve an industrial problem. The result of this creativity workshop is to generate a maximum of ideas. The participants use natural language to write and structure every idea card (IC) composed by a title, a description and a schema of the idea.

We have observed that students generated more than 1500 idea cards (IC) during the last 48H creativity workshops 2017 and 2018. The important quantity of generated ideas does not allow to the industrial partner to use them. It is important to propose approaches to evaluate, classify, compare and store the idea cards, in order to allow industrial partners to use them and to evaluate the innovation possibilities.

Creativity workshops have primordial elements such as creative solvers, creative supports, activities and methods to generate ideas. Their objectives are to apply creativity methods to generate ideas. The ideas generation process is a collaborative process among different activities (ideas creation, clustering, evaluation, etc.) and among participants that have different roles, point of view and experiences. We consider each activity as an organization where participants work together to achieve a common goal which is the idea generation.

The rules to participate of the creativity challenge are:

- a) To join a group of participants,
- b) To apply creativity methods,
- c) To generate a huge number of ideas.

The roles and some applications give the sources of information, Industrial manager offers an industrial problem and receives many possible solutions. Creative expert provides personal data, institution, an activity, a collaborative creative method. Organizer facilitates site, role, team, industry. Solver participant gives personal data, individual ideas, and possible solutions. Technical expert has knowledge to share to solver participants.

There exist more than 400 different creativity methods; many of them clustered in some groups: basic idea generation-ticklers, combinations-free associations-grab bag, Brainstorming and Brainwriting according to (Arthur B. VanGundy 2005). According to Smith in (Smith 1998), there are 172 methods and fifty idea-generation devices of three types: strategies, tactics and enablers. The creative expert has a method to advice to the group of solver participants.

We observe creativity groups inside the 48H in order to understand how the participants share their know-how and knowledge to create ideas. If creativity is historically considered as an individual process, the situation to solve complex problem requires collective and collaborative creative process. *Team collaboration is particularly important under several circumstances such as in dynamic situations, for team adaptation, and when creativity is needed (R. Reiter-Palmon, B. Wigert 2012).* Therefore, we can observe that creativity is the most important topic, ability, reason, generator during the 48H and has the purpose to solve industrial's problems. To generate a huge number of ideas, participants have to share knowledge. The objective of the next approach is to highlight the knowledge sharing inside the creativity collaborative process.

Thus, we propose to model the creative workshops to highlight knowledge generated by the participant and to understand the different roles of the participants and their interactions. To do this modeling we analyze the creativity workshop (CWS) called "48 hours to generate ideas" (48H) which the objective is to solve industrial problems where

participants use different rules, information sources, processes, creativity methods, and ways to generate ideas.

Our approach is to model knowledge by using an organizational meta-model called KROM (Knowledge Reuse Organizational Meta-Model) which facilitates the understanding of the collaboration among roles and highlights knowledge by collaborative activities.

This approach consists in two parts, the description of the organizational model and modelling the creativity workshop by using organizational model KROM. This last part describe eight aspects: i) a process, ii) the idea-card, iii) an activity, iv) how to identify and analyze knowledge, v) the role and its characteristics, vi) other CWS comparative and analysis, vii) why capitalize knowledge and finally, viii) using an organizational model to capitalize knowledge.

### II.3. Our approach to design an organizational model to highlight knowledge.

The KROM organizational model (*cf.* Figure II.5) aims to describe the human organizations. This model has been used to model human engineering organizations. It highlights the skills of the professional actors, the description of the knowledge that they create, use and share, and the formalization of the organizational structure that they enforce. The fundamental elements of KROM can be divided into three main descriptions.

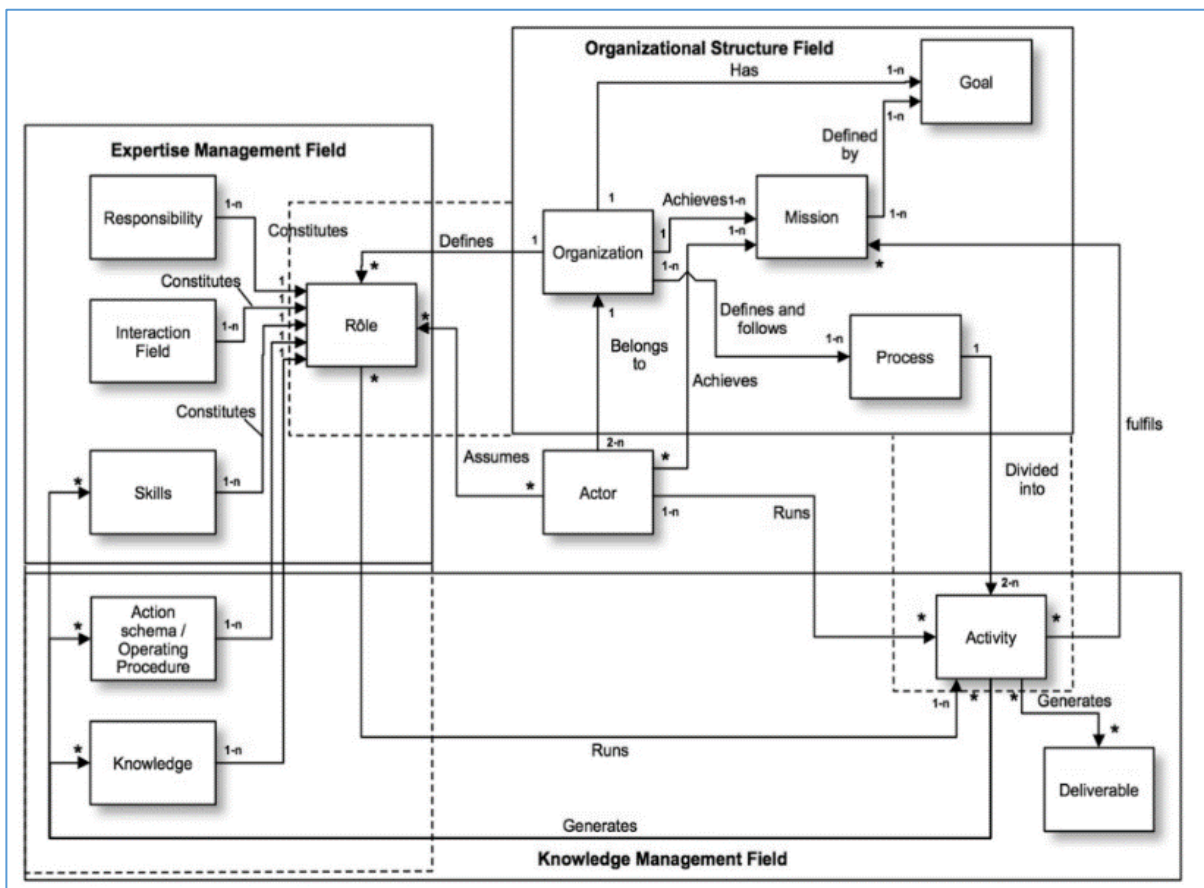


Figure II.5: Meta-model KROM.

The organizational structure contains the organization identity and the organization actions; with respect to the organization identity, it defines the missions and goals from the

organization; in reference to the organization actions, it describes the processes that the organization defines and follows, this part is the organization actions. The missions rely on the procedures and contributes to achieve the goals.

The description of expertise management explains roles, responsibility, interaction fields, skills, action schema and knowledge.

The description of knowledge management clarifies the deliverable name, generated knowledge, generated competence, generated action schema, and relations of leadership with alliance (same goals) and coalition (sharing information).

Following the description offers by KROM (*cf.* Figure II.5), in order to understand a collaborative CWS, is essential to help solver-participants to manage ideas, to apply creative techniques and sharing knowledge. This description assist us to fill the model in three stages, first, we define the organizational structure (*cf.* Figure II.6), after that, all processes and activities are detailed (*cf.* Figure II.7 and Figure II.12) and finally roles are defined with missions, competences, knowledge, interaction fields and responsibilities. When the model applied is finished, the 48H and two CWS were analyzed with respect to roles, countries, technics, student's level, objectives, and days.

- How to identify and analyze knowledge during a CWS:

The model KROM allows highlighting the roles, missions, goals, processes and activities in a creative workshop. During each activity, the role(s) requires knowledge but the roles(s) generates it too. In the table of role (*cf.* Table II.2 Role of creativity expert), the interaction of the agents with their responsibilities require knowledge and competences. Knowledge has two resources, first, actors that assume a role, and second, processes that contain activities; after that, getting knowledge by mean of interaction of roles in the execution of an activity, the activity must follow a schema and an output or deliverable must be obtained. The generation of ideas and Idea Cards create knowledge; moreover, these idea cards have purpose of "solving an industrial problem through to creativity and collaboration.

- Why Capitalize Knowledge:

The KROM model gives us the possibility to capitalize knowledge and the context where the ideas are created. This context will be used to annotate ideas. It will be necessary to compare different ideas formalize in idea cards.

**To compare idea-cards**, we need to separate the information of every field according to the type of data. We have to interpret the information inside the idea-card according to the context where the idea was created and also with the content inside the fields which composed an idea card. In addition, **we have to use annotation process to compare ideas and to find the best idea-card to answer an industrial issue.**

The creativity workshop will evolve in the way: to write the text's fields, to draw and design the solution, and to produce sound about the idea-card. We think that part of this evolution consists to create tools to help us in some activities related to the general process of creativity. An initial part of these activities is the field's capture text, image, sound, video in the idea cards such as to edit the fields in order to eliminate typographic and lexical errors, to create points, lines, curves to help in the solution's draw and to create and edit sound. These tools will make an easy formal way to specify the content or description of each idea card (annotation) although the sound's topic, video and the draw are not a simple and trivial field of the problem.

The way to annotate will make easy the way to compare idea-cards and the way to find the idea-card that makes the best solution to the problem. However, these processes have some semantics problems:

- The quantity of ideas cards is too important to be analyzed by human.
- How to evaluate the idea cards?
- How to be sure that the idea answer to a subject (problem solving)?
- How to be compare two ideas?
- The ideas are written in natural language and are difficult to exploit.
- Words or acronyms used by the solver participants.
- How to analyze a schema, a video, an audio associate to an idea card?
- The solver participants need assistance to manage ideas during a workshop and to understand the information they need.

We have to annotate in the organizational context to explain where the ideas were created and use NLP annotation to explain and compare idea-cards in order to classify and to define the relevance of ideas according to an industrial problem. The way to annotate must be evolving every year in the creativity workshop 48H in order to obtain the best idea-card in an automatic process.

- Using Organizational Model to Capitalize Knowledge:

Fortunately, we have a creativity workshop 48H every year and we could use an organizational model to capitalize knowledge. Thus, we could improve the annotation process and get better results in the comparative of idea-cards and to find the best idea-card that solve the industrial problem.

Everything has an evolution and the 48H is not the exception, thus we need to use models to understand the creativity workshops and get knowledge, perhaps the idea-card change or the condition in the workshop or the industrial purpose might change. All the workshops have knowledge and we must use a model in order to understand them, besides, the organization capitalizes knowledge in the middle of their processes. Using a model has other benefits such as understand the roles and the interaction among them, to know mission, objectives, processes, activities, and perhaps other organizational models have better results to understand creativity workshops.

## II.4. Organizational Structure

The CWS “48H” has two specific parts: the organization identity and organization actions. Inside the organization identity there are missions and goals, the organization actions contain the processes. These missions rely on five processes and contribute to goals (cf. Figure II.6).

The first mission is to declare an invite stakeholders, universities, institutes and investigation centers to collaborate in the event 48H, to add the students from the different universities. The invitation to collaborate are national and international. This mission contributes to the goal 1 to enroll students as much as possible to the event 48H.

The mission two implies that in an interval of 48 hours, students will apply a collaborative and creative method. That mission contributes to the goal 2, to enroll students and participants to the event of 48H. The goal 2, to generate, write, share, evaluate and select ideas in order to solve problems.

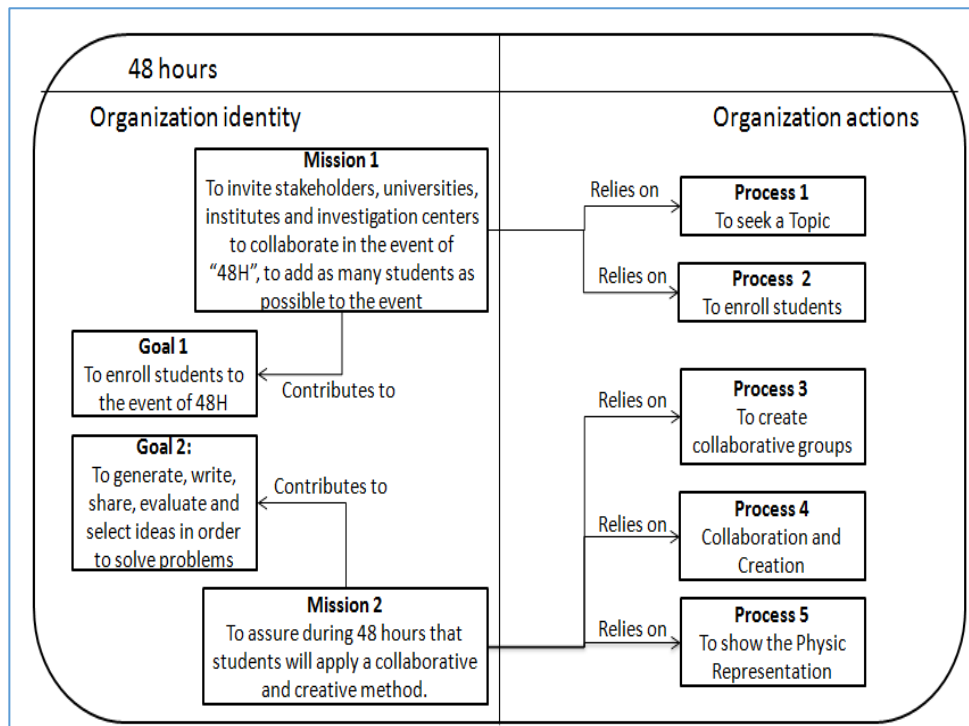


Figure II.6: Organizational Structure.

The organization actions, missions rely on processes, five processes form the organization. The processes are to seek a topic, to enroll students, to create collaborative groups, collaboration and creation, to show the physic representation.

After describing the missions, we present the process in the next section.

**Processes:**

The process 1

The mission 1 contributes to the goal 1 to enroll students to the event 48H, the process associated to reach the goal are the processes to seek a topic and to enroll students. We model both processes, the process to seek a topic (cf. Figure II.7) with three activities "to talk with industrial manager", "To capture Industry and Topic" and "To capture the Industrial Manager and talk about Technical Expert".

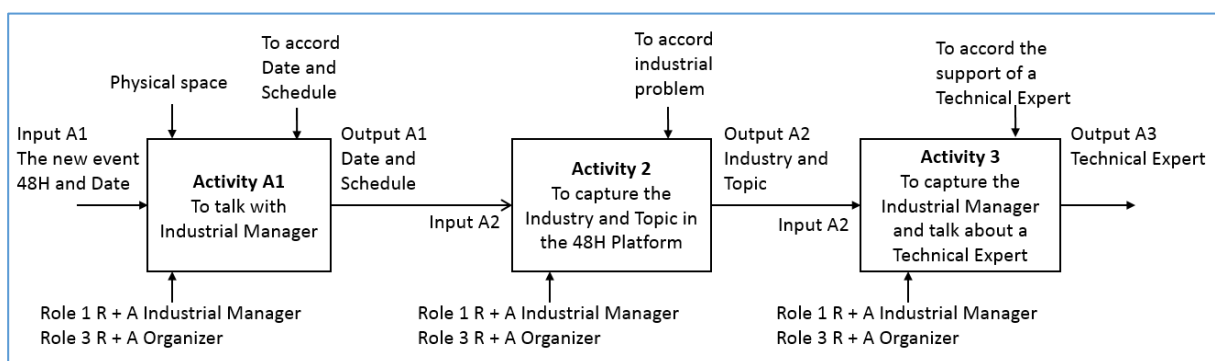


Figure II.7: The Process 1 to seek a topic.

The process 2

The process to enroll students has two activities (cf. Figure II.8), “to invite students from institutions and universities to 48H event” and “to capture data of students. The activities from processes have data input, data output, the place physic or by platform, the target or authority and the roles that works during these activities.

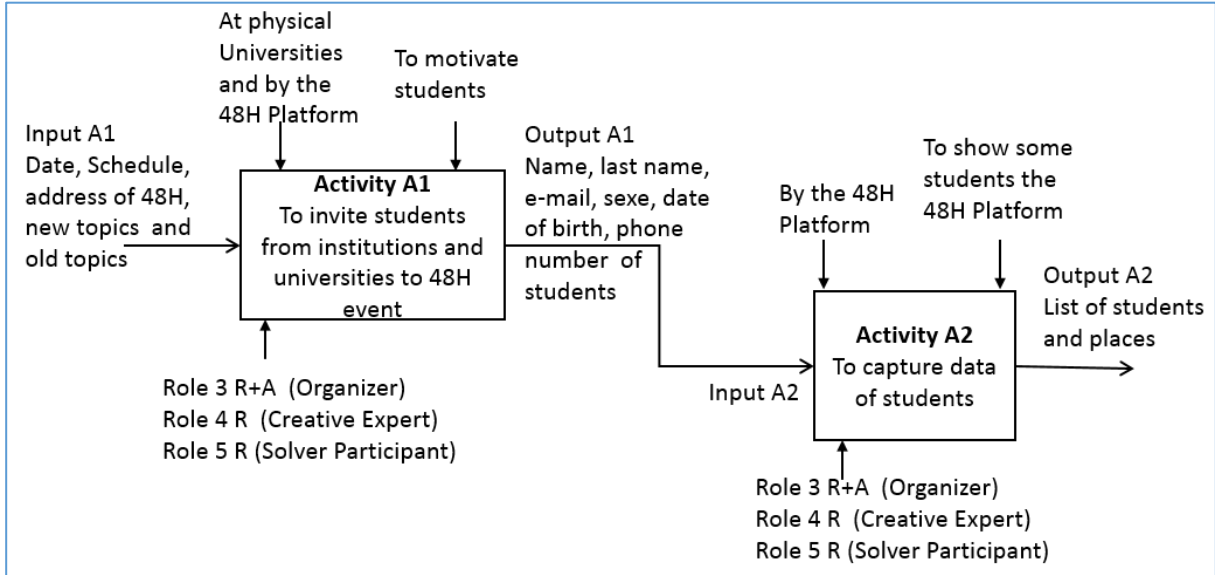


Figure II.8: The Process 2 to enroll students.

The process 3

The goal 2 “to generate, write, share, evaluate and select ideas cards in order to solve problems” has associated the processes “to create collaborative groups”, “collaboration and creation” and “to show physic representation”. Modelling these processes, we obtain the process “to create collaborative groups” (cf. Figure II.9) with two activities and five activities for the process “collaboration and creation” (cf. Figure II.10) and two activities for the process “to present the physic representation to the jury” (cf. Figure II.11) that it is the idea card or possible solution, with two activities.

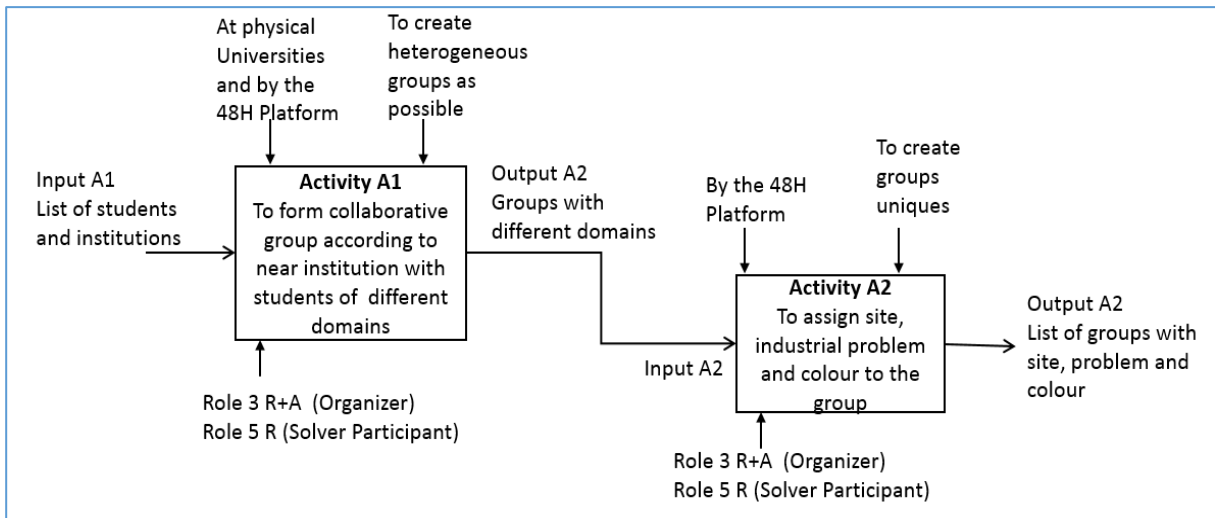


Figure II.9: The Process 3 to create collaborative groups.

### The process 4

The general process of creation of ideas or process 4 Collaboration and Creation the most complex process (cf. Figure II.10) which defines five activities. The first activity called “Domain discovery, Meeting group”, second activity is “collaborative and creative methods, Individual and group activities”, third activity is “to write idea cards”, fourth activity is “to give advice” and finally the fifth activity called “Selecting innovative ideas”. This process is long and have in consequence many interactions among users, the utilization of activities and collaborative creative methods inside it that make it the most important.

Here we can observe that the role solver participant will be responsible pendant all the event; in addition, we know the inputs and outputs required during the process. This general process has five activities from A1 to A5, the most important outputs in this general process are the ideas (I), idea cards (IdC) and the possible solutions (PS), the principal actions are to produce, to improve and to evaluate the ideas where the roles creative experts and solver participants are working in all the process.

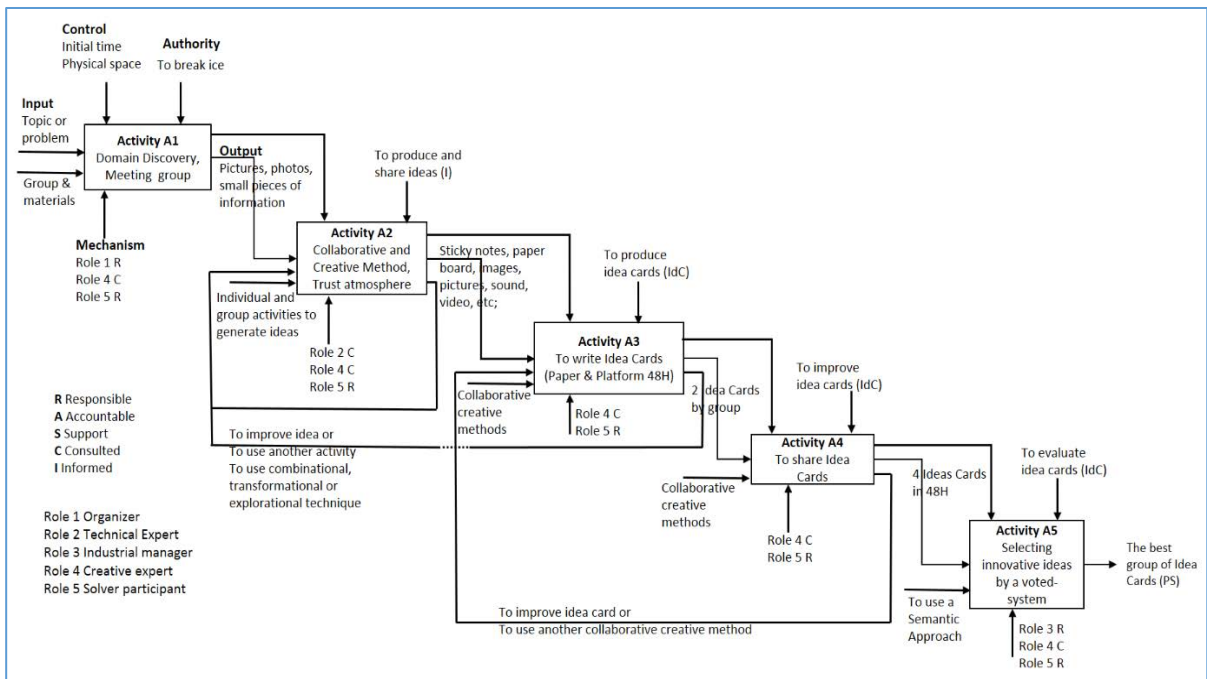


Figure II.10: The Process 4 Collaboration and Creation.

Every activity has an input(s) and an output(s), as an example: in the first activity, the inputs are the topic and the group; the outputs are pictures, photos and small pieces of information, that outputs will be the input for the next activity. The outputs for second activity are sticky notes, paperboard, images, picture, sound, video; these outputs will be the inputs for the next activity. The same idea will be for activities three, four and five; thanks to this process, we will have “the best idea-cards”.

In addition, every activity has the roles that will interact during the activity and the characteristic of the role during the activity (Responsible, Accountable, Support, Consulted and Informed), as an example: in the activity 2 of the process of collaboration and creation, the solver-participant is responsible, the technical expert and creative expert like consulted role.

In every activity the roles are working in a collaborative way, during the process, the team of solver-participant is using collaborative creative methods to generate many ideas also



work in individual and a group way to generate ideas. These ideas are writing in an idea-card format, after that, the group selects two ideas in order to share them to other teams. Every group scores ideas, in consequence of that the best idea-cards.

### The process 5

This process relies on mission 2, it is the process to show physic representation (cf. Figure II.11) with two activities.

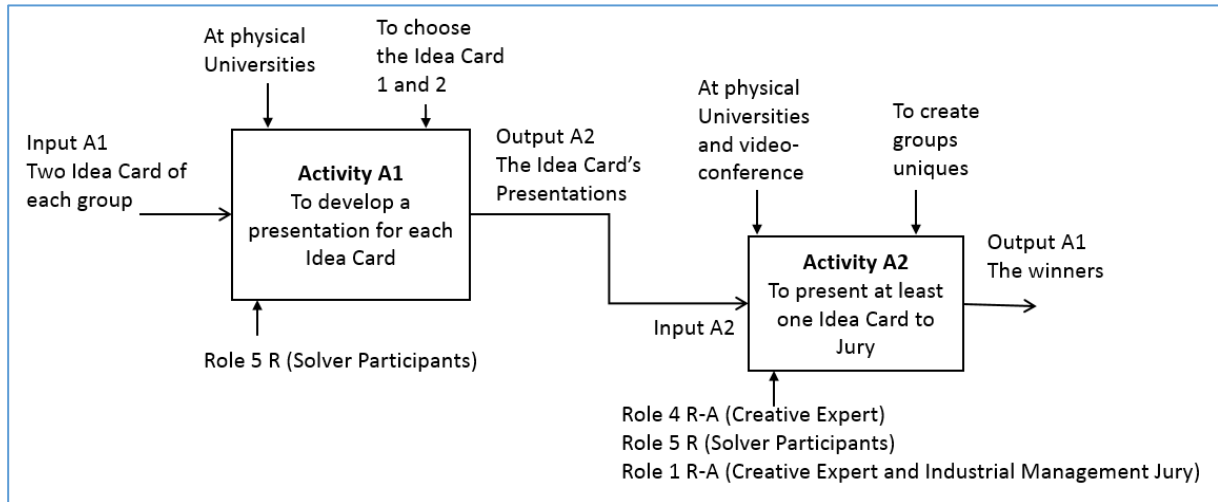


Figure II.11: The Process 5 to show physic representation.

Having all the processes defined, we need to describe the activities that are part of each process. Some process has only a simple activity, but another has two or five complex activities, now we are going to present every activity.

### **Activities:**

In every activity like, it shows the interaction among roles to achieve the generated knowledge, generated competence, generated action schema and deliverable name which are been obtained by three types of interactions: Alliance (the same goals), Coalition (share information) and Leadership (there is a leader role) (Girodon, Monticolo, Bonjour, et al. 2015). To know the process to whom the activity belongs, we write the number of the process point the number of the activity.

#### Activity 1.1 To talk with industrial manager and capture the topic

This activity (cf. Figure II.12) shows the interaction of the roles like industrial manager, technical expert and organizer, this activity produces the generated knowledge: missions, goals and processes of 48H. It generates the competence: to understand and know 48H and the generated action schema, for the organizer, to do a list of possible candidates and send them mission, goals and processes of 48H, to manage a schedule of meeting and to get topics. The role technical expert and industrial manager generate the action schema that are to know missions, goals and processes of 48H.

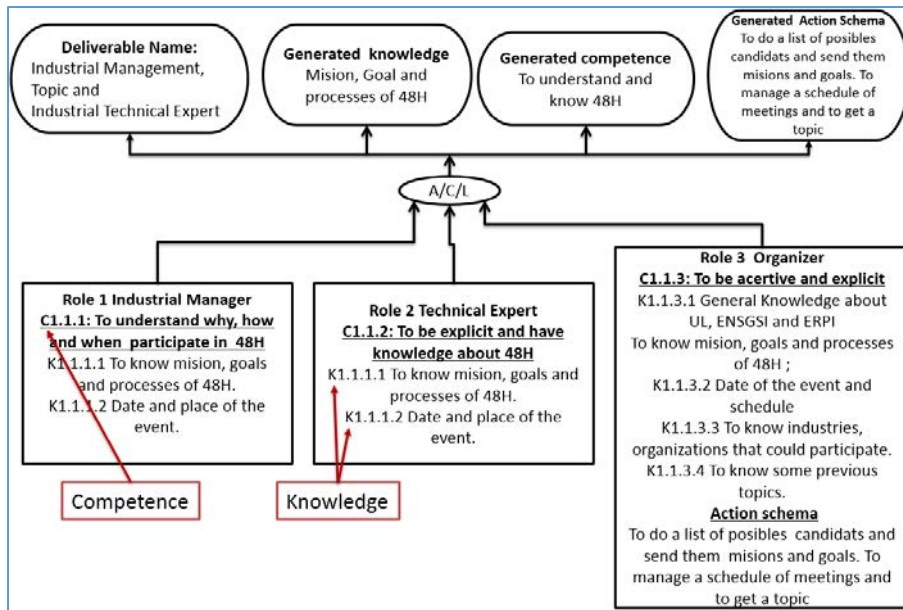


Figure II.12: Activity to talk with industrial manager and capture the topic.

This activity shows the roles necessary to execute the activity, the competence of the role and knowledge generated. The Role 1 Industrial manager must have the ability to understand why, how and when participate in the event. The action schema has, first, to do a list of possible candidates and send them missions and goals, second, to manage a schedule of meetings and to get topic.

Activity 2.1 To invite students from institutes and universities to the 48H

Organizer, creative expert and solver participants interact in the as activity 1 (cf. Figure II.13) to obtain missions, goals, processes, collaboration, activity and the platform 48H. Furthermore, the interactions generate to be assertive and explicit, to domain and control groups, to be confident, calm and to be collaborative.

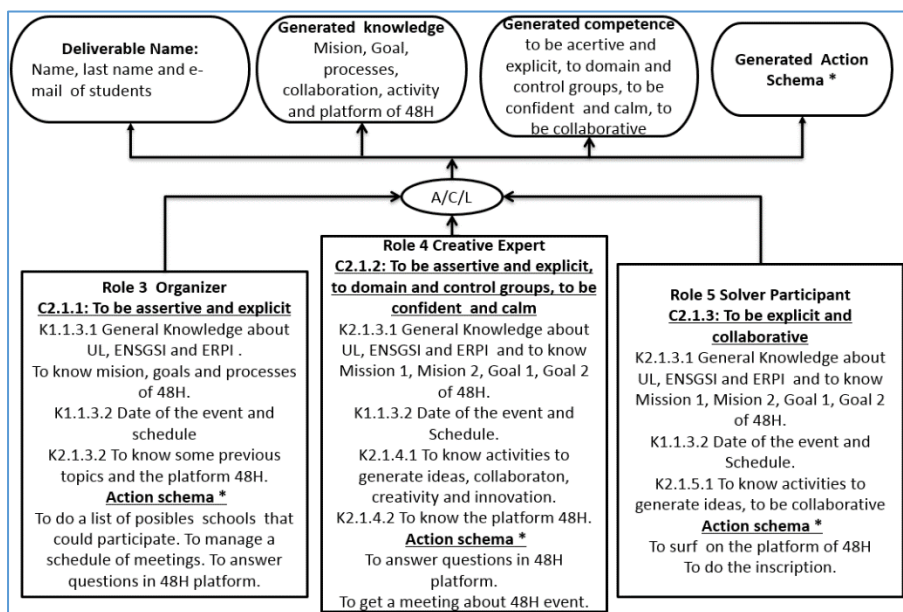


Figure II.13: Activity 2.1 to invite students from institutes & universities to the 48H.

The action schema are to do a list of possible schools and institutes that could participate, to manage a schedule of meetings, to answer questions in 48H (organizer), to answer

questions in 48H, to get a meeting about 48H event (Creative Expert); to surf on the platform 48H, to do the inscription (solver participant). As an example, the organizer invites students from many schools, institutes and universities. After, the creative expert get a meeting to choose the activity and collaborative creative method to offer to solver participants in the event, next, the students surfs in the platform 48H, where he has to write his name, last name and institution and send some questions about the event.

### Activity 2.2 To capture student's data

The activity “to capture student’s data”, again with the interaction of the roles organizer, creative expert and solver participants get the principal results (cf. Figure II.14). **The first** result is the deliverable name “list of students and places”. In addition, the **second results**, the generated knowledge are platform of 48H, inscription key and process of inscription.

Additionally, the **third result**, the competence achieved are to be assertive, explicit and collaborative. And **as fourth**, the generated actions states the knowledge by roles are to surf on the platform 48H (organizer), to surf on the platform 48H, to do some inscriptions (Creative Expert); to surf on the platform 48H, to do their inscriptions, to ask if there is or are doubts (solver participants).

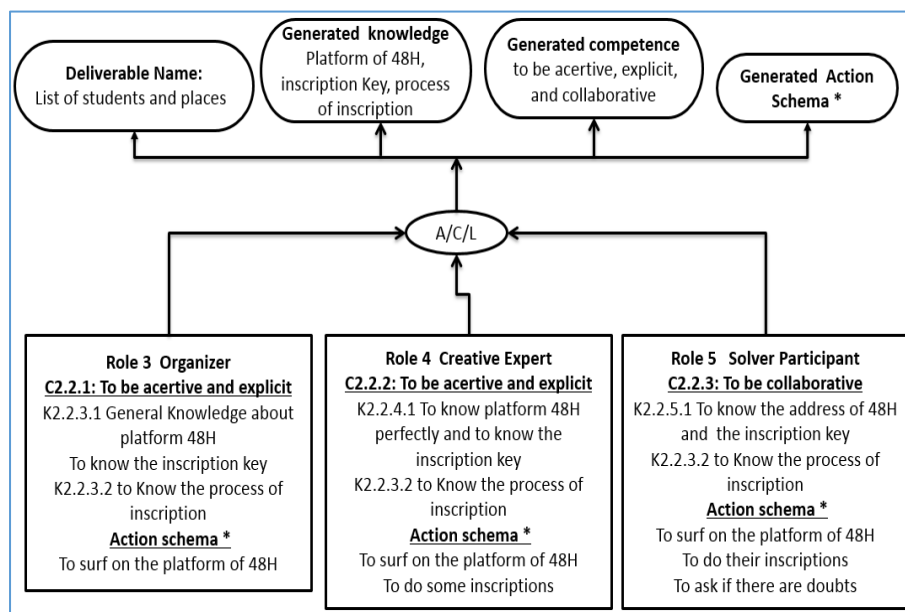


Figure II.14: Activity 2.2 to capture student's data.

An illustration of this, the organizer and creative expert solve answer questions from students and motive them to do their inscription and participate in this important international event next the students do their inscriptions, they write his name, last name and institution and send them to the organizer who creates the teams.

### Activity 3.1 To create collaborative groups

The interactions between Creative Experts and Solver Participants to create the teams to work during the event present the activity “collaborative groups” (cf. Figure II.15). Here, creative expert and solver participants produce a positive schema of action just to be participative and the creative expert will have a list with solver participants, place, team and

colour. The generated competence: how to create a report of team in the platform 48H, to be collaborative.

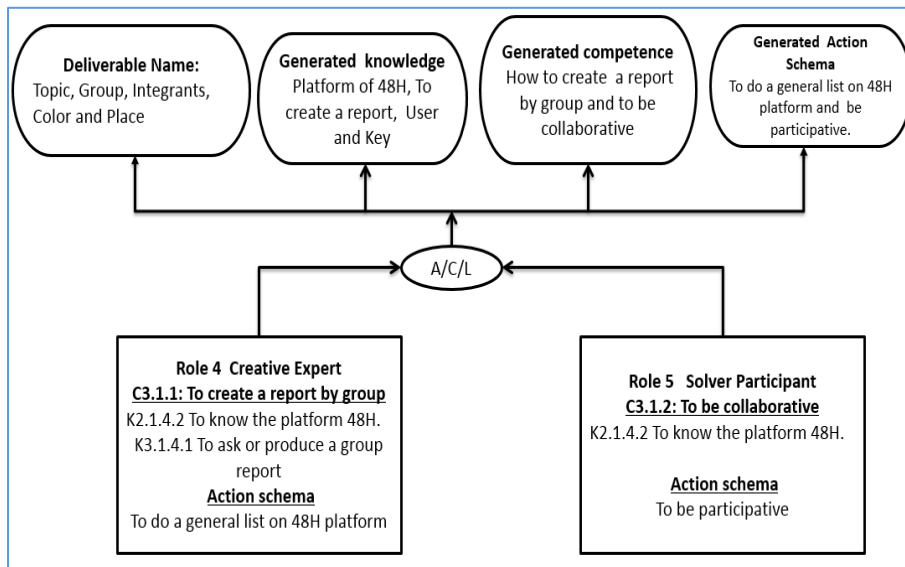


Figure II.15: Activity 3.1 collaborative groups.

**Activity 4.1 Domain discovery and meeting groups**

In the Activity 1 domain discovery and meeting groups (cf. Figure II.16), the interaction of the roles creative expert and Solver Participant produces pictures, photos, small pieces of information. The creative expert has to lead the team and encourage the solvers participant to be participative in the generation of creative ideas. The solver participant must be active and start to be collaborative both roles know the topic at this moment. The explanation of the activity will produce many of individual ideas in the team at least in mind.

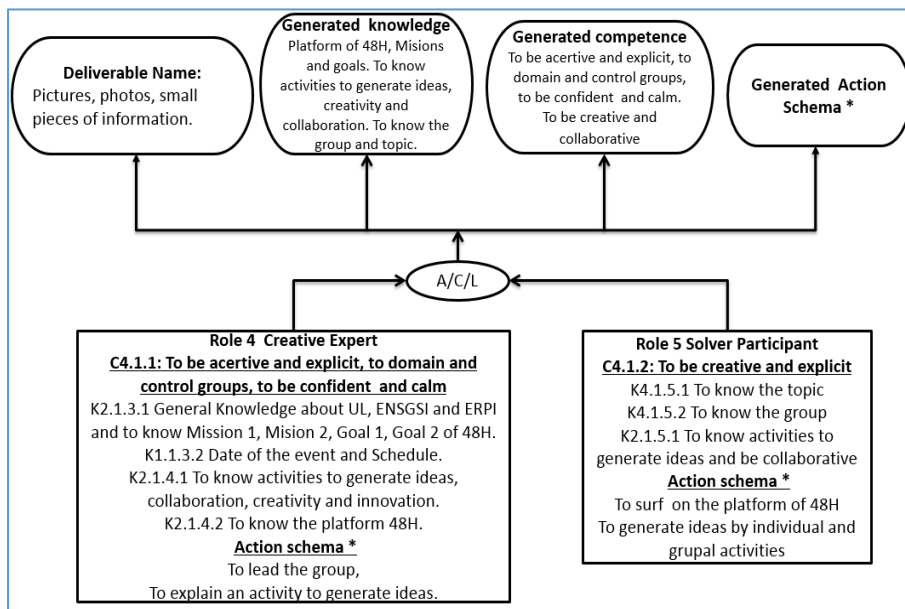


Figure II.16: Activity 4.1 domain discovery, meeting groups.

**Activity 4.2 Individual creative activities and collaborative creative methods**

During the next activity, the most important activity, “Individual creative activities and collaborative creative methods”, creative expert, technical expert and solver participants

interact to get the deliverable name, the generation of knowledge, competence and action schema in the activity 2 (cf. Figure II.17).

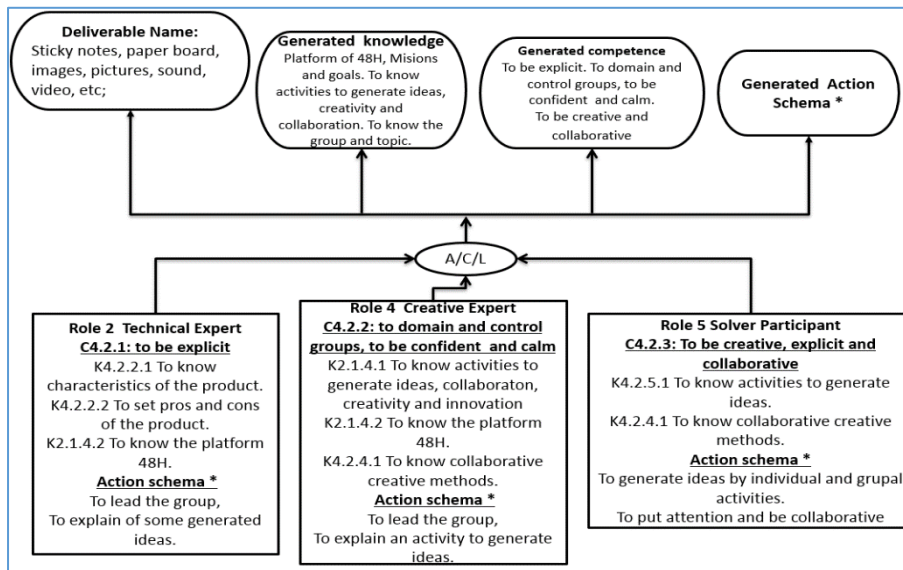


Figure II.17: Activity 4.2 Individual creative activities & collaborative creative methods.

The team of solver participants works, every individual produce ideas, and the creative expert offers in a first instance an activity after a collaborative creative method, the technical expert gives characteristics of the ideas as a product. The activity produces ideas represented on sticky notes, paperboard, images, pictures, sounds and videos. The methods produce the idea cards. The creative expert as technical expert help to the solver participant in the productions of ideas and idea cards in this activity.

Activity 4.3 To write idea cards (Paper and Platform 48H)

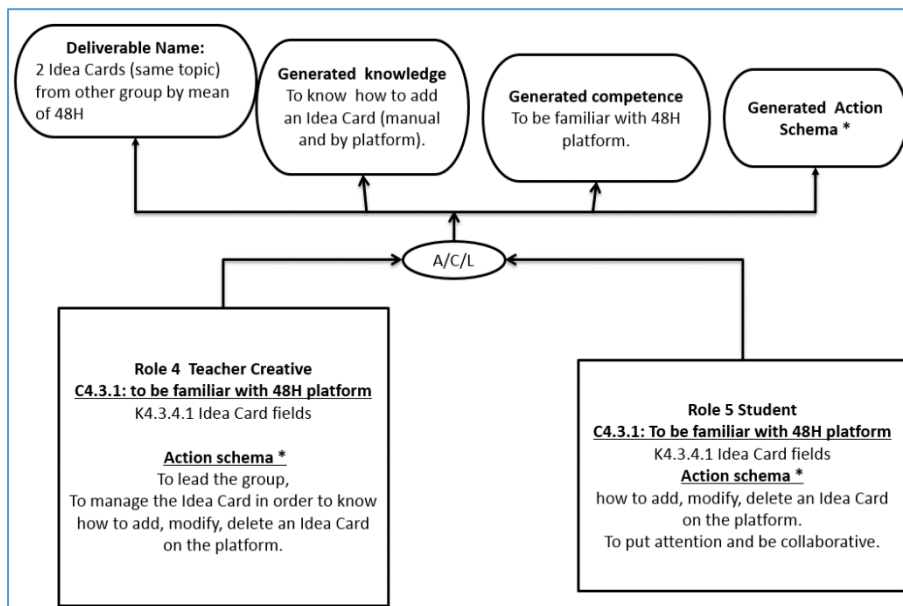


Figure II.18: Activity 4.3 to write idea cards.

The activity 3 “to write idea cards”, with the interaction of the roles creative expert and solver participants interact to obtain the principal results (cf. Figure II.18). Deliverable name:

two idea cards with the same topic with respect to another group. Generated knowledge: to know how to add an idea card (manual and on the platform 48H). Generated competence: to be familiar with the platform 48H. Generated action schema: to lead the group, to manage idea card in order to add, modify, delete from the platform 48H (Creative Expert); to know how to add an idea card, to put attention and to be collaborative (solver participant).

#### Activity 4.4 To give advice

“To give advice” is the activity four (cf. Figure II.19). The generated knowledge: address 48H, login, password, number of idea, name of idea, knowledge\_needprob, number of knowledge, description, knowledge description will have important sentences, propositions and words that offer a specific objective, schema description, scenery\_usage. The generated competence: Promote ideas. The generated schema: to lead the group and to be in the video conference feedback (creative expert). To put attention, to be collaborative, to participate in the video conference (solver participant). The deliverable name: four idea cards. The interaction between the creative expert and solver participant generates these results.

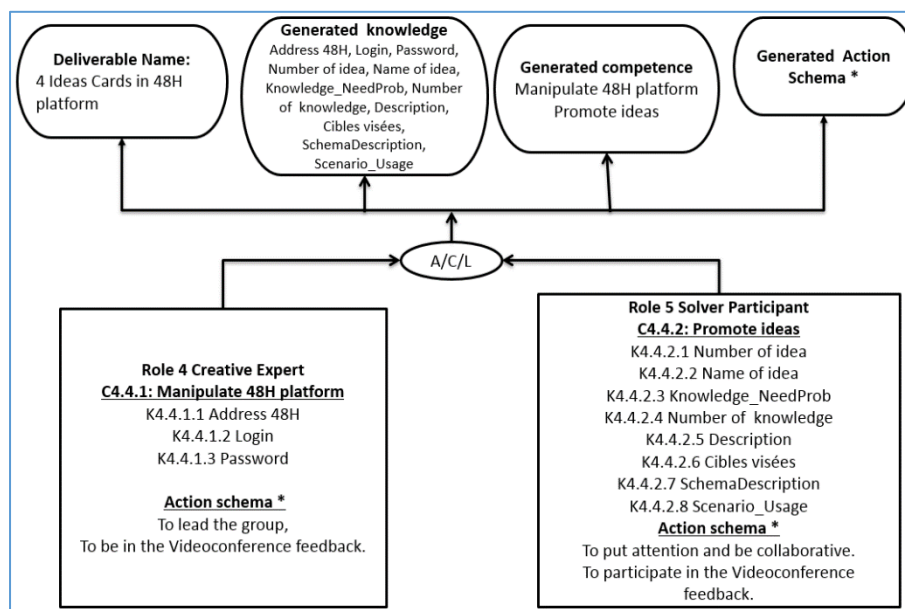


Figure II.19: Activity 4.4 to give advice.

#### Activity 4.5 Select the best idea cards by a voted system

There are two important generate schema actions in the role of solver-participant, the first is “put attention and be collaborative” and the second “to do the procedure of voting. With respect to the role creative expert, the action schema is “to lead the group” but also “to be in the procedure of voting”. This interaction is carried out in the activity five “selecting innovative ideas or possible solutions” (cf. Figure II.20). The deliverable name: the best idea card. The generated knowledge: to know how to visualize other idea cards, to know how to vote and to vote. The generated competence: to be familiar with the platform, to be collaborative and loyal.

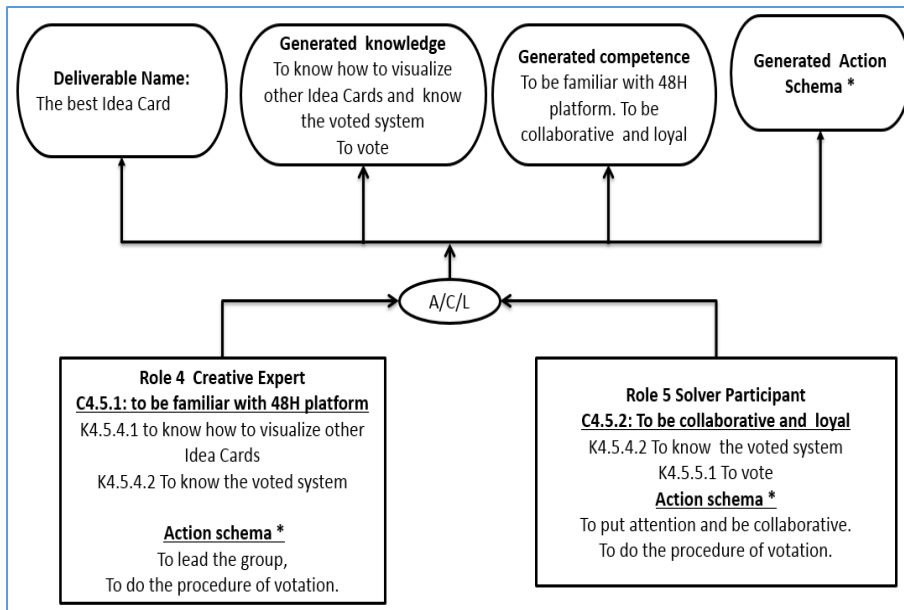


Figure II.20: Activity 4.5 selecting idea cards as possible solutions.

**Activity 5.1 To present the idea cards or possible solutions to the jury**

Here, the activity “to present the idea card to jury” (cf. Figure II.21). There are some interactions among solver participants, creative experts, and industrial manager present the deliverable name: the winners. At this moment, the team know all the positive characteristics of their possible solutions and they have to improve it in any moment. The union among the participants and loyalty is in the environment. The generated competence: to be collaborative and clear in ideas, to be loyal. The presentation of the possible solution is the primordial action in this activity.

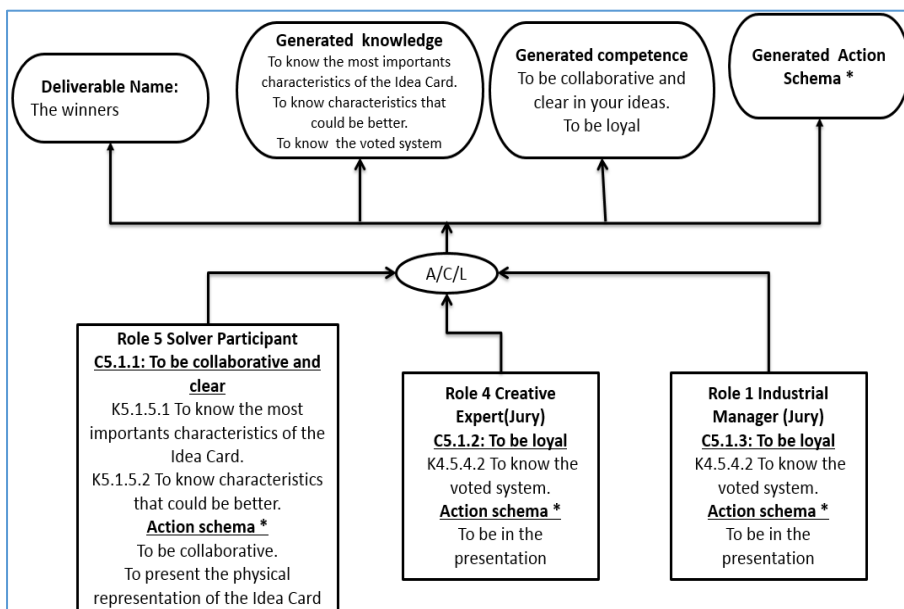


Figure II.21: Activity 5.1 to present idea cards as possible solutions.

The missions, goals and processes defined in the organizational structure, besides, the interactions among the roles, responsibilities, skills, action schema and knowledge described in all the activities before, gives us the opportunity to describe the role’s characteristics. Here, we show one of the most important roles “Creative Expert”.

**The Roles and its characteristics:**

The role creative expert (cf. Table II.2) defines the five characteristics of him inside the organization 48 hours of creativity. These characteristics are main missions, competences, knowledge, interaction fields and responsibilities. The missions:

<b>Role 4 Creative Expert</b>	
<b>Organization</b>	<b>48H of Creativity</b>
<b>Main missions:</b>	<p><b>Mission 1</b> To invite stakeholders, universities, institutes and investigation centers to collaborate in the event of "48H", to add as many students as possible to the event.</p> <p><b>Mission 2</b> To assure that in 48 hours students will apply a collaborative and creative method.</p>
<b>Competences:</b>	<p>C2.1.2: To be assertive and explicit, to domain and control groups, to be confident and calm. (C-process, activity, competence)</p> <p>C2.2.2: To be assertive and explicit.</p> <p>C3.1.1: To create a report by group.</p> <p>C4.1.1: To be assertive and explicit, to domain and control groups, to be confident and calm.</p> <p>C4.2.2: To domain and control groups, to be confident and calm</p> <p>C4.3.1: To be familiar with 48H platform, C4.4.1 Manipulate 48H platform</p> <p>C5.1.2: To be loyal.</p>
<b>Knowledge:</b>	<p>Knowledge (process, activity, role, knowledge), the knowledge in dark belong to the role Creative Expert. The four initial knowledge is general.</p> <p>K1.1.1.1 To know mission, goals and processes of 48H.</p> <p>K1.1.1.2 To know description, date and place of the event.</p> <p>K1.1.3.1 General Knowledge about UL, ENSGSI and ERPI. To know mision, goals and processes of 48H.</p> <p>K1.1.3.2 Date of the event and Schedule.</p> <p><b>K2.1.4.1 To know activities to generate ideas, collaboration, creativity and innovation.</b></p> <p><b>K2.1.4.2 To know the platform 48H.</b></p> <p><b>K2.2.4.1 To know platform 48H perfectly and to know the inscription key.</b></p> <p><b>K3.1.4.1 To ask or produce a group report.</b></p> <p><b>K4.2.4.1 To know collaborative creative methods.</b></p> <p><b>K4.3.4.1 To know how to add an Idea Card (manual and platform).</b></p> <p><b>K4.4.4.1 Address 48H.</b></p> <p><b>K4.4.4.2 Login.</b></p> <p><b>K4.4.4.3 Password.</b></p> <p><b>K4.5.4.1 To know how to visualize other Idea Cards.</b></p> <p><b>K4.5.4.2 To know the voted system.</b></p>
<b>Interaction Fields:</b>	<p><b>Agents:</b> Account creation system/ Videoconference system/ Card Idea Voted System</p> <p><b>Humans:</b> <i>Role 1 Industrial Manager, Role 2 Technical Expert, Role 3 Organizer, Role 4 Creative Expert, Role 5 Solver Participant.</i></p> <p>The role creative expert (role 4) interacts with other roles in four process and almost all activities. We describe the process and activities where the creative expert takes participation and the roles that are acting with him.</p> <p>Process 2, Activity 1-2 : Role 3/ Role 4/ Role 5</p> <p>Process 3, Activity 1:Role 4/ Role 5</p> <p>Process 4, Activity 1 : Role 4/ Role 5; Activity 2: Role 2/ Role 4/ Role 5; Activity 3-4-5 :</p>



	Role 4/ Role 5 Process 5, Activity 1 : Role 4/ Role 5/Role 1; <b>Interfaces:</b> 48H platform
<b>Responsibilities:</b>	The role creative expert (role 4) has diverse responsibilities during the creativity workshop. We describe his responsibilities in process and activities where the creative expert take participation. Process 2, Activity 1-2: Role 3 Responsible-Accountable / Role 4 Responsible/ Role 5 Responsible. Process 3, Activity 1: Role 4 Responsible / Role 5 Responsible. Process 4, Activity 1 : Role 4 Consulted/ Role 5 Responsible; Activity 2: Role 2 Consulted / Role 4 Consulted / Role 5 Responsible; Activity 3-4-5 : Role 4 Consulted/ Role 5 Responsible; Process 5, Activity 1: Role 4 Responsible-Accountable/ Role 5 Responsible /Role 1-4 Responsible-Accountable.

Table II.2: Role of creative expert

Knowledge Management is the result of Organizational Structure and Expertise Management. The role has the description of the five essential characteristics in a CWS: Missions, Competences, Knowledge, Interactions and Responsibilities. The missions and goals are sharing by all roles to assure the interaction alliance and coalition among them.

#### II.4.1. Synthesis of Modelling

Through the modelling using KROM, we want to highlight knowledge; this model offers an adequate methodology to achieve our objectives. We define the actors or people interested in this event (stakeholders) that belong to the organization 48H where they take different roles during the event.

The role industrial manager has an important responsibility that is to deliver a topic or industrial problem to the organization. The creative expert is in charge to help solver participants and impulse the creation of collaborative creative idea cards. The organizer has several responsibilities, however, one of the most important activities is the creation of collaborative groups and assignation of industrial problems, without minimize the other task that the organizer does in order to help all stakeholders. The creative expert has a primordial assignation, to or offers activities and collaborative creative methods to the team. His main function is to impulse the production of ideas in the phase of divergence and idea cards in convergence. The aim role in the 48H is the solver participant since it will generate many ideas by using creative methods such as combinational, transformative and explorative technics.

The definition of the organizational structure, expertise management and knowledge management will help us in a better definition in our multi-agent system but previously the modelling of the model KROM help us in the description of knowledge used by the participants.

- Other Creativity Workshops, comparative and analysis

The creative workshop analyzed in the literature (Barry 2007),(Camacho et al. 2016) use different domains like education, industry or entrepreneurial. These CWS have three similar and important characteristics “Creative Techniques”, “Role Solver-Participant” and “Role

Creative Expert” and all integrate the concept of “creative thinking” to solve problems. The comparative shows (cf. Table II.3) three different creative workshops.

Creativity Workshop						
No. and Name	Country	Role	Techniques	Level of Students	Objective(s)	Days
I. The 48H	France, Canada, Chile, Argentina, Bahrein, Morocco, Tunis, and Algeria	1. Solver-participants, 2. Industrial stakeholder/ Decision makers, 3. Technical expert, 4. Organizers, 5. Creative experts.	Every creative expert selected a technique in a meeting several weeks before that the 48H starts	Students inside all the universities, schools or institute, these students must be registered in the system of 48H	To enroll students to the event of 48H. To generate, write, share, evaluate and select ideas in order to solve problems	2
II. Workshops in Creative Education for Students and Teachers	USA and Japan	1. Creativity thinker, 2. Teachers.	1 Multisensory Teaching Approach, 2 Science Fair Projects, 3 Reading stories and solving mysteries	Elementary students, middle school students, college students, and teachers	Turning students onto science and engineering, and to preparing them to be creative problem solvers	1
III. Creative Problem Solving Builds Entrepreneurial Mindset	Nicaragua and USA	1. Mentors from USA, 2. students and teachers from Nicaragua;	The business model canvas, I. The 20 Circles Challenge II. The Nine Dots Problem III. The Ball and Pipe Problem IV. The Newspaper Tower	K-12 students and Teachers	Fostering the development of creative thinking	4

Table II.3: Characteristics of three creativity workshops.

There are seven characteristics inside this comparative table showed above, clearly, 48H has a notable quantity of countries participants in contrast to the other CWS with just two countries. The roles created in 48H are specialized, but the mentors, in workshop III, applies many creative technics so the quantity of ideas is huge. In the other workshops (II educational and III entrepreneurial), the number of technics is minimum, but the participant produces a very important quantity of ideas too. Children achieved the workshops II and III, they are more creative than adults are.

The CWS “48H” spends 2 days, “Workshop in Creative Education for Students and Teachers” lasts one day, in contrast with the workshop “Creative Problem Solving Builds Entrepreneurial Mindset” that was executed during four days in Fabretto’s Education Center in San José de Cusmapa, Nicaragua. To ensure an enjoyable and active learning environment, a balanced combination of hands-on and creative problem-solving activities, in addition to the introduction of important business concepts, were implemented. Because a successful

entrepreneurial venture usually initialized by an idea aiming to solve an important problem, understanding how to generate unique ideas, solving problems creatively, and overcoming the negative influences that obstruct creativity through various practical activities were the early steps of the concept development process and the central topics of the first day workshop. The second day, students focus on the development of the components that make a business work properly using the business model. The last two days were centered on the financial aspects (revenue streams and cost structures) of the business model while continuing with more creative problem solving activities to supplement the discussion of the business components (Camacho et al. 2016).

The creation of an idea card is the result of the creative techniques that allow to participant to share their experiences and knowledge to generate a new concept. *Nowadays, organizations are conscious of the importance of their knowledge capital which constitutes a valuable source of wealth and a decisive competitive asset* (Hassen et al. n.d.). According to that, the organization 48H agree and for this reason, we find knowledge at the same time understand the CWS.

The capitalization of the knowledge has four facets; one of the first tasks is to locate the crucial knowledge: it must be identified, located, characterized and classified. Next, it must be preserved, in other words conceptualized, formalized and conserved. Furthermore, it must be value-enhanced, i.e., put at the service of the development and expansion of the company. In other words, it must be accessed; disseminated, used more effectively, combined, and new knowledge must be created. Finally, *it must be maintained - evaluated, made updateable, and improved in accordance with rules governing its confidentiality and security* (Grundstein 2000); with respect to this, during the 48H, knowledge is located like idea-cards and preserved by mean of the platform where solver participants can capture their idea-cards. The big quantity of idea cards can be observed, improved and evaluated, finally, all these idea cards and actions are stored and can be consulted by the people who are going to give an opinion about the solution of the problem.

In the 48H, knowledge is an object, every object is an idea-card that is created, captured, modified and stored; moreover, knowledge is a capacity too, with this knowledge competences are created, and problems are solved. *Knowledge may be viewed from several perspectives (1) a state of mind, (2) an object, (3) a process, (4) a condition of having access to information, or (5) a capability* (Leidner and Alavi 2001);

In consequence of this, knowledge in 48H is modeled to understand how the participants create new concepts and ideas. This creative workshop is an organization where different participants with different roles (solver-participants, creative expert, technical experts, organizer, industrial) work together to solve a problem by generating many ideas in a creative way; besides, in this organization participants will share their experiences and knowledge by interacting with each other.

After presenting our model based on KROM with definitions of missions, goals, processes, and activities with respect to the creativity workshop 48 hours, we conclude this chapter.

## II.5. Chapter conclusion

The organizational model to highlight knowledge during the creativity workshop helps us to describe the organizational structure, knowledge management fields and expertise management fields; the principals results of this model are missions, objectives, procedures, activities, roles, the idea card, roles. These results impulses the understanding about the organization and understand that data and information highlight knowledge that represents the reality during this creativity workshop. The CWS spends only 48 hours but during a year, there are actions that highlight knowledge such as the capture of many data, the creation of huge quantities of information, and according to the human interpretation of the information.

This chapter creative idea models sets the base for definition of processes and activities and allows us to have a target and a direction, two essential characteristics to accomplish our work. We must have in mind during this thesis: the organizational model, the sematic approach and the implementation systems; without lost these challenges and working and thinking around them, we could achieve this important job and support creativity and innovation.

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## **Chapter 3: An Intelligent System for Ideas Management**

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# Topics of Intelligent System for Ideas Management

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## III. Implementation of an Intelligent System for Ideas Management

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### III.1. Chapter Introduction

This chapter describes an intelligent system to support ideas management. To explain the design of the intelligent system, it is necessary to take in account about the previous chapters where the creativity activities and the different roles of the participant have been explained. The creativity workshop is an environment where actors are sharing their knowledge. Furthermore, this knowledge is created and is evaluated in a dynamic way. The collaboration among these actors is physically distant and their interactions could be asynchrony or synchrony so we can say that the process is distributed. The nature of the information is heterogeneous (ideas, experiences, schema, etc.) and also distributed. For these reasons we have chosen to use a multi agent system approach since these systems are already prove their efficiency to manage distributed and heterogeneous information (Dignum et al. 2005).

#### III.1.1. Multi-Agent System (MAS)

The concept of multi-agent system appears at the end of last century. The multi-agent system has two forms of vision the interaction among agents and the interaction among humans, *the first, as an artificial intelligence (AI) concept attributed to Nils Nilsson "all AI is distributed-1980" and the second as artificial life (Alife) based in the complex adaptive behaviors of communities of humans* (Weyns, Parurak, and Michel 2004). *By relating an individual to a program, it is possible to simulate an artificial world populated of interacting processes* (Drogoul, Ferber, and Cambier 1992). The individual is an agent that interacts according to his environment which is clearly defined with respect to the reality. These interactions among agents and their environments are an important aspect in the MAS. In the beginning of the century XXI, *an initial model tools used to create generic multi-agent platforms based on an organizational mode based in the core model agent-role-group* (Gutknecht and Ferber 2000), and also *multi-agent model involving some agents to hundreds focusing in break down a problem therefore the agent can solve a simple problem* (Simonin and Ferber 2003). At present, the multi-agent systems have been used to improve energy efficiency (Zhang et al. 2014). However, thinking in our intelligent system based in agents, the interactions among the actors in the creativity workshop 48H is complicated and we have to help them in their individual and collaborative activities inside this organization where *the organization is defined by a group of roles that interact among them* (Ferber 1994). Several design methodologies of multi-agent system exist such as GAIA (Wooldridge et al. 2002), (Zambonelli, Jennings, and Wooldridge 2003) and DOCK (Girodon, Monticolo, Bonjour, et al. 2015) are examples of these design. The multi-agent systems have two principal methodologies, (Esparcia, Argente, and Botti 2011) *the methodologies oriented to agents and the methodologies oriented to organizations that base in organizational unit, service, environment and norm* (Argente, Julian, and Botti 2009). Due to the uncountable times that agent is mention and the interaction of agent in a multi-agent system, we have to

write some definitions about the concept of agent, it takes some primordial functions during the creation in our intelligent system.

### III.1.2. Agents

Since the last century and initial years of this century the concept of agent and its characteristics appears. *There are several definitions about agent, description of agent's requirements, uses of agent (Shen and Norrie 1999) and description about agent's evolution (Vanhée, Ferber, and Dignum 2013).* In a software design an agent represents state components, which are structured aggregations (*sequences, sets, multisets, etc.*) of elements such as events, actions, beliefs, plans and tasks (Kinny 2002).

An actual definition, "Agent" is a system whose behavior is neither casual nor strictly causal, but teleonomic (Castelfranchi 2012), "goal-oriented" toward a certain state of the world . an agent is specified as *an active communicating entity which plays roles inside groups (Gutknecht and Ferber 2000). An agent is a computer system **situated** in some **environment**, and that is capable of autonomous **action** in this environment in order to meet its design objectives where **autonomous** means to act without interventions of humans of other agents (Jennings and Wooldridge 1998). A (PSI) agent is a strong encapsulation of state and behavior whose elements include an epistemic component, beliefs and a procedural components, intentions, which includes tasks and plans (Kinny 2002).* The definition of agent in a general and complete AI idea: *an agent is anything that can be viewed as perceiving its environment through sensors and acting upon that that environment through effectors. A human agent has eyes, ears, and other organs for sensors, and hands, legs, mouth, and other body parts for effectors. A robotic agent substitutes cameras and infrared range finders for the sensors and various motors for the effectors (Russell and Norvig 2003).*

There are some varieties of agents but in a robotic sense: *Autonomous agents require be reactive to changes in the environment, it must be able to predict, incompatible goal management and adaptivity (prediction) (Decugis and Ferber 1998).* The agents, in our environment of creativity workshop 48H, is part of teams and can play one or more roles. Another definition, an agent is a physical or virtual entity that have several properties. These properties are the capacity to interact with its environment, the capacity of communication with other agents, the necessity to achieve an objective, the capacity to manage its resources, the capacity to perceive the environment, the capacity to represent partially or totally the environment and eventually the capacity of reproduction (Ferber 1995). With a different Wooldridge's conceptions, an agent is an informatic system in a specific environment, with autonomous actions to achieve its objectives (Wooldridge, Jennings, and Kinny 1999). For a language, agent could be a mental state consisting in beliefs, desires and intentions (Wooldridge et al. 2002). A definition based in software, agent are coarse-grained computational system, each making use of computational resources, they are heterogeneous (Wooldridge et al. 2002). A Final definition according to a multi agent system where agents interact among them to achieve a global objective, there exist two kind of agents, cognitive and reactive agents(Ferber 1995).

#### A. Cognitive and reactive agents

The best classification of agents according its behavior and environment is developed in the last century. The behavior of agents is governed by the opposition between *teleonomic*



*behaviors* directed towards explicit goals and *reflexive behaviors* governed by perceptions. The relation of the agent to his environment, if *the agent has a symbolic and explicit representation of the world from which he can reason*, or if *his representation is situated under -symbolical*, that is to say, integrated in its sensorimotor capacities (Piaget and Inhelder, 1966). In the first case, we will talk about cognitive agents and, in the second case, about reactive agents. The combination of cognitive and reactive agents (cf. Table III.4) with the teleonomic and reflexive behaviors give us the different types of agents (Ferber 1995).

Relation in the world Behaviors	Cognitive Agents	Reactive Agents
Teleonomic	Intentional agents	Drive agents
Reflexive	Module agents	Tropical agents

Table III.4: Types of Agents (Ferber 1995).

## B. Artificial Intelligence and Agents

Early works about artificial intelligence and robotics proposes the creation of little robots (insects) as agents to solve engineering problems (Brooks 1986). The concept of artificial intelligence comes from Alan Turing, although the name try to appears after, and works of Newell and Simon about intelligence appears until sixties with computers that simulate intelligence and finally Marvin Minsky announced the topic an Dreyfus works with it (Dreyfus 1972), (Papert 1969). The artificial intelligence (AI) is an important discipline that defines agent in different ways. *AI borrows concepts (states, actions and rational agents) and techniques for autonomic computing. The definition of rational agent: is any entity that perceives and acts upon its environment, selecting actions that, on the basis of information from built-in knowledge, are expected to maximize de agent's objective (Kephart and Walsh 2004).* The most simple definition about agent, *A software agent has encoded bit strings as its percepts and actions (Russell and Norvig 2003).*

*The design of rational agents has three approaches: reflex agent (uses if-then action rules), goal-based agent (rationality degree in how to determine an actions) and utility-based agent (how to maximize the function) (Russell and Norvig 2003).*

The definition of agent is different, this definition manages some specific concept attached to agent but there are five principal elements: objectives, environment, sensors, reactors and relations. In addition, some researches describe four *properties to the agents* (Wooldridge and Jennings 1995): *autonomy (Castelfranchi 2012)*, *social ability (interoperate) (Genesereth and S.Ketchpel 1994)*, *reactivity and pro-activeness; in some multi-agent system the relations among hundreds of agents (sometimes robots) are used to create an application to solve problems (Simonin and Ferber 2003).*

In nineties researches, methods and tools use the concept of agent, distributed artificial intelligence and artificial intelligence to solve big and difficult problem by mean of agents there by the communication among different types of agents inside a defined environment is essential to achieve the shared mission. *Tools for implementing distributed artificial intelligence using agents of various size and intelligence to communicate, appeared MERING IV (Ferber and Carle 1991). Distributed artificial intelligence (DAI) is a subfield of artificial intelligence that deals with interactions of intelligent agents (Chaib-Draa et al. 1992).* Nowadays, a method to build artificial societies applies the concept of agent to every

individual problem using multi-agent system quadrant MASQ formalism (Vanhée et al. 2013).

## III.2. Methodologies to design Multi-Agent Systems

There are some methodologies to design a multi-agent system (MAS). These methodologies involve mainly roles, agents, interactions among agents and the environment. First methodologies were developed at the end of the century based on interaction of roles (Wooldridge et al. 1999) but in this century several methodologies appears such as ICTAM (Elsawah et al. 2015), DOCK methodology (Girodon, Monticolo, and Bonjour 2015), MOBMAS (Tran and Low 2008), ADELFE (Picard and Gleizes 2006), GAIA (Wooldridge, Jennings, and Kinny 2000), (Zambonelli et al. 2003).

### III.2.1. Wooldridge's GAIA Methodology

The Gaia methodology is for agent-oriented analysis and design, in that it is applicable to a wide range of multi-agent systems, and comprehensive, in that it deals with both the macro-level (societal) and the micro-level (agent) aspects of systems. Gaia is founded on the view of a multi-agent system as a computational organization consisting of various interacting roles. Gaia has been specifically tailored to the analysis and design of agent-based systems (Wooldridge et al. 2000).

This methodology tries the aspects of the system in macro-level (society) and micro-level (agents) and their interactions. The main concepts used by this methodology are systems, roles, permissions, responsibilities, protocols, safety properties and liveness properties; the levels are 1 system, 2 roles, 3 attributes and 4 responsibilities (Wooldridge et al. 1999).

To define the organization is necessary to define the role model and to capture and present the interaction model. This interaction model must be in the analysis, the protocol for these interactions are purpose, initiator, responder, inputs, outputs, and processing. The analysis process must describe four steps, 1 identify the roles in the system, 2 for each role identify protocols, 3 to elaborate the roles model and finally 4 repeats until the analysis be right.

The agent model describes the types of agents and agent instances. A simple agent type tree defines the agent model. The agent instances that will appear in a system by annotating agent types in the agent mode. Inheritance is not part of the system.

The service model identifies the services associated which each agent role and to specify the main properties of these services (function of the agent or method). For each service that an agent performs, it is necessary to document its properties. Specifically, we must identify the inputs, outputs, pre-conditions, and post-conditions of each service. The acquaintance model defines the communication links between agent types and identify any potential communication bottlenecks. An agent acquaintance model is simply a graph, with nodes in the graph corresponding to agent types and arcs in the graph corresponding to communication pathways.

### III.2.2. DOCK Methodology

DOCK (Gabriel 2016) helps to model a multi-agent system based in knowledge management. This methodology describes an intelligent knowledge system; it uses human

organizations, roles, collaborations, skill, goals and knowledge. The methodology DOCK defines four elements: the organizational structure to identify agents (roles), the process model, the activity model and the role model. The model defines three stages: human organization, agent organization and interactions (cf. Figure III.22).

To carry out the modelling of the MAS with the DOCK methodology, it is necessary to create the organizational structure, the model process, the activity model and the role model. These models are created in the previous work “an organizational model to understand the creativity workshop” and in the process model using IDEF-0.

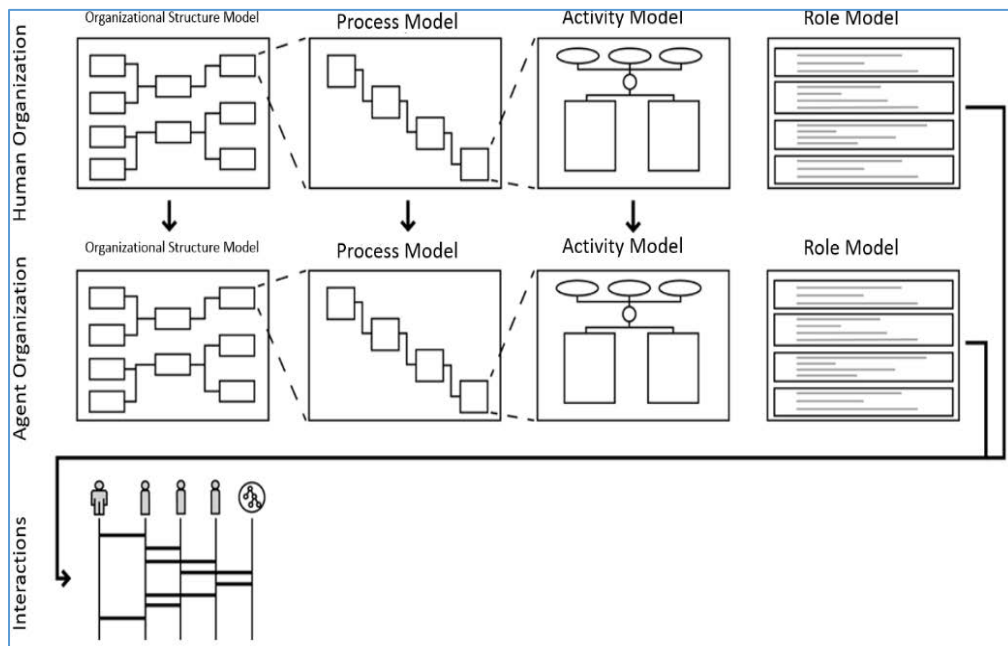


Figure III.22: Methodology DOCK to specify MAS dedicated to knowledge management.

### III.2.3. MOBMAS Methodology

This ontology-based methodology, used for the analysis and design of multi-agent systems (Tran and Low 2008); MOBMAS is the first methodology that explicitly identifies and implements the various ways in which ontologies can be used in the MAS development process and integrated into the MAS model definitions.

Conforming to the definition of a software engineering methodology (Henderson-Sellers, Simmons, and Younessi 1998), MOBMAS is comprised of a software engineering process that contains activities and associated steps to conduct the system development, techniques to assist the process steps and a definition of the models.

The five core activities (cf. Figure III.23) in the development process of MOBMAS. Each section elaborates on the activity’s associated steps, techniques and model definitions:

- Analysis Activity: Develops a conception for the future MAS, namely a first-cut identification of roles that comprise the MAS organization.
- MAS Organization Design Activity: Specifies the organizational structure for the target MAS and defines a set of agent classes that comprise the system.

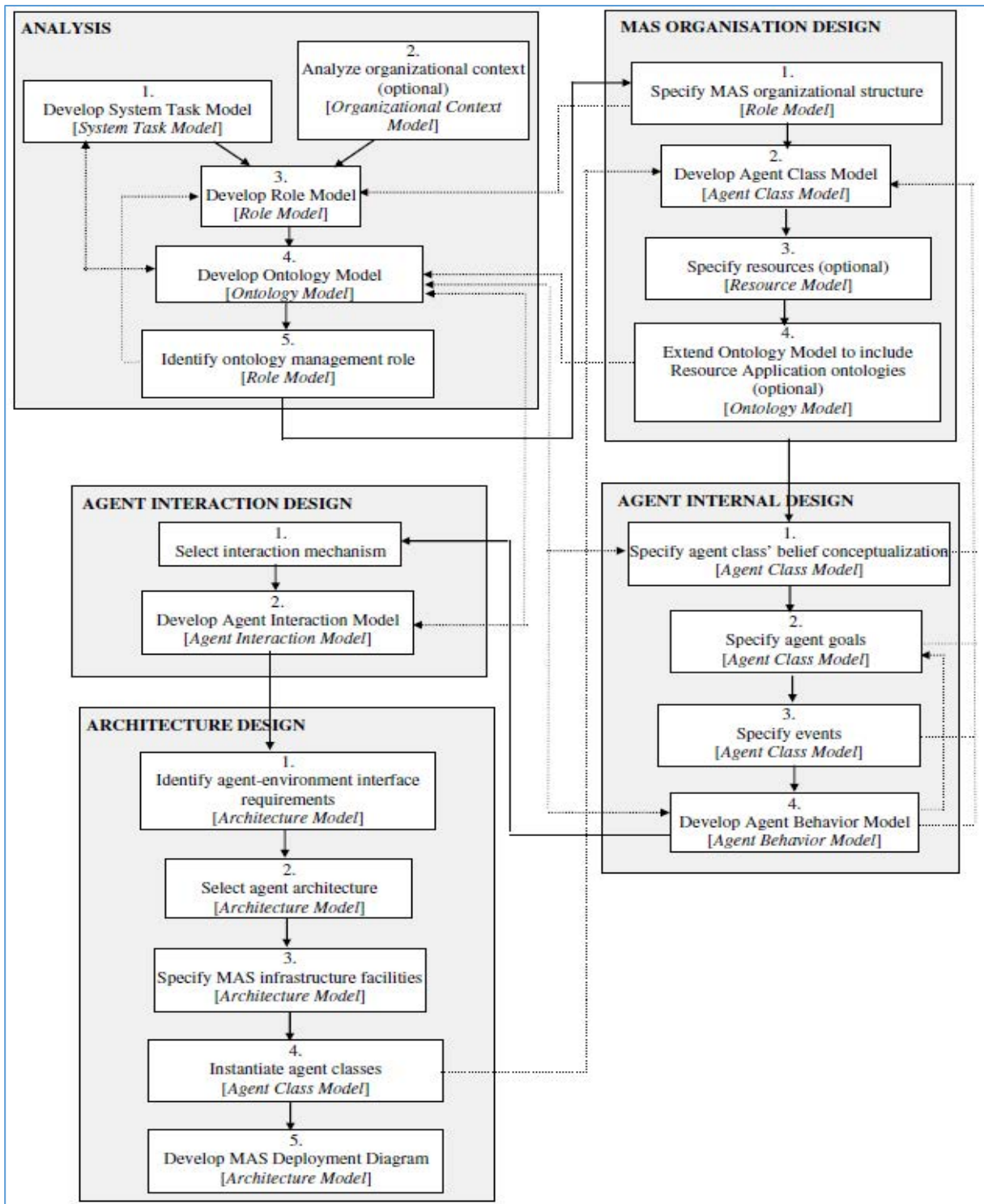


Figure III.23: MOBMAS Development process (Henderson-Sellers et al. 1998) pg. 3.

- Agent Internal Design Activity: Deals with the specification of each agent class, including its belief conceptualization, goals, events, plan templates and reflexive rules.
- Agent Interaction Design Activity: Designs the interactions between agent classes by selecting a suitable interaction mechanism for the target MAS and then defines the patterns of data exchanges amongst agent classes.

- Architecture Design: Deals with various architecture-related issues, namely the identification of agent-environment interface requirements, the selection of the agent architecture, the identification of required infrastructure facilities, the instantiation of agent classes and the deployment configuration of agents.

### III.2.4. GAIA Methodology with abstractions

This multi-agent system paradigm introduces a number of new abstractions and design/development issues. Gaia exploits the organizational abstractions to provide clear guidelines for the analysis and design of complex and open software systems (Zambonelli et al. 2003).

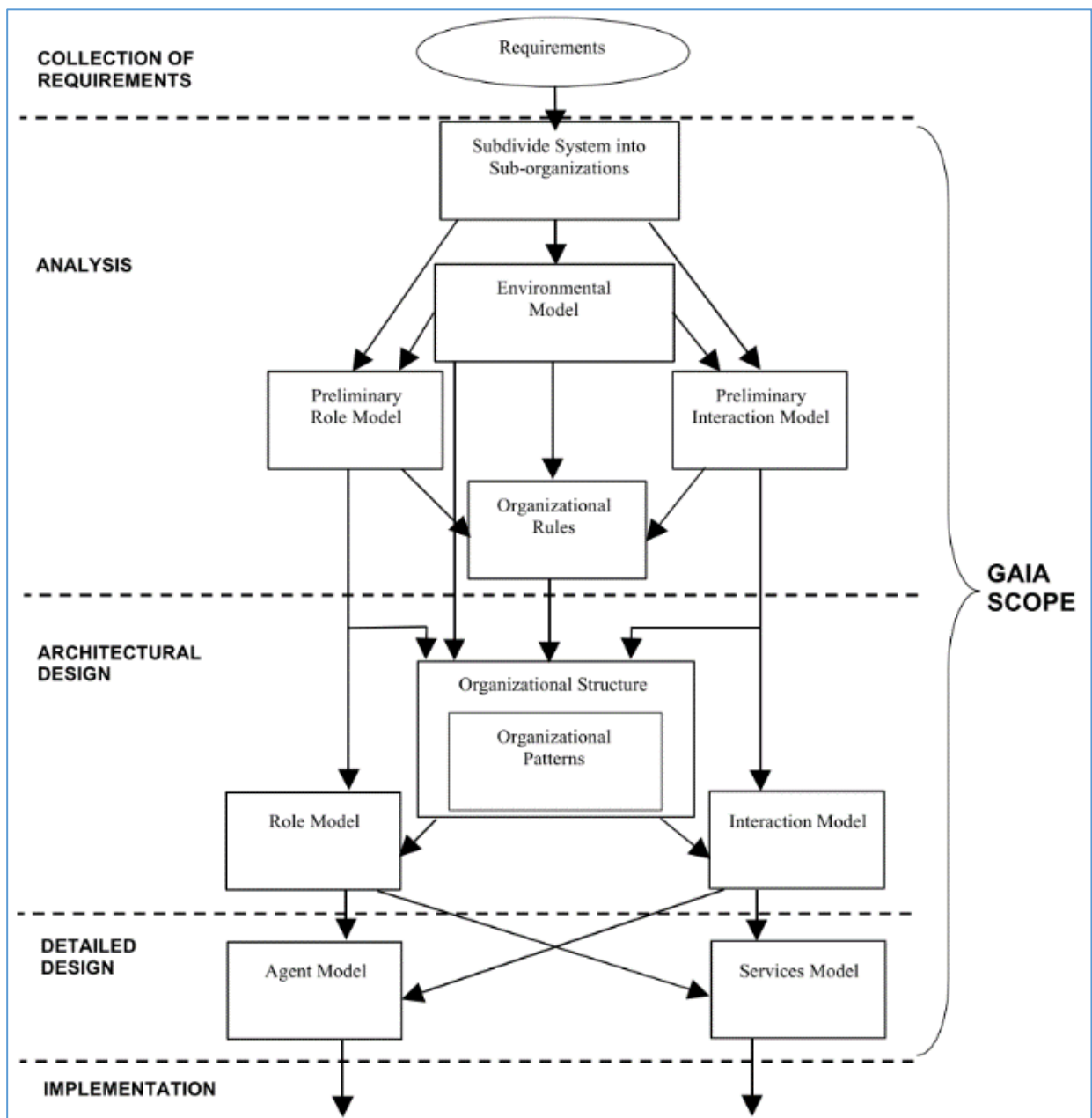


Figure III.24: GAIA Methodology with abstractions (Zambonelli et al. 2003) p. 20.

GAIA uses the organizational view to construct the development methodology also in GAIA an agent organization has collection of roles with responsibilities and interaction among roles. The design process is to produce an ordered sequence of steps, an identifiable set of models, and an indication of the interrelationships between the models, showing how and when to exploit which models and abstractions in the development of a MAS (cf. Figure III.24).

### III.2.5. SABPO Methodology

The SABPO methodology use an organizational metaphor, in which each agent plays a specific role to achieve the global goals of the organization, in addition, the methodology introduces a new interaction pattern. This approach puts the FIPA (the foundation for Intelligent Physical Agent) abstract architecture specification to the center of the methodology as a basic organizational structure and tries to create a concrete FIPA architecture that satisfies system requirements.

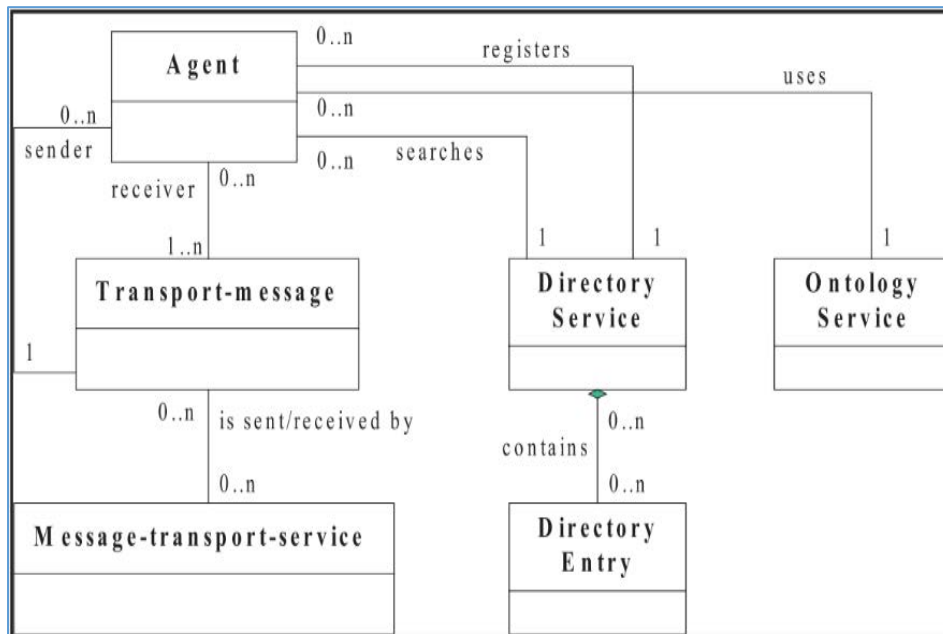


Figure III.25: Basic agent relationship of SABPO (Dikenelli and Cenk Erder 2002) p. 215.

Agents communicate using transport messages (cf. Figure III.25), which are sent or received by message transport service. Each transport-message includes a message, which is written in FIPA agent communication language.

### III.2.6. ADELFE Methodology

ADELFE is another methodology focus on the adaptive nature of the environment. It introduces the concepts of Non Cooperative Situations (NCS) that defines the behavior of local agents when they encounter an unpredictable situation in a dynamic environment. Rational Unified Process leads ADELFE that is devoted to software engineering adaptive MAS. ADELFE guarantees that the software is developed according to the adaptive multi-agent systems AMAS theory. The AMAS theory provides a solution to build complex systems for which classical algorithmic solutions cannot be applied, these systems are open and

complex. All the interactions the system may have with its environment cannot be enumerated (Picard and Gleizes 2006).

ADELFE is an agent-oriented methodology for designing Adaptive Multi-Agent Systems (AMAS), it is a French acronym for “Atelier de Développement de Logiciels à Fonctionnalité Emergente” (Rougemaille et al. 2009).

The ADELFE’s phases version 2.0 are preliminary requirements, final requirements, analysis, design and implementation.

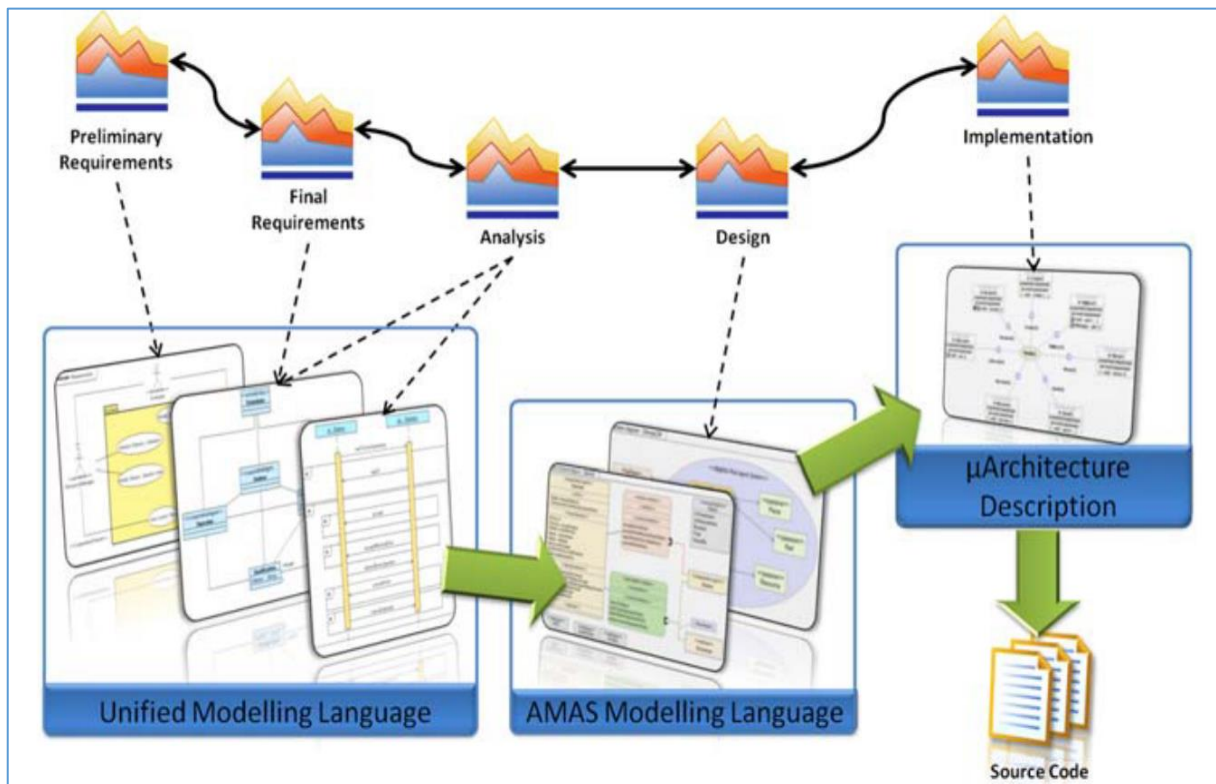


Figure III.26: Phases and Diagrams, Improved ADELFE (Rougemaille et al. 2009) p. 5.

Using a Domain Specific Modeling Language (DSML) and adding a Model Driven Implementation phase using model transformations, DSMLs and code generation (cf. Figure III.26), the design phase has been improved and the implementation phases is added.

### III.3. Applying the MAS methodology GAIA

*Why GAIA is appropriate?* Agents are heterogeneous, in that different agents may be implemented using different programming languages, architectures, and techniques. We make no assumptions about the delivery platform. The organization structure of the system is static, in that inter-agent relationships do not change at run-time. The overall system contains a small quantity of agents.

In addition, we chose this model because GAIA encourages us to think of building agent-based systems as a process of organizational design. We have to divide the main concepts in two abstracts and concepts time (Wooldridge et al. 2000); furthermore, GAIA is one of the first methodologies applicable to multi-agent systems and created by three important researchers Wooldridge, Jennings and Kinny which are starters of this topic.

The analysis process of GAIA identifies roles, the protocols of interaction among roles, using the protocol model elaborate the roles model. In the organizational model for a creativity workshop to highlight knowledge describe the missions, goals and processes. We can complete the analysis required by GAIA methodology (roles model and interaction model) because we have already identified the processes, the activities and the roles.

The design processes of GAIA have three models, agent model, services model and acquaintance model that help us to understand the roles and interactions described before in the analysis phase. *Gaia is concerned with how a society of agents cooperate to realize the system-level goals, and what is required of each individual agent in order to do this. Actually how an agent realizes its services is beyond the scope of Gaia, and will depend on the particular application domain (Wooldridge et al. 2000).*

### III.3.1. In applying GAIA

The models in GAIA are in two phases, first the analysis phase with the role model and interaction models and the second phase, the design phase with the agent model, service model and acquaintance model (cf. Figure III.27).

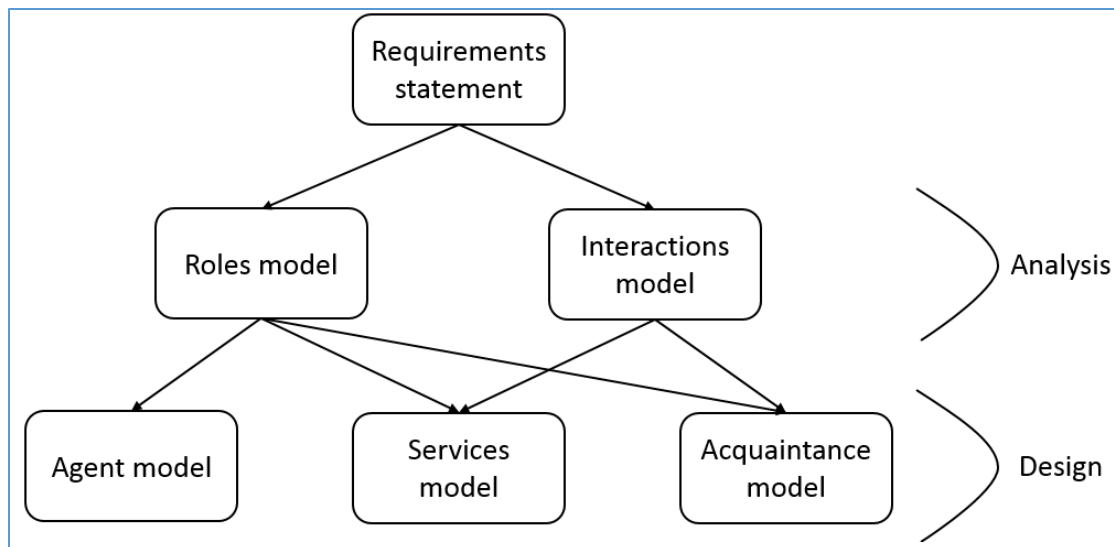


Figure III.27: Relations between the GAIA's models(Wooldridge et al. 2000) p. 3.

### III.3.2. Analysis of concepts

The objectives of a multi-agent system are to manage idea cards, to take decisions, and to enhance the creative techniques by means of the reactive and cognitive agents in the environment of 48H creativity workshop.

The most abstract concept is the system. The organization is a collection of roles and interactions among them (Figure cf. III.28). The analysis moves from abstract to concrete concepts.



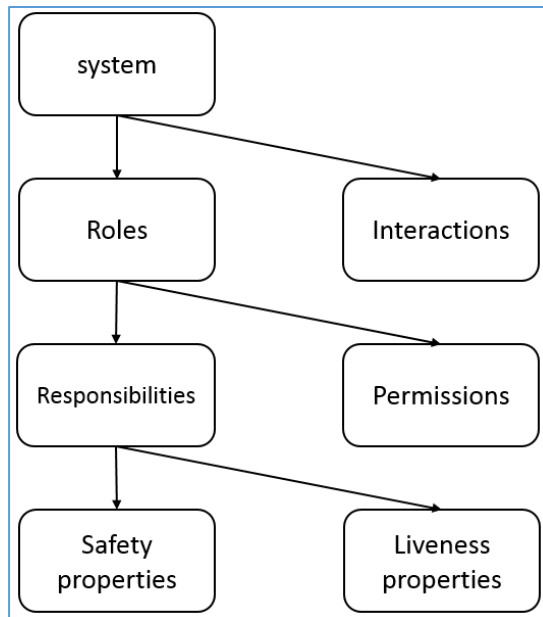


Figure III.28: Analysis of concepts (Wooldridge et al. 2000) p. 4.

The table of Abstract and Concrete Concepts (cf. Table III.5) describes every abstract concept. First, the most abstract concept the system after roles (stakeholders), permissions (rights), responsibilities (duty to deal), protocols as the interaction with other roles as Smith writes in (Smith 1980), activities, safety properties and liveness properties. The last two abstract concepts have measures about “something good and nothing bad happens” (Wooldridge et al. 2000); finally, three concrete concepts as agent types, services and acquaintances:

Abstract Concepts	Definition
1 Roles	Creative expert, organizer, technical expert, industrial manager and solver participant.
2 Permissions	The “rights” associated with a role. The permissions of a role thus identify the resources that are available to that role in order to realize its responsibilities. In the kinds of system that we have typically modelled, permissions tend to be information resources. For example, a role might have associated with it the ability to read a particular item of information, or to modify another piece of information. A role can also have the ability to generate information.
3 Responsibilities	Responsibilities determine functionality and, as such, are perhaps the key attribute associated with a role. An example responsibility associated with the role of company president might be calling the shareholders meeting every year. Responsibilities are divided into two types: liveness properties and safety properties
4 Protocols	Define the way that it can interact with other roles with a number of protocols. For example, a “seller” role might have the protocols “Dutch auction” and “English auction” associated with it; the Contract Net Protocol is associated with the roles: “manager” and “contractor”.
5 Activities	The activities of a role are computations associated with the role that may be carried out by the agent without interacting with other agents.
6 Liveness properties	Liveness properties intuitively states that “something good happens. They describe those states of affairs that an agent must bring about, given certain environmental conditions.
7 Safety properties	In contrast, safety properties are invariants. Intuitively, a safety property states that “nothing bad happens”. An example might be “ensure the reactor temperature always remains in the range 0–100.”
Concrete Concepts	Definition
1 Agent types	Cognitive agents belong to the group of intelligent agents that will represent our 48H environment; every cognitive agent inside this environment has one or some individual objectives that it must to achieve them. In our example, these objectives are described in the definition of the role.

	<p>Cognitive agents in 48H: Creative expert, organizer, technical expert, industrial manager and solver participant.</p> <p>Reactive agents are part also of the intelligent agents in the 48H creativity workshop environment; they react to some specific events in the 48H with the purpose to solve our hard problems like statistical calculation, mathematical calculation, and ordering. They will work together to achieve our principal objective to manage the idea cards.</p> <p>The 48H's reactive agents: Calculate Width Agent, Calculate Semantic Distance Agent, Compare Idea Cards Agent</p>
2 Services	<p>Collective Data Agent: Provides an easy way to show if the idea card has enough and different concepts.</p> <p>An agent to create lists and trees with semantic lexical database</p> <p>Calculate Semantic Distance and depth Agent</p> <p>Gives the semantic distance between two concepts that belong to different Idea Cards.</p> <p>Compare Idea Cards Agent.</p> <p>Offers a numeric comparative between two Idea Cards from 0 (not similar) to 1 (similar).</p>
3 Acquaintances	The communication among the seven agents that cover our system

Table III.5: GAIA Concepts.

### III.3.3. Analysis - Roles Model

In this section, we will describe the roles of the agents. We have chosen to give the same role for the agents than for the participants of the creativity workshop i.e. “creative expert”, “Industrial manager”, “Organizer”, “solver participant” and “technical expert”. The objective of the agents is to assist the participants to achieve their activities and to manage their ideas during the creativity workshop process.

#### A. Role Schema: Creative Expert

The schema of creative expert (cf. Table III.6) describes the proposition of activities and collaborative creative methods to the teams; there are fifteen protocols that describe the communication of creative expert some of them require parameters such as the protocol RequirementsInscription (Name, Last Name, Institution). The permissions of the creative expert are the actor must be register as a creative expert, to think previously about activities and collaborative creative methods.

The part of responsibilities has the liveness and safety, with respect to the liveness, the creative expert starts with the protocols RequirementsInscriptions and GiveRequirements that executed at least one time (+), the protocols of finish are “WatchingPossibleSolutions” and “AwardsEnd”. Now, with respect to the safety, the numbers of activities must be one or more, with the same expression to the collaborative creative methods.

Role Schema	Name of the role
Description and objective	<p>The role creative expert:</p> <p>Propose activities to the team of solver participants to produce ideas in an individual way.</p> <p>Propose collaborative creative methods to the team of solver participants to Produce idea cards.</p>
Protocols and Activities	<p>RequirementsInscription (Name, Last name, Institution), GiveRequirements (Name, Last name, Institution).</p> <p>Assignment (Assign_InstToWork, Assigned_ind, assigned_rol), Provides (part_team, problem)</p> <p>Offer_activity, SelectActivity, WorkIdeas.</p> <p>Offer_method, SelectMethod, WorkIdeaCards, Improve, CompareIdeas, ReceivingPossibleSolutions, WatchingPossibleSolutions, AwardsEnd.</p>
Permissions	The actor must be register as a Creative Expert

	To think previously about individual activities, to offer an individual activity. To think previously about a collaborative creative method, to offer a collaborative creative method.
<b>Responsibilities:</b>	
Liveness	CreativeExpert = (RequirementsInscription.GiveRequirements) <sup>+</sup> · (Assignment) <sup>+</sup> · (Provides) <sup>+</sup> · (Offer_activity.SelectActivity.WorkIdeas) <sup>+</sup> · (Offer_method.SelectMethod.WorkIdeaCards.Improve) <sup>+</sup> · (CompareIdeas) <sup>+</sup> · (ReceivingPossibleSolutions) <sup>+</sup> · (WatchingPossibleSolutions.AwardsEnd) <sup>+</sup>
Safety	<ul style="list-style-type: none"> <li>• Activity &gt; =1</li> <li>• Collaborative Creative Method &gt;=1</li> </ul>

Table III.6: Role Creative Expert.

### B. Role Schema: Industrial Manager

The industrial manager's description has the proposition of problems and choosing probable solutions (cf. Table III.7). Eight protocols describe the communication of the industrial manager with the other participants, these protocols are RequirementsInscription, GiveRequirements, Assignment, Provides, SendingIdeaCards, ReceivingPossibleSolutions, WatchingPossibleSolutions, and AwardsEnd. The responsibilities of the industrial manager agent start with the protocols "RequirementsInscriptions" and finish with "WatchingPossibleSolutions" and "AwardsEnd", in liveness. The problems and possible solutions have to be >= 1 in the part of safety.

Role Schema	Name of the role
Description and objective	The role industrial manager: To propose industrial problems. To choose probable solutions.
Protocols and Activities	RequirementsInscription (Name, Last name, Institution), GiveRequirements (Name, Last name, Institution). Assignment (Assign_InstToWork, Assigned_ind, assigned_rol), Provides (part_team, problem). SendingIdeaCards, ReceivingPossibleSolutions, WatchingPossibleSolutions, AwardsEnd.
Permissions	The actor must be register as an Industrial manager To provide at least an industrial problem To read Idea Cards and select Possible Solutions
<b>Responsibilities:</b>	
Liveness	Industrialmanager= (RequirementsInscription.GiveRequirements) <sup>+</sup> · (Assignment) <sup>+</sup> · (Provides) <sup>+</sup> · (SendingIdeaCards) <sup>+</sup> · (ReceivingPossibleSolutions) <sup>+</sup> · (WatchingPossibleSolutions.AwardsEnd) <sup>+</sup>
Safety	<ul style="list-style-type: none"> <li>• problem &gt;=1</li> <li>• Possible_solutions &gt;= 1</li> </ul>

Table III.7: Role Industrial Manager.

### C. Role Schema: Organizer

The role schema of organizer (cf. Table III.8) states descriptions, protocols and activities, and permission in a first part. The description of this role has the creation of the event and the assignment of institution, industry, role, team and problem. This role participates in six protocols and when he is an actor, he has to have permission as an organizer.

With respect to liveness and safety, the first has an important protocol "CreateEvent" just one event and finish with WatchingPossibleSolutions and AwardsEnd. In the safety aspect,

are having at least 1 event, institution and industry, in addition, to have at least 2 roles, 2 teams and 1 industrial problem to offer.

Role Schema	Name of the role
Description and objective	The role organizer: To create event's edition To assign institution to work to the actor To assign industry to actor To assign role to actor To assign team to actor To assign problem
Protocols and Activities	RequirementsInscription (Name, Last name, Institution), GiveRequirements (Name, Last name, Institution) Assignment (Assign_InstToWork, Assigned_ind, Assigned_role), Provides (part_team, problem) WatchingPossibleSolutions, AwardsEnd.
Permissions	The actor must be register as an Organizer To have at least 1 event, 1 institution, 1 industry, 2 Roles, 2 team and 1 industrial problem to offer.
<b>Responsibilities:</b>	
Liveness	Organizer = (CreateEvent) <sup>1</sup> · (RequirementsInscription.GiveRequirements) <sup>+</sup> · (Assignment) <sup>+</sup> · (Provides) <sup>+</sup> · (WatchingPossibleSolutions.AwardsEnd) <sup>+</sup>
Safety	<ul style="list-style-type: none"> <li>• Event =1</li> <li>• Institution &gt;=1</li> <li>• Industry &gt;= 1</li> <li>• Role &gt;= 2</li> <li>• Team &gt;= 2</li> <li>• Problem &gt;=1</li> </ul>

Table III.8: Role Organizer.

#### D. Role Schema: Solver Participant

The schema of solver participant (cf. Table III.9) details the production of ideas an idea cards. There are fifteen protocols (showed in the table III.9 Protocols and activities) where solver participant acts. The permissions are producing an individual idea using individual activities, to produce at least two idea cards using a collaborative creative method, to have the same problem in WorkIdeaCards at the time of sharing with colleague team, to evaluate idea cards from the same problem except your idea card.

The part of responsibilities, the complete liveness of the role is (RequirementsInscription.GiveRequirements) + · (Assignment)<sup>+</sup> · (Provides)<sup>+</sup> · (Offer\_activity.SelectActivity.WorkIdeas) + · (Offer\_method.SelectMethod.WorkIdeaCards.Improve)<sup>+</sup> · (CompareIdeas) + · (SendingIdeaCards.ReceivingPossibleSolutions)<sup>+</sup> · (WatchingPossibleSolutions.AwardsEnd) +. According to safety, the solver participant must produce more than zero ideas and 2 idea cards by team.

Role Schema	Name of the role
Description and objective	The role solver participant: To produce ideas in an individual way using activities. To produce idea cards by mean of collaborative creative methods.
Protocols and Activities	RequirementsInscription (Name, Last name, Institution), GiveRequirements (Name, Last name, Institution) Assignment (Assign_InstToWork, Assigned_ind, assigned_rol), Provides (part_team, problem)

	Offer_activity, SelectActivity, WorkIdeas Offer_method, SelectMethod, WorkIdeaCards, Improve, CompareIdeas, SendingIdeaCards, ReceivingPossibleSolutions, WatchingPossibleSolutions, AwardsEnd
Permissions	The actor must be register as a Solver Participant; To produce at least 1 individual idea using individual activities. To produce 2 Idea Cards using a collaborative creative method. To have the same problem in WorkIdeasCards at the time of sharing with colleague team. To evaluate idea cards from the same problem except your idea cards and the idea cards from your team partner.
<b>Responsibilities:</b>	
Liveness	Solverparticipant = (RequirementsInscription.GiveRequirements) <sup>+</sup> · (Assignment) <sup>+</sup> · (Provides) <sup>+</sup> · (Offer_activity.SelectActivity.WorkIdeas) <sup>+</sup> · (Offer_method.SelectMethod.WorkIdeaCards.Improve) <sup>+</sup> ·(CompareIdeas) <sup>+</sup> · (SendingIdeaCards.ReceivingPossibleSolutions) <sup>+</sup> · (WatchingPossibleSolutions.AwardsEnd) <sup>+</sup>
Safety	<ul style="list-style-type: none"> <li>Idea &gt; 0</li> <li>Idea Card = 2 by team.</li> </ul>

Table III.9: Role Solver Participant.

### E. Role Schema: Technical Expert

The technical expert's description has as proposition to help teams (cf. Table III.10); eight protocols describe his communication. In permissions, as an actor, he must take the role of technical expert and to offers help to the team of solver participants.

Their responsibilities start with the protocols RequirementsInscriptions and finish with WatchingPossibleSolutions and AwardsEnd, in liveness. Inside safety, the variable "Help\_team" must be true.

Role Schema	Name of the role
Description and objective	The role technical expert: To help collaborative creative groups.
Protocols and Activities	RequirementsInscription (Name, Last name, Institution), GiveRequirements (Name, Last name, Institution) Assignment (Assign_InstToWork, Assigned_ind, assigned_rol), Provides (part_team, problem) Improve, WatchingPossibleSolutions, AwardsEnd.
Permissions	The actor be register as a Technical Expert To offer help to the team of solver participants.
<b>Responsibilities:</b>	
Liveness	TechnicalExpert = (RequirementsInscription.GiveRequirements) <sup>+</sup> · (Assignment) <sup>+</sup> · (Provides) <sup>+</sup> · (Improve) <sup>+</sup> · (WatchingPossibleSolutions.AwardsEnd) <sup>+</sup>
Safety	<ul style="list-style-type: none"> <li>Help_team = True</li> </ul>

Table III.10: Role Industrial Manager.

### III.3.4. Analysis - Interaction Model

The analysis of the model GAIA describes the role model, previous section, and the interaction model, this second model describes the communication's protocols for each agent.

The agent's protocol has some elements (cf. Figure III.29) that help us to improve the explanation about the protocol's description (Coleman et al. 1996) in the interaction of the agents.

Protocol		
Brief description and purpose		
Role Initiator	Role Responder	Inputs
Processing		
Textual description of any processing the protocol initiator performs during the course of the interaction		Outputs

Figure III.29: Protocol description.

The protocol description holds four interior and two exterior parts. The interior consists in protocol, role initiator, role responder [it could be Organizer (OR), Solver Participant (SP), Creative Expert (CE), Industrial Manager (IM) and Technical Expert (CE), for both roles] and processing. The exterior are data inputs and outputs.

#### A. Role Organizer:

The interaction model describes the protocols with the attributes: purpose, initiator, responder, inputs, outputs, processing; the protocols for the role organizer (*cf.* Figure III.30) defines all these attributes, before to start the protocols, the Organizer must create an event with name, date and edition as attributes.

The protocol “Requirements Descriptions” has as a role initiator the Organizer; the responders are the roles Solver Participant, Creative Expert, Industrial Manager and Technical Expert. There are not inputs, it is the information used by the organizer while enacting the protocol. The output are the details of all the stakeholders (name, last name and institution) and finally the processing that the organizer executes during the interaction.

The protocol “Give Requirements” has as roles initiators Solver Participant, Creative Expert, Industrial Manager and Technical Expert; the responder is the Organizer. The input are personal Data. The output are the requirements of the stakeholders (name, last name and institution) and at the end the processing “Provides data for inscription and institution details.

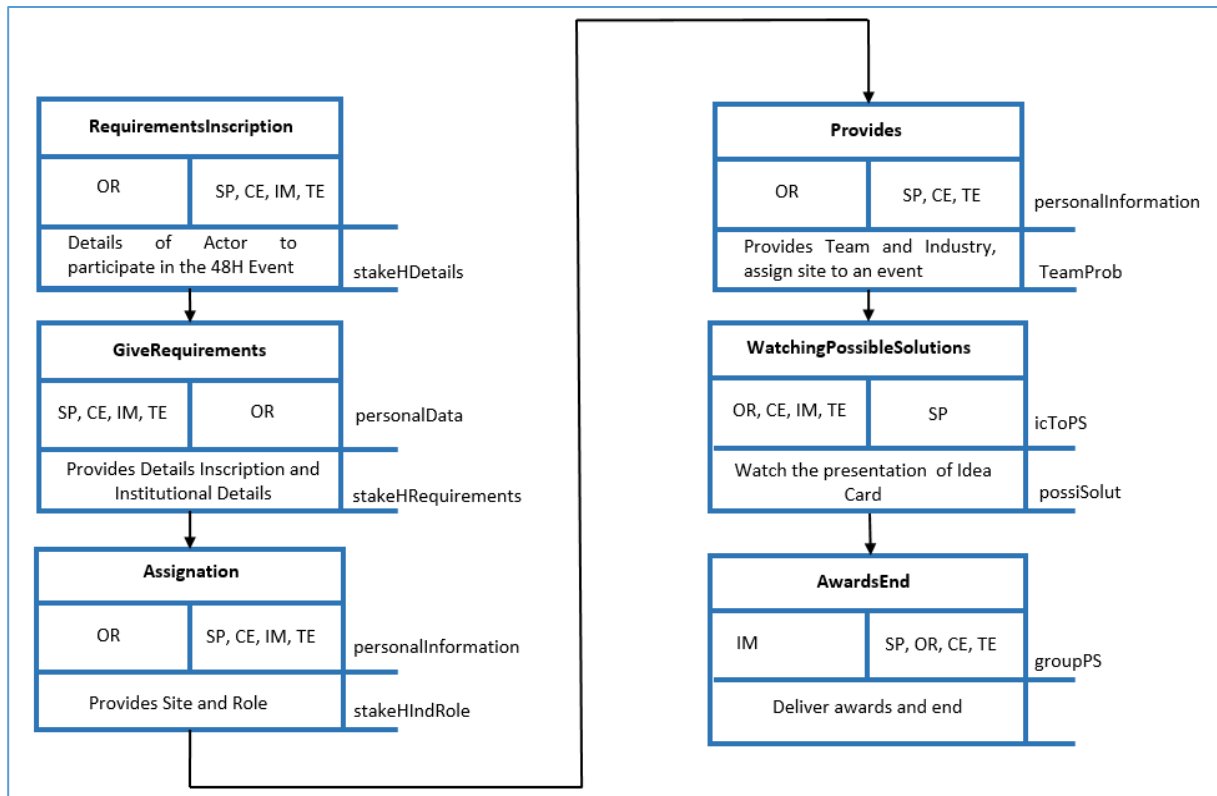


Figure III.30: Definition of protocols associated with Role Organizer.

The protocol “Assingnation” has as a roles initiator the Organizer. The responders are the roles “Solver Participant”, “Creative Expert”, “Industrial Manager” and “Technical Expert”. The personal information is the inputs (name, last name, date of birth, sex and institution where his belong). The output is the stakeHoldersIndRole (Site and Role). Finally, the processing “Provides Site and Role”.

The protocol “Provides” has as a roles initiator the Organizer. The responders are the roles Solver Participant, Creative Expert and Technical Expert. The personal information is the inputs (name, last name and institution where his belong). The output is the teamProb where the Industry has the problem (Team, Industry and assign the site to the Event). At the end, the processing “Provides team and problem”.

The protocol “WatchingPossibleSolutions” has as roles initiators the Organizer, Creative Expert, Industrial Manager and Technical Expert. The responder is the role Solver Participant. The personal information is the idea card that could be a possible solution. The output is the Possible Solution. The processing is “Watch the presentation of Idea Card”.

The protocol “AwardsEnd” has as a role initiator the Industrial Manager. The responders are the roles Solver Participant, Organizer, Creative Expert and Technical Expert. The group of possible solutions are the inputs. The output is null. Finally, the processing “Delivers awards and End”.

The role organizer has function as unique initiator in “Requirements Descriptions” and “Assingnation”, during these protocols, organizer has relation with all the other roles; in the “Provides”, organizer doesn’t have relation with industrial manager; next we present the role solver participant.

## B. Role Solver Participant:

The interaction model for the role Solver Participant describes some protocols from the role Organizer plus other protocols to define in (cf. Figure III.31) that defines all the attributes. The definition of these solver participant's protocols in red, this colour represent the divergence and convergence phases for the solver participant the most important role in the collaborative creative process.

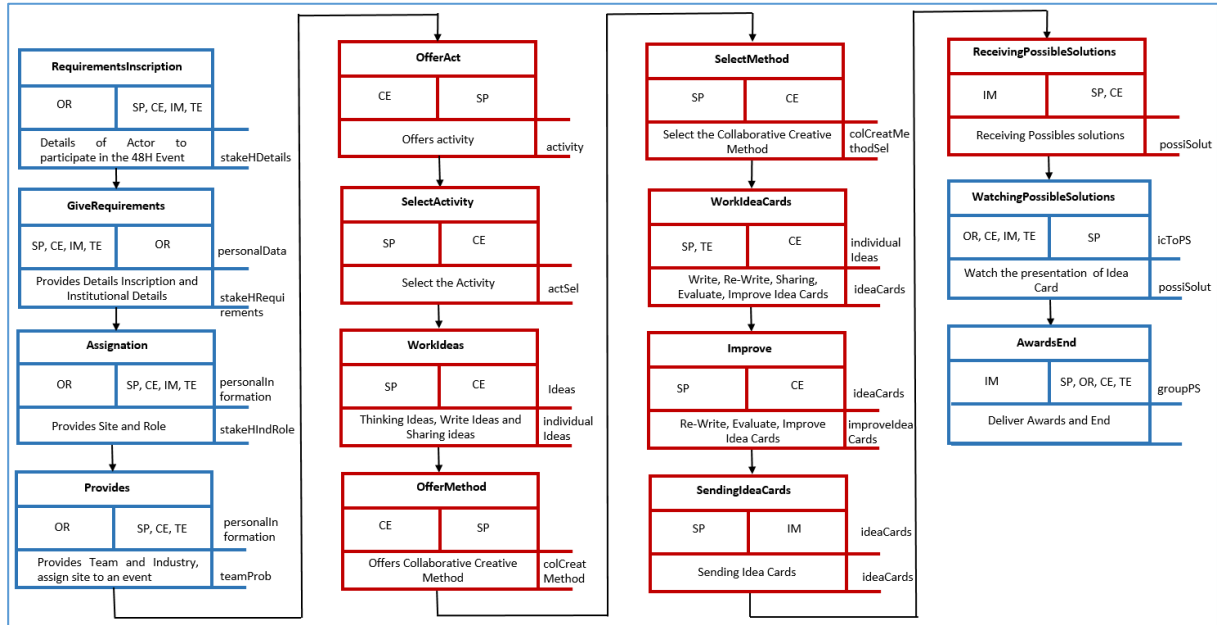


Figure III.31: Definition of protocols associated with Role Solver Participant.

The protocol “OfferAct” has as a role initiator the Creative Expert; the responder is the role Solver Participant. There is not inputs. The output is the activity; the team of Solver Participants might use the activity. The processing “Offers Activity”.

The protocol “SelectActivity” has as a role initiator the Solver Participant; the responder is the role Creative Expert. There is not inputs. The output is the activity, it is used to produce individual ideas many of them are in the mind of the Solvers Participant; the team of Solver Participants use an activity. The processing “Select the Activity”.

The protocol “WorkIdeas” has as a role initiator the Solver Participant; the responder is the role Creative Expert. There are many individual ideas written and shared as an input that impulse to participate. The output are the individual ideas (name and description); the team of Solver Participants use an activity to produce a huge quantity of individual ideas. The processing “Thinking Ideas, Write Ideas and Sharing Ideas”.

The protocol “Offer Method” has as a role initiator the Creative Expert; the responder is the role Solver Participant. There is not inputs. The output is the collaborative creative method, the team of Solver Participants choose a collaborative creative method ; the team of Solver Participants might use the collaborative creative method offered by the Creative Expert or they can select another. The processing “Offers Collaborative Creative Method”.

The protocol “SelectMethod” has as a role initiator the Solver Participant; the responder is the role Creative Expert. There is not inputs. The output are the collaborative creative method; the team of Solver Participants use a collaborative creative method to stat the production. The processing “Select the Collaborative Creative Method”.



The protocol “WorkIdeaCards” has as a role initiator the Solver Participant; the responder is the role Creative Expert. There are many individual ideas written and shared as an input. The output are the Idea Cards with all their information such as Title, Description, Scenery, Risks, Priority Clients, Advantages and Draw (ICTitle, ICDesc, ICScenery, ICRisk, ICPrioCli, ICAvant and ICDraw); the team of Solver Participants use a collaborative creative method to produce two Idea Cards, share their two Idea Cards with other collaborator team (with the same industrial problem). The team evaluates the similar idea cards except their two idea cards and the other two idea cards that belong to his colleague team; finally, the team improves their idea cards. The processing “Write, Re-write, Sharing, Evaluate, Improve Idea Cards”.

The protocol “Improve” has as roles initiators the Solver Participant and Technical Expert; the responder is the role Creative Expert. There are two idea cards written and shared as an input. The output are the improved Idea Cards with all their information such as Title, Description, Scenery, Risks, Priority Clients, Advantages and Draw (ICTitle, ICDesc, ICScenery, ICRisk, ICPrioCli, ICAvant and ICDraw); the team of Solver Participants and the Technical Expert works together to improve the two Idea Cards, technical Experts offers characteristics about the final product. The processing “Re-Write, Evaluate, Improve Idea Cards”.

After the protocol “improve”, the protocol “CompareIdeas” might have as a roles initiator the intelligent reactive agents: Semantic model knowledge agent SMKA, width density-semantic distance agent WSDA, and comparative similarities agent CSA; the responder might be all the intelligent cognitive agents. We just explain the protocol; but forward, the design model presents these agents and in the chapter of experimentation will be their processes. The idea cards written and shared as an input. The outputs are the semantic distance SD, width-density WD and the comparative of similarities CS; taking in account the ICTitle and ICDesc of the Idea Cards. The team of Solver Participants executes a function to obtain SD, WD and CS during the processing “Compare Idea Cards”.

After “CompareIdeas”, the protocol “SendingIdeaCards” has as a role initiator the Solver Participant; the responder is the role Industrial Manager. There are two idea cards written and shared as an input. The outputs are the two Idea Cards. The team of Solver Participants Send the idea cards to the Industrial Manager IM. The processing “Sending Idea Cards”.

The protocol “ReceivingPossibleSolutions” has as a role initiator the Industrial Manager. Two idea cards are part of an input. The outputs are the two Idea Cards. The Industrial Manager receives the Possible Solutions (PS). The processing “Receiving Possible Solutions”.

It is important to write that the analysis model defines the intelligent cognitive agent. The role solver participant has function as unique initiator in “SelectActivity”, “WorkIdeas”, “SelectMethod”, “Improve” and “SendingIdeaCards”; during these protocols, solver participant has relation with creative expert.

### **C. Role Industrial Manager:**

The interaction model for the role Industrial Manager describes the protocols “RequirementsInscription”, “GiveRequirements”, “Assignment”, “SendingIdeaCards”, “ReceivingPossibleSolutions”, “WatchingPossibleSolutions” and “AwardsEnd” (cf. Figure III.32). Before to start the protocols the Industrial Manager proposes an industrial problem that will be the motive principal to produce ideas, idea cards and possible solutions. The

most important protocols for industrial manager are “SendingIdeaCards” and “ReceivingPossibleSolutions” in red.

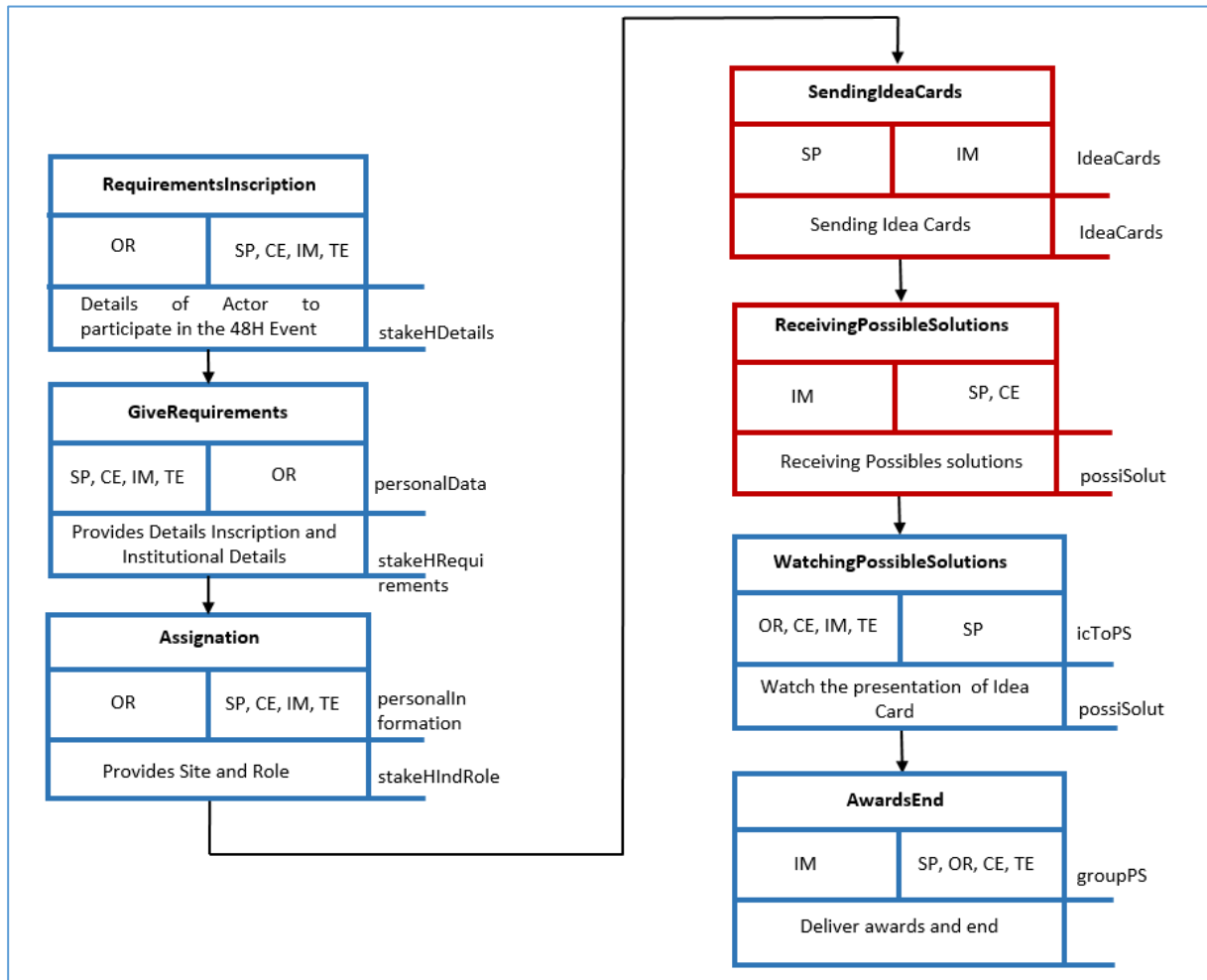


Figure III.32: Definition of protocols associated with Role Industrial Manager.

#### D. Role Creative Expert:

The interaction model for the role Creative Expert describes almost all the protocols from the role Solver Participant except the protocol SendingIdeaCards and ReceivingPossibleSolutions.

#### E. Role Technical Expert:

The interaction model for the role Technical Expert describes the protocols “RequirementsInscription”, “GiveRequirements”, “Assignment”, “Provides”, “WatchingPossibleSolutions” and “AwardsEnd” (cf. Figure III.33) where the main protocol is “WorkIdeaCards” in red.

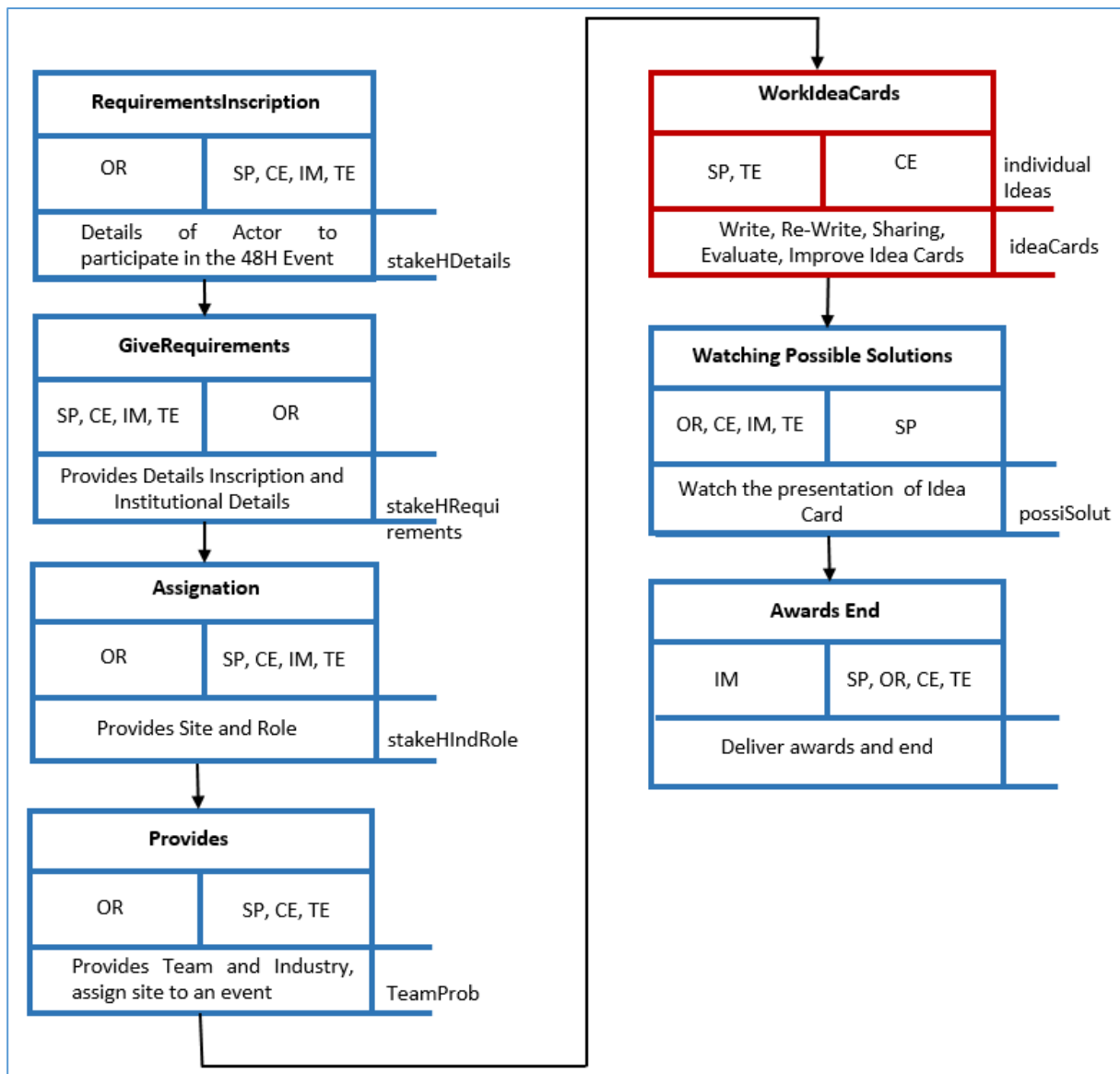


Figure III.33: Definition of protocols associated with Role Technical Expert.

The roles model and interaction model describe the analysis model of GAIA, having this part, next design model will conclude the GAIA model.

### III.3.5. Design - Agent Model

The design model based on the GAIA methodology, has three elements: the agent model, the services model and the acquaintance model that we are going to present. First, we have the aim in GAIA and the agent model explanation.

The aim in Gaia is to transform the analysis models into a sufficiently low level of abstraction that traditional design techniques (including object-oriented techniques) may be applied in order to implement agents. We need to document of various types of agents that will be used in the system under development, and the agent instances that will realize these agent types at run-time (Wooldridge et al. 2000).

In the agent model (cf. Figure III.34), we identify seven agents and their instances that will make up the system. During the creativity workshop, it identifies easily the five roles

according to the agent model proposed. The role creative expert and Technical Expert will form an agent called Creative Technological Expert Agent (CTEAgent-CTEA), the number of CTEA agents are 1 or more. The rest of the roles have their agents, making note that the agent Organizer (ORAgent-ORA) has one or more instances. However, we add three agent, semantic model knowledge agent (SMKA), width semantic distance agent (WSDA) and the comparative similarity agent (CSA). These agents help us to order ideas according to semantic distance, width-density and comparative similarity of Idea Cards. The definitions of the agents are:

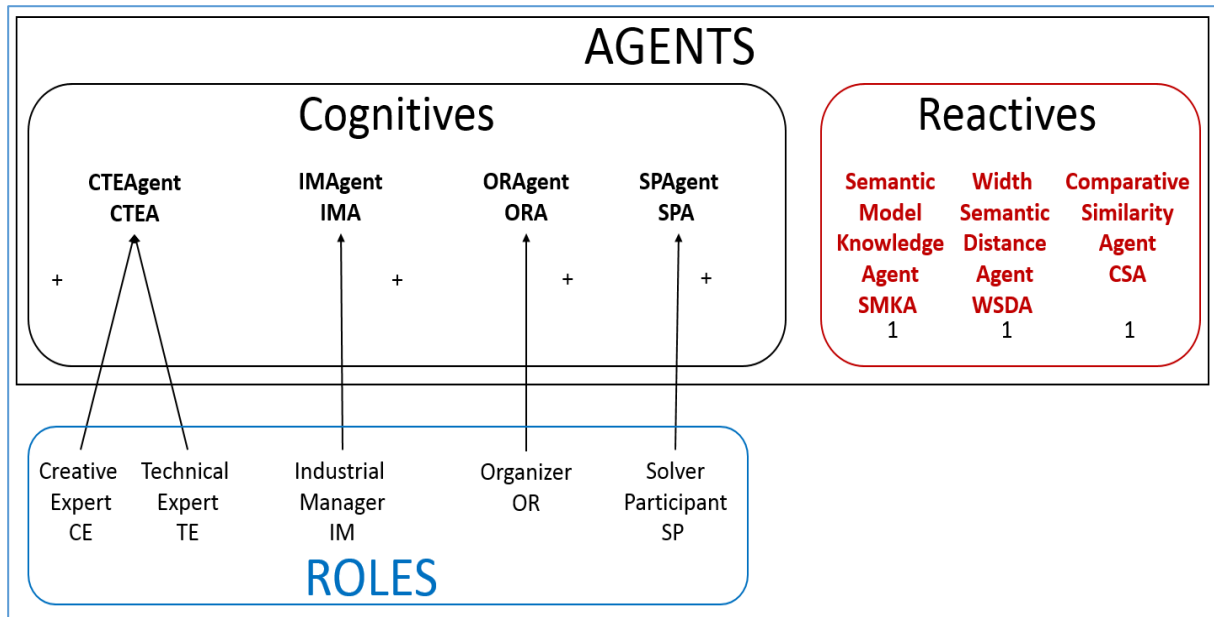


Figure III.34: The Agent Model.

Semantic knowledge model agent (SMKA) is dedicated to find concepts from idea cards and to find for each concept its semantic related concepts according to the synonyms, hyponyms, identics and hypernyms synset concepts (semantic lexical database). After, to create lists that represent the semantic graph with the inherited hypernym concepts.

Width and semantic distance agent (WSDA) calculate the idea card's width and semantic distance.

Comparative similarity agent (CSA) is devoted to compare the idea cards, with values from zero (very different) to one (similar).

Creative and technical expert agent (CTEA), both helps to the solver participant agent, their principal action to offer individual activities to generate individual creative ideas in the divergence phase and to give collaborative creative methods to create idea cards in the convergence phase.

Industrial manager agent (IMA) receives the possible solutions.

The organizer agent (ORA) asks details to the actors (personal data), assigns site and role also assigns team and industry (problem) to solver participants.

Solver participant Agent (SPA) executes the phases of divergence and convergence.

### III.3.6. Design - Service Model

The services model identifies the main services that are required to realize the agent's role. These services (cf. Table III.11) are functions that the agents have to execute according to the protocols described before.

Service	Inputs	Outputs	Pre-Condition	Post-Condition
Obtain information of actors and assignation of roles	Actor details Name, last name, institution, sex, date of birth	Actor requirements	Event=1	Institution>=1 Industry>=1 Role>=2 Team>=2 Problem>=1
Selection and application of activity for ideas	Group, Creative Technical Expert, Activities	Ideas	Ideas per participant at least in mind	Idea>0
Selection and Application of Methods for idea Cards	Thousands of Ideas, many methods	Idea Cards	2 Idea Cards per group =2	Idea Cards >2
Evaluation by partners and improving idea card as a goal	Two ideas per group	Idea Cards	2 Idea Cards per group	Idea Cards > 2
Classification of Idea Cards	n Idea Cards	n Idea Cards	At least 2 Idea Cards	Idea Cards >n
Sending Possible Solutions	Idea Cards	Possible Solutions	2 possible solution per group	Possible solution >=2

Table III.11: Services Model.

### III.3.7. Design - Acquaintance Model

The acquaintance model, (cf. Figure III.35), documents the lines of communication among the different agents.

The agents Creative Expert CTEA, Organizational ORA, Solver Participant SPA and Industrial Manager have communication among them during the entire creativity workshop, the agents CTEA and SPA has relation with the agents Semantic Distance SDA, Width Density WDA and Comparative Similarity CSA. The agents SDA, WDA and CSA take action with the purpose of classify the ideas at the end of the creation, evaluation (among partner group and the rest of the groups) and improving.

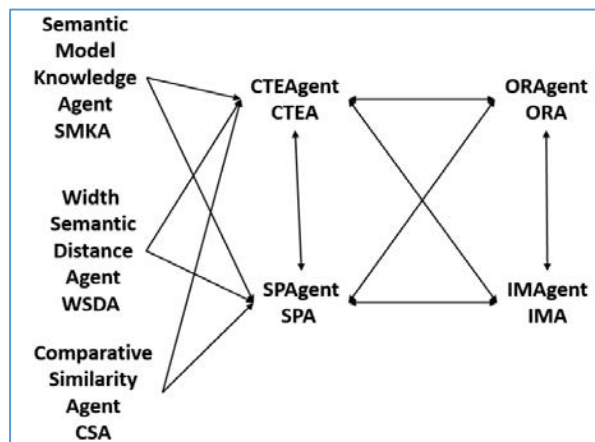


Figure III.35: The Acquaintance Model.

With the agent model, service model and acquaintance model, we describe design model of GAIA.

### III.3.8. Intelligent system

The GAIA methodology helps us during the creation of our intelligent system based in agents (cf. Figure III.36). The six creativity phases (problem, divergence ideas, convergence idea cards, evaluation, enregistrement and possible solutions) represents the creativity workshop 48H inside these stages the phases of divergence and convergence impulse the creation of ideas and idea cards.

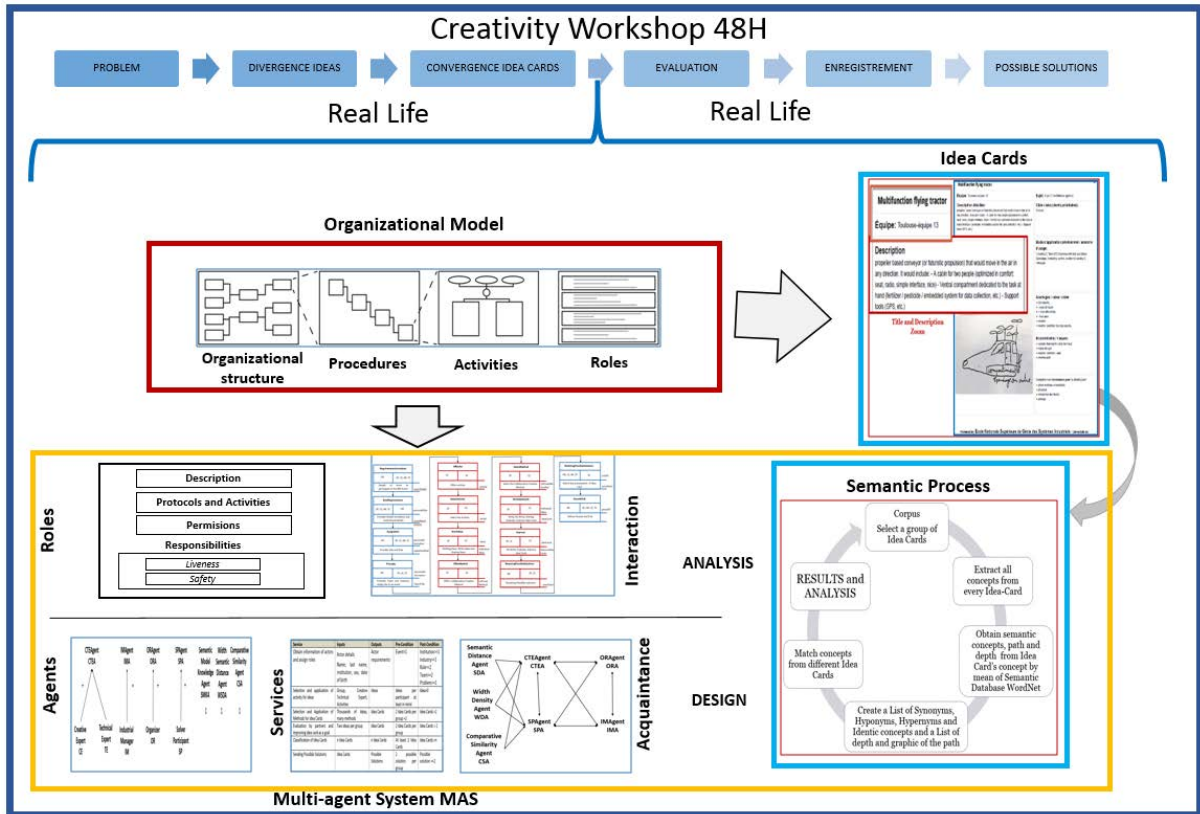


Figure III.36: Intelligent System for Innovation Management.

The organizational model highlights knowledge besides during the definition of organization identity and description of processes and activities, where ideas and idea cards were in the output, we could understand the interaction among the roles of the creativity workshop in consequence we understood too the knowledge, competences and actions generated.

Having represented the creativity workshop 48H, the organizational model and knowing how to produce ideas and idea card from activities and collaborative creative methods, we propose to implement an intelligent system for innovation management. We use a methodology that has the best conditions and characteristics to carry out a multi-agent system, we choose the GAIA methodology because it works **initially** with concepts like roles and interactions models in analysis **and after** with services, agents and acquaintances in design as Wooldridge describe it in (Wooldridge et al. 2000).

At this moment, the organizational model, multi-agent system, idea cards and the semantic process describe the reality of creativity workshop 48H. Ontology, the new topic in the next chapter, use these four elements to represent the real life in a way that a computer

can understand using graphs that form subject, verb and action. The ontology will represent all interactions among actors, roles, teams, events, industries, institutions, activities, methods, ideas, idea cards and possible solutions furthermore all these elements are easy to identify in the real life. The interaction of these elements has three parts the subject (circle or oval), the verb (arrow) and the object (circle or oval) for perhaps for this reason the graphic of ontology could be complex.

### III.4. Chapter conclusion

The definition of role's schemas helps to define the analysis in the part of the role model and interaction model, so both models contribute to the description of role, protocols, activities, permissions, liveness, safety and interactions for each role such as organizer, solver participant, industrial manager, technical expert and creative expert. With respect to the design, three models define the behavior of the agents, the service offered and the communication among agents.

However, even having both analysis and design of our agent system some specific details are not part of the GAIA model like the exact moment when every reactive agent take place only the cognitive agents present their whole interaction in both analysis and design but the reactive agents just appear in the agent model and in the acquaintance model.

Here the creation of new agents like semantic knowledge model agent, width semantic distance agent and comparative similarity agent are not derivate from roles and perhaps to be a different type of agent, provoke, that we must try in another way to explain better theirs functions. We need a chronogram part to show how much time the agent works during runtime therefore I think that I have to use a method, process or tool to schedule all the activities.

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## **Chapter 4: An Ontology Dedicated to Ideas**

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## Topics of Ontology Dedicated to Ideas

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## IV. Ontology

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### IV.1. Chapter introduction

We have modeling the creativity workshop in the chapter two to highlight knowledge and ideas used and created by the participants. The model describes the organizational structure, the ideas, the processes, the activities, the actors, the roles, the methods, the idea cards and the  $n$  possible solutions. All these concepts composed the knowledge created during a creativity workshop. We propose in this chapter to build an ontology to structure and represent the knowledge of the creativity workshops. This ontology will be used by the multi agent system described in the chapter three in order to annotate the idea card and to facilitate the ideas management.

The word ontology has several definitions; the compound word ontology combines onto from the Greek “being” and logia “logical discourse”<sup>1</sup>. The etymology of ontology comes from ancient Greeks, but the concept of ontology appeared in the century XVII in the work “Ogdoas Scholastic” by Jacob Lorhard, he provided a useful key to the understanding of the Protestant Europe in a grammar text book (Øhrstrøm, Shârphe, and Uckelman 2008).

In the last century, the concept of ontology focus in the definition of objects, concepts, entities, relationships among them in a defined area (Gruber 1995), (Genesereth and Nilsson 1987), and ontology works as database with information, properties, relationships about concepts that exist in the world or domain (Mahesh 1996).

Berners-Lee proposes to use the ontologies in the context of the Internet in order to bring a semantic dimension of the Web. He explains, “*The Semantic Web will enable machines to comprehend semantic documents and data, semantic web uses collections of information called ontologies that is a component of the semantic web. Artificial-intelligence and Web researchers have co-opted the term for their own jargon, and for them an ontology is a document or file that formally defines the relationships among terms* (Berners-Lee and Hendler 2002)”. The semantic Web allow us to build ontologies by using a set of languages as RDF, RDFs and OWL to structure knowledge resources.

The creation of a domain ontology need to define in detail the concepts, the procedures, the activities and the relationships that belong specially to this domain or field trying to eliminate ambiguity and doubts due to the communication among web researches and machines (computers) using software applications, as Staab and Studer explain in (Staab and Studer, 2004).

Mathieu d’Aquin defines “Ontologies represent the essential technology that enables and facilitates interoperability at the semantic level, providing a formal conceptualization of the data which can be shared, reused, and aligned” (D’Aquin and Noy 2012a)”.

Elbassadi in (Elbassiti and Ajhoun 2014) complete those definitions by explaining that the Ontologies provide a semantic representation of a common language to foster interoperability, declaratively, and intelligent services between tools and to support the innovation life cycle.

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<sup>1</sup> Online Etymology Dictionary and A Greek-English Lexicon. Verified 9 may 2019.

Semantic innovation management, its architecture combines ontology, inference and mediation technologies used to create a semantic web of innovation knowledge; items ontology is created with common subjects (Ning et al. 2006).

There are several existing libraries dedicated to ontology. An ontology library is a distributed data space where users and software agents can publish and access information from many different sources, the format RDF guarantees the interoperability making it possible for applications to reuse data and to link diverse data (D'Aquin and Noy 2012b). BioPortal is a library of biomedical ontologies developed by the National Center for Biomedical Ontologies, it provides essential domain knowledge to drive data integration, information retrieval, data annotation, natural-language processing and decision support (Noy et al. 2009). This library has 773 ontologies with 9 million of classes, 95000 million of direct annotations according to Bioportal<sup>2</sup>.

Cupboard, created as part of the NeOn-project, is built around the idea of spaces, enabling each user to create her own ontology space, containing and relating the ontologies it has selected. This system intends to support both ontology built by knowledge engineers and users/practitioners. For the developers of ontologies, it offers a complete infrastructure to host the ontologies in online spaces, providing mechanisms to describe, manage and effectively exploit these ontologies through APIs (Hutchison and Mitchell 2009). Cupboard is an online system that relies on these components and integrates them to provide a complete and friendly environment for ontology publishing, sharing and reuse (D'Aquin and Lewen 2009). The cupboard ontology has two application about pharmaceutical case studies supported by Neon-project<sup>3</sup> (technologies and methodologies), it provides also an open development platform with the basic structure implementation, Eclipse<sup>4</sup>, or a commercial toolkit like OntoStudio<sup>5</sup>.

We present in the next section the different existing methods to design ontologies.

## IV.2. Methodologies to design Ontologies

Ontology requires a well-defined process to represent the reality. Several methodologies already exist to build ontologies. We will present in the next section some methodologies to design ontologies.

### IV.2.1. Methodologies for ontology development

It is now widely recognized that constructing a domain model, or ontology, is an important step in the development of knowledge-based systems. What is lacking, however, is a clear understanding of how to build ontologies. The construction of ontologies is very much an art rather than a science. This situation needs to be changed and will be changed only through an understanding of how to go about constructing ontologies. We will present in the next section some approaches to build ontologies.

#### **Enterprise Approach**

Uschold and King propose a methodology for ontology construction in (Uschold and King 1995a). This methodology according to Jones (Jones, Bench-Capon, and Visser 1998) bases on four steps:

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<sup>2</sup> <http://bioportal.bioontology.org/> (verified: 15 may 2019)

<sup>3</sup> <http://neon-project.org/nw/Ontologies.html> (verified: 22 may 2019)

<sup>4</sup> <https://www.eclipse.org/> (verified 22 may 2019)

<sup>5</sup> <http://www.semafora-systems.com/> (verified 22 may 2019)

- Identify the purpose determines the level of formality at which the ontology should be described.
- Identify the scope: a “Specification” is produced which fully outlines the range of information that the ontology must characterize. This may be done using motivating scenarios and informal competency questions, as in TOVE or by “brainstorming and trimming” i.e. produce a list of potentially relevant concepts and delete irrelevant entries and synonyms.
- Formalization: create the “Code”, formal definitions and axioms of terms in the Specification.
- Formal evaluation: the criteria used may be general; this stage may cause a revision of the outputs of stages 2 identify the scope and 3 formalizations.

This Uschold’s methodology is one of the first ontology approach, it is emphasizing in the ontology capture phase and in the production of concepts.

### **Methontology**

The goal of this methodology, (Fernandez, Gomez-Pérez, and Juristo 1997), is to clarify to readers interested in building ontologies, the activities they should perform and in which order, as well as the set of techniques to be used in each phase of the methodology. He thinks ontology is an art and tries to transform in an engineering. Here, the steps:

(1) Specification: identify the purpose of the ontology, including the intended users, scenarios of use, the degree of formality required, etc., and the scope of the ontology including the set of terms to be represented, their characteristics and the required granularity. The output of this phase is a natural-language ontology specification document.

(2) Knowledge acquisition: this occurs largely in parallel with stage (1). It is non-prescriptive as any type of knowledge source and any elicitation method can be used, although the roles of expert interviews and analyses of texts are specifically discussed.

(3) Conceptualization: domain terms are identified as concepts, instances, verbs relationships or properties and each are represented using an applicable informal representation.

(4) Integration: in order to obtain some uniformity across ontologies, definitions from other ontologies, e.g. Ontolingua standard units ontology, should be incorporated.

(5) Implementation: the ontology is formally represented in a language, such as Ontolingua.

(6) Evaluation: much emphasis is placed on this stage in METHONTOLOGY. The techniques used are largely based on those used in the validation and verification of KBSs. A set of guidelines is given on how to look for incompletenesses, inconsistencies and redundancies.

(7) Documentation: collation of documents that result from other activities.

The Fernandez’s methodology highlights “ontology is an art and they want to convert in an engineering” this affirmation makes it attractive.

## **KBSI IDEF5**

This method is devoted to assist in the creation, modification and maintenance of ontologies according to Jones in (Jones et al. 1998) and (Peraketh et al. 1994), the process of IDEF5:

(1) Organizing and scoping establishes the purpose, viewpoint, and context for the ontology development project. The purpose statement provides a set of “completion criteria” for the ontology, including objectives and requirements. The scope defines the boundaries of the ontology and specifies parts of the systems that must be included or excluded.

(2) Data collection: the raw data needed for ontology development is acquired using typical KA techniques, such as protocol analysis and expert interview.

(3) Data analysis: the ontology is extracted from the results of data collection. First, the objects of interest in the domain are listed, followed by identification of objects on the boundaries of the ontology. Next, internal systems within the boundary of the description can be identified.

(4) Initial ontology development: a preliminary ontology is developed, which contains proto-concepts i.e. initial descriptions of kinds, relationships and properties.

(5) Ontology refinement and validation: the proto-concepts are iteratively refined and tested. This is essentially a deductive validation procedure as ontology structures are “instantiated” with actual data, and the result of the instantiation is compared with the ontology structure.

The method is attractive because it can improve and work with any ontology.

### **IV.2.2. Methodology for Ontology Ontolingua**

An ontology is a set of definitions of content-specific knowledge representation primitives: classes, relationships, functions, and object constants. Ontolingua is mechanism for writing ontologies in a canonical format, such that they can be easily translated into a variety of representation and reasoning systems. This allows one to maintain the ontology in a single, machine-readable form while using it in systems with different syntax and reasoning capabilities. The syntax and semantics are based on the KIF knowledge interchange format (Genesereth, Fikes, and Gruber 1992). Ontolingua extends KIF with standard primitives for defining classes, relationships, and organizing knowledge in object-centered hierarchies with inheritance.

The methodology used to design Ontolingua was:

- A well-defined, declarative semantics for all statements in the language.
- A mechanism that allows operational use of the ontologies within in a variety of implemented representation systems.
- A syntax that facilitates the modular definition of terms in an ontology, and the modular packaging of ontologies.
- A means for capturing conventions in knowledge representation and organization, such as class hierarchies and domain and range constraints on relationships, in a

system independent, declarative form without sacrificing the efficient implementation of these conventions by various representation systems.

- An architecture and support library that makes it easy to write additional KIF translators.

The importance of this methodology is due to the use of syntax and semantic based in knowledge interchange format (KIF) to define classes and relationships.

### IV.2.3. Methodology to design ontologies from organizational models

The phases and activities applied to creativity workshops that represent the ontology process (cf. figure IV.37), it describes an ontology to model knowledge in creativity workshop, its description:

#### Phase 1: Definition

- Definition of domain, the Scope and Purpose.
- Definition of the questions-skills of the ontology (aptitudes).

#### Phase 2: Conceptualization

- Conceptualization and acquisition.
- The reuse of existing ontology concepts

#### Phase 3 Development

- The development of the ontology (programming, formalization).
- Population of the ontology

#### Phase 4: Validation/Evaluation

- Evaluation

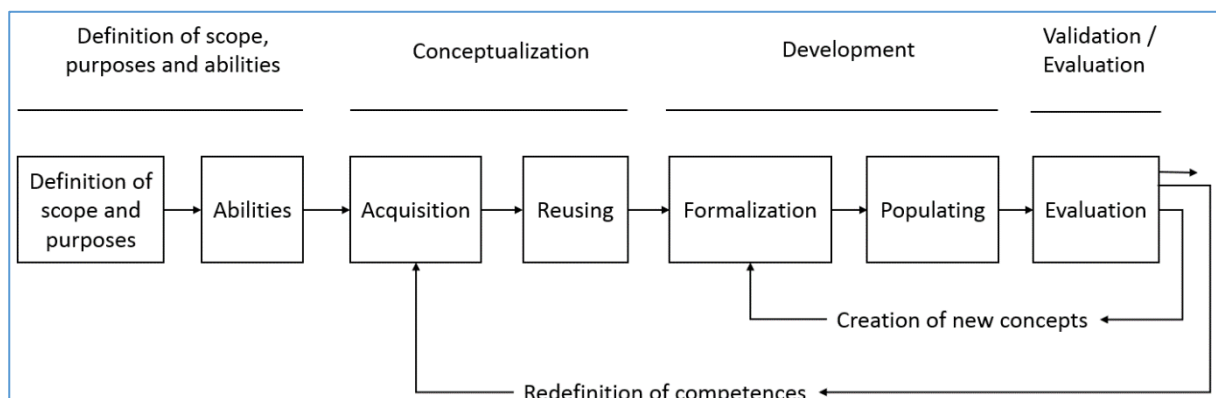


Figure IV.37: Ontology process. Cf.(Gabriel et al. 2019).

A better-detailed process is present in this methodology, in addition, two different cycles to enhance the process.

In the next section, we present a synthesis table with the methodologies to build ontologies.

## IV.2.4. Synthesis of the methodologies

Uschold and King 1995	Abburu and Babu Golla 2017	Gabriel 2019
<p><b>Identify purpose</b> It is important to be clear about why the ontology is being built and what its intended uses are? It will also be useful to identify and characterize the range of intended users of the ontology.</p>	<p><b>First phase, Ontology based NLP Process</b> Ontology based NLP process identifies entities and their associated information from semi structured documents of disaster management domain. <i>Features:</i> Generic solution for any kind of disaster management.</p>	<p><b>Phase 1: Definition</b> Definition of domain, the Scope and Purpose. Definition of the questions-skills of the ontology (aptitudes)</p>
<p><b>Building the Ontology</b> <i>An Ontology capture.</i> <i>i.</i> Identification of the key concepts and relationship in the domain of interest. <i>ii.</i> Production of precise unambiguous text definitions for such concepts and relationships. <i>iii.</i> Identification of terms to refer to such concepts and relationships. <i>iv.</i> Agreeing on all of the above <i>B Ontology coding.</i> The explicit representation of the conceptualization captured in the above stage in some formal language. This will involve committing to some meta-ontology, choosing a representation language, and creating the code. <i>C Integrating existing ontologies</i> During either or both of the capture and coding processes, there is the question of how and whether to use ontologies that already exist. In general, this is a difficult problem, and although much progress has been made in the context of Ontolingua, the general problem is very hard.</p>	<p><b>Second phase, Information Extraction and Integration.</b> Extracts identified information, integrates into a common format using RDF, maps RDF triples to domain ontologies and stores into a triple store. <i>Features:</i> Semantic based information extraction from semi structured text documents which contain information of various disasters using NLP process.  Provide common and universal structure for the extracted information using RDF.</p>	<p><b>Phase 2: Conceptualization</b> Conceptualization and acquisition. The reuse of existing ontology concepts.</p>
<p><b>Evaluation</b> To make a technical judgement of the ontologies, their associated software environment, and documentation with respect to a frame of reference... The frame of reference may be requirements specifications, competency questions, and/or the real world (Gomez-Pérez 1995).</p>	<p><b>Third phase, Semantic Query and Visualization Ontology</b> Runs inference engine on the RDF triples with the support of domain ontologies and stores inferred triples. It also provides semantic query support on the knowledge base (domain ontologies, RDF triples and inferred triples) and interprets results. <i>Features:</i> Ontology based semantic query. Effective visualization of query results using verity of charts.</p>	<p><b>Phase 3 Development</b> The development of the ontology (programming, formalization). Population of the ontology</p>
<p><b>Documentation</b> It may be desirable to have established guidelines for documenting ontologies, possibly differing according to type and purpose of the ontology.</p>		<p><b>Phase 4: Validation/Evaluation</b> Evaluation</p>

Table IV.12: Methodologies building ontologies 1/2.

Methontology to Clarify Activities	KBSI IDEF5	The methodology for ontology Ontolingua
<p>This methodology is proposed by , (Fernandez et al. 1997)</p> <p>(1) Specification: identify the purpose of the ontology and the scope of the ontology.</p> <p>(2) Knowledge acquisition: this occurs largely in parallel with stage (1).</p> <p>(3) Conceptualization: domain terms are identified as concepts, instances, verbs relationships or properties and each are represented using an applicable informal representation.</p> <p>(4) Integration: in order to obtain some uniformity across ontologies, definitions from other ontologies.</p> <p>(5) Implementation: the ontology is formally represented in a language, such as Ontolingua.</p> <p>(6) Evaluation: A set of guidelines is given on how to look for incompletenesses, inconsistencies and redundancies.</p> <p>(7) Documentation: collation of documents that result from other activities.</p>	<p>This method is devoted to assist in the creation, modification and maintenance of ontologies according to Jones in (Jones et al. 1998).</p> <p>(1) Organizing and scoping establishes the purpose, viewpoint, and context for the ontology development project.</p> <p>(2) Data collection: the raw data needed for ontology development is acquired using typical KA techniques.</p> <p>(3) Data analysis: the ontology is extracted from the results of data collection.</p> <p>(4) Initial ontology development: a preliminary ontology is developed, which contains proto-concepts.</p> <p>(5) Ontology refinement and validation: the proto concepts are iteratively refined and tested.</p>	<p>Ontolingua is mechanism for writing ontologies in a canonical format. The syntax and semantics are based on the KIF knowledge interchange format (Genesereth et al. 1992). The design requirements for Ontolingua are:</p> <ol style="list-style-type: none"> <li>1. A well-defined, declarative semantics for all statements in the language.</li> <li>2. A mechanism that allows operational use of the ontologies within in a variety of implemented representation systems.</li> <li>3. A syntax that facilitates the modular definition of terms in an ontology, and the modular packaging of ontologies.</li> <li>4. A means for capturing conventions in knowledge representation and organization, such as class hierarchies and domain and range constraints on relationships.</li> <li>5. An architecture and support library that makes it easy to write additional KIF translators.</li> </ol>

Table IV.13: Methodologies building ontologies 2/2.

We have six methodologies in our synthesis. Three methodologies define phases that facilitates the understanding, these phases contains specific steps. The first phase reserves the definition and purpose of the ontology. The phase II concerns to build the ontology, the Uschold’s methodology makes an effort to describe every step with details in capture, code and integration while the Abburu’s methodology integrates the information to work immediately in RDF format, with respect to Gabriel’s methodology, and it is concise in the explanation: conceptualization, acquisition and reuse. The phase III consigns to different actions, Uschold uses it to evaluate while Abburu and Gabriel are focus in the development. The phase IV reserves to the guidelines according to Uschold, Gabriel utilize it to validate and evaluate while Abburu has already finished (cf. Table VI.12).

The Methontology, FBSI IDEF5 and the methodology for ontology Ontolingua (cf. Table VI.13) explain their methodology with right steps among five or seven. The Methontology has a favorable explanation in their steps and a simple path: Specification, knowledge acquisition, conceptualization, integration, implementation, evaluation and documentation. The methodology KBSI IDEF5 omits the documentation but gives great importance to data collection and add a preliminary ontology, it remarks the iteration to refine and validate. The methodology for ontology Ontolingua explains the definition of terms, range, domain and constraints on relationships; its syntax and semantic is based in knowledge interchange format KIF.



### IV.3. Our methodology to design an ontology

The proposed methodology, to build our ontology, must help to represent the evolution of the ideas, the individual ideas, after idea cards and finally possible solutions, all this evolution in an organizational model called 48H. This methodology follows a process based primarily on building the ontology. Initially, it expresses the meaning of the organization after it works on the design of ontology, finally the judgement and documentation.

The methodology chosen is the ontology of (Uschold and King 1995b). It has four phases:

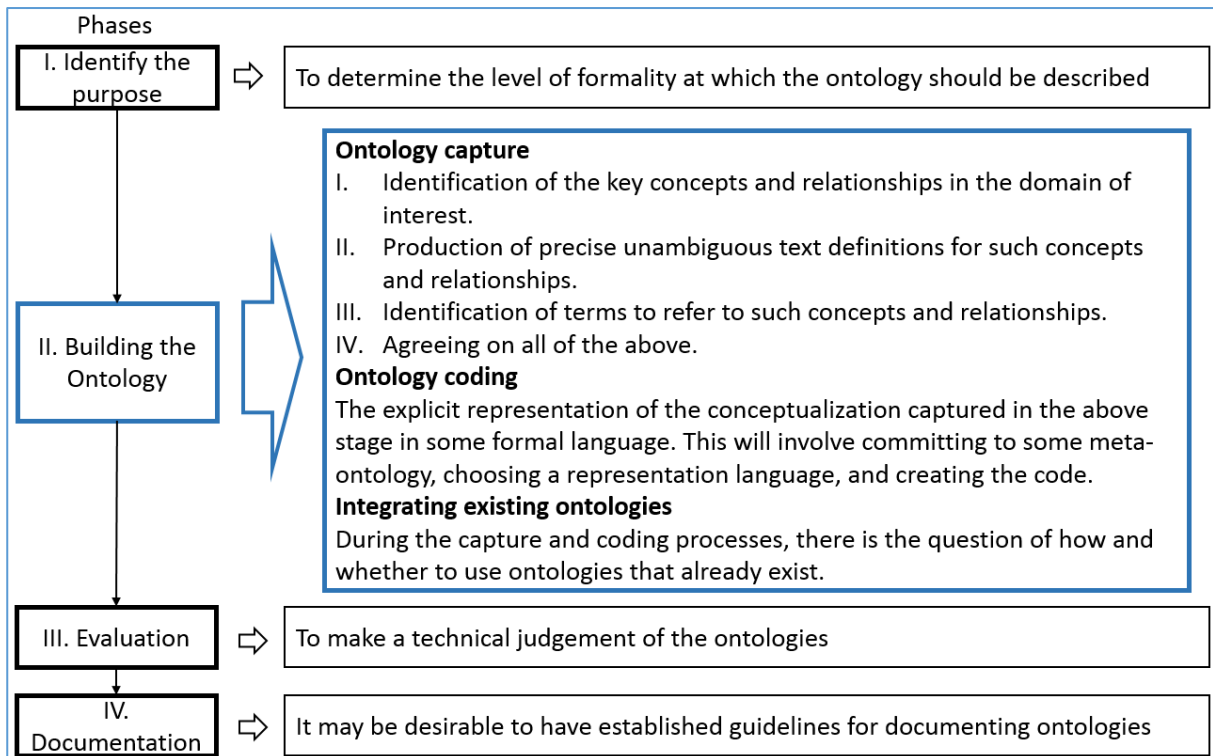


Figure IV.38: Ontology Uschold phases.

With this ontology, we can define easily the phases and identify the steps with the finality to do several iterations to correct our job. The Uschold ontology (cf. Figure VI.38) focus mainly in building the ontology that is something that we appreciate, for us the capture, coding and to integrate existing ontologies are vital steps without forget the iteration to improve. We think, the step ontology capture has a step to iterate or improve called "Agreeing in all above" and it helps to keep improving.

#### IV.3.1. Needs of Knowledge Organization Ontology

The organization are in constant evolution, since the last century the representation of knowledge is primordial because knowledge is as important as humans are. Nowadays, the technology in communications and informatics impulse the creation of new systems of such as ontologies to organize, structure and handle knowledge *concepts* (Fensel et al. 1998).

The ontology helps to solve our particular problem that is represent the creativity workshop taking in account an organizational model to highlight knowledge and a semantic process to compare ideas. The intrinsic characteristics to measure an ontology are the proper use of various relationships found within an ontology. So, with the design process of ontology, we will achieve some characteristics to allow us evaluate our ontology such as

concepts, facts, relationships, data type relationships, range or constraints, *using a process or methodology will ensure the quality of the resultant ontology* (West and Bennett 2014).

Our approach is to define a common vocabulary with key concepts to share information in the domain of creativity workshops (cf. Figure IV.38). The next section describe the first phase “Identify the purpose”.

## IV.4. Phase I Identify the purpose

To identify the purpose of our ontology it is necessary to define the domain of our ontology with respect to the level of abstraction (Russell and Norvig 2010).

### A. About Domain

Knowledge representation works with reasoning, *knowledge is the application of logic and ontology to the task of constructing computable models for some **domain*** (Sowa 1999). Ontology is the representation of our environment in a graphic and reasoning way using concepts, *ontology is the study of existence of all kinds of entities (abstract and concrete) that make up the world, A choice of ontological categories is the first step in designing a database, a knowledge base or an object-oriented base* (Sowa 1999). Ontology helps to communicate concepts inside a group of people, these concepts must belong from a specific **domain** with the purpose of eliminate ambiguity, *ontologies disambiguate and provide a conceptual vocabulary* (Bullinger, Haller, and Möslein 2009).

To deals with the richness of a **domain**, several abstraction levels should be distinguished in ontologies (Russell and Norvig 2010):

- Domain ontologies capture the knowledge valid for a particular domain
- Generic ontologies are valid across several domains
- Applications ontologies contain all the necessary knowledge for modeling a particular domain
  - o Task ontologies provide terms specifically for particular tasks
  - o Method ontologies provide terms specific to particular problem-solving method
- Representational ontologies do not commit to any particular domain

We have chosen a domain ontology dedicated to the creativity. We call it “the Collaborative Creative IDEAS” (CCIDEAS) ontology.

The domain of this ontology is the management of collaborative creative ideas in a creativity workshop (CCIDEAS). We build this ontology to represent the management of creative ideas during a creativity workshop in terms that a machine can understand (intelligent system). This process helps us to know the quantity of ideas, the persons that manage the idea, the concepts for idea, and the best group of ideas according to a semantic approach and the actors (organizer, industrial manager, solver participant, creative expert and technical) that work and interact in this process.

### B. Scope

The scope describes, specifies and represents all the concepts relate to the creativity workshop 48 hours challenge. These concepts are identified inside of an organizational model. The Scope of the ontology covers a set of questions such as which is a good idea? , When an idea is a creative idea? , how can I improve my idea card? , what is the activity used in the idea? , what is the method used by an idea card? , which are the possible solutions to

the problem? , could I have an order list of ideas? , Who manages the ideas and ideas cards?, which are the roles and the relationships?, Which are my entities?, how my entities are related?, which is the relationship among industries, event and ideas?

We might answer these questions to provoke the creation of new ideas and relationships also to improve their definitions.

### C. Purpose

The purposes of this ontology are to represent knowledge and ideas and to understand the creativity workshop. The ontology will be used to compare ideas in the intelligent system.

With respect to the organizational model that defines the organizational structure, has two missions, two goals and five processes. The missions contribute to the goals and relies on the processes. The organization 48 Hours has the mission 1 to invite stakeholders, universities, institutes and investigation centers to collaborate in the event and to add students. The mission 2 is to assure that in an interval of 48 hours students will apply collaborative and creative methods. The goal 1 is to enroll students to the event of 48H, the goal 2 is to generate, write, share, evaluate and select ideas in order to solve problems. Concerning to represent a semantic approach to compare ideas, we will have a general vision of all entities and relationships. The next section will present the building process of the ontology.

## IV.5. Phase II Building the Ontology

The ontology requires concepts and relationships, these elements are vital in this building phase. We have to look for concepts, which specify the knowledge used during the creative process. It is possible to create four major groupings, which arguably represent the major phases of a creative process as seen by the researchers in the psychology domain. Broadly put, these phases are **analysis**, **generation**, **evaluation** and **communication/implementation** (Howard, Culley, and Dekoninck 2008) or in based in the model of Gero (Gero and Kannengiesser 2004): **Analysis of Task**, **Conceptual Design** and **Embodiment Design** based in the variables Function, Behavior and Structure.

Based in the processes and activities from organizational structure, we could describe them and after to state the processes' aptitudes and the processes' questions. The aptitude of the process is the capacity to do a task, each process its own aptitudes and questions.

The analysis of the processes from the organizational structure and the activities in our collaboration and creation process can give us essential information to deduce our requirements of concepts and relationships. Some analysis demonstrates that a divergence of semantic similarity, an increased information content and a decreased polysemy predict the success of generated ideas (Georgiev and Georgiev 2018). This complex analysis assists our ontology's concepts but also in a new future way of selection of ideas; Idea generation and idea selection are tightly linked in creativity theories, research on idea selection lags far behind research on idea generation (Zhu et al. 2017).

For example, the process of the mission 1 is based on the activities "to seek a topic", "to enroll students", "to create collaborative groups", "collaboration and creation" and "to show physic representation". Every process has specific aptitudes and questions that impulse the

generation of concepts and relationships. These processes of collaboration and creation have crucial activities about the generation of ideas also this information could induce to other requirements and provoke or find new concepts or new relationships.

#### IV.5.1. Identify the key concepts and relationships

##### I. Identify the key concepts and relationships in the domain of interest

The processes and activities produce our key concepts and relationships. Our defined processes have aptitudes and questions to identifying or generate our key concepts and relationships. The table processes, aptitudes and questions (cf. Table IV.14) shows the aptitudes of the five processes that support the missions of the 48H of CWS:

##### *Processes and aptitudes*

Process	Aptitudes or task able to do and questions
To seek a topic	<p><i>Aptitudes:</i>  Organizer and creative expert are looking for industrial problems.  Industrial selects a technical expert to help students.  Organizer, creative expert and industrial generates a problem.  *** In the CWS 48H ***</p> <p><i>Questions:</i>  How many events are?  How many industries are?</p>
To enroll students	<p><i>Aptitudes:</i>  Organizer and creative expert invite students to participate in the Creativity Workshop.  Organizer and creative expert promote the industrial problem.  Students fill out an online form to enter to the CWS.  *** In the CWS 48H ***</p> <p><i>Questions:</i>  How many sites are?  How many students are?  What are the roles?</p>
To create collaborative groups	<p><i>Aptitudes:</i>  Organizer creates collaborative group of students to participate in the Creativity Workshop.  Organizer defines roles to students as solver participant.  Organizer defines roles to technical expert and industrial manager.  Organizer gives the group to the actors  *** In the CWS 48H ***</p> <p><i>Questions:</i>  How many teams are?  How many creative experts are?  How many activities are?  What are the activities?  How many ideas are produced?</p>
Collaboration and creation	<p><i>Aptitudes:</i>  Solver participants know their group colleagues and creative expert.  Solver participants know their creative expert.  Creative expert breaks the ice with some activities.  Solver participant discovers the topic or industrial problem.  Creative expert has a collaborative creative method to generate ideas.  *** Divergence appears ***</p> <p>Solver participant generates initial ideas (I) by writing, speaking, or holding in mind and use combinational, transformational, exploration methods to build ideas (I).  Technical expert gives some details and characteristics about the problem and</p>

	<p>probable characteristics of the idea.</p> <p>The group of solver participants use some collaborative creative activities to build idea cards (IdC).</p> <p>The solver participant of each group creates their idea cards (IdC) in a format sheet.</p> <p>The solver participant of each group captures their idea cards (IdC) in an electronic format.</p> <p>*** Convergence appears ***</p> <p>The solver participant of each group evaluates the best idea cards (IdC) in a format sheet.</p> <p>The solver participant of each group improves their idea cards (IdC) in the electronic format.</p> <p>The IdC with the highest score (possible solutions (PS)) could be selected by Industrials, solver participants and creative schools.</p> <p>*** In the CWS 48H ***</p> <p><i>Questions:</i></p> <p>How many collaborative creative methods are?</p> <p>What are the collaborative creative methods?</p> <p>How many idea cards are produced?</p> <p>Which element form an idea card?</p> <p>Which element of the idea card are text?</p> <p>Which element of the idea card are image?</p> <p>Which element of the idea card are date?</p>
To show the physic representation	<p><i>Aptitudes:</i></p> <p>The group of solver participant presents the best idea card (IdC).</p> <p>The IdC presented (possible solutions (PS)) could be selected by Industrials, solver participants and creative schools</p> <p>*** In the CWS 48H ***</p> <p><i>Questions:</i></p> <p>How many possible solutions are produced?</p> <p>Which teams produce the possible solutions?</p>

Table IV.14: Processes and aptitudes.

### Activities and questions

The activities in the general process of generation of ideas has some questions that could be use in generate concepts and relationships (cf. Table IV.15).

Activity	Questions
Domain discovery and meeting groups.	<p>Which are the industrial problems (InP)?</p> <p>How many InP the organizer has?</p> <p>How many solver participants, technical experts, creative experts, industrial managers and organizers does the InP has?</p> <p>Which are the groups of solver participants assigned to the solution of the InP?</p> <p>Which are the creative experts to this industrial problem?</p> <p>Which are the technical experts to this industrial problem?</p> <p>Which are the industrials for this industrial problem?</p>
Collaborative and creative methods, trust atmosphere.	<p>*** Ideas (I) ***</p> <p>How many ideas (I) does group produce?</p> <p>*** Idea cards (IdC) ***</p> <p>How many concepts does the idea card (IdC) has?</p> <p>How many ideas cards (IdC) does group produce?</p>
To write Idea Cards	<p>*** Ideas (I) ***</p> <p>Who adds the idea (I)? ***CLUSTER***</p> <p>Who modifies the idea (I)?</p> <p>*** Idea cards (IdC) ***</p> <p>Who adds the idea card (IdC)? ***CLUSTER***</p> <p>Who modifies or improve the idea card (IdC)?</p> <p>Who evaluates the idea card (IdC)?</p>

To share Idea Cards	<p>***CORPUS ***</p> <p>How many groups try to solve the industrial problem?</p> <p>How many idea cards (IdC) are produced to solve the industrial problem?</p> <p>*** EVALUATION ***</p> <p>How many concepts has the idea card (IdC)?</p> <p>How many concepts without repetition has every idea card (IdC) of a Corpus' sample?</p> <p>Which are the identics, synonyms, hyponyms and inherited hypernym by concept?</p> <p>Which are the common concepts by identics, synonyms, hyponyms and inherited hypernym?</p> <p>Which are the uncommon concepts by identics, synonyms, hyponyms and inherited hypernym?</p> <p>What is the semantic distance between 2 concepts of the same idea?</p> <p>*** COMPARATIVE ***</p> <p>What is the semantic similarity between 2 concepts of the different idea?</p> <p>What is the width of the idea?</p> <p>What is the idea with most identics, synonyms, hyponyms and inherited hypernym?</p>
To select possible solutions	<p>To produce artifacts for testing the idea and communicate.</p> <p>*** Possible solutions (PS) ***</p> <p>How many possible solutions (PS) does group produce?</p> <p>Which are the bests "n" possible solutions?</p> <p>Which are the worst "n" possible solutions?</p>

Table IV.15: Activities and questions.

## II. Production of precise unambiguous text definitions for concepts and relationships *Creation of concepts*

These concepts and relationships determine the ontology. The definition of every concept that are part during this creativity workshop (cf. Table IV.16); this definition will be used to create triplets among concepts.

Name of concept	Definition
1 Activity	The action(s) that actor follows to produce ideas (I) in the phase of divergence. The activities of divergence used to produce individual ideas. Type: String
2 Actor	The person that will participate in the event and can take a role to solve problems. The concept will indicate the role or several roles to assume during a CWS. Type: String
3 Collaborative creative method (CCM)	Set of instructions applied by solver participants to generate idea cards (IC). The methods of convergence are used to produce Idea cards. Type: String.
4 Event	The name of the CWS and its edition. Type: String
5 Idea	The individual ideas (I) are produced in the phase of divergence; they are created using combinational, exploratory and transformational techniques with individual activities. The actor captures the initial individual idea. Type: String
6 IdeaDesc	Idea's description. Type: String
7 IdeaCard	The result of the use of ideas (I) and collaborative creative methods (CCM). An actor with the role of solver participant and from a team creates idea cards using CCM.
8 ICDesc	Idea Card's description. Type: String.
9 ICTitle	Idea Card's title. Type: String.
10 ICScenery	Idea Card's scenery. Type: String.
11 ICPrioCli	Idea Card's priority client. Type: String.
12 ICAdvant	Idea Card's advantage. Type: String.

13 ICRisk	Idea Card's risk. Type: String.
14 Industry	The name of the industry, this concept has the problem. The industrial manager proposes the industry that contains the problem. Type: String
15 Problem	The reasons why the organization creates the creativity workshop CWS events every year. Industries like Assystem, Bostik, CEA Tech, Decathlon, GRDF, ICM, MSA Safety, Muller, Normande Aerospace, Pierre Fabre, and Scarabée Biocop participate in those events. The problem is assigned to a team by mean of the industry. Type: String
16 Role	The type of character that the actor takes. (Organizer, solver participant, creative expert, technical expert, Industrial manager). Type: String
17 Site	The place where actors will work (ASU BAHRAIN, CESI NANTERRE, ENSGSI NANCY, etcetera). The site given to an actor. Type: String
18 Team	The set of actors with the same role (solver participant), event, problem, site, name of team and colour. (Str_Ass_1, Lyo_Assy_1, Uca1, Str_Ass_2, etcetera). An actor takes part of a team. Type: String
19 Vocabulary	The vocabulary is formed by ADJECTIVE, ADVERB, NOUN, VERB, ARTICLE, PRONOUN, PREPOSITION, CONJUNCTION AND INTERJECTION; some fields of the idea card's concept use these concepts such as title, description, priority client, name, scenery, advantages and risk. The vocabulary is part of idea's description. Type: String
20 Organizer	The actor who takes the role in activities of assignation of roles, industries, team and event. Initially, this role create the event and he is asking for information to the actors with the purpose to do the inscription. Type: String
21 Solver Participant	This concept is part of the roles and part of the team. The site is assigned to the solver participant; other relationships are: Select activity, Create ideas, Send possible solutions. Type: String
22 Creative Expert	The creative expert offers activities and collaborative creative methods to the team of solver participants. Type: String
23 Technical Expert	Technical expert helps teams to improve idea cards. Type: String
24 Industrial Manager	The industrial manager proposes an industry to the creativity workshop. Type: String
25 Possible Solutions	The concept possible solutions are the idea cards with best score according to the semantic skills like width, semantic distance and similarity.

Table IV.16: Definition of concepts.

### *Creation of relationships proposed*

The creation of relationships uses the format subject-verb-object with the purpose of create sets of three elements; *the term of relationships the concepts (Bachimont 2000) where the relationship represents the verb (cf. Table IV.17).*

Relation proposed	name	Domains (Concepts)	Range (Concepts)	Triplet and/or Definition
1Select		Solver Participant	Activity. Examples: Brainstorming, write storming, Bend it and Shape it, Brain borrow, Copy cat, ...	Solver Participant selects Activity. The property indicates that the Solver Participant select an Activity to create individual ideas during the phase of divergence
2 Offers		Creative Expert	Activity. Examples:	Creative Expert offers Activity. The property indicates that Creative offers an

		Brainstorming, write storming, Bend it and Shape it, Brain borrow, Copy cat, ...	activity.
3 Plays	Actor	Role. Examples: Creative Expert, Technical Expert, Industrial Manager, Solver Participant and Organizer	Actor plays a Role.
4 Assign	Organizer	Role. Examples: Creative Expert, Technical Expert, Industrial Manager and Solver Participant.	Organizer assign Role. The property indicates that Organizer assigns all the roles in the creativity workshop.
5 Propose	Industrial Manager	Industry. Examples: Decathlon, ICM, Bostik, etc.	Industrial Manager proposes an industry. The property indicates that Industrial Manager proposes an industry.
6 Create	Organizer	Event. Examples: 48h InnovENT-Edition 2016, Operation 2015 InnovENT-E 48 hours to bring ideas to life.	Organizer creates an Event.
7 Assign	Organizer	Site. Examples: INSA LYON, ENSGSI, UCA MARRAKECH, etc.	Organizer assigns Site.
8 Assign	Organizer	Industry; Examples: Examples: Decathlon, ICM, Bostik, etc.	Organizer assigns Industry.
9 Assign	Organizer	Team. Examples: Nan_Dec_1, Nan_Dec2, Str_Ass_2, etc.	Organizer assigns Teams.
10 Requires	Organizer	Actor. Examples: Any institutional, educative or industrial person interested in creativity and solving problems.	Organizer requires Actor.
11 Help	Technical Expert	Team. Examples: Nan_Dec_1, Nan_Dec2, Str_Ass_2, etc.	Technical Expert helps Team. The property indicates that Technical experts helps teams.
12 IsAssignedTo	Industry	Team. Examples: Nan_Dec_1, Nan_Dec2, Str_Ass_2, etc.	Industry is assigned to Team.
13 Receive	Industrial Manager	Possible Solutions	Industrial Manager receives Possible Solutions. The property indicates that Industrial Manager receives the possible Solutions.
14 IsPartOf	Actor	Team. Examples: Nan_Dec_1, Nan_Dec2, Str_Ass_2, etc.	Actor is part of Team.
15 IsAssignedTo	Site	Event. Examples: 48h InnovENT-Edition 2016, Operation 2015 InnovENT-E 48 hours to bring ideas to life.	Site is assigned to an Event.



16 Send	Solver Participant	Possible Solutions	Solver Participant sends Possible Solutions. The property indicates that Solver Participant sends the possible Solutions.
17 Present	Team	Possible Solutions	Team presents Possible Solutions. The property indicates that Team presents the possible Solutions.
18 IsAssignedTo	Site	Role. Range: Technical Expert, Solver Participant and Creative Expert.	Site is assigned to Role.
19 IsAssignedTo	Team	Role. Range: Technical Expert, Solver Participant and Creative Expert.	Team is Assigned to Role.
20 Create	Team	Idea Card	Team creates Idea Card. The property indicates that Team creates the Idea Cards.
21 Improve	Team	Idea Card	Team improves Idea Card. The property indicates that Team improves the Idea Cards.
22 Select	Team	CCM. Examples: Six hats of thinking, The shirt off your back, Puzzle pieces, Organizational brainstorming, Best off, Rice storm, ...	Team select CCM. The property indicates that Team selects the Collaborative Creative Method.
23 Use	CCM	Idea.	CCM uses Ideas.
24 Form	Idea	Idea Cards	Ideas form Idea Card.
25 Use	Idea Card	CCM. Examples: Six hats of thinking, The shirt off your back, Puzzle pieces, Organizational brainstorming, Best off, Rice storm, ...	Idea Card uses CCM.
26 Offer	Creative Expert	CCM. Examples: Six hats of thinking, The shirt off your back, Puzzle pieces, Organizational brainstorming, Best off, Rice storm, ...	Creative Expert offers CCM.
27 IsPartOf	IdeaDesc	Idea	IdeaDesc is part of Idea. The property indicates that Idea Description (IdeaDesc) is part of the Idea.
28 Create	Solver Participant	Idea	Solver Participant creates Idea. The property indicate that Solver Participant creates ideas.
29 IsPartOf1	ICDesc	Idea Card	ICDesc is part1 of idea card. The property indicates that the field Idea Card Description (ICDesc) is part of the Idea Card.
30 IsPartOf2	ICTitle	Idea Card	ICTitle is part2 of idea card. The property indicates that the field Idea Card Title (ICTitle) is part of the Idea Card.
31 IsPartOf3	ICScenery	Idea Card	ICScenery is part3 of idea card. The property indicates that the field Idea Card Scenery (ICScenery) is part of the Idea Card.
32 IsPartOf4	ICPrioCli	Idea Card	ICPrioCli is part4 of idea card. The property indicates that the field Idea Card Priority Clients (ICPrioCli) is part of the Idea Card.
33 IsPartOf5	ICAdvant	Idea Card	ICAdvant is part5 of idea card. The property indicates that the field Idea Card Advantage (ICAdvant) is part of the Idea Card.
34 IsPartOf6	ICRisk	Idea Card	ICRisk is part6 of idea card. The property indicates that the field Idea Card Risk (ICRisk) is part of the Idea Card.

Table IV.17: Definition of relationships.

### III. Identification of terms to refer to such concepts and relationships

#### *Verification of concepts from other ontologies*

Sometimes the concepts have already their URI and we can use them to create our ontology. Several concepts are similar but other have almost the same name (*cf.* Table IV.18) Therefore we can use them to adapt our initial table of entities and relationships. To verify the concepts, we use dedicated search engines as:

- Linked Open Vocabulary<sup>6</sup> (LOV),
- Swoogle<sup>7</sup>,
- Watson<sup>8</sup>.

Concepts (Domain)	Similar	URI concept
1 Activity	y	cwmo:Activity(cwmo) <a href="http://online-presence.net/opo/ns#Activity">http://online-presence.net/opo/ns#Activity</a>
2 Actor	y	dbpedia-owl:Actor(dbpedia-owl) <a href="http://dbpedia.org/ontology/Actor">http://dbpedia.org/ontology/Actor</a> cwrc:Actor(cwrc) <a href="http://sparql.cwrc.ca/ontologies/cwrc#Actor">http://sparql.cwrc.ca/ontologies/cwrc#Actor</a>
3 Collaborative creative Method	n	hydra:method(hydra) <a href="http://www.w3.org/ns/hydra/core#method">http://www.w3.org/ns/hydra/core#method</a>
4 Event	y	swpo:Event(swpo)0.556 <a href="http://sw-portal.deri.org/ontologies/swportal#Event">http://sw-portal.deri.org/ontologies/swportal#Event</a>
5 Idea	y	cwmo:Idea(cwmo)0.556 <a href="http://purl.org/cwmo/#Idea">http://purl.org/cwmo/#Idea</a>
6 IdeaDesc	n	Not Found
7 Idea Card	n	Not Found
8 ICDesc	n	Not Found
9 ICTitle	n	Not Found
10 ICScenery	n	Not Found
11 ICPrioCli	n	Not Found
12 ICAvant	n	Not Found
13 ICRisk	n	Not Found
14 Industry	y	ostop:Industry(ostop)0.556 <a href="http://www.ordnancesurvey.co.uk/ontology/Topography/v0.1/Topography.owl#Industry">http://www.ordnancesurvey.co.uk/ontology/Topography/v0.1/Topography.owl#Industry</a>
15 Problem	y	cwmo:Problem(cwmo)0.556 <a href="http://purl.org/cwmo/#Problem">http://purl.org/cwmo/#Problem</a>
16 Roles		itm:roles(itm)0.556 <a href="http://spi-fm.uca.es/spdef/models/genericTools/itm/1.0#roles">http://spi-fm.uca.es/spdef/models/genericTools/itm/1.0#roles</a>
17 Site	y	org:Site(org)0.706 <a href="http://www.w3.org/ns/org#Site">http://www.w3.org/ns/org#Site</a> sioc:Site(sioc)0.525 <a href="http://rdfs.org/sioc/ns#Site">http://rdfs.org/sioc/ns#Site</a> br:Site(br)0.480 <a href="http://vocab.deri.ie/br#Site">http://vocab.deri.ie/br#Site</a>
18 Team	y	vivo:Team(vivo)0.944 <a href="http://vivoweb.org/ontology/core#Team">http://vivoweb.org/ontology/core#Team</a> cbo:team(cbo)0.485 <a href="http://comictmeta.org/cbo/Team">http://comictmeta.org/cbo/Team</a>
19 Vocabulary	n	kees:vocabulary(kees)0.545 <a href="http://linkeddata.center/kees/v1#vocabulary">http://linkeddata.center/kees/v1#vocabulary</a>
20 Organizer	y	Shema:organizer (schema) <a href="http://schema.org/organizer">http://schema.org/organizer</a>
21 Solver	n	Shema:participant (schema)

<sup>6</sup> Linked Open Vocabulary: <http://lov.okfn.org/dataset/lov/>, verified may 2019.

<sup>7</sup> Swoogle semantic Web search engine: <http://swoogle.umbc.edu/2006/>, verified may 2019.

<sup>8</sup> Watson semantic Web search: <http://watson.kmi.open.ac.uk/WatsonWUI/>, verified may 2019.

Participant			<a href="http://schema.org/participant">http://schema.org/participant</a>
22 Creative Expert	n		Cwmo:Expert (cwmo) <a href="http://purl.org/cwmo/#Expert">http://purl.org/cwmo/#Expert</a>
23 Technical Expert	n		Cwmo:Expert (cwmo) <a href="http://purl.org/cwmo/#Expert">http://purl.org/cwmo/#Expert</a>
24 Industrial Manager			Ioto:Manager (ioto) <a href="http://www.irit.fr/recherches/MELODI/ontologies/IoT-O#Manager">http://www.irit.fr/recherches/MELODI/ontologies/IoT-O#Manager</a>
25 Possible Solutions			cold:possible (cold) <a href="http://purl.org/configurationontology#possible">http://purl.org/configurationontology#possible</a>

Table IV.18: Verification of URI's concepts.

We verified other ontologies to find some or one of them after to reuse it, to analyze the big quantity and diversity of concepts and relations in different fields, and to understand the syntax of RDF triplets.

### Verification of relationships from other ontologies

Similar to concepts, the relationships have already their URI so we should use them to create our ontology (cf. Table IV.19), nevertheless some relationships are not in any ontology.

It allows me to detect or identify new relationship in other ontologies.

Relationship Name	URI relationship
UsedBy	voaf:usedBy(voaf)0.518, <a href="http://purl.org/vocommons/voaf#usedBy">http://purl.org/vocommons/voaf#usedBy</a>
IsOfferedBy	saref:isOfferedBy(saref)1.204, <a href="https://w3id.org/saref#isOfferedBy">https://w3id.org/saref#isOfferedBy</a>
Plays	wai:plays(wai), <a href="http://purl.org/wai#plays">http://purl.org/wai#plays</a>
IsUsedFor managedBy	saref:isUsedFor(saref)0.556, <a href="https://w3id.org/saref#isUsedFor">https://w3id.org/saref#isUsedFor</a>
IsUsedFor	drm:managedBy(drm)0.458, <a href="http://vocab.data.gov/def/drm#managedBy">http://vocab.data.gov/def/drm#managedBy</a> saref:isUsedFor(saref)0.556, <a href="https://w3id.org/saref#isUsedFor">https://w3id.org/saref#isUsedFor</a>
HasSite	org:hasSite(org)1.807, <a href="http://www.w3.org/ns/org#hasSite">http://www.w3.org/ns/org#hasSite</a>
Contains	nsI:contains(nsI)0.556, <a href="http://purl.org/ontology/storyline/contains">http://purl.org/ontology/storyline/contains</a>
Uses	pmofn:uses(pmofn)0.556, <a href="http://premon.fbk.eu/ontology/fn#uses">http://premon.fbk.eu/ontology/fn#uses</a>
Is created	prv:createdBy(prv)0.770, <a href="http://purl.org/net/provenance/ns#createdBy">http://purl.org/net/provenance/ns#createdBy</a>
Contains	saref:contains(saref)0.482, <a href="https://w3id.org/saref#contains">https://w3id.org/saref#contains</a>
IsGeneratedBy	opmw:isGeneratedBy(opmw)0.556, <a href="http://www.w3.org/ns/prov#generated">http://www.w3.org/ns/prov#generated</a>
Uses	being:uses(being), <a href="http://contextus.net/ontology/ontomedia/ext/common/being#uses">http://contextus.net/ontology/ontomedia/ext/common/being#uses</a>
Contains	saref:contains(saref)0.482, <a href="https://w3id.org/saref#contains">https://w3id.org/saref#contains</a>
Is assigned	pdo:isAssignedTo(pdo)1.056, <a href="http://ontologies.smile.deri.ie/pdo#isAssignedTo">http://ontologies.smile.deri.ie/pdo#isAssignedTo</a>
Contains	nsI:contains(nsI)0.556, <a href="http://purl.org/ontology/storyline/contains">http://purl.org/ontology/storyline/contains</a>
Belongs	ispra:belongsTo(ispra)0.556, <a href="http://dati.isprambiente.it/ontology/core#belongsTo">http://dati.isprambiente.it/ontology/core#belongsTo</a>
Creates	ppo:Create(ppo)0.554, <a href="http://vocab.deri.ie/ppo#Create">http://vocab.deri.ie/ppo#Create</a>
Executes	pwo:executes(pwo)2.464, <a href="http://purl.org/spar/pwo/executes">http://purl.org/spar/pwo/executes</a>
Offers	vivo:offers(vivo)0.479, <a href="http://vivoweb.org/ontology/core#offers">http://vivoweb.org/ontology/core#offers</a>
Manages	drm:manages(drm)1.323, <a href="http://vocab.data.gov/def/drm#manages">http://vocab.data.gov/def/drm#manages</a>
Manages	drm:manages(drm)1.323, <a href="http://vocab.data.gov/def/drm#manages">http://vocab.data.gov/def/drm#manages</a>
Helps	xhv:help(xhv)0.556, <a href="http://www.w3.org/1999/xhtml/vocab#help">http://www.w3.org/1999/xhtml/vocab#help</a>
Assigns	vivo:assigns(vivo)0.545, <a href="http://vivoweb.org/ontology/core#assigns">http://vivoweb.org/ontology/core#assigns</a>
IsAssignedTo	pdo:isAssignedTo(pdo)1.056, <a href="http://ontologies.smile.deri.ie/pdo#isAssignedTo">http://ontologies.smile.deri.ie/pdo#isAssignedTo</a>
isPartOf	rami:isPartOf(rami), <a href="http://iais.fraunhofer.de/vocabs/rami#isPartOf">http://iais.fraunhofer.de/vocabs/rami#isPartOf</a> dcterms:isPartOf(dcterms)0.718, <a href="http://purl.org/dc/terms/isPartOf">http://purl.org/dc/terms/isPartOf</a>

Table IV.19: Verification of URI's relationships.

We verified other ontologies, as we said before, to find some or one of them that be adequate to our group of concepts and relationships, after, reuse the ontology chosed.

#### IV. Agreeing on all the above

Global ontology that represents concepts and relationships

In this part, we represent the global ontology (cf. Figure IV.39) of the CCIDEAS, after, the part of ontology about Idea, Idea Card and Possible solutions:

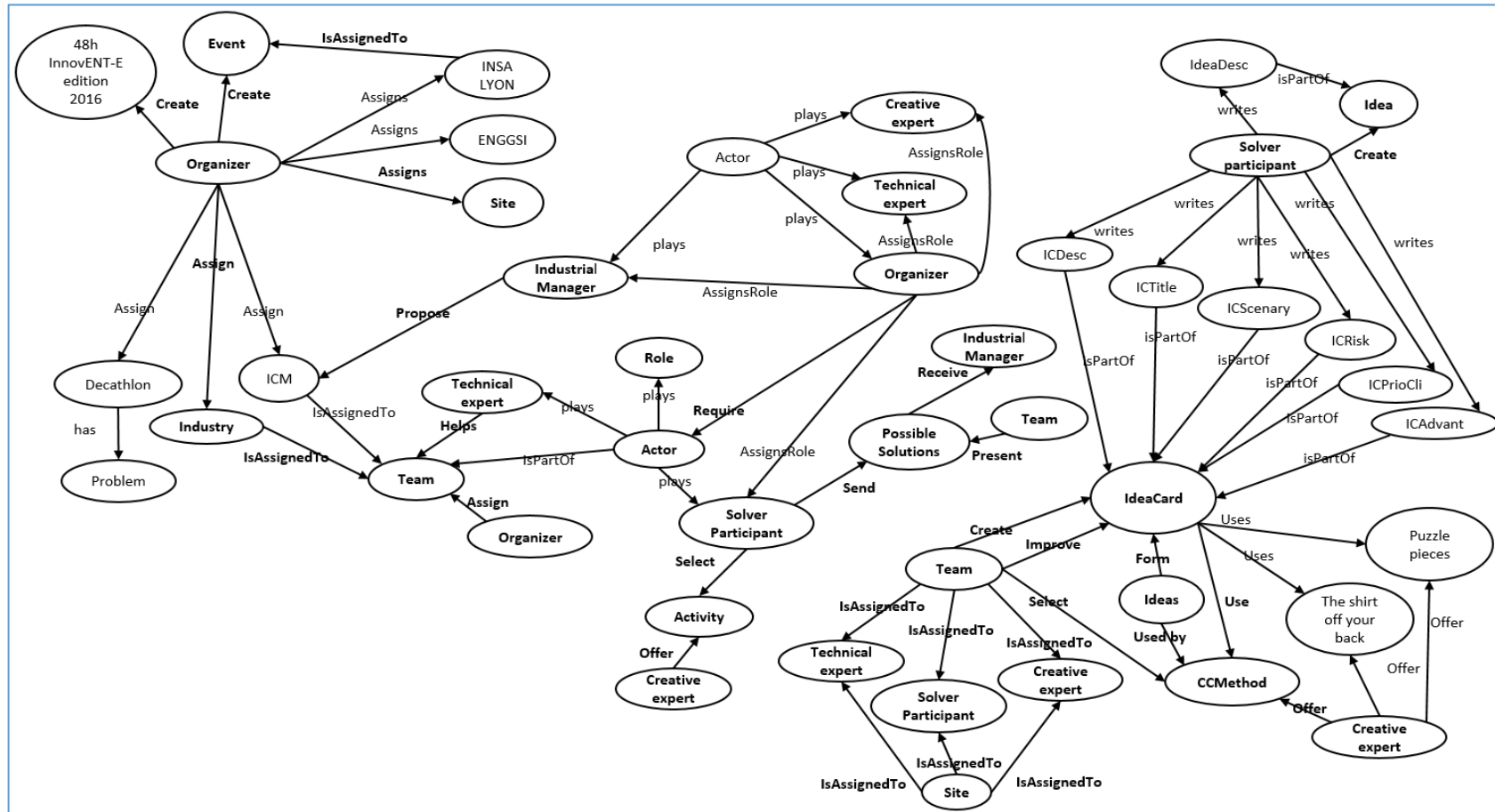


Figure IV.39: Global Ontology.

### Part of Ontology about Idea and Possible Solutions

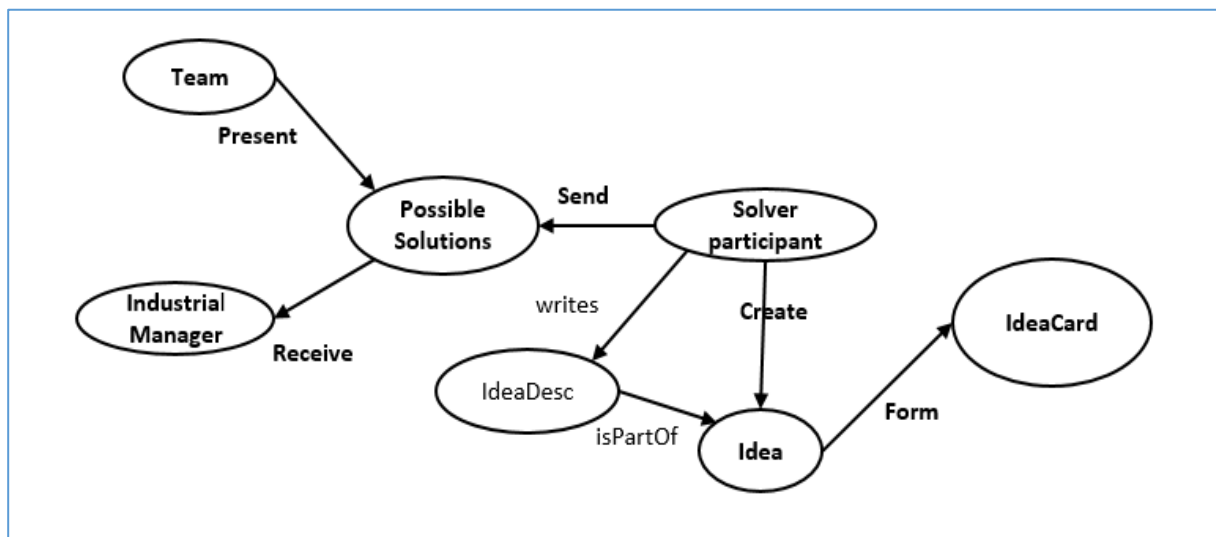


Figure IV.40: Idea and Possible Solutions.

The relationships of the entities “Idea”, “Possible solutions” and “Solver participant” (cf. Figure IV.40) need other concepts like Team, Industrial Manager, Idea Description and Idea Card. We propose the following relationships :

- Present : Team presents PossibleSolutions.
- Receive : Industrial Manager receive PossibleSolutions.
- Send : SolverParticipant send PossibleSolutions.
- Writes : SolverParticipant write IdeaDesc.
- Create : SolverParticipant create Idea.
- IsPartOf : IdeaDesc isPartOf Idea.
- Form : Idea form IdeaCards.

### Part of Ontology about Idea Cards

The concept IdeaCard (cf. Figure IV.41) is linked to the concepts SolverParticipant, ICDesc, ICTitle, ICScenery, ICRisk, ICAvant, ICPrilo, Team, Collaborative Creative Method and Ideas. The relationship between these concepts are:

- Write : SolverParticipant write in ICDesc, ICTitle, ICScenery, ICRisk, ICAvant, ICPrilo.
- IsPartOf : ICDesc, ICTitle, ICScenery, ICRisk, ICAvant, and ICPrilo isPartOf IdeaCard.
- Create : Team create IdeaCard.
- Improve : Team improve IdeaCard.
- Use : IdeaCard use Collaborative Creative Method.
- Form : Ideas form IdeaCard.
- Used by : Ideas used by CCM.
- Use : IdeaCard use collaborative creative method

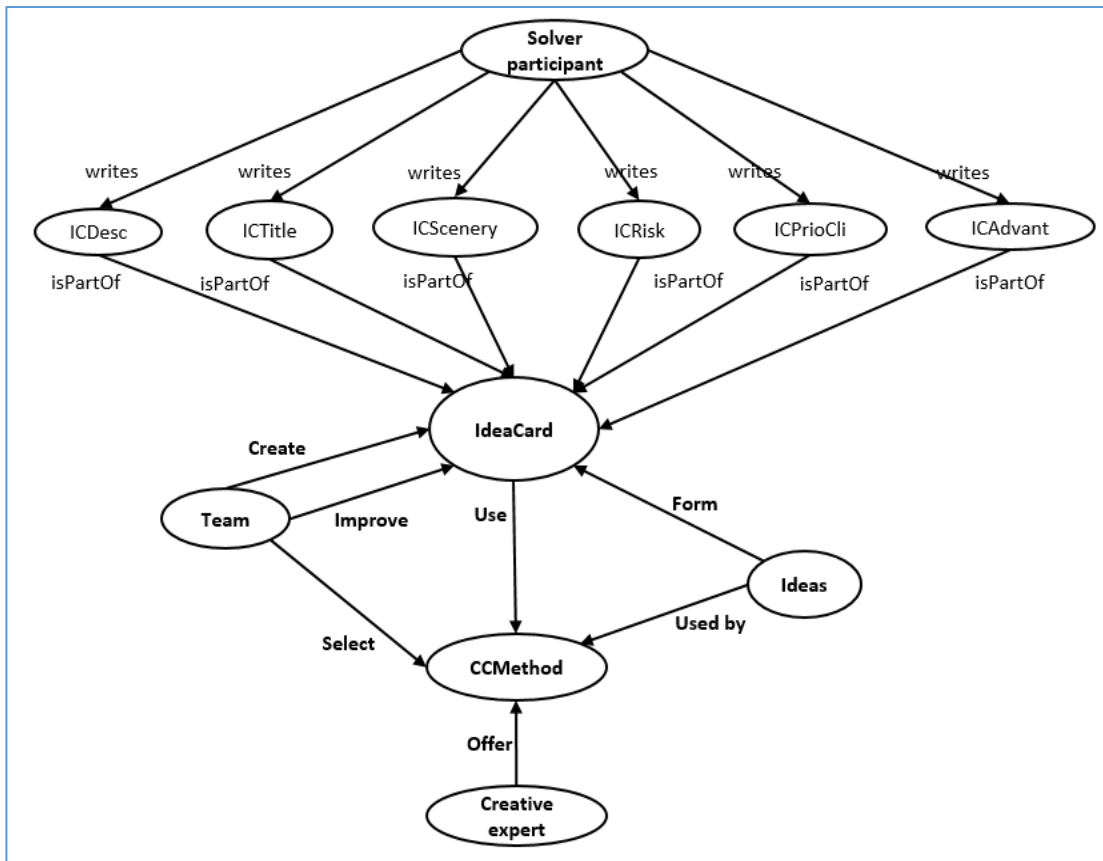


Figure IV.41: Collaborative Creative Idea Cards.

The creative expert and solver participant (Team) are the principal actors in the creation of an idea card. The ICDesc, ICTitle, ICScenery, ICRisk, ICPrioCli and ICAdvant form the IdeaCard.

#### IV.5.2. Ontology coding

The explicit representation of the conceptualization captured in the section “concepts capture” in formal language. This will involve committing to some meta-ontology, choosing a representation language, and creating the code.

##### Idea Cards

The concept of idea cards (*cf.* Figure IV.42) has relationship with the following concepts collective creative, methods, idea card’s description, idea card’s title ICTitle, idea card’s scenery ICScenery, idea card’s risk ICRisk, idea card’s priority clients ICPrioCli idea card’s advantages ICAdvant, Ideas and Team.

We create the code to represent this part of the ontology with the concept mentioned before and the next relationships:

- IsPartOf with the following concepts ICDesc, ICTitle, ICScenery, ICRisk, ICAdvant, and ICPrioCli isPartOf IdeaCard.
- Create: Team create IdeaCard.
- Improve: Team improve IdeaCard.
- Use: IdeaCard use Collaborative Creative Method.
- Form: Ideas form IdeaCard.

- Use: IdeaCard use collaborative creative method.

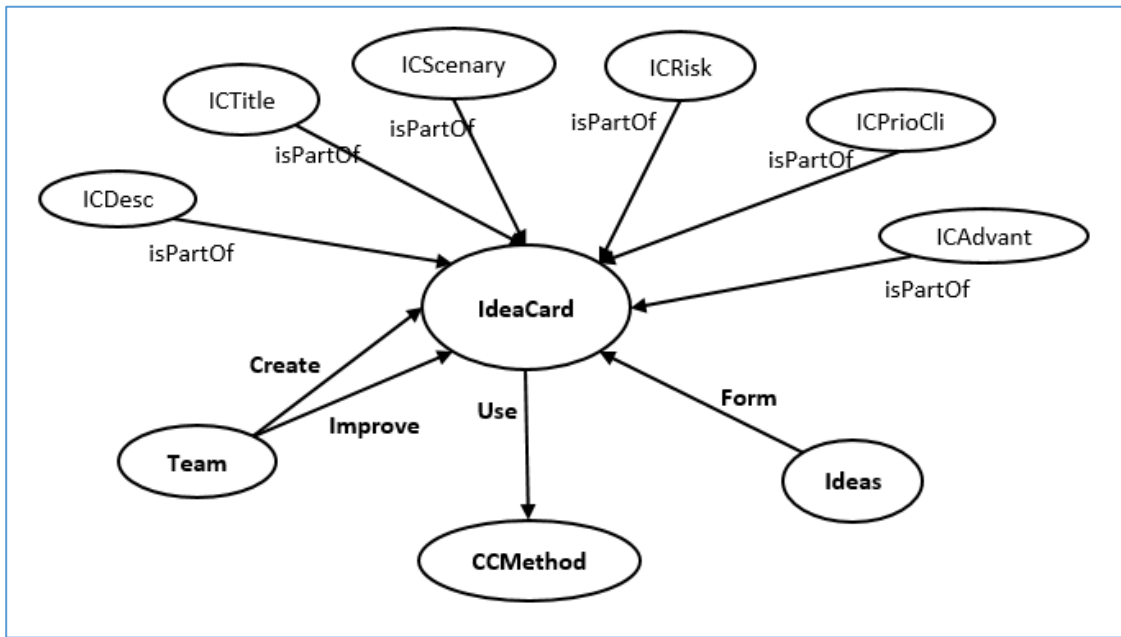


Figure IV.42: The concept IdeaCard

### The concept IdeaCard and its relationships

The concept IdeaCard (cf. Table IV.20), is linked with the concepts Roles, Methods, ICDesc, ICTitle, ICScenery, ICPrioCli, ICAdvant and ICRisk. The table IV.9 describes the relationships between these concepts.

Subject	Predicate	Object
Team	Create	IdeaCard
Team	Improve	IdeaCard
IdeaCard	Use	Collaborative Creative Method CCM
Ideas	Form	IdeaCards
ICDesc	isPartOf	ICDesc
ICTitle	isPartOf	ICTitle
ICScenery	isPartOf	ICScenery
ICPrioCli	isPartOf	ICPrioCli
ICAdvant	isPartOf	ICAdvant
ICRisk	isPartOf	ICRisk

Table IV.20: Verification of URI's relationships for Idea Card.

## IV.6. Chapter conclusion

We have created an ontology called CCIDEAS to describe the knowledge and ideas created during a creativity workshop. The organizational model allows us to identify the concepts of the ontology. Then we have defined the domains, concepts and relationships to build the graphs of the ontology. Concepts and relationships form the triplets to represent graphically the ontology build with subjects, predicates and objects. We have evaluated and developed our ontology using the application Protégé. We also have written a guideline to specify all the concepts of the ontology to give a complete documentation. The guideline is based on the description of the concepts (cf. Table IV.16) and their relationships (cf. Table IV.17)

In the next chapter, we present how to use the ontology to compare, cluster and evaluate ideas in the creativity workshops.

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## **Chapter V: Semantic Approach to Manage Ideas**

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## Topics of Semantic Approach to Manage Ideas

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## V. Semantic Approach to Manage Ideas

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### V.1. Chapter Introduction

This chapter describes our semantic approach to manage the ideas during a creativity workshop. The semantic approach is applying in the four stages of the creativity workshop (needs, ideas, creativity and innovation).

The semantic word has two important meanings, the semantic (computer science) is concerned with mathematical study of programming languages as Bossi writes in (Bossi et al. 1994) and semantic (linguistic) is the subfield that is devoted to the study of meaning, as inherent at the levels of words, phrases, sentences, and larger units of discourse (termed *texts*, or *narratives*). In some particular examples, a common problem in the study of semantic is to calculate the semantic similarity between two words (Li, Bandar, and McLean 2003) or evaluating semantic relatedness using network representations (Resnik 1995); others problems are:

Word sense disambiguation, where Resnik use an algorithm that take advantage of taxonomic similarity in resolving syntactic and semantic ambiguity (Resnik 1999). Detection and correction of word spelling errors (malapropisms) (Budanitsky and Hirst 2001). Coherence, text segmentation scheme provides the framework for recognizing coherent text structure (Kozima 1993).

We will present in the next section our semantic approach to manage and annotate ideas.

### V.2. Semantic approach and experiments

In this section, we describe the semantic approach to compare Idea Cards in the creativity workshop 48H. To achieve this proposal, we present a methodology (*cf.* Figure V.43) in three steps “1- to organize the content of idea cards”, “2- to compare idea cards in a semantic way” and “3- to annotate Idea Cards” as a process for Knowledge Organization.

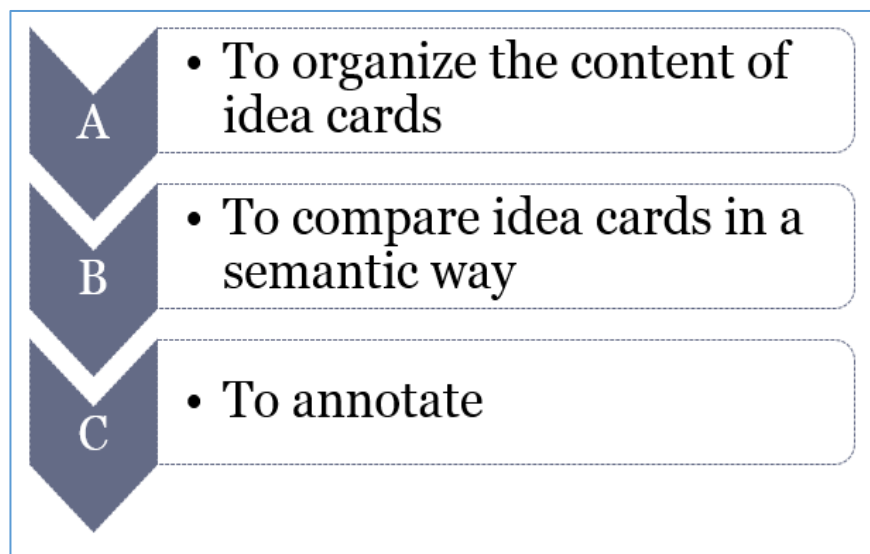


Figure V.43: Semantic approach methodology.

### V.2.1. The research context and problems

A huge quantity of idea cards (IdC) are generated during the creativity workshop to solve industrial problems by using collaborative creativity techniques.

The main issue of the huge quantity of generated Idea cards is how to classify, select, compare and evaluate them. We can observe different properties and issues to exploit these idea cards' fields (Title and Description), due to:

- Participants write out these fields in natural language,
- The description of an idea is a vision of the solver participants and sometimes might not answer to the industrial problem,
- Several Titles or Descriptions might describe the same idea but with different words,
- Some Titles and Descriptions seem to propose an idea that do not answer to the industrial problem but can be very relevant for the industrial manager.

During 48H, we annotated the idea cards by describing the organizational context to explain the creation of ideas and highlighted knowledge, but also we use natural language processing NLP annotation to cluster and compare idea-cards in order to classify and to define the relevance of ideas according to an industrial problem.

### V.2.2. Illustration of idea card:

The following idea card (*cf.* Figure V.44) describes an example of an Idea Card called “Multifunction flying tractor”, it is well structured according to nine components: 1-Title of the idea (Text informative), 2-Team, 3-Description, 4-Schema (draw), 5-Topic (industrial problem), 6-Priority clients, 7-Scenery of use, 8-Advantages, 9-Risks, Competences. *The format of each field is heterogeneous* (Sidhom et al. 2002).

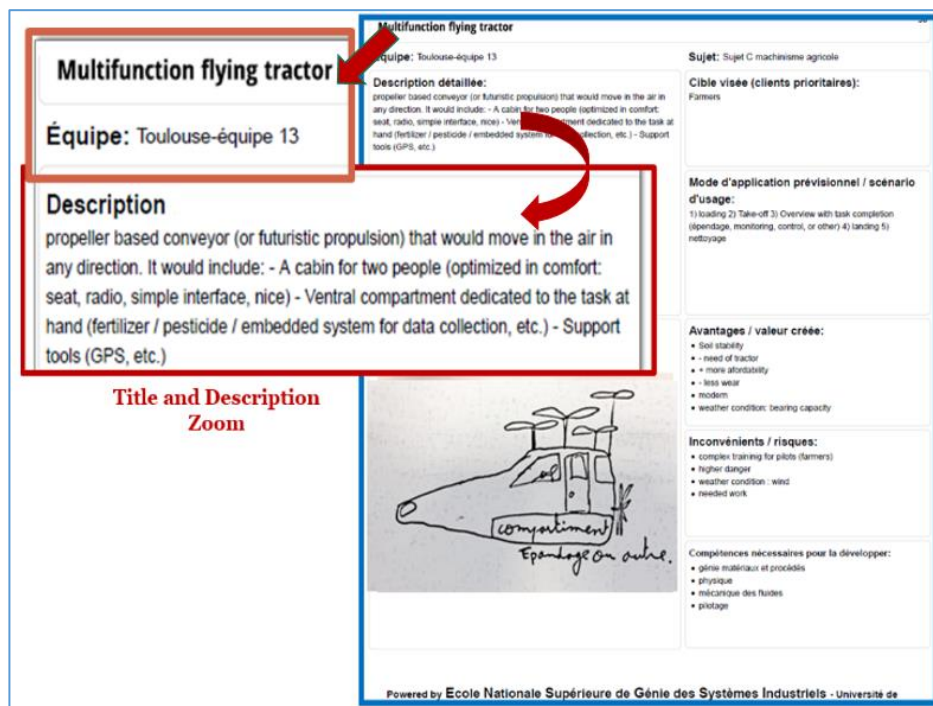


Figure V.44: Example of Title and Description of an Idea Card (IdC).

For each idea card, inside this semantic process take in account the content of “Title” and “Description”. In figure V.2, the idea card describes a collaborative creative idea that is our

main source of data; the title's content "Multifunction flying tractor" and description's content "propeller base conveyor (or futuristic propulsion) that would move in the air in any direction; It would include:

- A cabin for two people (optimized in comfort: seat, radio, simple interface, nice)
- Ventral compartment dedicated to the task at hand (fertilizer / pesticide / embedded system for data collection, etc.)
- Support tools (GPS, etc.)"; both fields of the Idea Card write in natural language with possible errors in its creation.

There exist some constraints and issues related to the idea card:

- Some participants write out these fields in two languages or some nouns are writing out in different language.
- The other field's description such as schema, priority clients, mode of application or scenario, advantages, risks and necessary competences would not be part of the semantic analysis. It due to two aspects, first the quantity of nouns would increase without not order in fields and second the comparative among idea cards using schema would be with images and the other fields (priority clients, mode of application or scenario, advantages, risks and necessary competences), the comparative must be done by sentences.
- Some idea cards are partially empty or with minimal information in the field description, but the other fields are perfect; these idea cards propose an important solution too and perhaps at the stage of innovation it might be a good solution for the industrial manager.

### V.2.3. Semantic Approach Proposal

During the creativity workshop 48H, participants produce a big quantity of idea cards (IdC) that form the corpus, every idea has several concepts, as consequence, the number of concepts to analysis will increase too. As we said previously, the idea card's concepts will be taken from the Title and Description fields of each idea card.

Every idea card's concept produces a group of concepts or synsets, using a semantic lexical relation (SLR) database (DB); we use the SLR WordNet 3.1 that is available online (<http://wordnetweb.princeton.edu/perl/webwn>). It is a large lexical database of English where the types of concepts or words are nouns, verbs, adjectives and adverbs, they are grouped into set of cognitive synonyms (synsets) each expressing a distinct concept (University 2010). We use the concept noun because we obtain all nouns from every idea card to compare, to evaluate and to order the idea cards. **The group of concept nouns (synsets) are synonyms but in the line or paragraph of explanation of every synset's noun could have the *identic(s)* noun(s) in blue.** The quantity of synonyms of a noun could be as much as 1, 10, 40, 50 on the contrary the quantity of identic of a noun could be from 1 to 6 or maybe none; we say that the nouns of synonyms and nouns of identics are in the same level of the noun of concept. Every noun's synset has a conceptual relation such as hyponyms, hypernym, inherited hypernym, meronym, and instances. Every one of them has a group of concepts. We use the conceptual relation synonym and inherited hypernym in order to calculate width, depth, semantic distance and to compare ideas.

Having the characteristics of some models, knowing how to produce nouns from synset and concept relations, we define the requirements (*cf.* Table V.21) to carry out the semantic process.

Requirements	
Corpus	Idea Cards
Representation of Concepts (nouns)	Annotation R(Idea, Concept),
Elements from Semantic Lexical Relation (SLR)	Graphic Representation of semantic lexical elements
SLR Database (DB)	WordNet 3.1

Table V.21: Requirements before the semantic process.

#### V.2.4. Semantic process

Having all these relations, we could carry out the comparative process among different concepts from different idea cards, these concepts are nouns. We present a semantic process (*cf.* Figure V.45) in order to achieve the results and carry out the analysis after that we explain every step until the results and analysis.

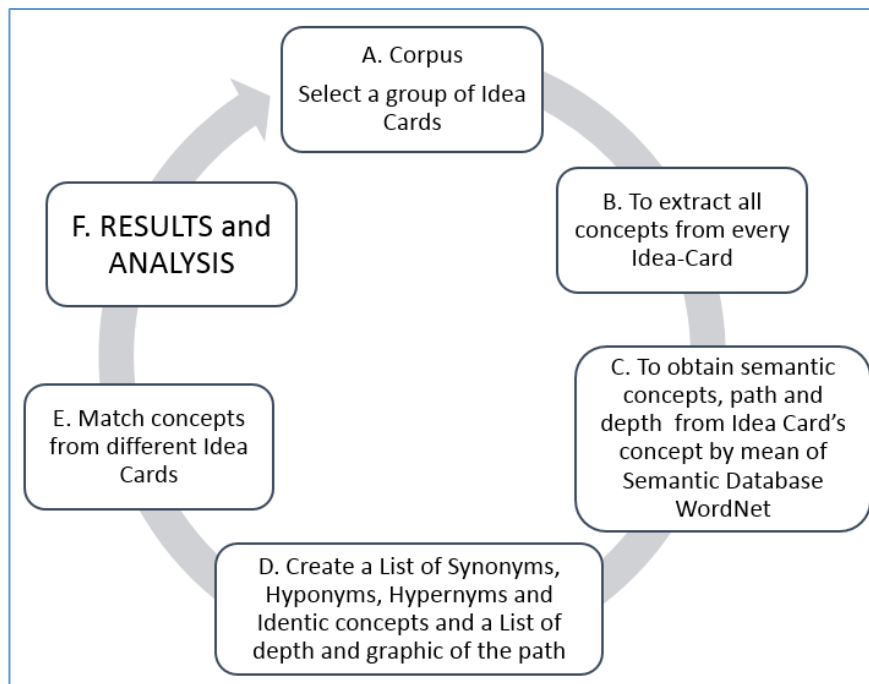


Figure V.45: Semantic Process.

The semantic process approach compares idea cards during a CWS using a semantic lexical database (SLD). The steps of the process:

##### **A. Select a group of Idea Cards from corpus**

The corpus of data is formed by the group of thousands idea cards (IdC) which are created by the “48Hour’s organization, all this IdCs are written using the natural language.

Corpus = {I<sub>1</sub>, I<sub>2</sub>, I<sub>3</sub>... I<sub>x</sub>} I = idea card IdC and x>0

The initial process is to take a sample of the three first IdCs from the corpus that contains IdCs in ordinal order; when the process is finished to take a new sample of the 10 first IdCs, and again, when the process is finished to take a new bigger sample.

**B. Extract all concept from every Idea Card from the sample**

For every IdC, selects all different concepts nouns (C) from the fields “Title” and “Description” after to create an order list with these concept nouns in an ascendant way without no repetition and trying to avoid plural concepts, every idea card will have a unique and particular list of concepts nouns.

**C. To obtain the group of synonyms and conceptual relations nouns (synonyms, identic, conceptual relations nouns from hyponyms and inherited hypernym), path and depth from Idea Card’s concept by mean of semantic lexical relation database WordNet 3.0.**

To obtain the group of synonyms and conceptual relation nouns using the semantic lexical relation database SLR-DB. We represent these elements in the next way: synonyms ( $S_{x,y}$ ), hyponyms ( $H_{x,y}$ ), hypernyms ( $HY_{x,y}$ ), Identic ( $It_{x,y}$ ) and inherited hypernym ( $IH_{x,y}$ ) concepts. To obtain the nouns ( $S_{x,y}$ ), ( $H_{x,y}$ ), ( $HY_{x,y}$ ), ( $It_{x,y}$ ) and ( $IH_{x,y}$ ) we will use a semantic lexical database.

The concept nouns C are represented by mean of annotation relation (R):  $R(I, Concept)$ , elements in the table of representation of elements (cf. Table V.22).

Representation of 48H elements from the semantic process		
Element	Description	Representation
Corpus	Set of idea cards	Corpus = $\{I_1, I_2, \dots, I_x\}, x > 0$
Idea	The product of creative collaborative method inside an organization	$I_x$
Concept (noun)	Nouns inside the idea	$C_{x,1}$
Synonym (synsets)	The group of synonyms of a noun	$S_{x,1}$
Identic Concept	The identic nouns in a synset line	$It_{x,1}$
Conceptual relation	Hyponyms from the synset (nouns)	$H_{x,1}$
Conceptual relation	Hypernyms from the synset (nouns)	$HY_{x,1}$
Conceptual relation	Inherited Hypernym path from the synset (group of nouns)	$IH_{x,1}$

Table V.22: Representation for 48H semantic process.

Applying this representation, an idea might have n concepts nouns ( $n \geq 0$ ) but also one concept might have p synonyms, q hyponyms, r hypernyms and s identic concepts ( $p, q, r$  and  $s \geq 0$ ). With the inherited hypernym, we get the path, depth and after to calculate Semantic Distance.

We use every concept of the list in the SLD, first to obtain the semantic relation in a generic and specific level (cf. Figure V.46), second to obtain the inherited hypernym. With concepts from generic and specific level, we could get a semantic group with synonyms, identical or equivalent, hyponyms and inherited hypernym concepts.

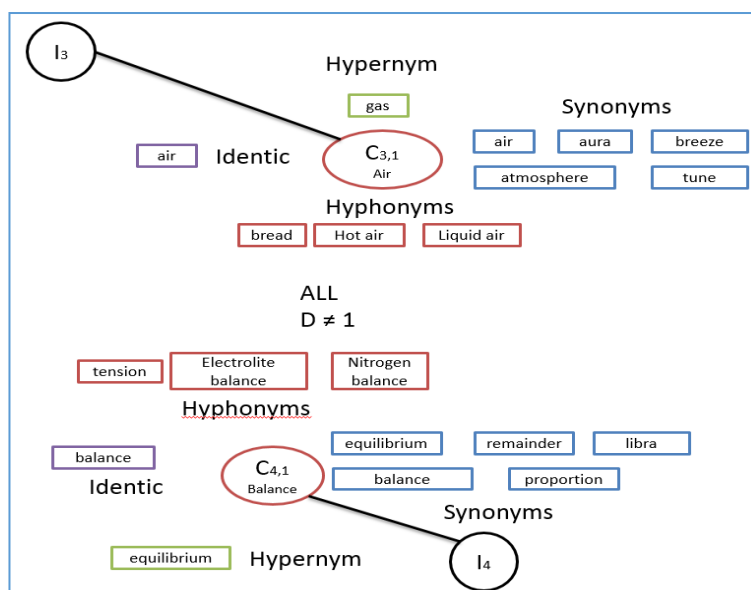


Figure V.46: Elements from Semantic Lexical Relation.

**D. Create a list of synonyms, hyponyms, Hypernyms with Inherited hypernym, and identic or equivalent concepts also a list of depth and graphic of the path.**

The elements from semantic lexical relation help us to produce the list of identical concepts, synonyms, generic concepts and specific concepts. The concept has semantic relation in generic and specific levels; however, we are interested in the immediate level in both cases. In addition, we consider the synonyms and identical concepts which are in the same level.

The list or concepts from Inherited Hypernym is used to get the width (Wd) and semantic distance (SD) of the idea card. To obtain the SD of the idea card, we take from the order concept  $I_x = \{ C_{x,1}, C_{x,2}, C_{x,3}, \dots, C_{x,n-2}, C_{x,n-1}, C_{x,n} \}$  the first three concepts and the last three concepts, forming pairs: pair1(  $C_{x,1}, C_{x,n}$  ), pair2(  $C_{x,2}, C_{x,n-1}$  ), pair3(  $C_{x,3}, C_{x,n-2}$  ), the last pair is formed with the deeper and higher concepts after that we calculate the semantic distance using the formula  $\delta_{wu-palmer}(C_p, C_q) = 2d/(L_p+L_q+2d)$ , also we take the first deeper and deepest concepts and we apply the formula again. To obtain the width of the IdC, we order all concepts by levels then we take in account the levels from 4 to 10; to calculate the level's width, we eliminate every similar concept, the number of concepts is the width of the level; finally, we obtain the average for width and semantic distance.

**E. Match concepts from different Idea Cards**

A graphic representation in (cf. Figure V.47) shows ideas, concepts nouns and conceptual relation elements from semantic lexical relation using inherited hypernym; the analysis of similarities is done between two different concepts ( $\neq$  nouns) from different idea cards. We could carry out the comparative process among all concepts nouns, synonyms, identic concepts, hypernyms, and hyponyms using some semantic lexical rules.

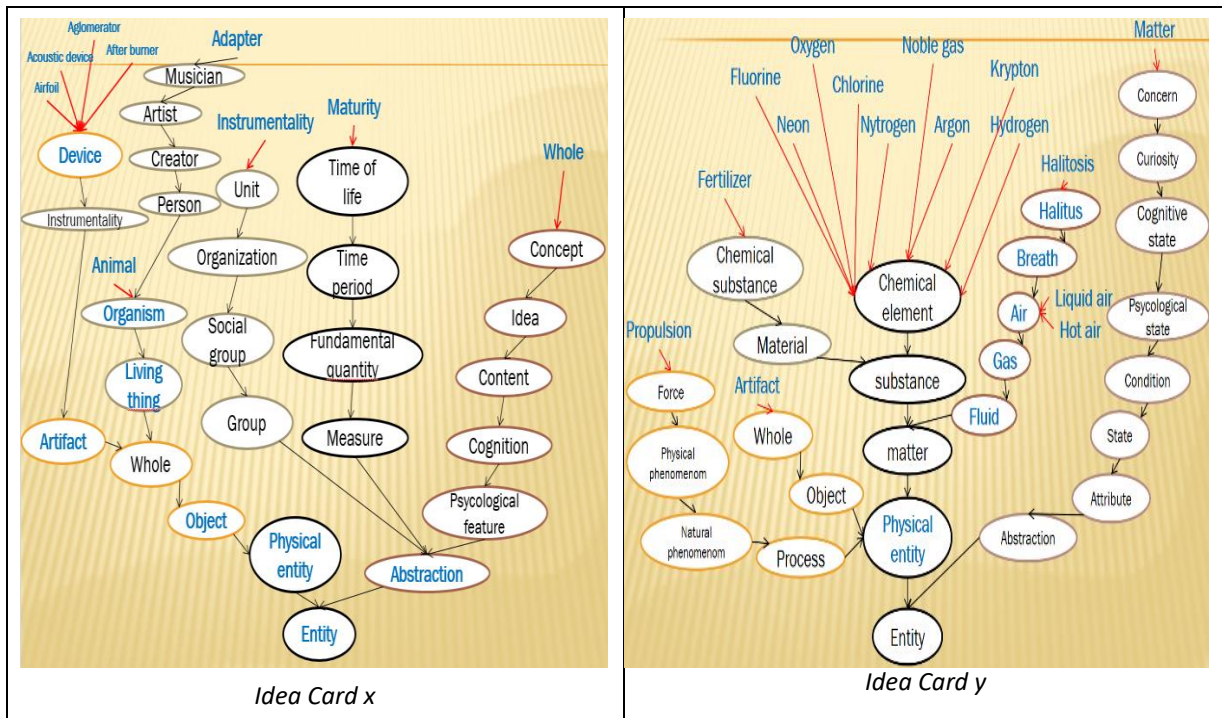


Figure V.47: Graphic representation of Idea Cards.

By obtaining the group of synsets with the help of the lexical database WordNet, we can carry out the process (cf. Figure V.48): to compare semantic nouns of different concepts, to get semantic distance, and to validate the idea card.

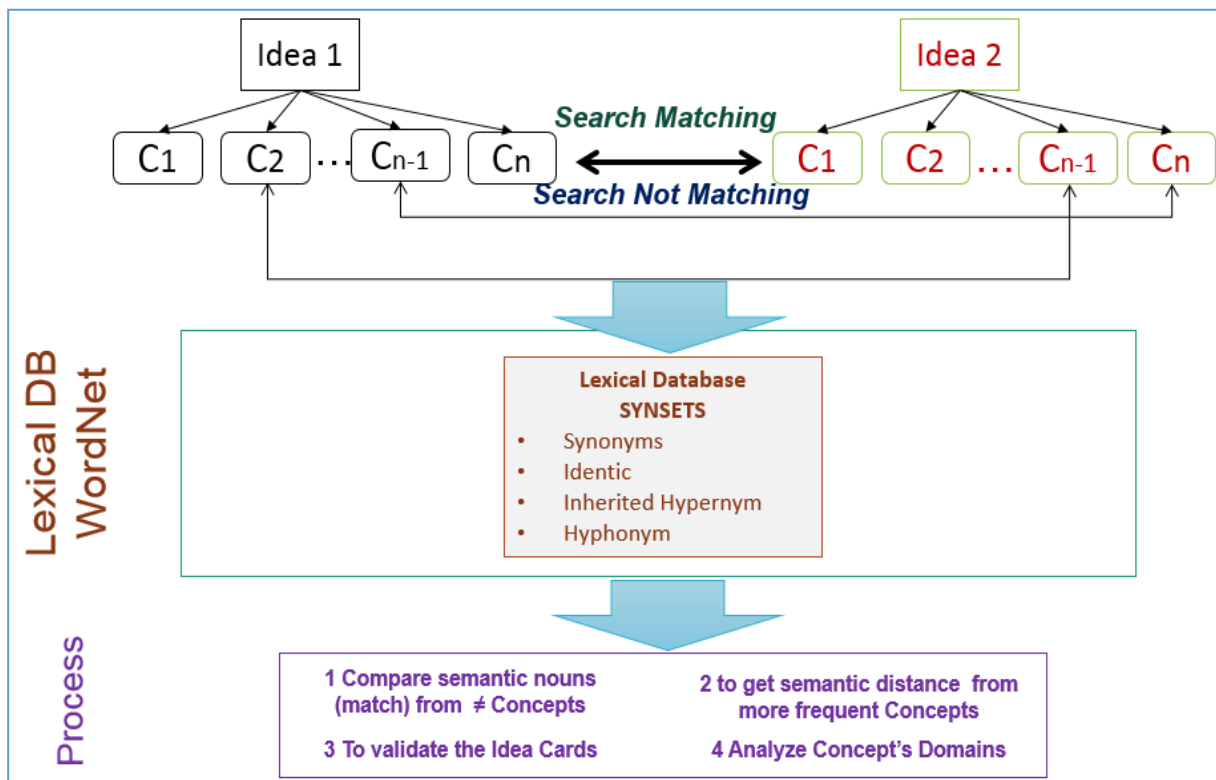


Figure V.48: Lexical Database WordNet and processes.



## ***E. Results and analysis***

During this step, we analyzed the result obtained, if the result has a congruent and important meaning we write why this result is important then we continue to do the process again with different idea cards or concepts nouns.

### ***Rules for Semantic Lexical database:***

We will use the semantic lexical database called WordNet 3.1. The information in WordNet is organized around logical groupings called synsets. Pointers represent two kinds of relations: lexical and semantic. Nouns and verbs are organized into hierarchies based on the hypernym /hyponymy relation between synsets. Additional pointers indicate other relations.

#### **Rules 1-6:**

**R1.** To write all nouns in singular and lowercase as possible; since some nouns like ceramic and ceramics don't have the singular-plural relation, "ceramics" is the art of making pottery while "ceramic" is an artifact of hard brittle material, be careful as much as possible.

**R2.** To set relation's degree (RD) in synonym (synsets) that is the quantity of synsets that we will take in account, we set RD=5 but RD could be from 2 to 7 TD=2|3|4|5|6|7.

**R3.** In WordNet Search 3.1, there is a text field "Word to search for", here we can write the word, noun or concept, after, clicking in the button Search WordNet. We should do this for every word, concept or noun to obtain the synsets related to the word. We will annotate the next data in the list A.

**R4.** To select 5 synsets (group of nouns) listed, after we have to analyze the group of noun(s) in order to pick up one noun for each group of nouns:

**Note 1:** if there are less or equal than 5 synsets we could take in account all of them.

From the first synset, if there is only one noun writes down. If there are more than one noun then select the first noun that is not similar to the word searched.

From the next synsets, we have to choose the noun that is different to the word searched and write down but if there is only one noun and it is similar to the word searched, don't worry, just write down.

**Note 2:** if there are more than 5 synsets, we just take in account some of them according to some specific rules:

a: from the first synset, if there is only one noun writes down; if there is more than one noun then select the first noun that is not similar to the word searched; in both cases the quantity of synsets is one.

b: from the next synsets, we have to choose the noun that is different to the word searched, write down and increment in one the quantity of synsets;

If the quantity of synsets is equal to 5 then go to the rule R5. else go to rule R2.

If there aren't more synsets then complete the quantity of synsets with noun that are similar to the word searched.

**Example 1:** using the word "product", their synonyms are all marked with **S (n)** and inside each synonym there are nouns with similar definition:

**S (n) Merchandise**, ware, product;

**S (n) Product**, **production**;

**S (n)** Product, **mathematical product**;

**S (n)** Product;

**S (n)** Product;

**S (n) Intersection**, product, Cartesian product;

We should pick up the nouns: Merchandise, production, mathematical product, intersection, and product.

**R5.** From the first synset (group of nouns): select the first three nouns with similar definition to the word searched.

**Example 2:** using the word “product”, the first synset has the group of nouns which the first noun is Merchandise:

**S (n) Merchandise, ware, product**;

We should pick up the three nouns with similar definition:

Merchandise, ware and product.

**Note 1:** if there are less or equal than 3 nouns we could write down all of them to the list; if there are more than 3, we just take in account the first 3 nouns from the group of nouns that are different to the word searched.

**R6.** Clicking in the letter “S” synset from the first synset or group of nouns, it shows “Synset Semantic Relation”, from these relations, we are interested in:

- Direct hyponym and
- Direct hypernym,
- Inherited hypernym, so we will annotate:

To select the first three synsets (group of nouns) listed that belong to Direct Hyponym (DHph) after to analyze the group of nouns in order to take one noun for each group of nouns:

**Note 1:** if there are less or equal than 3 synsets we could analyze them; if there are more than 3, we just take in account the first 3 synsets.

**Note 2:** if the group of nouns has a noun with the same name that the word searched, but there are more nouns with similar definition, we could select the next definition.

**Note 3:** if the group of nouns has a noun with the same name that the word searched and it is the unique noun, don't worry just write them.

**Note 4:** try not to repeat the other nouns selected.

**Example with the synset “merchandise”:**

- **S (n) Cargo**, lading, freight, load, loading, etc.
- **S (n) Contraband**,
- **S (n) Feature**
- **S (n) Generic**
- **S (n) Ironmongery**

We pick up Cargo, contraband and feature.

To write the first noun from the Direct Hypernym (DHpr) without take in account other nouns with similar definition.

Example with the synset “merchandise”:

- Commodity, trade good, good;

We should pick up commodity.

To write the entire path showed by Inherited Hypernym (IH) with the purpose to calculate semantic distance and width.

### V.3. Global Design System

The global design system describes the creativity support system, semantic approach system and the annotation system; we will explain every system and at the end, we will present the global frontiers of the system.

First, we define the object model and interface model to achieve our creativity support system.

#### **The Object Model**

The object model defines the static structure of the information where the system works with that information. Before to continue with this model, we are going to present the main elements used in the object model in order to help us in the construction of the global design.

#### **The interface Model**

The interface model defines the communication system by mean of inputs and outputs.

#### **Classes, attributes, relations, objects and instances**

An object is a perfect identified thing; a person, an organization, a machine or an event are objects. An object is associated to values or attributes. An Actor (class start with uppercase) might have the attributes (start with lowercase) name, last name and institution, its instances could be “Jonathan”, “Lacroix”, “Université de Lorraine”, “Angel”, “Balderas Puga”, “Universidad de Queretaro”. The objects are groups called class that is the general notion or idea. We could associate a verb to a class.

#### **Relations**

The relation formed between two classes and the relation.

#### **Constraints**

It represents the annotation of the arc between classes, the constraints could be a number, an interval, an \* (zero or more) or a + (one or more). If all the objects of a class participate in the relation, we must use a little black square.

#### **Invariants**

The invariants are attributes to describe affirmations.

#### **Roles**

The classes intervening in a relationship possess the roles. Every role could be named adding a name of role on the arc of relation, these roles names must be unique.

#### **Relation's attributes**

These attributes when two objects in relation cannot hold the attribute than it could be hold in the relation.

### Ternary and n-ary relations

These relations have three or plus objects and relations. (Colleman et al. 1996).

## V.4. Creativity Support System

The creativity support system has defined all the classes involved in the creativity workshop 48H. Having the object model and the interface model, we can complete the implementation, algorithms, results and discussions.

### V.4.1. Implementation

The phase of implementation describes classes, graphs, dictionary of data, the body of methods and the cycle of life. The implementation process has the code, the performances and the review.

The definition of roles' schemas (Creative Expert, Industrial Manager, Organizer, Solver Participant and Technical Expert) and interactions among these roles from the multi-agent system MAS (chapter Intelligent System Implementation) give us the path in the creation of relations and classes. All these represent the analysis of the MAS.

Afterward, the cognitive agents (CTEAgent CTEA, IMAgent IMA, ORAgent ORA, SPAgent ORA) and reactive agents (Semantic Model Knowledge Agent SMKA, Width Semantic Distance Agent WSDA and Comparative Similarity Agent CSA) will be integrated in the object model of the system, the interface model, the operative model and the cycle of life model. All these represent the design of the MAS.

#### A. Relations and Classes:

We present two examples about the relations between classes and sometimes relations among classes to explain the behavior of these classes, their attributes, and the constraints with respect to the objects that participate in the relation and how to create the class.

#### Relation Organizer-EventC

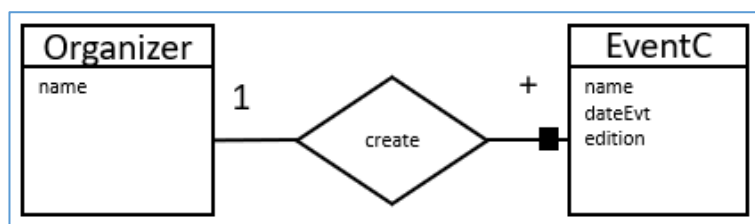


Figure V.49: Operation Create\_event.

1 Organizer creates 1 or more EventC, 1 or more EventC are created by 1 Organizer, all EventC participate in this relation (cf. Figure V.49). The classes' code (cf. Table V.23).

Class Organizer	Class EventC
<pre> public class Organizer extends Role{     String name;     void Organizer(String nameOR)     {         name = nameOR;     }   </pre>	<pre> Public class EventC{     String name;     Date dateEvt;     String edition;     void EventC(String name_E, Date dateEvt_E,     String edition_E)   </pre>

	<pre> { name = name_E; dateEvt = dateEvt_E; edition = edition_E; } } </pre>
--	-----------------------------------------------------------------------------

Table V.23: Classes Organizer and EventC.

### Relation Actor-Roles

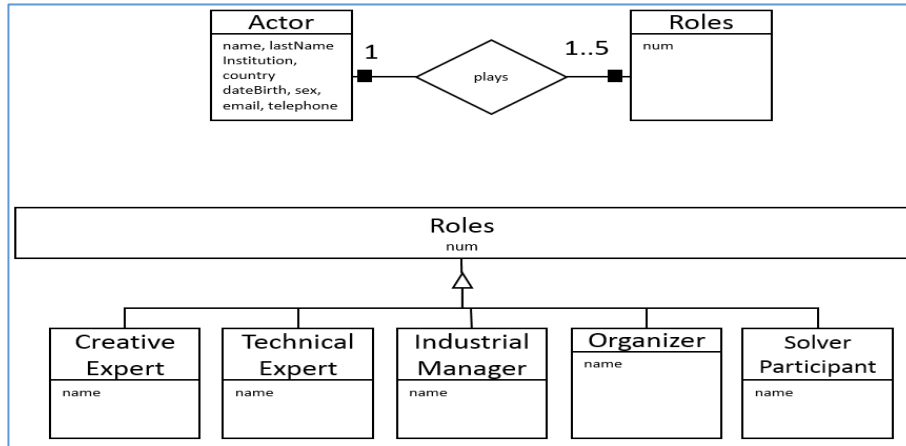


Figure V.50: Operation AssignmentRoleToActor.

Class Roles	CreativeExpert
<pre> public class Roles{ Integer num; void Roles(String num_R) { num = num_R; } } </pre>	<pre> public class CreativeExpert extend Roles{ String name; void Role(String name_CE) { name = name_CE; } } </pre>

Table V.24: Classes Roles and Creative Expert.

Class TechnicalExpert	IndustrialManager
<pre> public class TechnicalExpert extend Roles{ String name; void Role(String name_TE) { name = name_TE; } } </pre>	<pre> public class IndustrialManager extend Roles{ String name; void Role(String name_IM) { name = name_IM; } } </pre>

Table V.25: Classes Technical Expert and Industrial Management.

Class Organizer	SolverParticipant
<pre> public class Organizer extend Roles{ String name; void Role(String name_O) { name = name_O; } } </pre>	<pre> public class SolverParticipant extend Roles{ String name; void Role(String name_SP) { name = name_SP; } } </pre>

Table V.26: Classes Organizer and Solver Participant.

1 Actor plays from 1 to 5 Roles or from 1 to 5 Roles are played by 1 Actor, all Actors and Roles participate in this relation, in addition 5 sub class are generated from the class Roles Solver Participant, Creative Expert, Technical Expert, Industrial Manager and Organizer (*cf.* Figure V.50). The classes of Industry and Industrial manager code (*cf.* Table V.24, *cf.* Table V.25, and *cf.* Table V.26).

#### V.4.2. Interface Human Machine IHM: the system behavior

The model of interface takes in account the operating model and the cycle of life.

The operating model defines the behavior of individual operations while the cycle of life defines the communication of the system during its existence.

##### A. Interface Model :

To achieve to the interface model, it is necessary to describe the object model of the system. *The object model of the system is a subset of an object model, the object model of system depends of the function of the system to build and the object model of a system describe the structure of the system but it does not describe its behavior* (Colleman et al. 1996). The interface model defines de behavior of the system. The interface system is the set of events that it can receive and the set of events that it can produce (output).

**B. Object Model :**

Having those principles, we could produce our map of relations among objects (cf. Figure V.51) this object model represents the objects in the creativity workshop 48H.

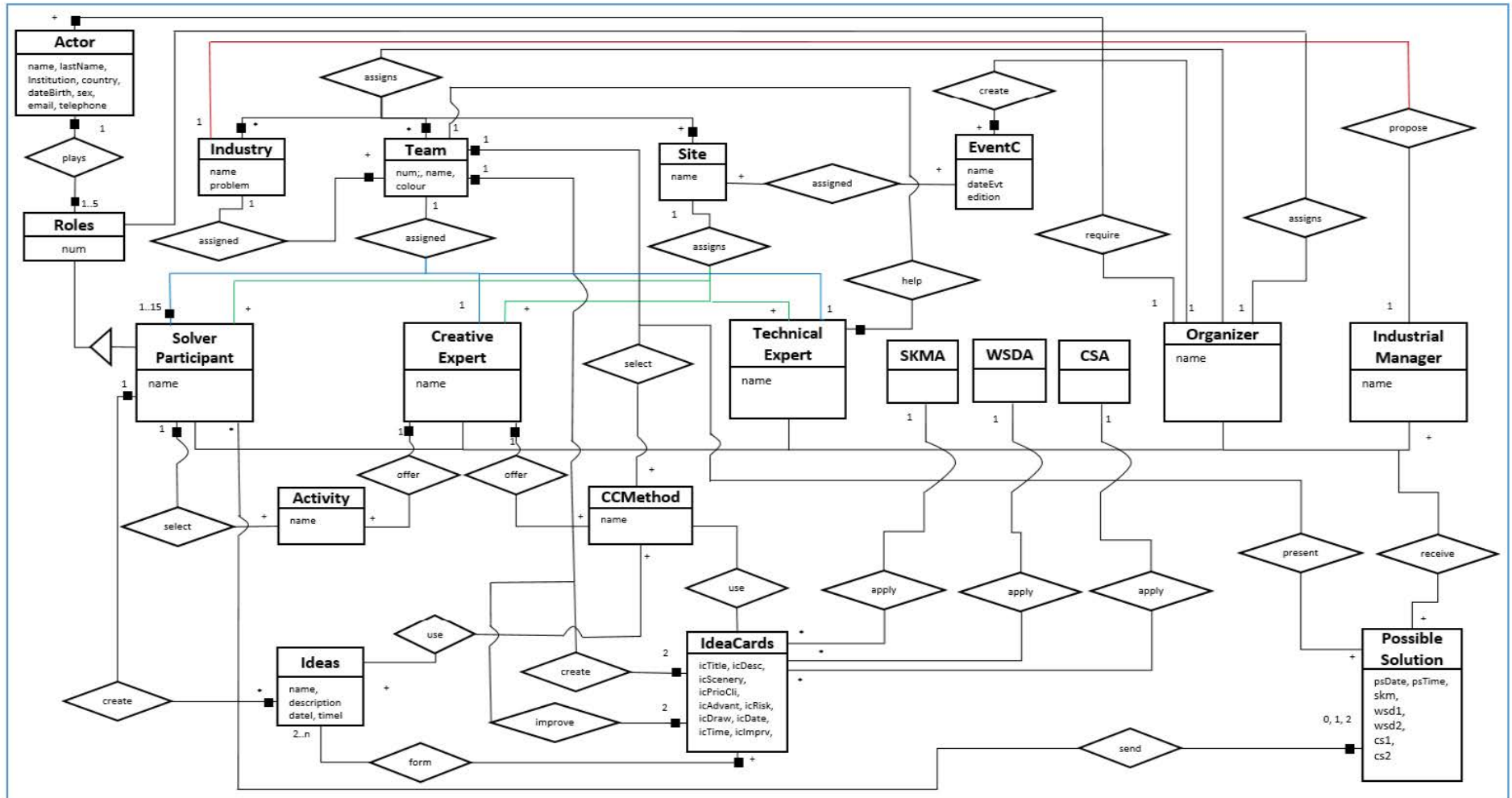


Figure V.51: The Agents and Objects Model of the System.

C. The multi-agent system:

Agents allow managing the information created or used by the human users. . A set of agents forms an environment with which a communication system (cf. Figure V.52).

The system is composed by 7 agents designed by CTEA, IMA, ORA, SPA, SKMA, WSDA and CSA (cf. Figure III.34) chapter III.

An event is an atomic instantaneously unit of communication among the system and their environment. An agent sends an input event to the system and the system send an output event to the agent. The communication is asynchronous because the sender does not wait that receptor has received the event. A system operation is an input event and its effects. At any moment, just one operation can be active.

The interface model has two model to define its behavior, the operative model and the cycle of life model.

The operations of the system, agents and events (cf. Table V.27) the cycle of life is the sequence of operations and events.

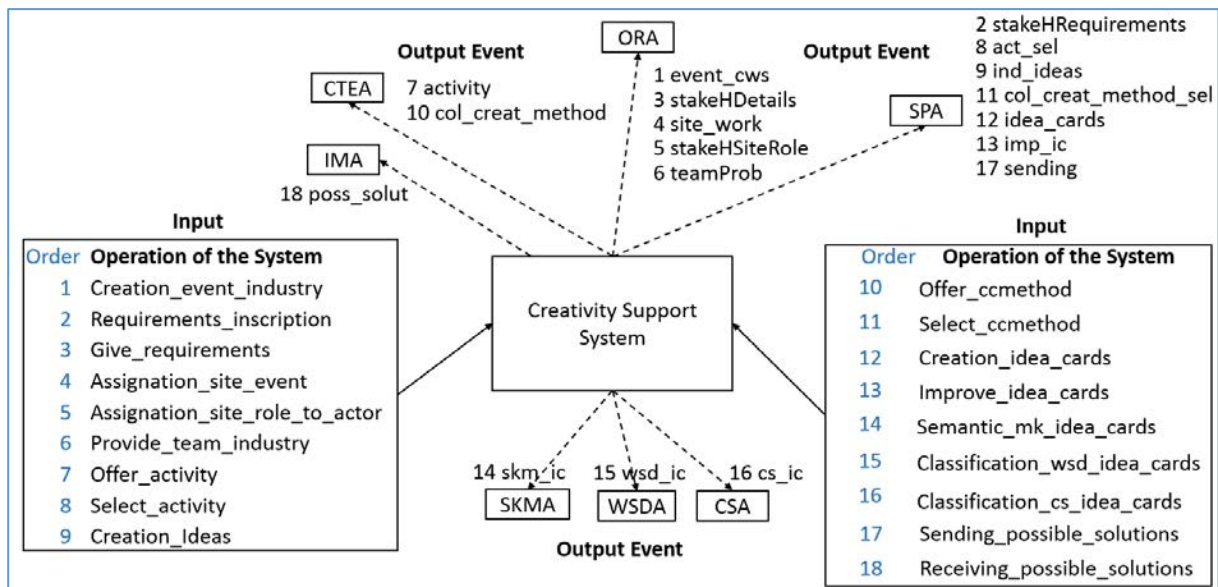


Figure V.52: The Interface Model.

N	Operation	Agent	Event
1	Creation_event_industry	ORA	Event_cws
2	Requirements_inscription	ORA	stakeHDetails
3	Give_requirements	SPA	stakeHRequirements
4	Assigation_site_event	ORA	site_work
5	Assigation_site_role_to_actor	ORA	stakeHSiteRole
6	Provide_team_industry	ORA	teamProb
7	Offer_activity	CEA	activity
8	Select_activity	SPA	act_sel
9	Creation_ideas	SPA	ind_ideas
10	Offer_ccmethod	CEA	col_creat_method
11	Select_ccmethod	SPA	col_creat_methodsel
12	Creation_idea_cards	SPA	idea_cards
13	Improve_idea_cards	SPA	imp_ic



14	SemanticModKnow_idea_cards	SMKA	smk_ic (semantic model knowledge)
15	Classification_wd_idea_cards	WSDA	wd_ic (classification Width and semantic distance)
16	Classification_cs_idea_cards	CSA	cs_ic
17	Sending_possible_solutions	SPA	sending
18	Receiving_possible_solutions	IMA	poss_solut

Table V.27: Interface Model.

#### D. Operative Model :

The operative model expresses the behavior of the operations. An operation system can create a new instance of class, changer the value of an attribute, add or eliminate some n-tuplets object from a relation and send an event to an agent.

The operative model specific the operations with help of preconditions and postconditions.

The precondition characterizes the conditions necessary for the operation to be satisfied (it that must be true before).

The postconditions describes how the state of the system has changed and which events are sending them to the agents (modification done).

We describe in the next tables two examples of operations done by agents:

##### 1. *Creation\_event\_industry*

This operation describes the behavior with the elements description, reading, writing, sending, pre-requirement and results (*cf.* Table V.28). The creation of a new event and industry starts with the organizer agent ORA and finish with solver participant agent SPA. During this space of time, to verify, to create a new event, to create a new industry. The condition: if there is not an event for this year. The result: at least 1 event has been created and at least 1 industry must be created with its name and problem.

Operation	1 Creation_event_industry
Description	Creation of a new EventC and Industry.
Reading (Items)	If there are not an event for this year. Read(name, dateEvt, edition) from EventC If date <> year of dateEvt then create a new instance of event.
Writing (Items)	<i>EventC</i> To create <b>new</b> EventC (name, dateEvt, edition).  <i>Industry</i> To create <b>new</b> Industry (name, problem).
Send (Agent and Event)	Send (ORA, event_cws) At beginning of the operation1. Send (SPA, stake Requirements) At the end of operation 1.
Pre-requirement (Cond)	Condition: If Event.date <> year (actual) then create the Event. If there is not instances in Industry then to create (Proposed by Industrial Manager but captured by Organizer).
Result (Cond)	At least 1 event has been created to the class event. <b>Event.name, Event.dateEvt, Event.edition.</b> Instances EventC > 0. At least 1 industry with a name and problem must be created. <b>Industry.name, Industry.problem.</b> Instances Industry > 0.

Table V.28: Operation Creation\_event\_industry.

### 15. Classification\_wd\_idea\_cards

During this operation (cf. Table V.29), the Width Semantic Distance Agent WSDA calculates the width and the semantic distance for every idea card improved. Using a cycle, reading every IdeaCard and calculate the width and semantic distance. The creation of a new event and industry starts with the WSDA agent and finish with the CSA agent. In this space of time, to verify, to modify the wsd1 and wsd2 that contains the values calculated. The condition: the PossibleSolutions.skm = True that means that the list of synonyms, identics, hyponyms and inherited hypernyms have been created. The result: to have the width and semantic distance for every Possible Solution.

Operation	15 Classification_wd_idea_cards
Description	The Width Semantic Distance Agent (WSDA) calculates the width and semantic distance for every Idea Card improved.
Reading (Items)	Var n=end of instances For i=0; i++; i=n Read position(i) of IdeaCards (icTitle, icDesc, icDate, icTime, icImprv) To calculate Width and Semantic Distance according to the semantic process.
Writing (Items)	To modify : PossibleSolutions.wsd1, PossibleSolutions.wsd2, Rel16-smk.psWsd1, Rel16-smk.psWsd2,
Send (Agent and Event)	Send (WSDA, wsd_ic) // at the beginning of the operation 15, after Send (CSA, cs_ic) // the operation 15 had finished; CSA can start with the operation 16.
Pre-requirement (Cond)	Condition The fourth steps of semantic process are executed, the possibleSolutions.skm must be True.
Result (Cond)	<i>PossibleSolution</i> <b>PossibleSolution.wsd1</b> <b>PossibleSolution.wsd2</b>  For all PossibleSolutions: The PossibleSolution.wsd1 > 0 The PossibleSolution.wsd2 > 0

Table V.29: Operation Classification\_wd\_idea\_cards.

### E. Cycle of life Model :

The behavior of a system takes in account the cycle of life model and operative model besides the cycle of life (cf. Table V.30) determines the acceptability of an event while the precondition from pre-requirement determines if its effect is right or not.

This model describes the communication between the system and the environment from its creation to its end. The definition of the sequence admissible of interactions that the system can have during its existence. If at any point, the system receives an event that is not in the sequence, this event is ignored.

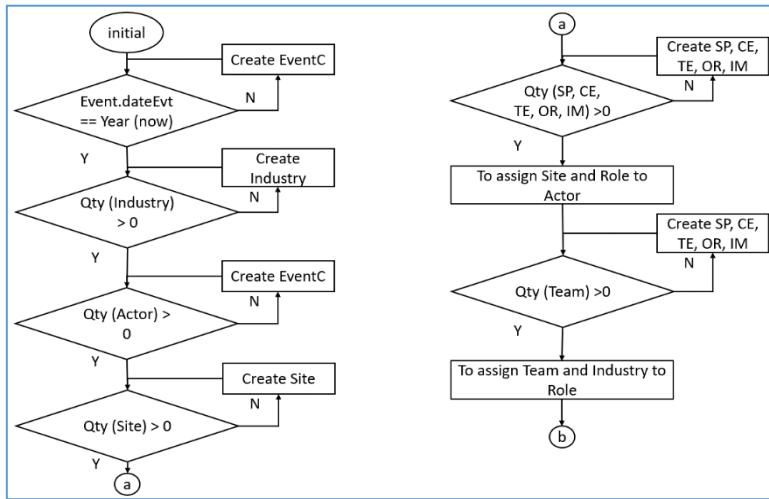
The pre-condition sets the condition and values necessities before to execute the operation.

The post-condition sets the condition and values necessities at the end of the operation.

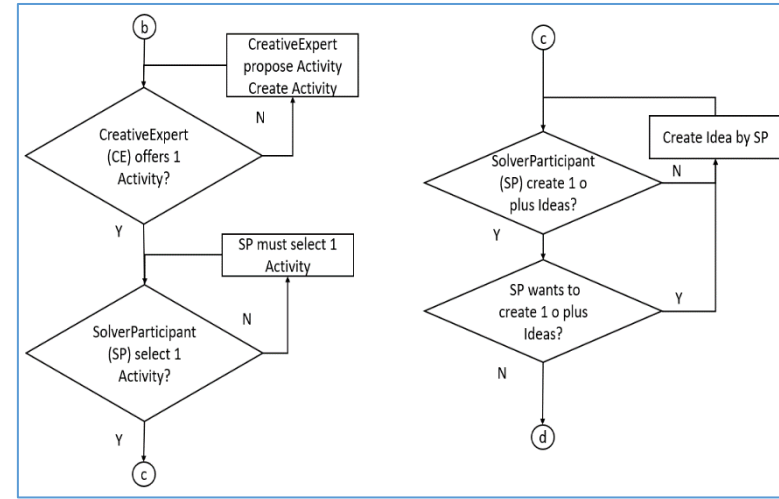
Operation/Agent/Event	Pre-Condition	Post-Condition
Creation_event (industry/ ORA/ event_cws	If Event.dateEvt <> year (actual) then create the Event. If there is not instances in Industry then to create (Propose by Industrial Manager but captured by Organizer).	EventC > 0 Industry > 0
Requirements_inscription/ ORA/ stakeHDetails	If actor not exist then require data (invite). instances actor = 0	Actor > 0
Give_requirements/ SPA/ stakeHRequirements		New Actor
Assignment_site_event/ ORA/ site_work	Event from this year > 0	At least 1 site is created Site > 0
Assignment_site_role_to_actor/ ORA/ stakeHIndR	Site > 0	At least 1 Role of SolverParticipant, CreativeExpert, TechnicalExpert, Organizer and IndustrialManager is created SolverParticipant > 0 CreativeExpert > 0 TechnicalExpert > 0 Organizer > 0 IndustrialManager > 0
Provide_team_industry/ ORA/ teamProb	Actor > 0	Team > 0 Industry > 0
Offer_activity/ CEA/ activity	CreativeExpert > 0	Activity > 0
Select_activity/ SPA/act_sel	Activity > 0	SolverParticipant must select 1 or more Activity (s)
Creation_ideas/SPA/ind_ideas	Activity > 0	SolverParticipant must create 1 or more Idea (s)
Offer_ccmethod/CEA/col_creat_method	CreativeExpert > 0	CCMethod > 0
Select_ccmethod/SPA/col_creat_methodsel	CCMethod > 0	Team must select 1 or more CCMethod (s)
Creation_idea_cards/SPA/idea_cards	CCMethod > 0	HelpTE=True Team must create 2 IdeaCards
Improve_idea_cards/SPA/Imp_ic	Every Team must create 2 IdeaCards	IdeaCards.imprv = True
SemanticModKnow_idea_cards/SMKA/ smk_ic	All IdeaCards are improved, IdeaCards.imprv = True	PossibleSolution > 0 PossibleSolution.skm = True Lists of Semantic Lexical Relation
Classification_wd_idea_cards/WSDA/ wd_ic	PossibleSolution.skm = True Lists of Semantic Lexical Relation	PossibleSolution.wsd1 > 0 PossibleSolution.wsd2 > 0
Classification_cs_idea_cards/CSA/cs_ic	PossibleSolution.skm = True Lists of Semantic Lexical Relation	PossibleSolution.cs1 > 0 PossibleSolution.cs2 > 0
Sending_possible_solutions/SPA/sending	PossibleSolution.skm > 0 PossibleSolution.wsd1 > 0 PossibleSolution.wsd2 > 0 PossibleSolution.cs1 > 0 PossibleSolution.cs2 > 0	Send the relation of PossibleSolutions.
Receiving_possible_solutions/IMA/poss_solut		All StakeHolder could see the PossibleSolutions

Table V.30: Cycle of Life.

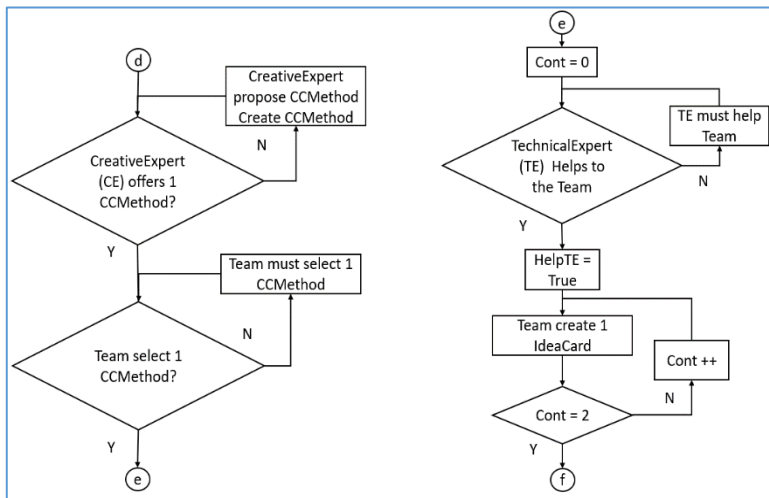
### V.4.3. Algorithms and Flowcharts:



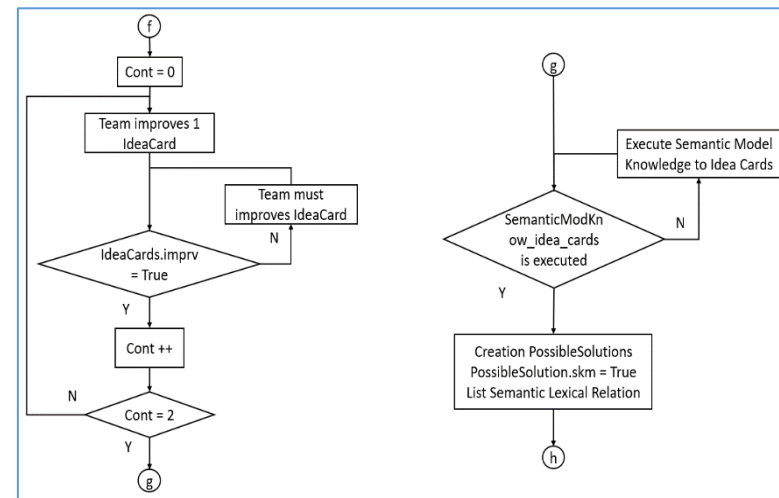
Flowchart V.1: The initials procedures



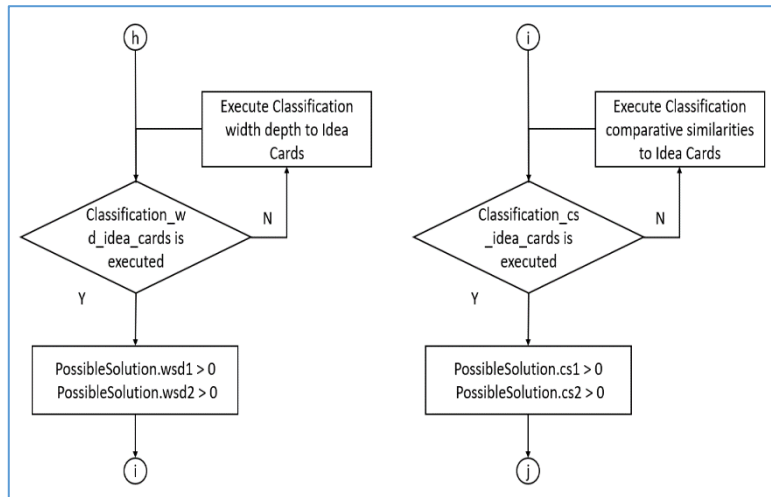
Flowchart V.2: Creation of Ideas with Activities.



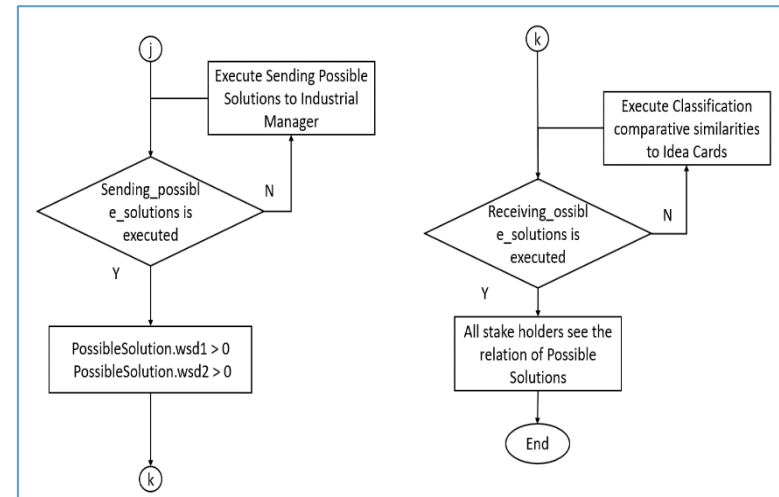
Flowchart V.3: Creation of Idea Cards with CCMMethod.



Flowchart V.4: Improving IdeaCards and the semantic Model Knowledge.



Flowchart V.5: Width, semantic distance and comparative of similarities.



Flowchart V.6: Sending Possible Solutions.

#### V.4.4. Results

The design of the system consists in the description and definition of the organizational model, the multi-agent system and the semantic approach, these form the scientific approach but also guide us to define our system:

A. The organizational model to understand the creativity workshop.

The design of a model to highlight knowledge allows us to define the organization, missions, goals, procedures, activities and finally the roles. During the design of a creativity support system, we could define the classes and relations according to the organizational model. The classes defined according to the organizational model are EventC, Actor, Industry, Roles, Organizer, IndustrialManager, CreativeExpert, TechnicalExpert, Sites, Teams, Ideas and Idea Cards.

B. Multi Agent System and implementation.

With the implementation of the multi-agent system following the GAIA model, we could define the reactive agents SKMA, WSDA and CSA, the procedures, events and the cycle of life. Knowing all these aspects, we could represent it in the design of system where the reactive agents interact with the class Idea Cards.

C. The Semantic Approach to compare Idea Cards in a creativity workshop and Ontology.

During the implementation and applying the semantic approach to manage Ideas, we use semantic lexical database WordNet 3.1 (University 2010) to define our semantic knowledge model. This semantic model, previously mentioned, describe the types of noun used to manage the idea cards, these are hyponyms, hypernym, synonym, and identic that come from the Wordnet's synset. The design of the system describes the semantic knowledge model agent (SMKA) and after this agent represent a main frontier system. The semantic approach has another two agents Width semantic distance agent and comparative similarity agent. The algorithms describe the initial procedures (*cf.* Algorithm V.1), creation of ideas (*cf.* Algorithm V.2), creation of idea cards (*cf.* Algorithm V.3), improving idea cards, the semantic knowledge model (*cf.* Algorithm V.4), width, semantic distance and comparative similarities (*cf.* Algorithm V.5), and sending possible solutions (*cf.* Algorithm V.6).

#### V.4.5. Discussions

The decision to carry out the creativity support system in three steps, such as organization model, multi-agent system and semantic approach, is due to several aspects. These aspects are to understand the organization and to learn the way to highlight knowledge, to set a multi-agent system and offer a better system to manage ideas, to give possible solutions to the industrial and to comprehend the evolution of the ideas from ideas to possible solutions.

## V.5. Semantic Approach System

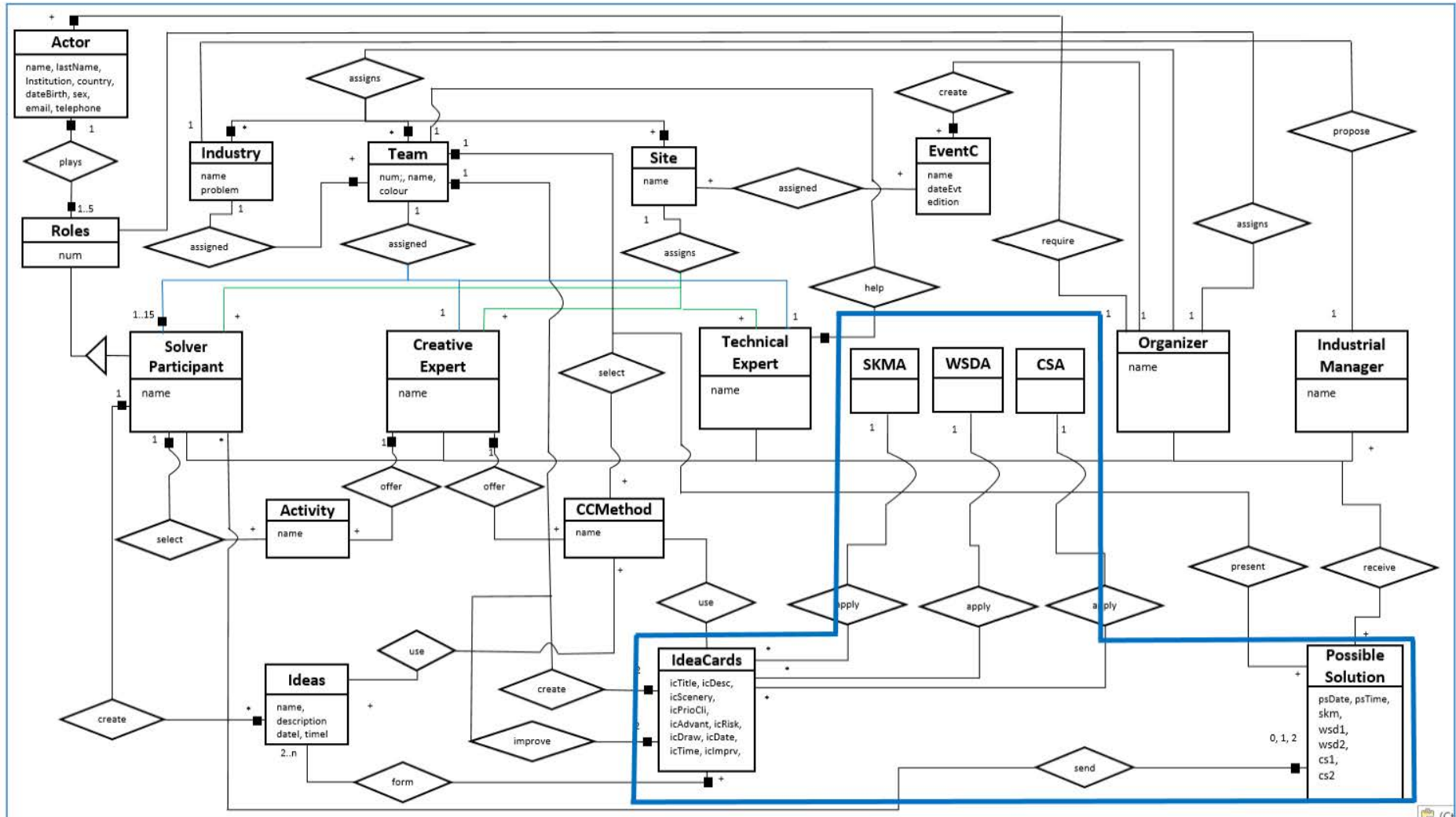


Figure V.53: Frontier for the Semantic Approach System.

## V.5.1. Implementation

### Classes and Relations:

The agents SKMA, WSDA and CSA execute the operations about semantic approach System. The SMKA is an agent that create lists using the concepts from Idea Cards, a Semantic Lexical Database and a General Semantic Process. WSDA calculate the width and semantic Distance of the Idea Cards. The CSA determines the semantic comparative among an Idea card with its predecessor and its antecessor.

The semantic approach system has defined two classes; the class IdeaCards and the class Possible Solutions.

## V.5.2. Interface Human Machine IHM: the semantic approach

### Interface Model:

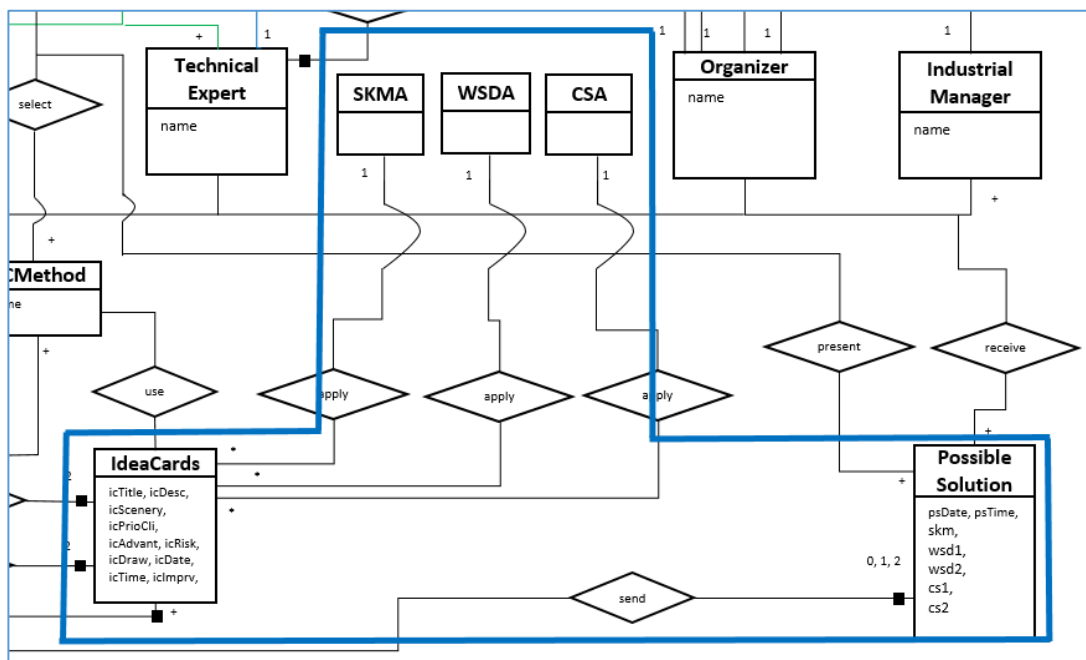


Figure V.54: Object model for semantic approach system.

The object model for semantic approach (*cf.* Figure V.54), in zoom from the semantic approach system (*cf.* Figure V.53), describes two classes (Idea Cards, Possible Solutions) and three reactive agents. The interface has three operations, the operation SemanticModKnow\_idea\_cards executed by SKMA agent, Classification\_wd\_idea\_cards executed by WSMA agent and Classification\_cs\_idea\_cards executed by CSA agent.

The dataflows that represent the procedures are improving idea cards, “the semantic knowledge model” (*cf.* Dataflow V.4), and “width, and the semantic distance and comparative similarities” (*cf.* Dataflow V.5).

We can observe that taking all concepts from the idea cards, after, using these concepts one by one, and looking for synset, we can obtain lexical semantic similarities among concepts from synonym, identic, hyponym and hypernym.



### V.5.3. Algorithms:

The semantic approach system has two important algorithms, first using “the part of Semantic Model Knowledge” (cf. Dataflow V.4) that describe the execution of this step that belong to the semantic general process and second the execution of the step to obtain depth, semantic distance and comparative similarities (cf. Dataflow V.5).

The first algorithm semantic Model knowledge, it has the initial steps of the semantic general process, step 1 to select a group of Idea Cards from the corpus, the step 2 is about the extraction of concepts from all idea cards (cf. Algorithm V.7).

```

Corpus = {I1, I2... Ix}
For each idea Ix ∈ Corpus
  For each concept ∈ idea Ix
    Cx,k ← concept | x>0 and k>0.
  End For
  Return concepts Cx,1, Cx,2... Cx,k, x>0 and k>0.
End For

Return sets of ideas, Ix = {Cx,1, Cx,2... Cx,k}, x>0 and k>0.

```

Algorithm V.7: Get the Corpus and extract the concepts.

The step 3 of the semantic general process is about to obtain the semantic concepts, path and depth from concepts of the Idea Cards by mean of Semantic Lexical Database and the step 4 to create the lists of synonyms, identic, hyponyms, hypernym and inherited hypernym (cf. Algorithm V.8).

```

// the concept Cx,k ∈ idea Ix, Cx,k is the first element of the path in the inherited hypernym (IH).
For each idea Ix ∈ Corpus
  IHx,k,1 ← Get Cx,k
  For each concept Cx,k ∈ idea Ix
    Sx,k,a ← Get synset-synonyms, 0=< a <=5
    Comment the first synset-synonym is the second element of the path in the IH.
    IHx,k,2 ← Get synset-synonym
    Itx,k,b ← Get synset-identics, 0=< b <=4
    Hx,k,c ← Get synset-hyponyms, 0=< c <=4
    HYx,k,d ← Get synset-direct-hypernym, 0=< d <=1
    For each IH concept ∈ Cx,k and e starts in 3, e=3
      IHx,k,e ← Get synset inherited-hypernym concept
      And e++
    Comment the last concept is entity for all concepts and e is the concept's depth
  End For
End For
Return concepts Sx,k,a, Itx,k,b, Hx,k,c, HYx,k,d, IHx,k,e | a>=0 and a<=5, b>=0 and b<=4, c>=0 and c<=4, d>=0 and d<=1, and e>=1.
End For

```

Algorithm V.8: To obtain semantic related concepts from the lexical database.

The algorithm to obtain the semantic distance from an idea card presents in detail their steps (cf. Algorithm V.9).

```

To get semantic distance between deeper and un-deeper concepts from the idea
For each idea Ix ∈ Corpus
Comment Cpx,k1, Cqx,k2, LCSx,k3 ∈ idea Ix, x, kn>0

```

```

Cpx, k1 ← Get the first deeper concept
Cqx, k2 ← Get the first un-deeper concept
LCSx, k3 ← Get LCS between deeper & un-deeper
d ← Get LCS's depth
Lp ← Difference between deeper's depth and d
Lq ← Difference between un-deeper's depth and d
Return SD1 (Cp, Cq) ← Get δwu-palmer's semantic distance =  $2d/(Lp+Lq+2d)$ 

```

End For

### To get semantic distance

TotalConcepts=ttlcon

For *i*=1 to 3

Comment *Cp<sub>x, i</sub>*, *Cq<sub>x, ttlcon</sub>*, *LCS<sub>x, k3</sub>* ∈ *idea I<sub>x</sub>*, *x*, *kn*>0

*d<sub>i</sub>* ← Get the depth of the *i* concept *Cp<sub>x, i</sub>*

*d<sub>ttl-con</sub>* ← Get the depth of the *ttl-con* concept *Cq<sub>x, ttlcon</sub>*

*LCS<sub>x, k3</sub>* ← Get LCS between *Cp<sub>x, i</sub>* & *Cq<sub>x, ttlcon</sub>*

*d* ← Get LCS's depth

*Lp* ← Difference between *d<sub>i</sub>* and *d*

*Lq* ← Difference between *un- d<sub>ttl-con</sub>* and *d*

*SD<sub>i</sub>* (*Cp<sub>x, i</sub>*, *Cp<sub>x, TotalConcepts</sub>*) ← Get *δwu-palmer's semantic distance<sub>i</sub>* =  $2d/(Lp+Lq+2d)$

TotalConcepts- -

*SD<sub>si</sub>* ← To add *SD<sub>i</sub>*

End For

*SD<sub>idea</sub>* ← *SD<sub>si</sub>* + *SD1* (*Cp*, *Cq*)

Return *SD<sub>idea</sub>*/4

Algorithm V.9: To obtain semantic distance.

The algorithm to calculate the width of an idea card (cf. Algorithm V.10).

```

For each idea Ix ∈ Corpus
  Comment the ideas IHx, k, e ∈ Cx, k
  For each concept Cx, k ∈ idea Ix
    IHx, k, 1, IHx, k, 2, IHx, k, 3 IHx, k, e ← Get the list of inherited hypernym concepts
  End For
  For k=4 to 10
    Widthk ← Get the number of different concepts per level
    Ideaw ← Add Widthk to the ideas' width
  End For
  Return Ideaw/7
End for

```

Algorithm V.10: To obtain Width of Idea Card.

To compare the similarity between two concepts is necessary to have all the concepts generated by the semantic knowledge model and after to verify the coincidences (cf. Algorithm V.11).

```

For1 each idea Ix, Ix2 ∈ Corpus
  Comment idea Cx, k ∈ idea Ix, idea Cx2, m ∈ idea Ix2
  Cx, k, Cx2, m ← Get two different concepts from each idea
  Get semantic lexical relation for each concept
  Sx, k, a, Sx2, m, a ← Get synset-synonyms,  $0 \leq a \leq 5$ 
  Itx, k, b, Itx2, m, b ← Get synset-identics,  $0 \leq b \leq 4$ 
  Hx, k, c, Hx2, m, c ← Get synset-hyponyms,  $0 \leq c \leq 4$ 
  HYx, k, d, HYx2, m, d ← Get synset-direct-hypernym,  $0 \leq d \leq 1$ 

```

End For

*Syn* ← Get the number of synonyms concepts among synset-synonyms  $S_{x,k,a}, S_{x2,m,a}$

*Ide* ← Get the number of identical concepts among synset-identic  $It_{x,k,b}, It_{x2,m,b}$

*Hypon* ← Get the number of hyponyms concepts among synset-hyponyms  $H_{x,k,c}, H_{x2,m,c}$

*Hyper* ← Get the number of direct hypernym concepts among synset-direct hypernym  $HY_{x,k,d}, HY_{x2,m,d}$

Return *Syn, Ide, Hypon, Hyper*

Algorithm V.11: To match concepts from different Idea Cards.

#### V.5.4. Results

In the application of the Semantic Approach to compare Idea Cards in a creativity workshop:

We can observe that taking all concepts from ten idea cards and using the semantic knowledge model we could manage our idea cards. Taking concepts with respect to inherited hypernym, we could observe in semantic distance among the concepts of an idea, an aspect, there is not similar quantities and the difference between the first and the last position is 0.031 with respect to semantic Distance among idea cards higher 0.1404 and 0.1089.

With respect to width, the difference between the highest 11.1428 and the lowest 3 is 8.14. Finally, we think that we could order our idea cards in three aspects, first by semantic distance, second by width and third by similarities, the comparative between two idea cards has values between zero and one, it uses the semantic distance among concepts from different idea cards.

##### A. List of concepts

The second action is the construction of a list with the inherited hypernym, this list represents the path of every concept from itself to entity that is the root for all concepts using the semantic lexical database Wordnet 3.0 (*cf.* Table V.31). Having the lists of concepts for all idea cards, we could calculate the depth and semantic distance from every idea card and make comparative using it.

##### B. Comparative of Idea Cards A-B

The comparative between two idea cards using the semantic distance among every concept from the idea card A against the idea cards' concepts of B, the maximum semantic distance value is 1. We get the semantic distance's average per concept at the end and average total (*cf.* Table V.32).

Looking for a higher average in the comparative between two idea cards, we found that the idea card 44 with the idea card 90 (with initial match concepts 3-5) from the corpus have an average of similarity according to the semantic distance of 0.5. In addition, the idea card 43 with 44 (with initial match concepts 5-6) have an average of 0.54. These idea cards have in average 5 initial match concepts.

We take in account these comparative of idea cards according to the coincidence of initial concepts of 30 idea cards, the first 1-10 and after the prime number idea card, if the idea card is empty or with errors then take another idea card, working with 100 idea cards (*cf.* Table V.33). Some pairs of Idea cards with any match have average of 0.4 like idea cards (5-8) and (5-53).

Show Synset (semantic) relations											
Num-noun	1	2	3	4	5	6	7	8	9	10	11
Q-synsets (C	0	0	0	0	0	0	0	0	0	0	0
Q-SameDef (	0	0	0	0	0	0	0	0	0	0	0
Q-Direct Hyp	0	0	0	0	0	0	0	0	0	0	0
Q-Inh hyper	8	10	9	9	8	9	15	6	6	11	7
15							human				
14							homo				
13							hominid				
12							primate				
11							placental		mammal		
10	cortex						mammal		mammalian		
9	cerebral cort	gyrus	hippocampi		horn	vertebrate			vertebrate		
8	brain	neopallium	convolution	hippocampus	hippocampus	noisemaker			chordate		
7	neural struct	neural struct	frontal gyrus	neural struct	neural struct	device	animal		animal	memory	
6	structure	structure	structure	structure	structure	instrumenta	organism	information	lobe	organism	representation
5	body part	body part	body part	body part	body part	artifact	living thing	info	body part	living thing	content
4	part	part	part	part	part	whole	whole	message	part	whole	cognition
3	thing	thing	thing	thing	thing	object	object	communicat	thing	object	psychological fee
2	physical enti	physical enti	physical enti	physical enti	physical enti	physical enti	physical enti	abstraction	physical enti	physical enti	abstraction
1	entity	entity	entity	entity	entity	entity	entity	entity	entity	entity	entity
Semantic Distance			Pair	Semantic Distance Cp, Cq	LCS	d	Lp	Lq	SD-WuPalmer	Avg-WuPalmer	
SD-WuPalmer(Cp, Cq)=2d/(lp+lq+2d)			1	human	part	entity	1	14	4	0,1	0,113439542
			2	brain	vertebrate	physical enti	2	6	7	0,11764706	
			3	cortex	system	physical enti	2	8	6	0,11111111	
			4	gyrus	surface	physical enti	2	7	5	0,125	
TTL-concepts	21										
Concept dep	15	human									
Concept de	5	part	1	2	3	4	5	6	7	8	9
width level	10	4	cortex	mammal	mammalian	clergyman					
	9	6	cerebral cort	gyrus	hippocampi	horn	vertebrate	spiritual leader			
	8	7	brain	neopallium	convolution	hippocampus	noisemaker	chordate	leader		
	7	7	neural struct	frontal gyrus	device	animal	memory	person	system		
	6	9	structure	instrumenta	organism	information	lobe	representati	side	surface	instrumentality
	5	7	body part	artifact	living thing	info	content	part	region		
	4	6	part	whole	message	cognition	portion	location			
AVG Depth	6,57142857										

Table V.31: List of concepts, depth and semantic distance.

Q-Inh hyper (IH)	4	9	5	8	9	10				SD-WuPalmer(Cp, Cq)=2d/(lp+lq+2d)							concept	ALL CONCEPTS					
15	event	farmer	network	platform	social	supplier				ID5	dist p	ID8	dist q	LCS	dLCS	Lp	Lq	SD-WuP	Avg-WuPalmer	AVG ALL	AVG HIGH		
14										event	4	building	7	entity	1	3	6	0,18182	0,666666667	0,303102	0,59688109	0,4	
13										farmer	9	condition	5	abstraction	2	2	3	0,44444					
12										network	5	course	8	event	4	0	4	0,66667					
11										platform	8	cycle	5	abstraction	2	2	3	0,44444					
10						supplier				social	9	farming	13	event	4	0	9	0,47059					
9		farmer			social	businessperson				supplier	10	fish	11	entity	1	3	10	0,13333					
8		creator		platform	sociable	capitalist					0	natural	9	entity	1	3	8	0,15385					
7		person		horizontal su	party	person					0	structure	6	entity	1	3	5	0,2					
6		organism		surface	social gather	organism												0,33689					
5		living thing	network	artifact	gathering	living thing				ID5	dist p	ID8	dist q	LCS	dLCS	Lp	Lq	SD-WuP	Avg-WuPalmer				
4	event	whole	system	whole	social group	whole				event	4	building	7	whole	4	5	3	0,5	0,777777778				
3	psychological	object	group	object	group	object				farmer	9	condition	5	entity	1	8	4	0,14286					
2	abstraction	physical entity	abstraction	physical entity	abstraction	physical entity				network	5	course	8	entity	1	8	7	0,11765					
1	entity	entity	entity	entity	entity	entity				platform	8	cycle	5	entity	1	8	4	0,14286					
Q-Inh hyper (IH)	7	5	8	5	13	11	9	6		social	9	farming	13	entity	1	8	12	0,09091					
15	building	condition	course	cycle	farming	fish	natural	structure		supplier	10	fish	11	organism	5	3	5	0,6					
14											0	natural	9	person	7	2	2	0,77778					
13					farming						0	structure	6	whole	4	5	2	0,53333					
12					cultivation													0,36317					
11					production	fish				ID5	dist p	ID8	dist q	LCS	dLCS	Lp	Lq	SD-WuP	Avg-WuPalmer				
10					industry	aquatic vertebrate				event	4	building	7	entity	1	4	6	0,16667	0,4				
9					commercial	vertebrate	natural			farmer	9	condition	5	abstraction	2	3	3	0,4					
8			course		commerce	chordate	achiever			network	5	course	8	abstraction	2	3	6	0,30769					
7	building		education		transaction	animal	person			platform	8	cycle	5	abstraction	2	3	3	0,4					
6	structure		activity		group action	organism	organism	structure		social	9	farming	13	abstraction	2	3	11	0,22222					
5	artifact	condition	act	cycle	act	living thing	living thing	artifact		supplier	10	fish	11	entity	1	4	10	0,125					
4	whole	state	event	time interval	event	whole	whole	whole			0	natural	9	entity	1	4	8	0,14286					
3	object	attribute	psychological	measure	psychological	object	object	object			0	structure	6	entity	1	4	5	0,18182					
2	physical entity	abstraction	abstraction	abstraction	abstraction	physical entity	physical entity	physical entity										0,24328					
1	entity	entity	entity	entity	entity	entity	entity	entity		ID5	dist p	ID8	dist q	LCS	dLCS	Lp	Lq	SD-WuP	Avg-WuPalmer				
										event	4	building	7	artifact	5	3	2	0,66667	0,714285714				

Table V.32: Comparative using semantic distance between 2 idea cards.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
	1	2	3	4	5	6	7	8	9	10	11	13	17	19	22	23	29	31	33	37	41	43	44	47	53	57	67	85	90	99
1	animal	banana	air	balance	events	animal	button	building	agriculture	aerator	arboricult	agrimousse	accessory	farmer	culture	animal	area	data	boat	control	aim	air	concentrat	autonomy	communicat	drone	burner	arm	concentrat	cropping
2	bar code	concept	cabin	base	farmer	cattle	crop	condition	bottom	air	area	agrofoam	air	limit	disease	couch	base	farmer	camper	device	air	analyser	data	battery	dashboard	fibers	dust	back	data	design
3	birth	degree	collection	beach	idea	considerati	culture	course	capacity	crack	bar	developme	appearanc	order	drone	crop	drone	maintenan	car	diseminat	analysis	bacteria	fertilizer	contamina	kind	flower	energy	connection	mineral	device
4	card	detector	comfort	cab	network	drone	diode	cycle	city	cylinder	branch	fertilizer	application	planing	flying	culture	herbicide	mineral	concept	dispenser	atmospher	climate	field	data	mail	period	engine	counter-we	moisture	field
5	database	drone	compartm	cabin	platform	end	field	farming	fruits	fertilizer	breeding	foam	cabin	point	outbreak	drone	parcel	nutrient	environme	ecology	bacteria	computer	informatio	description	networking	place	fuel	device	sensor	harvesti
6	date	ethylene	conveyor	center	social	energy	floor	fish	land	ground	combine	goal	client	replenish	sensor	field	pass	precision	fall	effect	box	data	metal	efectivenes	phone	pollen	particulate	ground	soil	line
7	device	fruit	data	cockpit	supplier	farmer	harvestin	natural	nutrient	impeller	corn	ocean	consumpti	retail	signal	flock	pesticide	rate	farm	example	catalysis	database	network	equipment	tablet	pollinatio	role	height	system	module
8	DNA	gas	direction	correction		fence	humidity	structure	parasite	interior	cutter	part	consession	stock	threat	hail	pieces	sensor	garden	fertilizer	desease	decision	position	fertilizer	tractor		source	pillar	unit	operatio
9	farming	harvest	fertilizer	cylinder		field	measurement	plant	peak	cutting	product	criteria	system	user	laser	plant	soil	germinatio	field	detection	drone	rate	field			system	pressure		printer	
10	health	maturity	flying	descent		function	middle		roof	propulsion	farming	quality	customer		wheat	livestock	product	treatment	herb	government	example	field	sending	loading		waste	rail		rail	
11	location	molecule	function	dynamic		innovation	monitor		space	soil	grain	seed	database			load	reserve		kit	health	field	flying	sensor	mole			rams		scatterin	
12	meet	plots	hand	gravity		intrusion	pipes		spring	spike	harvestin	sodium	fuel		mission	servin		land	idea	objective	fungi	soil	objectives				soil		side	
13	product	process	interface	inclination		issues	plantation		stage	hoof	studies	hardware			speed	surface		land	machinery	photo	hygrometry	technique	parcel				span		sowing	
14	system	sensor	people	machine		line	sensor		structure	infra	vegetable	information			spreading	tanker		plant	offer	picture	informatio	temperatur	platform				system	picture	system	
15	trace	target	pesticide	mobile		motor	status		system	jet	water	innovation			task			production	partnership	plant	insects	water	pollution				tractor			
16	tracking	time	propeller	position		pest	system		water	laser	possibility	installation			user			region	pesticide	presence	pathogenic		process				utility			
17	type	vegetable	propulsio	rapid		purpose	temperature				machine		item					roof	purchase	principle	pollution		robot							
18			radio	response		transmitter	value				plant		machine					season	taxes	reaction	problem		surface							
19			seat	servo		ultrasound					pressure		model					spring		sample	quality		world							
20			system	short							shear		modelling					trailer		sampling	real time									
21			task	slope							space		modernization					truck		solution	sample									
22			tool	system							system		need					vehicles		test	sensor									
23			tractor	time							tank		outlet					water			statistics									
24				tractor							technique		possibility					week			system									
25											technology		power								technic									
26											tool		radio								treatment									
27											tree		reorganization								understanding									
28											ultrasound		result																	
29											ultraviolet		retailer																	
30											use		screen																	
31											viticulture		software																	
32											water		space																	
33											wheat		system																	
34													tool																	
35													tractor																	
36													vision																	
37																														
38																														

Table V.33: Comparative of initial concepts from 30 idea cards.

### V.5.5. Discussions

We take the decision to compare idea cards using semantic distance, width and similarity. The combination of these characteristics is an aspect of the creativity. To get these characteristics, we use a semantic knowledge model. We utilize a semantic lexical database to obtain the group of concepts related to the main concept and with this group of concepts; we determine the width and semantic distance of an idea card. The semantic distance between two concepts from different idea cards or the semantic distance between two concepts from the same idea card, and to calculate the semantic similarity of two idea cards using the average of semantic distance among idea card's concepts.

## V.6. From Knowledge to Annotation System

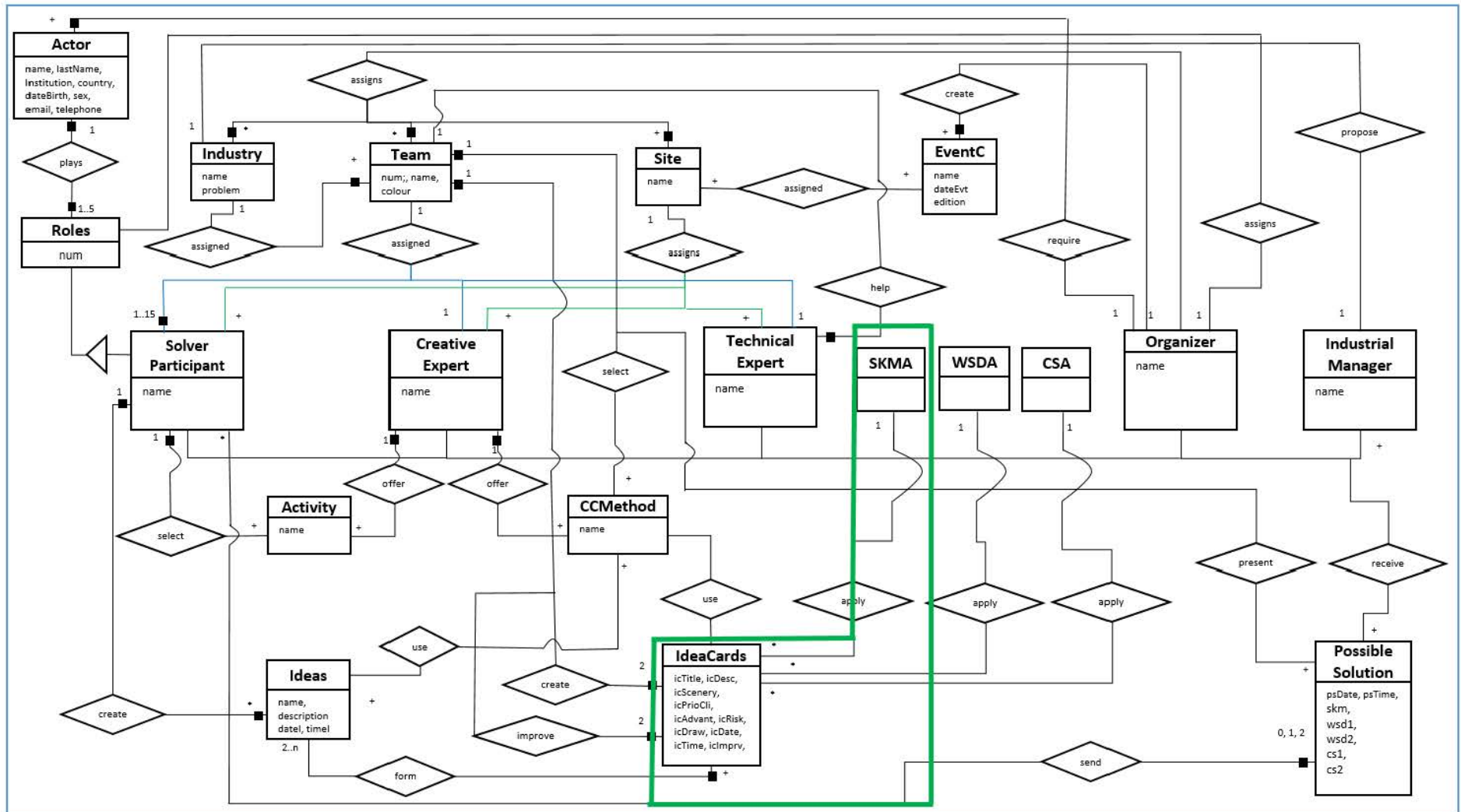


Figure V.55: Frontier of Semantic Knowledge Model System.



## V.6.1. Implementation

### Classes and relations:

The agents SKMA execute the operations about “From knowledge to annotation system”. The SMKA is an agent that create lists using concepts from Idea Cards, a Semantic Lexical Database and a General Semantic Process. The class used is IdeaCards.

### I.1.1. Interface Human Machine IHM: the semantic concepts

#### Interface Model:

The interface has the semantic knowledge agent (*cf.* Figure V.56) from frontier of semantic knowledge model system (*cf.* Figure V.55) and the class IdeaCards. The agent appears in the operation semantic knowledge model of idea cards “SemanticModKnow\_idea\_cards” during the cycle of life (*cf.* Table V.30) at the end of the operation the event *wsd\_ic* will be sent to next agent WSDA width semantic distance agent.

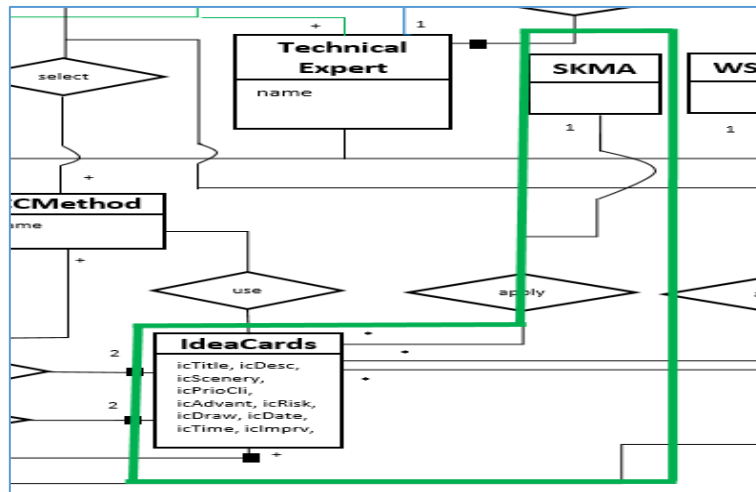


Figure V.56: Object model for “from knowledge to annotation” system.

During this operation, the semantic knowledge model takes place every concept produces relatives-concepts according to it.

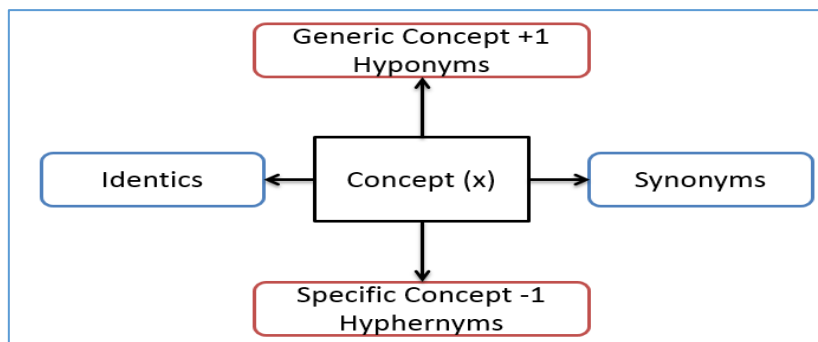


Figure V.57: Semantic knowledge model.

The semantic knowledge model gives us the relation of the concept that we take in account having support of a semantic lexical database. At the same level of the concept are identic and synonym. Hyponym places the superior level and the inferior level by hypernym (*cf.* Figure V.57).

## V.6.2. Algorithm

The dataflow “Improving idea cards and semantic knowledge model” (cf. Dataflow V.4), “Get the corpus and extract the concepts” (cf. Algorithm V.7), and “To obtain semantic related concepts from the lexical databases” (cf. Algorithm V.8) express the steps in detail.

## V.6.3. Results

There are two initial action with the data from the semantic lexical database.

### A. First action

The first, the comparative among concepts (concepts and concepts produced by the semantic knowledge model) from different idea cards (ten idea cards) give us a minimal percentage of similarity among idea card’s concepts. The test executed takes five synonyms, four identics, four hyponyms and one hypernym (direct).

IDEAS	1	2	3	4	5	6	7	8	9	10	suma
1	1	0	1	1	0	1	1	1	0	0	5
2	0	1	0	1	0	1	0	0	0	0	2
3	1	0	1	3	0	0	1	0	0	3	8
4	1	1	3	1	0	0	1	0	0	1	7
5	0	0	0	0	1	1	0	0	0	0	1
6	1	1	0	0	1	1	1	0	0	0	4
7	1	0	1	1	0	1	1	0	0	0	4
8	1	0	0	0	0	0	0	1	1	0	2
9	0	0	0	0	0	0	0	1	1	0	1
10	0	0	3	1	0	0	0	0	0	0	4
Suma	5	2	8	7	1	4	4	2	1	4	38

Table V.34: Match of concept from 10 idea cards.

The average of the idea card’s concepts is 16.8 with 168 concepts; there are 38-matches maximum among the concepts of two idea cards (cf. Table V.34). That is a minimal quantity considering all concepts (from ten idea cards).

IDEAS	1	2	3	4	5	6	7	8	9	10	suma
1		0	5	6	0	1	5	2	2	1	22
2	0		0	5	0	5	5	0	3	0	18
3	5	0		8	0	5	5	0	1	8	32
4	6	5	8		0	1	7	1	0	2	30
5	0	0	0	0		3	0	0	0	0	3
6	1	5	5	1	3		5	1	0	0	21
7	5	5	5	7	0	5		0	0	0	27
8	2	0	0	1	0	1	0		5	1	10
9	2	3	1	0	0	0	0	5		1	12
10	1	0	8	2	0	0	0	1	1		13
Suma	22	18	32	30	3	21	27	10	12	13	188

Table V.35: Match of synonym from 10 idea cards.

IDEAS	1	2	3	4	5	6	7	8	9	10	suma
1		0	1	1	0	3	1	3	1	0	10
2	0		0	2	0	1	3	0	1	0	7
3	1	0		4	0	4	1	0	0	4	14
4	1	2	4		0	0	5	0	0	0	12
5	0	0	0	0		4	0	0	0	0	4
6	3	1	4	0	4		1	0	0	0	13
7	1	3	1	5	0	1		1	0	0	12
8	3	0	0	0	0	0	1		3	0	7
9	1	1	0	0	0	0	0	3		1	6
10	0	0	4	0	0	0	0	0	1		5
Suma	10	7	14	12	4	13	12	7	6	5	90

Table V.36: Match of identical from 10 idea cards.

IDEAS	1	2	3	4	5	6	7	8	9	10	suma
1		0	4	4	0	3	4	3	0	0	18
2	0		0	0	0	0	4	0	3	0	7
3	4	0		7	0	4	4	0	0	6	25
4	4	0	7		0	0	8	0	0	2	21
5	0	0	0	0		4	0	0	0	0	4
6	3	0	4	0	4		5	1	0	0	17
7	4	4	4	8	0	5		0	0	0	25
8	3	0	0	0	0	1	0		4	0	8
9	0	3	0	0	0	0	0	4		1	8
10	0	0	6	2	0	0	0	0	1		9
Suma	18	7	25	21	4	17	25	8	8	9	142

Table V.37: Match of hyponym from 10 idea cards.

IDEAS	1	2	3	4	5	6	7	8	9	10	suma
1		0	1	1	0	1	1	1	1	1	7
2	0		0	2	0	1	1	0	1	0	5
3	1	0		3	0	2	1	0	0	3	10
4	1	2	3		0	1	3	0	0	1	11
5	0	0	0	0		1	1	0	0	0	2
6	1	1	2	1	1		1	0	1	0	8
7	1	1	1	3	1	1		0	0	0	8
8	1	0	0	0	0	0	0		1	0	2
9	1	1	0	0	0	1	0	1		0	4
10	1	0	3	1	0	0	0	0	0		5
Suma	7	5	10	11	2	8	8	2	4	5	62

Table V.38: Match of hypernym direct from 10 idea cards.

## B. Second action

The second action is to do a comparative among the synonyms, identics, hyponym and hypernym direct.

The match in synonyms 188, identics 90, hyponym 142, hypernym 62; these quantities are minimal considering the average in the total quantity of concepts, 494 synonyms, 307 identics, 418 hyponym and 154 hypernym direct (*cf.* Table V.35, 36, 37, 38).

### V.6.4. Discussions

To get the characteristic of every concept, we work with a semantic knowledge model that use a concept to determine several concepts related to it with respect to synonym, hypernym direct, inherited hypernym, hyponym and concept identic. We decide to use the inherited hypernym to calculate the semantic distance and to produce a graphe that stand the path from the concept to the root (the word entity). The graphe is translated to a list in order to obtain the semantic distance and width. Synonyms, hypernym direct, hyponym and identic help us to calculate the comparative similarity.

## V.7. Conclusion: the Global Frontiers of the Systems

The global frontiers of the system (*cf.* Figure V.58) offers a clear view about the different systems that form the creative workshop 48H in thin blue. The organizational model system in red, the semantic approach system in dark blue, and the semantic knowledge model in green.

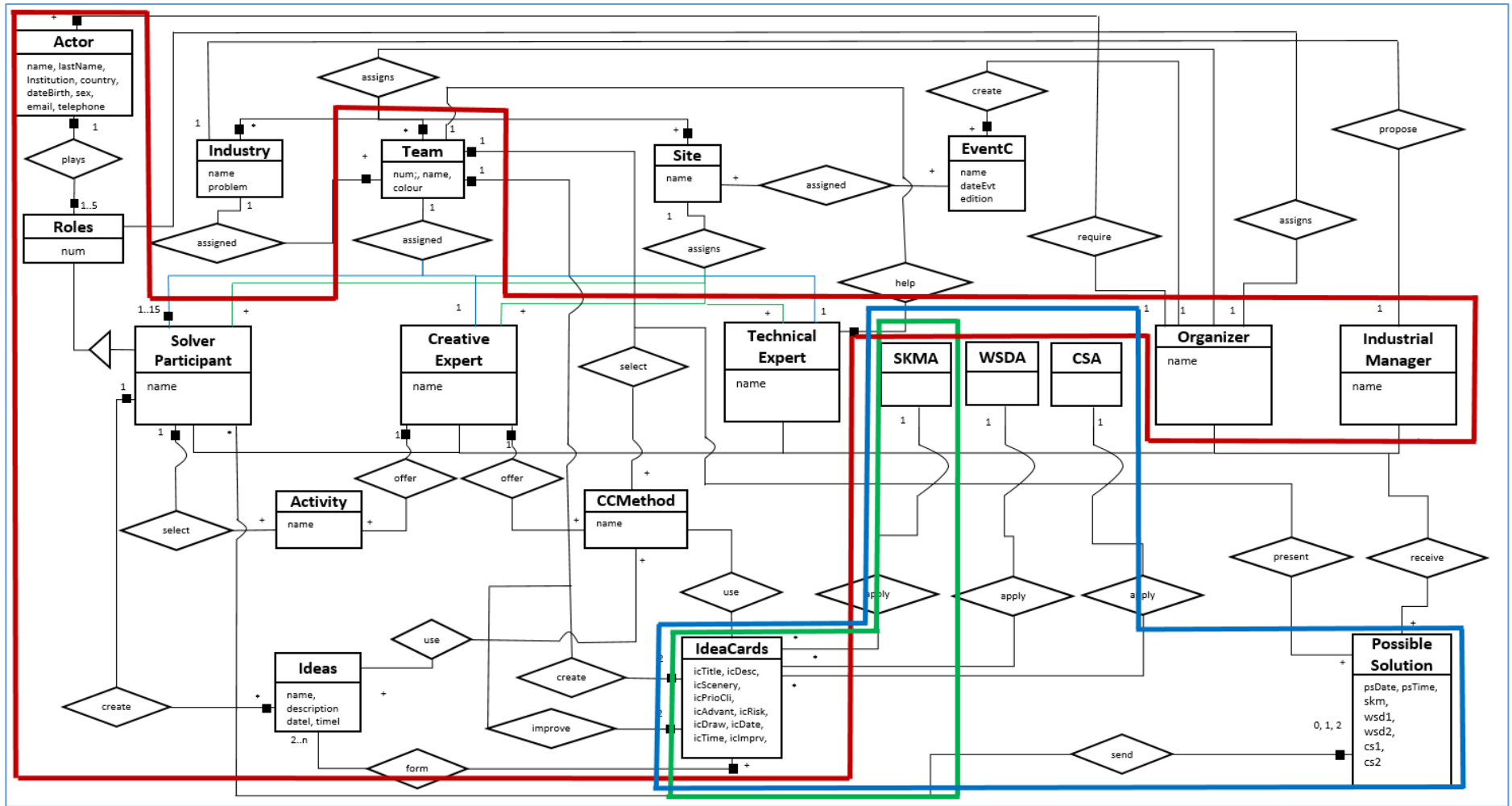


Figure V.58: The Global Frontiers of the system.

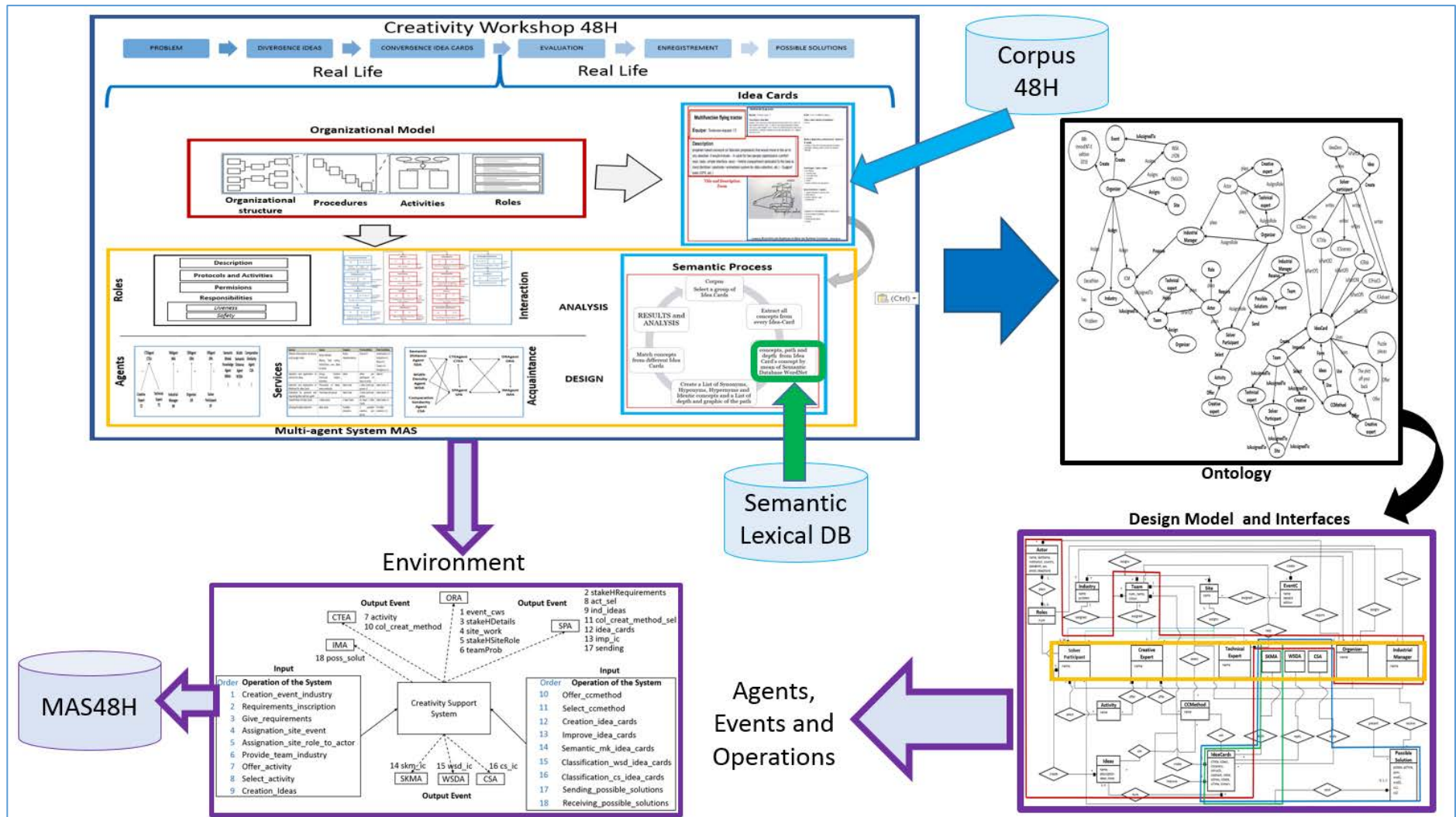


Figure V.59: The Global system architecture.

## **The global system architecture**

### A. The global system Architecture in blue thin line

The architecture of the creativity workshop 48 H (cf. Figure V.59) exposes their steps part of the 48H's process, which is the source of this work, the organizational model, the multi-agent system, ontology, and design model and interfaces.

### B. The creativity workshop in blue

The creativity workshop 48 H exposes their elements; needs, ideas, creativity and innovation that are the steps part of the 48H's process.

### C. The organizational model in red

This model shows the organizational structure, process, activities and roles using the organizational model KROM to understand the human organization; initially defining missions, goals and procedures and finally to explain how to produce idea cards and highlight knowledge.

### D. The multi-agent system in orange

The multi-agent system presents the analysis and design describing roles and their interaction after agents, services and the acquaintance among agents.

### E. The semantic approach system in light blue

The semantic approach system process offers a way to classify and compare idea cards by mean of the corpus where we obtain the idea cards and a semantic process to extract concepts from the idea cards, to obtain semantic lexical concepts, create list according to the semantic knowledge model. With the lists that represent the semantic of idea cards then calculate semantic distance, depth, make the comparatives and get results to analysis. The semantic approach system has two external databases that help giving the data about corpus of idea cards and data from a semantic lexical database.

### F. From knowledge to annotation system in green

The production of semantic lexical concept derivate from every simple concept, it is carries out inside the semantic approach system. It utilizes a semantic knowledge model to obtain the concepts related to every concept according to hyponyms, hypernyms, synonyms, identic and inherited hypernym and using a semantic lexical database that gives the data required by semantic knowledge model such as synonym, identic, hyponyms, hypernym and inherited hypernym.

### G. Ontology in black

It gives us the representation of the reality by mean of graphs and arrows using triplets with the purpose that computer can understanding it. These triplets describe subject verb and object.

### H. Design Model and Interfaces in purple

The design model explains the classes and relations among these classes, it helps us to describe in detail the cycle of life of the creativity workshop 48H and the procedures, methods, agents that are interacting with the environment.

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# General Conclusion of Thesis

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## Topics of General Conclusion of the thesis

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<b>1</b>	<b><u>Contributions and Perspectives</u></b> .....	<b>157</b>
	<b><u>Contributions</u></b> .....	<b>157</b>
	<b><u>Perspectives</u></b> .....	<b>160</b>

# 1 Contributions and Perspectives

The objective of this chapter is to present a global conclusion of our research and also the contributions and the perspectives.

## Contributions

Our thesis contributes to design an intelligent system to support creativity and innovation Process. The manuscript of the thesis consists of five chapters. They are devoted to describe our **challenges**, **hypothesis** and the process to achieve our mission and to complete our thesis with opinions and contributions. These chapters answer to three essential scientific issues :

- (i) How to identify the knowledge and ideas created during the creativity workshops? We have proposed to model the creativity workshops with an organizational point of view in order to highlight the processes, activities, roles, knowledge and ideas created during the event.
- (ii) How to design an Intelligent system to support the ideas management during the creativity workshop? We have proposed to design a multi agent system based on the organizational model in order to collect, manage and share the ideas during the creativity workshops.
- (iii) How to structure knowledge and ideas of the creativity workshops? We have proposed to build an ontology to structure the concepts and the relationships related to the creativity workshops and modeled in the organizational model.
- (iv) How to compare, cluster and evaluate the ideas during the creativity workshop? We have proposed a semantic approach and an annotation process.

## The Organizational model to understand the creativity workshop

Our contribution is to offer an approach to model knowledge by using an organizational meta-model called KROM (Knowledge Reuse Organizational Meta-Model) facilitates the **understanding of the collaboration** among roles and **highlights knowledge** by mean of individual activities and collaborative creative methods. This organizational model helps us to define the organizational structure, processes, activities and roles with their characteristics.

The organizational structure inside the creativity workshop requires to define the processes, goal and mission of the actors and roles during the creativity workshops. The description of these processes and activities impulse the identification of knowledge. In the creativity workshops, processes and activities manage information that flows as an input data and after as output result.

As a result of the organizational model, we obtain:

Five roles such as Organizer, Technical Expert, Industrial Manager, Creative Expert and Solver Participant.

Five processes like "To seek a topic", "To enroll students", "To create collaborative groups", "Collaboration and creation" and "To show physic representation".

The activities generated are 14, "To talk with Industrial Manager", "To capture the Industry and Topic in the 48H platform", "To capture the Industrial Manager and talk about

Technical Expert”, “To invite students form institutions and universities to the 48H event”, “To capture data of students”, “To form collaborative group according to near institutions and with students of different domains”, “To assign site, industrial problem and colour to the group”, “Domain discovery, meeting group”, “Collaborative and creative method, trust atmosphere”, “To write Idea Cards”, “To share idea cards”, “Select innovative ideas by mean of voted system”, “To develop a presentation for each idea card”, “to present at least one idea card to the jury”.

The knowledge (33) are missions, goals, processes, date of the event, schedule, place of the event, industry name, industry problem, previous topic, activities to generate ideas, ideas, to know the platform 48H (address, login, password), inscription key, inscription process, the group report, team or group, collaborative creative methods, idea cards, number and name of the idea card, idea card’s fields (team, description, schema, Topic, priority clients, Scenery of use, advantages, risks, competences), to know the voted system, To know how to visualize other Idea Cards.

## **MAS**

The objective of the multiagent system is to assist the management of ideas during a creativity workshop.

The definition of an intelligent system contains the analysis and design, the first has the role model and interaction model; so, both models contribute to the description of role, protocols, activities, permissions, liveness, safety and interactions for each role such as organizer, solver participant, industrial manager, technical expert and creative expert. With respect to the design, three models define the behavior of the agents, the service offered and the communication among agents.

The multi agent system is composed by reactive and cognitive agents. Four cognitive agents like Creative Technical Expert Agent (CTEA), Industrial Manager Agent (IMA), Organizational Agent (ORA), and Solver Participant Agent (SPA). Three reactive agents as Semantic Model Knowledge Agent (SMKA), Width Semantic Distance Agent (WSDA) and Comparative Similarity Agent (CSA).

A model of roles describes the task of the agents. An interaction model specifies the communication between the agents. In the interaction model, the protocols illustrate the input and output information through every protocol, and the agents and their roles that process this information. The model of roles describes the information activities. We design three reactive agents. The missions of the agent are to obtain the semantic knowledge concepts, to calculate the semantic distance and width and to execute the comparative similarity among idea cards. These complex actions will be executed by these reactive agents (SW) to improve the task of the human being in the CWS 48H.

The objective of the four cognitive agents (Creative Technical Expert Agent (CTEA), Industrial Manager Agent (IMA), Organizational Agent (ORA), and Solver Participant Agent (SPA)) is to manage the idea cards. The CTEA has 3 main functions, to propose activities to the team to generate ideas, to propose collaborative creative methods to the team to foster the production of idea cards and to help to the team to define characteristics of the idea card. The IMA proposes the industry with an industrial problem and to choose the probable solutions. The ORA creates the event and assigns institution, industry, role, team and problem to the actor. The SPA produces thousands of ideas and idea cards.

## **Ontology**

We have proposed an ontology called Collaborative Creative Ideas (CCIDEAS) to structure knowledge during the creativity workshops. We have used the organizational model to identify the concepts we want to structure in the ontology.

The ontology represents the environment inside the creativity workshop 48 hours with special focus in concepts and relations among them. Our ontology is based on the organizational model and multi-agent system where role, agents, processes, missions, goals, interactions services, acquaintances, activities, collaborative creative methods, ideas, idea cards and possible solutions support and impulse the creation of concepts and relations of our ontology. The definition of domains, concepts and relations are the principal elements to create our graphic representation of our environment and to represent this environment towards the computer by mean of triplets to represent graphically all relations using the subject, predicate and object.

The concepts Idea Card has ten relationships with every element of the idea card (ICDesc, ICTitle, ICScenery, ICRisk, ICPrioCli and ICAdvant), Team, Idea and CCMethod. The concept Idea has two relationships with IdeaDesc and with Solver Participant. The concept Possible Solutions has relationships with Team, Industrial Manager and Solver Participant.

According with the roles, the concept Organizer has relations with Event, Site, Industry, Actor, Team, Creative Expert, Technical Expert, Industrial Manager and Solver Participant. The concept Solver Participant has relationships with Actor, Possible Solutions, Organizer, Activity, Idea, IdeaDesc, ICTitle, ICScenery, ICRisk, ICPrioCli and ICAdvant, Team. Creative Expert has relationships with Actor, Organizer, Activity, CCMethod. Technical Expert has relationships with Actor, Organizer and Team. Finally, Industrial Manager has relationships with Industry, Actor, Organizer and Possible Solutions.

Our ontology defines 25 concepts and 34 Relations. Some concepts are Activity, Actor, Collaborative creative method, Event, Idea, IdeaDesc, IdeaCard, ICTitle, ICScenery, ICRisk, ICPrioCli, ICAdvant, Industry, Problem, Role, Site, Team, Vocabulary, Organizer, SolverParticipant, Creative Expert, Technical Expert, Industrial Manager and Possible Solutions; and relations such as Select, Offers, Plays, Assign, Propose, Create, Assign, Require, Help, IsAssignedTo, Receive, IsPartOf, Send, Present, Improved, Use, Form, IsPartOf.

The utilized syntax, the tools to validate and to create the graph and other syntax, were used in the construction of triplets. The documentation benefits the understanding of every concept and relationship.

## **Semantic Approach**

We have developed a semantic approach to compare and evaluate the idea cards and possible solutions. We extract the concepts inside the Idea Card, and we use the lexical database to associated synonyms, hypernyms and hyponyms. With these groups of concepts and their semantic relationships we obtain graphs. We could calculate and compare each graph of concepts with semantic distance algorithms.

## Perspectives

### **Perspectives in the organizational model to understand creativity workshop.**

Our organizational model to understand creativity workshop depends completely of the model KROM, all processes and activities are result of this model, although it is not a limitation, we might use other models and compare their organizational structure and the production of knowledge inside our creativity workshop CWS 48H.

The final product in the CWS is the idea card that contains heterogeneous fields, during this research, we were focus only in textual information, an attractive challenge will be to start the analysis in the comparative of images, mainly, how to manage the idea cards with respect to their images or maybe sounds and video.

### **Perspective in an intelligent system by developing an annotation process.**

The methodology GAIA is used to obtain our multi-agent based system in our CWS. Our Multi Agent system is design to assist the creativity workshops participants in their activities during the workshop. Our first work was to design agents to manage ideas. One of the perspectives will be to design other agents to assist all the participants of the creativity workshop such as the technical expert or the creativity expert. The agent could bring information to help them to choose the best creativity technics to apply with the group of participants.

### **Perspectives in the semantic approach to compare idea cards.**

In our semantic approach to compare idea cards, we take in account concepts from the idea cards, however, a better approach would be to take in account complete phrases with subject, verb object.

A more complete approach will be to take in account the heterogeneous fields of the idea card, with this vision we could manage our idea cards according to the text, image, video or sound, a huge challenge in the future.

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# Publications

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1<sup>st</sup>. paper published: In conference paper reference: An Organizational Model to Understand the Creativity Workshop. Pedro Chavez Barrios, Davy Monticolo, Sahbi Sidhom, Alex Gabriel; The 13th International Conference on SIGNAL IMAGE TECHNOLOGY & INTERNET BASED SYSTEMS, Dec 2017, Jaipur, India.

**Abstract:**

There is a great interest in developing and using creativity in our society. We observe that industry and educative centers organize creativity workshops in order to solve problems. Creativity workshops have primordial elements such as creative solvers, creative supporters, and some activities to generate ideas. Their objectives are to apply creativity methods to generate ideas. The ideas generation process is a collaborative process among different activities (ideas creation, clustering, evaluation, etc.) and among participants that have different roles, point of view and experiences. We consider each activity as an organization where participants work together to achieve a common goal which is the idea generation. We propose in this paper to use an organizational approach to model the idea management process from the interaction among the roles during all the creativity activities.

2<sup>nd</sup>. paper published: Gabriel A., Chavez P., and Monticolo D. Methodology to design ontologies from organizational models: application to creativity workshops, Artificial Intelligence for Engineering Design, Analysis and Manufacturing (AIEDAM), accepted in March 2019.

**Abstract:**

Innovation and creativity are a mandatory for companies who wish to stay competitive. In order to promote an inventive dynamic, it implies to set up tools, habits, and an adapted environment to foster creativity. Creativity is the wealth of companies that should be valorized. To promote creativity, companies implement creativity workshops that gather people with various roles and expertise exchange and create knowledge to solve collectively open-ended engineering problems. However, group dynamics or facilitation can make the wrong decision and make the creative problem-solving unfruitful. The aim of our research project is to create a digital system to manage and valorize knowledge during creativity workshops. To design this system, we need to formalize the knowledge domain of creative workshops. The ontologies are used for decades to structure and manage information and knowledge in different domains. However, methodologies to design these ontologies are either hardly reproducible or not oriented to extract knowledge from organization. This article describes a methodology based on an organizational modeling to build ontologies. We will illustrate our approach by designing an ontology which models knowledge in creativity workshops.

3<sup>rd</sup>. paper published (as Poster paper): Poster communication reference: A Semantic Approach to Manage Ideas in an Innovation Process. Pedro Chavez Barrios, Davy Monticolo, Sahbi Sidhom. SÉMINAIRE DE L'ÉCOLE DOCTORALE RP2E : 13 Février 2018. Nancy, France.

**Abstract of the poster:**

For almost one decade, the organization “48 hours generating ideas” (48H) makes every year a creativity workshop (CWS) to generate thousands of idea cards (IdC) by mean of creative methods with the purpose of solving industrial problems; inside of this organization, creativity depends on solver participants, creative experts, organizers, technical expert and industrial managers like Acar states in (Acar and Runco 2012) “Organizational creativity is influenced by many thing. Some are social other are brought to the organization by individuals who comprise it. To certain degree, the organizational creativity depends on the individuals inside it”; the huge quantity of these IdC’s creates a problem “how to manage, to select and to compare these ideas that contain several and different fields” as Khemiri wrote in (Sidhom et al. 2011) “Text representations in a multimedia corpus with heterogeneous ideas”; the 48H has several complexities such as people from different continents and cultures, but also, different industries and educative centers are participating during this event; We want to implement a semantic approach to manage ideas for the same industrial problem.

4<sup>th</sup>. paper published (in ISKO-Maghreb 2018 int. Symposium): This paper is selected to be published in RIST journal: Pedro Chavez Barrios, Davy Monticolo and Sahbi Sidhom. Semantic Approach to Compare Ideas in a Creativity Workshop. *Revue de l'Information Scientifique et Technique*. (<https://www.asjp.cerist.dz/en/PresentationRevue/134>) *information processing at the digital age*, EISSN: 2571-9947, Périodicité: Biannuelle, Taux d'acceptation: 64%, Temps moyen de réponse: 69 Jours, Temps moyen de publication après acceptation: 75 Jours, Année de création: 1991, Pays: Algérie Institution: Centre de Recherche sur l'Information Scientifique et Technique (CERIST).

**Abstract of the paper:**

Creativity is one part of the innovation process where people propose ideas to solve a problem. Creative workshop is organized to apply several creative techniques that allow hundreds of participants to produce a huge quantity of ideas. The huge quantity of ideas implies that we have to group, select and compare the whole ideas to exploit them. Those ideas are writing in natural language by participants and they are heterogeneous since some of them are described by schema, text or scenario of use. We propose to solve this problem by using semantic analysis in order to compare, cluster and select the idea-cards. This paper presents our semantic approach and model design.

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# Bibliography

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- Acar, Selcuk and Mark A. Runco. 2012. "Creative Abilities: Divergent Thinking." Pp. 115–39 in *HandBook of Organizational Creativity*. Athens, GA, USA.
- Ackoff, Russell. 1999. "From Data to Wisdom." 170–72.
- Agars, Mark, James Kaufman, Amanda Deane, and Blakely Smith. 2012. "Fostering Individual Creativity through Organizational Context." P. 273 in *HandBook of Organizational Creativity*.
- Alavi, Maryam. 1999. "KNOWLEDGE MANAGEMENT." 1(February):1–37.
- Amabile, Teresa M. 1983. "The Social Psychology of Creativity: A Componential Conceptualization." *Journal of Personality and Social Psychology* 45(2):357–76.
- Amabile, Teresa M. 1986. *Creativity in Context*.
- Amabile, Teresa M. and Michael G. Pratt. 2016. "The Dynamic Componential Model of Creativity and Innovation in Organizations: Making Progress, Making Meaning." *Research in Organizational Behavior* 36:157–83.
- Amabile, TM. 1988. "A Model of Creativity and Innovation in Organizations." *Research in Organizational Behavior* 123–65.
- Anderson, Neil, Kristina Potocnik, and Jing Zhou. 2012. "Innovation an Creativity in Organizations." 1–71.
- Anon. 2018. "Oxford Dictionary." Retrieved (<https://en.oxforddictionaries.com/definition/knowledge>).
- Argente, Estefania, Vicente Julian, and Vincent Botti. 2009. "MAS Modeling Based on Organizations." *Agent-Oriented Software Engineering IX: 9th International Workshop* 16–30.
- Arthur B. VanGundy. 2005. *101 Activities for Teaching Creativity and Problem Solving*.
- Bachimont, Bruno. 2000. "Engagement Sémantique et Engagement Ontologique : Conception et Réalisation D'ontologies En Ingénierie Des Connaissances." *Ingénierie Des Connaissances Évolutions Récentes et Nouveaux Défis* 505.
- Barry, Dana. 2007. "Workshops in Creative Education for Students and Teachers in the United States and Japan." 16–20.
- Barry, Dana and Hideyuki Kanematsu. 2007. "Workshops in Creative Education for Students and Teachers in the United States and Japan." 16–20.
- Basadur, Min, Tim Basadur, and Gordana Licina. 2012. "Organizational Development." Pp. 667–98 in *HandBook of Organizational Creativity*.
- Benkhelifa, Elhadj, Ashutosh Tiwari, and Anthony Pipe. 2010. "Evolutionary Design Optimisation of a 32-Step Traffic Lights Controller." *2010 IEEE World Congress on Computational Intelligence, WCCI 2010 - 2010 IEEE Congress on Evolutionary Computation, CEC 2010* 1–5.
- Berners-Lee, Tim and James Hendler. 2002. "The Semantic Web." *Scientific American* 21.
- Berthier, Denis, Chantal Morley, and Michel Maurice-Demourieux. 2005. "Enrichissement de La Modélisation Des Processus Métiers Par Le Paradigme Des Systèmes Multi Agents." *Systèmes d'information et Management* 3(10):25–45.



- Bessant, John and Joe Tidd. 2007. *Innovation and Entrepreneurship*.
- Bhowmik, Tanmay, Nan Niu, Anas Mahmoud, and Juha Savolainen. 2014. "Automated Support for Combinational Creativity in Requirements Engineering." *2014 IEEE 22nd International Requirements Engineering Conference, RE 2014 - Proceedings* 243–52.
- Boden, Margaret A. 2004. "The Creative Mind : Myths and Mechanisms." (1994):344.
- Boden, Margaret A. 2009. "Computer Models of Creativity." *AI Magazine* 30(3):23.
- De Bono, Edward. 2000. *Six Thinking Hats* : Penguin.
- Bossi, Annalisa, Maurizio Gabbrielli, Giorgio Levi, and Maurizio Martelli. 1994. "THE S-SEMANTICS APPLICATIONS APPROACH : THEORY AND." (October 1993):149–97.
- Boughzala, Imed. 2007. *Ingenierie de La Collaboration, Theories, Technologies et Pratiques*. edited by H.-L. Paris.
- Brooks, Rodney. 1986. "ACHIEVING ARTIFICIAL INTELLIGENCE THROUGH BUILDING." 1–16.
- Brown, Tim and Barry Katz. 2011. "Change by Design." *Journal of Product Innovation Management* 28(3):381–83.
- Budanitsky, Alexander and Graeme Hirst. 2001. "BudanitskyHirst-2001-SemanticsW." 6.
- Bullinger, A. C., J. Haller, and K. Möslin. 2009. "Innovation Mobs -- Unlocking the Innovation Potential of Virtual Communities: Proceedings of the Fifteenth Americas Conference on Information Systems (AMCIS), San Francisco."
- Burguer-Helmchen, Thierry, Hussler, Caroline, and Patrick Cohendet. 2016. *Les Grands Auteurs En Management de l'innovation et de La Créativité*.
- Camacho, Adriana Perez, Allison Janowski, Abdullah Konak, and Sadan Kulturel-Konak. 2016. "Creative Problem Solving Builds Entrepreneurial Mindset." *ISEC 2016 - Proceedings of the 6th IEEE Integrated STEM Education Conference* 65–70.
- Carmeli, Abraham, Roy Gelbard, and Roni Reiter-Palmon. 2012. "LEADERSHIP, CREATIVE PROBLEM-SOLVING CAPACITY, AND CREATIVE PERFORMANCE: THE IMPORTANCE OF KNOWLEDGE SHARING." 95–122.
- Carsten K.W. De Dreu, Matthijs Baas, and Bernard A. Nijstad. 2012. "The Emotive Roots of Creativity: Basic and Applied Issues on Affect and Motivation." Pp. 217–40 in *HandBook of Organizational Creativity*.
- Castelfranchi, Cristiano. 2012. "Guarantees for Autonomy in Cognitive Agent Architecture." 56–70.
- Chaib-Draa, B., B. Moulin, R. Mandiau, and P. Millot. 1992. "Trends in Distributed Artificial Intelligence." *Artificial Intelligence Review* 6(1):35–66.
- Chen, Ying-hueih, Tzu-pei Lin, and David C. Yen. 2014. "Information & Management How to Facilitate Inter-Organizational Knowledge Sharing : The Impact of Trust." *Information & Management* 51(5):568–78.
- Chen, Zhibin, Xiping Jia, and Zhenghong Xiao. 2015. "A Computational Cognitive Model of User Applying Creativity Technique in Creativity Support Systems." *Procedia Computer Science* 55(I tqm):818–24.
- Colleman, D., P. Arnold, S. Bodoff, C. Dollin, H. Gilchrist, F. Hayes, and P. Teremaes. 1996. *Fusion, La Méthode Orientée-Object de 2e Génération*. edited by Masson.
- D'Aquin, Mathieu; and Helger. Lewen. 2009. "Cupboard – A Place to Expose Your Ontologies

- to Applications and the Community.” Pp. 973–918 in *The Semantic Web: Research and Applications, Lecture Notes in Computer Science*.
- D’Aquin, Mathieu and Natalya F. Noy. 2012a. “Where to Publish and Find Ontologies? A Survey of Ontology Libraries.” *Journal of Web Semantics* 11:96–111.
- D’Aquin, Mathieu and Natalya F. Noy. 2012b. “Where to Publish and Find Ontologies? A Survey of Ontology Libraries.” *Journal of Web Semantics* 11:96–111.
- Damanpour, Fariborz and Deepa Aravind. 2012. “Organizational Structure and Innovation Revisited: From Organic To Ambidextrous Structure.” Pp. 483–512 in *HandBook of Organizational Creativity*.
- Dean Keith Simonton. 2012. “Fields, Domains, and Individuals.” Pp. 67–83 in *HandBook of Organizational Creativity*.
- Decugis, V. and J. Ferber. 1998. “Action Selection in an Autonomous Agent with a Hierarchical Distributed Reactive Planning Architecture.” *AGENTS ’98: Proceedings of the Second International Conference on Autonomous Agents* 354–61.
- Dikenelli, Oguz and Riza Cenk Erder. 2002. “SABPO, A Standard Based and Pattern Oriented Multi-Agent Development Methodology.” Pp. 213–25 in *Engineering Societies in the Agents World III*.
- Dougherty, Deborah and Danielle Dunne. 2012. “Organizing for Change, Innovation, and Creativity.” Pp. 569–81 in *HandBook of Organizational Creativity*.
- Dretske, Fred. 1981. “Philoso Stud: The Pragmatic Dimension of Knowledge.” 363.
- De Dreu, Carsten K. W., Matthijs Baas, and Bernard A. Nijstad. 2012. “The Emotive Roots of Creativity: Basic and Applied Issues on Affect and Motivation.” Pp. 217–40 in *HandBook of Organizational Creativity*.
- Dreyfus, Hubert. 1972. *What Computer Still Can’t Do, A Critique of Artificial Reason*.
- Drogoul, Alexis, Jacques Ferber, and Christophe Cambier. 1992. “Multi-Agent Simulation as a Tool for Analysing Emergent Processes in Societies.” 49–63.
- Drown, Keith James and Damon. 2012. “Organizations and Creativity: Trends in Research, Status of Education and Practice, Agenda for the Future.” Pp. 17–37 in *HandBook of Organizational Creativity*.
- El-sharkawy, Sascha, Per Pascal Grube, and Klaus Schmid. 2009. “Using Semantically Linked Content to Support Creativity in Product Innovation.” 638–42.
- Elbassiti, Lamyaa and Rachida Ajhoun. 2014. “Semantic Representation of Innovation, Generic Ontology for Idea Management.” *Journal of Advanced Management Science* 2(1):128–34.
- Elsawah, Sondoss, Joseph H. A. Guillaume, Tatiana Filatova, Josefine Rook, and Anthony J. Jakeman. 2015. “A Methodology for Eliciting, Representing, and Analysing Stakeholder Knowledge for Decision Making on Complex Socio-Ecological Systems: From Cognitive Maps to Agent-Based Models.” *Journal of Environmental Management* 151:500–516.
- Esparcia, Sergio, Estefanía Argente, and Vicente Botti. 2011. “An Agent-Oriented Software Engineering Methodology to Develop Adaptive Virtual Organizations.” *IJCAI International Joint Conference on Artificial Intelligence* (i):2796–97.
- Fahey, L. and L. Prusak. 1998. *The Eleven Deadliest Sins of Knowledge Management*. edited by C. M. Review.

- Familly, Gila. 2003. "Collective Creativity: A Complex Solution for the Complex Problem of the State of Our Planet." 0419(789685088).
- Fan, Yu and Hongyan Li. 2004. "ICUIS : A Rule-Based Intelligent ICU Information System." (973):1–5.
- Fensel, Dieter, Stefan Decker, Michael Erdmann, and Rudi Studer. 1998. "Ontobroker: The Very High Idea." *Proceedings of the 11. International Flairs Conference (FLAIRS-98)* (May):131–35.
- Ferber, Jacques. 1994. "Coopération Réactive et Émergence." 19–52.
- Ferber, Jacques. 1995. *Les Systèmes Multi-Agents Vers Une Intelligence Collective*. InterEditi.
- Ferber, Jacques and Patrice Carle. 1991. "Actors and Agents as Reflective Concurrent Objects : A MERING IV Perspective." 21(6):1420–36.
- Ferber, Jaques, J. Michel, and J. Baez. 2004. "AGRE: Integrating Environments with Organizations." P. 48 in *MAS State-de-Art*.
- Fernandez, Mariano, Asuncion Gomez-Pérez, and Natalia Juristo. 1997. "METHONTOLOGY : From Ontological Art Towards Ontological Engineering." 40.
- Findlay, Scott and Charles Lumsden. 1988. "The Creative Mind: Toward an Evolutionary Theory of Discovery and Innovation." *Journal of Social and Biological Systems* 11(1):3–55.
- Gabriel, Alex. 2016. "Gestion Des Connaissances Lors d'un Processus Collaboratif de Créativité. Université de Lorraine, ERPI Lab. Décembre 2016."
- Gabriel, Alex, Pedro Chavez Barrios, Davy Monticolo, and Mauricio Camargo. 2019. "Methodology to Design Ontologies from Organizational Models: Application to Creativity Workshops." Pp. 148–59 in *Knowledge Engineering and Management Applied to Innovation*.
- Gandon, Fabien. 2002. *Ontology Engineering : A Survey and a Return on Experience*.
- Garbacz, Pawel, Piotr Kulicki, Robert Trypuz, Piotr Kulicki, and Robert Trypuz. 2017. "A Formal Ontology of Knowing and Knowledge A Formal Ontology of Knowing and Knowledge." 8238(2012).
- Gayathri, R. and V. Uma. 2018. "Ontology Based Knowledge Representation Technique , Domain Modeling Languages and Planners for Robotic Path Planning : A Survey." *ICT Express* 4(2):69–74.
- Genesereth, Michael R., Richard E. Fikes, and Thomas Gruber. 1992. "Knowledge Interchange Format." *Interchange* (January).
- Genesereth, Michael R. and Nills J. Nilsson. 1987. "Logical Foundations of Artificial Intelligence: Nomotonic Reasoning." *Logical Foundations of Artificial Intelligence*.
- Genesereth, MR and S.Ketchpel. 1994. "Software Agents Michael R. Genesereth Logic Group Computer Science Department Stanford University." (1):12.
- Georgiev, Georgi V. and Danko D. Georgiev. 2018. "Enhancing User Creativity: Semantic Measures for Idea Generation." *Knowledge-Based Systems* 151:1–15.
- Gero, John S. 2000. "Computational Models of Innovative and Creative Design Processes." *Technological Forecasting and Social Change* 64(2–3):183–96.
- Gero, John S. and Udo Kannengiesser. 2004. "The Situated Function-Behaviour-Structure

- Framework." *Design Studies* 25(4):373–91.
- Gero, John S. and Mary Lou Maher. 1993. "Modeling Creativity and Knowledge-Based Creative Design."
- Girodon, Julien, Davy Monticolo, and Eric Bonjour. 2015. "How To Design a Multi Agent System Dedicated to Knowledge Management ; the DOCK Approach." 113–21.
- Girodon, Julien, Davy Monticolo, Eric Bonjour, and Maggy Perrier. 2015. "An Organizational Approach to Designing an Intelligent Knowledge-Based System: Application to the Decision-Making Process in Design Projects." *Advanced Engineering Informatics* 29(3):696–713.
- Giroto, Victor. 2016. "Collective Creativity through a Micro-Tasks Crowdsourcing Approach." *Proceedings of the 19th ACM Conference on Computer Supported Cooperative Work and Social Computing Companion - CSCW '16 Companion* 143–46.
- Goldschmidt, Gabriela and Dan Tatsa. 2005. "How Good Are Good Ideas? Correlates of Design Creativity." *Design Studies* 26(6):593–611.
- Gomez-Pérez, Asuncion. 1995. "Evaluation and Assesment of the Knowledge Sharing Technology." Pp. 289–95 in *Towards very large knowledge bases*.
- Gruber, Thomas R. 1995. "Toward Principles for the Design of Ontologies." *International Journal of Human-Computer Studies* 43(5):907–28.
- Grundstein, Michel. 2000. "From Capitalizing on Company Knowledge to Knowledge Management." Pp. 261–87 in *Knowledge Management, Classic and Contemporary Works*.
- Guilford, J. P. 1950. *Creativity: Yesterday, Today and Tomorrow*.
- Gutiérrez, Xavier. 2011. "Knowledge Representations Underlying Covert Metalinguistic Activity : A Working Hypothesis." 8416.
- Gutknecht, Olivier and Jacques Ferber. 2000. "MadKit: A Generic Multi-Agent Platform." *Proceedings of the Fourth International Conference on Autonomous Agents - AGENTS '00* 78–79.
- Hasebe, Yuichi, Hiroshi Kawakami, Toshihiro Hiraoka, and Kosuke Naito. 2013. "A Card-Type Tool to Support Divergent Thinking for Embodying Benefit of Inconvenience." *Proceedings - 2013 Conference on Technologies and Applications of Artificial Intelligence, TAAI 2013* 306–11.
- Hassen, Mariam Ben, Mohamed Turki, and F. Gargouri. n.d. "Towards a Meta-Model of the Organization ' s Processes Modelling for Knowledge Localization." (i).
- Hayama, Tessai, Saki Hayashi, and Yuichi Kondo. 2017. "Investigation of a Team-Based Activity Support System Used in a Project-Based Learning Course." *Proceedings - 11th 2016 International Conference on Knowledge, Information and Creativity Support Systems, KICSS 2016*.
- Henderson-Sellers, B., A. Simmons, and H. Younessi. 1998. *The OPEN Toolbox of Techniques*. edited by H. (Essex) Addison-Wesley Lonman. UK.
- Hilbert, Martin. 2016. "Formal Definitions of Information and Knowledge and Their Role in Growth through Structural Change." *Structural Change and Economic Dynamics* 38:69–82.
- Holyoak, Keith J. and Robert G. Morrison. 2005. *The Cambridge Handbook of Thinking and*

*Reasoning.*

- Holzner, Burkart and Evelyn Fisher. 1979. "Knowledge in Use." *Knowledge: Creation, Diffusion, Utilization* 1(2):219–44.
- Howard, T. J., S. J. Culley, and E. Dekoninck. 2008. "Describing the Creative Design Process by the Integration of Engineering Design and Cognitive Psychology Literature." *Design Studies* 29(2):160–80.
- Hrin, G. R., L. E. Anghel, and Adrian David. 2016. "An Intelligent System to Business and Enterprise Management - IDEA." *2008 IEEE International Technology Management Conference, ICE 2008*.
- Hutchison, David and John C. Mitchell. 2009. *The Semantic Web: Research and Applications. Lecture Notes in Computer Science*.
- Jennings, Nicholas R. and M. Wooldridge. 1998. *Applications of Intelligent Agents. Agent Technology: Formations, Applications and Markets*. edited by Springer.
- Jones, Dean, Trevor Bench-Capon, and Pepijn Visser. 1998. "Methodologies for Ontology Development." (November 2012).
- Kephart, Jeffrey O. and William E. Walsh. 2004. "An Artificial Intelligence Perspective on Autonomic Computing Policies." *Proceedings - Fifth IEEE International Workshop on Policies for Distributed Systems and Networks, POLICY 2004* 3–12.
- Kinny, David. 2002. "A Visual Programming Language for Plan Execution Systems." *Proceedings of the First International Joint Conference on Autonomous Agents and Multi-Agent Systems (AAMAS-2002, Featuring 6th AGENTS, 5th ICMAS and 9th ATAL), 15--19 July, Bologna, Italy* 721–28.
- Kozima, Hideki. 1993. "Computing Lexical Cohesion as a Tool for Text Analysis." *Computer Science and Information Mathematics, Graduate School of Electro-Communications*.
- Leidner, Dorothy and Maryam Alavi. 2001. "REVIEW : KNOWLEDGE MANAGEMENT AND KNOWLEDGE MANAGEMENT SYSTEMS :". 25(1):107–37.
- Leidner, Dorothy E. 2001. "REVIEW : KNOWLEDGE MANAGEMENT AND KNOWLEDGE MANAGEMENT SYSTEMS :". 25(1):107–37.
- Levy, M., Claire Blin, Françoise, Bradin Siskin, and Osamu Takeuchi. 2011. *WordCall, International Perspectives On Computer-Assisted Language Learning*.
- Levy, Mike. 1997. "Theory-Driven Call and the Development Process." *Computer Assisted Language Learning* 10(1):41–56.
- Li, Yuhua, Zuhair A. Bandar, and David McLean. 2003. "An Approach for Measuring Semantic Similarity between Words Using Multiple Information Sources." *In: IEEE Transactions on Knowledge and Data Engineering* 15(4):871–82.
- Lubart, Todd. 2001. "Models of Creative Process." *CIM Bulletin*.
- Mahesh, Kavi. 1996. "Ontology Development for Machine Translation: Ideology and Methodology." *Computing Research Laboratory New Mexico State University. MCCS-96-292* 87.
- Marion, Russ. 2012. "Leadership of Creativity: Entity-Based, Relational, and Complexity Perspectives." Pp. 457–74 in *HandBook of Organizational Creativity*.
- Martins, E. C. and F. Terblanche. 2003. "Building Organisational Culture That Stimulates

- Creativity and Innovation." *European Journal of Innovation Management* 6(1):64–74.
- Massetti, Brenda. 1996. "An Empirical Examination of the Value of Creativity Support Systems on Idea Generation." *MIS Quarterly* 20(1):83.
- McDonald, Meredith Tromble. 2009. "Notes on the Creative Process of Artist Collectives." *Proceeding of the Seventh ACM Conference on Creativity and Cognition - C&C '09* 397.
- Miyata, Kazunori. 2012. "Procedural Technology and Creativity Mining." *Proceedings - 2012 7th International Conference on Knowledge, Information and Creativity Support Systems, KICSS 2012* 169–74.
- Mumford, Michael D. 2012. *Handbook of Organizational Creativity*. Academic Press.
- Mumford, Michael D., Kimberly S. Hester, and Issac C. Robledo. 2012. "Creativity in Organizations: Importance and Approaches." Pp. 3–13 in *HandBook of Organizational Creativity*.
- Murah, Mohd Zamri, Zuraidah Abdullah, Rosilah Hassan, Marini Abu Bakar, Ibrahim Mohamed, and Hazilah Mohd Amin. 2013. "Kacang Cerdik: A Conceptual Design of an Idea Management System." *International Education Studies* 6(6):178–84.
- Nakakoji, Kumiyo, Yamamoto Yamamoto, and Atsushi Aoki. 2002. "Interaction Design as a Collective Creative Process." *Proceedings of the 4th Conference on Creativity & Cognition* 103–10.
- Nakakoji, Kumiyo, Yasuhiro Yamamoto, and Masao Ohira. 1999. "A Framework That Supports Collective Creativity in Design Using Visual Images." *Proceedings of the Third Conference on Creativity & Cognition - C&C '99* (743):166–73.
- Näykki, Piia and Sanna Järvelä. 2014. "How Pictorial Knowledge Representations Mediate Collaborative Knowledge Construction In Groups How Pictorial Knowledge Representations Mediate Collaborative Knowledge Construction In Groups." 1523.
- Ning, Ke, David O'Sullivan, Qinxiang Zhu, and Stefan Decker. 2006. "Semantic Innovation Management across the Extended Enterprise." *International Journal of Industrial and Systems Engineering* 1(1/2):109.
- Nonaka, Ikujiro, Ryoko Toyama, and Noboru Konno. 2000. "SECI, Ba and Leadership: A Unified Model of Dynamic Knowledge Creation." *Long Range Planning* 33(1):5–34.
- Noy, Natalya F., Nigam H. Shah, Patricia L. Whetzel, Benjamin Dai, Michael Dorf, Nicholas Griffith, Clement Jonquet, Daniel L. Rubin, Margaret-anne Storey, Christopher G. Chute, and Mark A. Musen. 2009. "BioPortal : Ontologies and Integrated Data Resources at the Click of a Mouse." 37(May):170–73.
- Øhrstrøm, Peter, Henrik Shârphe, and Sara Uckelman. 2008. "Jacob Lorhard's Ontology: A 17th Century Hypertext on the Reality and Temporality of the World of Intelligibles." Pp. 74–87 in *Conceptual Structures: Knowledge, Visualization and Reasoning. Lecture Notes in Artificial Intelligence*.
- Olszak, Celina M., Tomasz Bartuś, and Paweł Lorek. 2017. "A Comprehensive Framework of Information System Design to Provide Organizational Creativity Support." *Information & Management* (April).
- Oortmerssen, Lise A. Van, Cees M. J. Van Woerkum, and Noelle Aarts. 2015. "When Interaction Flows : An Exploration of Collective Creative Processes on a Collaborative Governance Board."

- Osborn, Alex. 1953. *Applied Imagination - Principles And Procedures Of Creative Writing*.
- Paletz, Susannah. 2012. "Project Management of Innovative Teams." Pp. 421–50 in *HandBook of Organizational Creativity*.
- Papert, Seymour. 1969. "The Artificial Intelligence of Hubert and Dreyfus by Seymour 1969 USA.Pdf." 1–76.
- Parjanen, Satu. 2012. "Experiencing Creativity in the Organization: From Individual Creativity to Collective Creativity." *Interdisciplinary Journal of Information, Knowledge, and Management* 7:109–28.
- Park, Jun-gi and Jungwoo Lee. 2014. "ScienceDirect Knowledge Sharing in Information Systems Development Projects : Explicating the Role of Dependence and Trust." *JPMA* 32(1):153–65.
- Paulus, Paul B., Mary Dzindolet, and Nicholas W. Kohn. 2012. "Collaborative Creativity— Group Creativity and Team Innovation." Pp. 327–58 in *HandBook of Organizational Creativity*.
- Paulus, Paul B. and Bernard A. Nijstad. 2003. *Group Creativity: Innovation Through Collaboration*. Oxford University Press, Inc.
- Peilloux, Aurélien and Marion Botella. 2016. "Ecological and Dynamical Study of the Creative Process and Affects of Scientific Students Working in Groups." *Creativity Research Journal* 28(2):165–70.
- Pennington, Martha. 1996. *The Power of CALL*.
- Peraketh, Benjamin, Christopher Menzel, Richard J. Mayer, Florence Fillion, Michael T. Futrell, Paula S. DeWitte, and Madhavi Lingineni. 1994. *Ontology Capture Method (IDEF5)*.
- Picard, Gauthier and Marie-pierre Gleizes. 2006. "THE ADELFE METHODOLOGY." Pp. 1–2 in *Methodologies and Software Engineering for Agent Systems - The Agent-Oriented Software Engineering Handbook*.
- Pizelle, Pascal, Jonas Hoffmann, Céline Verchère, and Miguel Aubuy. 2014. *Innover Par Les Usages*. edited by D'innovations.
- R. Reiter-Palmon, B. Wigert, and T. De Vreede. 2012. "Team Creativity and Innovation: The Effect of Group Composition, Social Processes, and Cognition,." Pp. 295–326 in *HandBook of Organizational Creativity*.
- Reiter-Palmon, Roni, Ben Wigert, and Triparna De Vreede. 2012. "Team Creativity and Innovation: The Effect of Group Composition, Social Processes, and Cognition." Pp. 295–326 in *HandBook of Organizational Creativity*.
- Reix, R., B. Fallery, M. Kalika, and F. Rowe. 2016. *Systemes d'information et Management*. 7e. Editio. edited by Vuibert. Paris.
- Resnik, Philip. 1995. "Using Information Content to Evaluate Semantic Similarity in a Taxonomy." 1.
- Resnik, Philip. 1999. "Semantic Similarity in a Taxonomy." 95–130.
- Richard, O. and I. Ian. 1973. "A Program for Research on Management Information Systems \*." *Management Science* 19(6):475–88.
- Riedl, C., N. May, J. Finzen, S. Stathel, V. Kaufman, and H. Krcmar. 2009. "An Idea Ontology

- for Innovation Management." *International Journal on Semantic Web and Information Systems* 5(04):1–18.
- Robledo, Issac, Kimberly Hester, David Peterson, and Michael Mumford. 2012. "Creativity in Organizations: Conclusions." Pp. 707–14 in *HandBook of Organizational Creativity*.
- Rougemaille, Sylvain, Jean Paul Arcangeli, Marie Pierre Gleizes, and Frédéric Migeon. 2009. "ADELFE Design, AMAS-ML in Action: A Case Study." *Lecture Notes in Computer Science (Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)* 5485 LNAI:105–20.
- Rowley, Jennifer. 2007. "The Wisdom Hierarchy: Representations of the DIKW Hierarchy." *Journal of Information Science* 33(2):163–80.
- Ruiz, Francisco J., Cristóbal Raya, Albert S, and Núria Agell. 2015. "A Transformational Creativity Tool to Support Chocolate Designers." *Pattern Recognition Letters* 67:75–80.
- Runco, Mark A. and Garrett J. Jaeger. 2012. "The Standard Definition of Creativity." *Creativity Research Journal* 24(1):92–96.
- Russell, S. and P. Norvig. 2003. *Artificial Intelligence: A Modern Approach*. 2nd. Ed. edited by Prentice Hall.
- Russell, Stuart and P. Norvig. 2010. *Artificial Intelligence: A Modern Approach*. edited by R. Hall.
- Sanders, Liz. 2001. "CollectiveCreativity." (3):1–6.
- Sawyer, R. Keith (Robert Keith). 2012. *Explaining Creativity: The Science of Human Innovation*. Oxford University Press.
- Shames, Victor and Victor Kihstrom. 1994. "Respecting the Phenomenology of Human Creativity." *In Precs of the Creative Mind: Myths and Mechanisms* 551.
- Shen, Weiming and Douglas H. Norrie. 1999. "Agent-Based Systems for Intelligent Manufacturing: A State-of-the-Art Survey." *Knowledge and Information Systems* 1(2):129–56.
- Shneiderman, Ben. 2007. "Creativity Support Tools: Accelerating Discovery and Innovation." *Communications of the ACM* 50(12):20–32.
- Sidhom, Sahbi, Nabil Khemiri, Malek Ghenima, and Henda Ben Ghezala. 2011. "Natural Ontology Representation Based on NP's Properties and Semantic Relations ESCE-University La Manouba (Tunisia), Nancy University (France), IGA Morocco, IEEE Morocco Section. Information Systems and Economic Intelligence, Feb 2011, Marrakech, Morocc." 1–8.
- Sidhom, Sahbi, Nabil Khemiri, Related Works Many, and I. Introduction. 2002. "Specific Ontologies for Semantic Indexing from Natural Language Properties EJDE – Electronic Journal of Digital Enterprise (ISSN: 1776-2960), Academic e-Journal E.J.D.E. (Www.Scientifics.Fr/Ejde), 2012, Evaluating Information Systems and Economic Intellige."
- Simonin, Olivier and Jacques Ferber. 2003. "Un Modèle Multi-Agent de Résolutio Collective de Problèmes Situés Multi-Échelles." 1–13.
- Simonton, Dean Keith. 2012. "Fields, Domains and Individuals." Pp. 67–83 in *HandBook of Organizational Creativity2*.
- Smith, Gerald F. 1998. "Idea-Generation Techniques : A Formulary of Active Ingredients."



32(2):107–33.

- Smith, Reid G. 1980. "Communication and Control in Problem Solver." *IEEE Transactions on Computers* 29(12):12.
- Soriano de Alencar, Eunice M. L. 2012. "Creativity in Organizations: Facilitators and Inhibitors." Pp. 87–107 in *HandBook of Organizational Creativity*.
- Sowa, John F. 1999. "Knowledge Representation : Logical , Philosophical , and Computational Foundations [ Paperback ]." (December):2–6.
- Stein, I. Morris. 1953. "Creativity and Culture." *The Journal of Psychology* 311–22.
- Sternberg, Robert J. 2005. "Creativity or Creativities?" *International Journal of Human Computer Studies* 63(4-5 SPEC. ISS.):370–82.
- Taghi, Mohammad and Amin Moghaddam. 2006. "A Framework to the Assessment and Promotion of Knowledge Management Maturity Level in Enterprise : Modeling and Case Study." 1–3.
- Thabrew, Hiran, Theresa Fleming, Sarah Hetrick, and Sally Merry. 2018. "Co-Design of EHealth Interventions With Children and Young People." *Frontiers in Psychiatry* 9(October):1–6.
- Tidd, Joe, John Bessant, and Keith Pavitt. 2005. "Managing the Internal Processes." *MANAGING INNOVATION Integrating Technological, Market and Organizational Change Third Edition* 347–424.
- Tisseyre, René Charles. 1999. *Knowledge Management, Théorie et Pratique de La Gestion Des Connaissances*.
- Tran, Quynh Nhu Numi and Graham Low. 2008. "MOBMAS: A Methodology for Ontology-Based Multi-Agent Systems Development." *Information and Software Technology* 50(7–8):697–722.
- Tuomi, Ilkka. 1999. "Data Is More Than Knowledge: Implications of the Reversed Knowledge Hierachy for Knowledge." *Management Information System* 16(3):107–21.
- University, Princeton. 2010. "Princeton University 'About WordNet.' WordNet. Princeton University. 2010. <<http://Wordnet.Princeton.Edu>>." Retrieved (<http://wordnet.princeton.edu>).
- Unoki, Masashi and Kazushi Nishimoto. 2012. "Improvements to Creativity in Singing Abilities Based on Perspective of Studies on Interaction between Speech Production and Auditory Perception." *Proceedings - 2012 7th International Conference on Knowledge, Information and Creativity Support Systems, KICSS 2012 (23300070)*:157–60.
- Uschold, Mike and Martin King. 1995a. "Towards a Methodology for Building Ontologies." *Methodology* 80(July):275–80.
- Uschold, Mike and Martin King. 1995b. "Towards a Methodology for Building Ontologies." *Methodology* 80(July):275–80.
- VanGundy, Arthur. 2005. *101 Activities for Teaching Creativity and Problem Solving*.
- Vanhée, Loïs, Jacques Ferber, and Frank Dignum. 2013. "Agent-Based Evolving Societies ( Extended Abstract ) Categories and Subject Descriptors." 1241–42.
- Veilleroy, Yann and Frederic Hoogstoel. 2012. "A Tool to Support Intelligence."
- Villanueva, Oscar Ardaiz, Xabier Nicuesa Chacón, Oscar Brene Artazcoz, Maria Luisa Sanz De

- Acedo Lizarraga, and Maria Teresa Sanz De Acedo Baquedano. 2009. "Web2.0 Tools to Support the Instructional Method 'Thinking Actively in a Creative Environment.'" *Proceedings - 12th IEEE International Conference on Computational Science and Engineering, CSE 2009* 4:868–73.
- Viriyayudhakorn, Kobkrit and Susumu Kunifuji. 2012. "The Impact of the Background Knowledge and the Friendship Closeness on the Team Creativity in a Realtime Creativity Support Groupware." *Proceedings - 2012 7th International Conference on Knowledge, Information and Creativity Support Systems, KICSS 2012* 89–96.
- Wang, Sheng and Raymond A. Noe. 2010. "Human Resource Management Review Knowledge Sharing : A Review and Directions for Future Research." *Human Resource Management Review* 20(2):115–31.
- Weiss, Carol H. 1980. "Knowledge Creep and Decision Accretion." *Knowledge: Creation, Diffusion, Utilization*. 1(3):381–404.
- West, Matthew and Mike Bennett. 2014. *Track C: Building Ontologies to Meet Evaluation Criteria From Toward Ontology Evaluation across the Life Cycle*.
- West, Michael A. and Claudia Sacramento. 2012. "Creativity and Innovation: The Role of Team and Organizational Climate." Pp. 359–80 in *HandBook of Organizational Creativity*.
- Westerski, Adam and Carlos A. Iglesias. 2011. "Exploiting Structured Linked Data in Enterprise Knowledge Management Systems: An Idea Management Case Study." *Proceedings - IEEE International Enterprise Distributed Object Computing Workshop, EDOC 2011* 395–403.
- Weyns, Danny, Van Dicke H. Parurak, and Fabien Michel. 2004. *Environments for Multi-Agent Systems, Lecture Notes in Artificial Intelligence*.
- Weyns, Danny, Van Dicke H. Parurak, Fabien Michel, Jaques Ferber, and Tom Holvoet. 2004. "Environments for Multiagents Systems, State-of-the-Art and Research Challenges." Pp. 1–9 in.
- Wooldridge, M., N. R. Jennings, and D. C. N. W. 2000-01 Kinny. 2000. "The Gaia Methodology for Agent-Oriented Analysis and Design." *Journal of Autonomous Agents and Multi-Agent Systems* 3(3):285–312.
- Wooldridge, Michael, Michael Fisher, Marc-philippe Huget, and Simon Parsons. 2002. "Model Checking Multi-Agent Systems with MABLE \*." 952–59.
- Wooldridge, Michael and Nicholas R. Jennings. 1995. "Intelligent Agents : Theory and Practice." 10(January):1–62.
- Wooldridge, Michael, Nicholas R. Jennings, and David Kinny. 1999. "A Methodology for Agent-Oriented Analysis and Design: A Conceptual Framework." *Proceedings of the Third Int. Conf. on Autonomous Agents* 69–76.
- Yan-hao, Huang, L. I. Wen-chen, L. I. Bai-qing, L. I. Ya-lou, Zhou Xiao-xin, and An Ning. 2014. "The Construction of Power System Knowledge Database Based on Ontology Theory and Semantic Web Technology." 2–5.
- Yang, Xiaohui. 2009. "To Facilitate Knowledge Management Using Basic Principles of Knowledge Engineering." 94–97.
- Zambonelli, Franco, Nicholas R. Jennings, and Michael Wooldridge. 2003. "Developing

Multiagent Systems: The Gaia Methodology.” *ACM Transactions on Software Engineering and Methodology* 12(3):317–70.

Zhang, Wei, Wenxin Liu, Xin Wang, Liming Liu, and Frank Ferrese. 2014. “Distributed Multiple Agent System Based Online Optimal Reactive Power Control for Smart Grids.” *IEEE Transactions on Smart Grid* 5(5):2421–31.

Zhu, Yuxi, Simone M. Ritter, Barbara C. N. Müller, and Ap Dijksterhuis. 2017. “Creativity: Intuitive Processing Outperforms Deliberative Processing in Creative Idea Selection.” *Journal of Experimental Social Psychology* 73(February):180–88.

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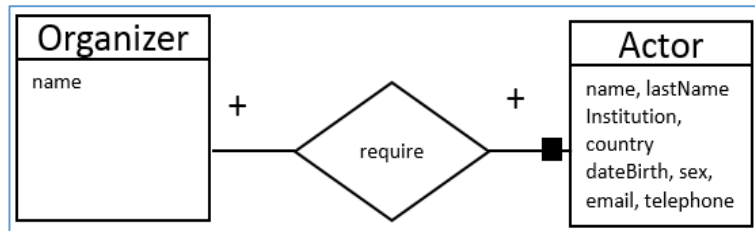
# Annexe A

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## Semantic Approach to Manage Ideas

### Relations and Classes

#### Relation Organizer-Actor

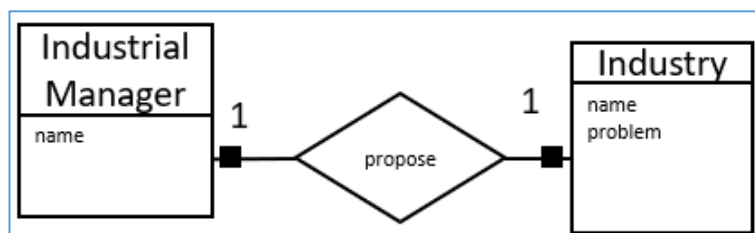


#### Class Actor

```
Public class Actor{
    String name;
    String lastName;
    String institution;
    String country;
    Date dateBirth;
    String sex;
    String email;
    String telephone;

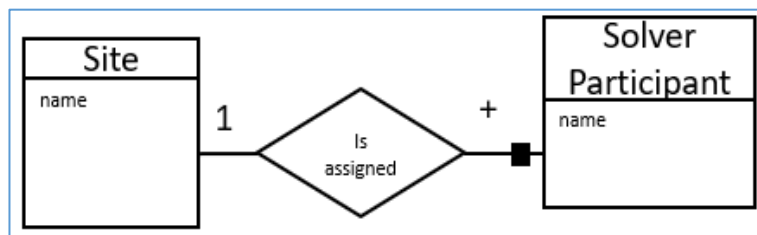
    void Actor(String name_A, String lastName_A, String institution_A, String country_A, Date dateBirth_A,
String sex_A, String email_A, String telephone_A)
    {
        Name = name_A;
        lastName = lastName_A;
        institution = institution_A;
        country = country_A;
        dateBirth = dateBirth_A;
        sex = sex_A;
        email = email_A;
        telephone = telephone_A;
    }
}
```

#### Relation Industrial Manager-Industry



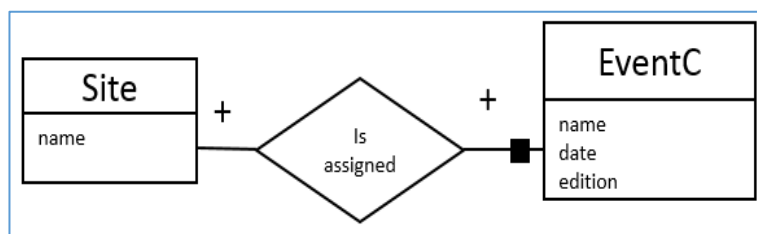
Class IndustrialManager	Class Industry
<pre>public class IndustrialManager extends Role{     String name;     void IndustrialManager(String nameIM)     {         name = nameIM;     } }</pre>	<pre>Public class Industry{     String name;     String problem;     void Industry(String name_I, String problem)     {         name = name_I;         problem = problem_I     } }</pre>

### Relation Site-Solver Participant

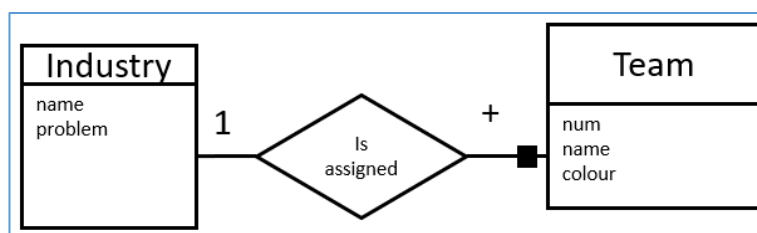


Class Site
<pre>public class Site{     String name;     void Site(String name, String name_S)     {         name = name_S;     } }</pre>

### Relation Site-EventCW



### Relation Industry-Team

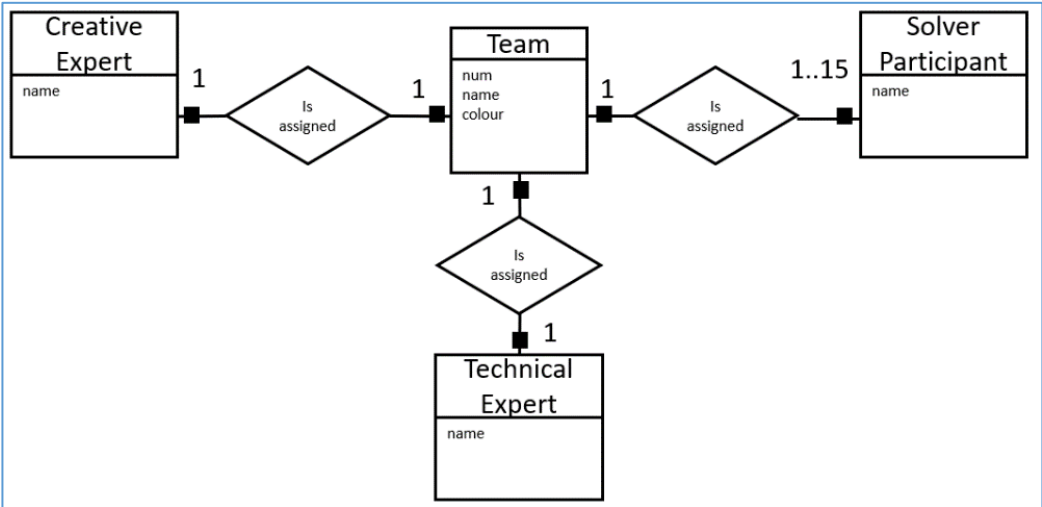


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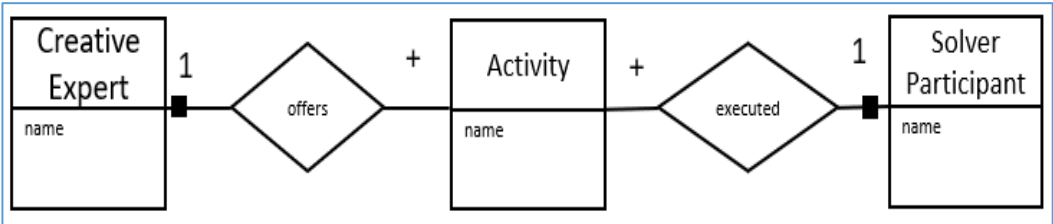
Class Team
Public class Team{
    Integer num;
    String name;
    String colour;
    void Industry(Integer num_T, String name_T, String colour_T)
    {
        num = num_T;
        name = name_T;
        colour = colour_T
    }
}

```

**Relation Creative Expert, Solver Participant, Technical Expert-Team**



**R9-Creative Expert, Solver Participant-Activity**

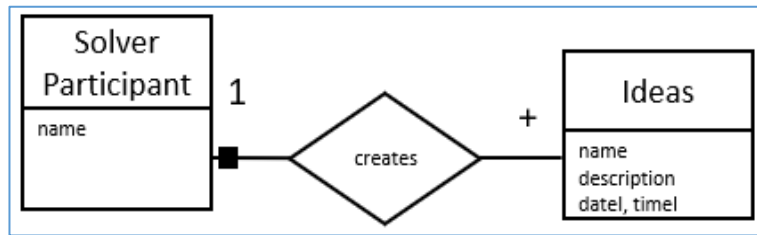


```

Class Activity
Public class Activity{
    String name;
    void CreativeExpert(String name_Act)
    {
        name = name_Act;
    }
}

```

## Relation Solver Participant-ideas

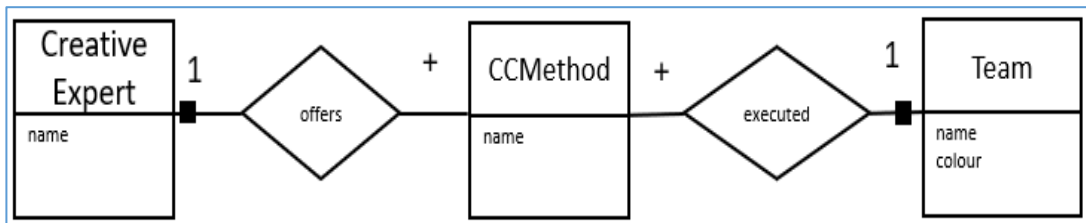


### Class Ideas

```

Public class Idea{
    String name;
    String description;
    Date dateI
    Time timeI
    void Idea(String name_Id, String description_Id, Date date_Id, Time time_Id)
    {
        name = name_Id;
        description = description_Id;
        dateI = date_Id;
        timeI = time_Id;
    }
}
  
```

## Relation Creative Expert, Team-CCMethod

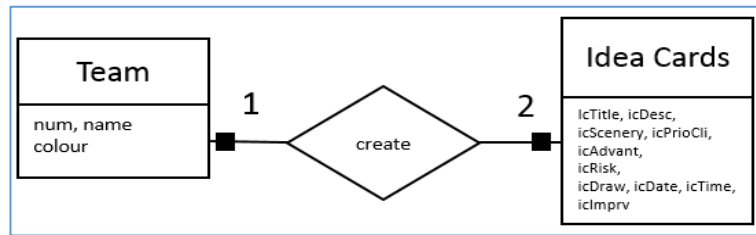


### Class CCMethod

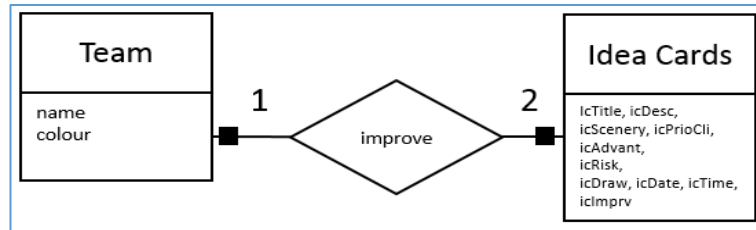
```

Public class CCMethod{
    String name;
    void Idea(String name_Ccm)
    {
        name = name_Ccm;
    }
}
  
```

## Relation Team-IdeaCards Creation



## Relation Team-IdeaCards Improve



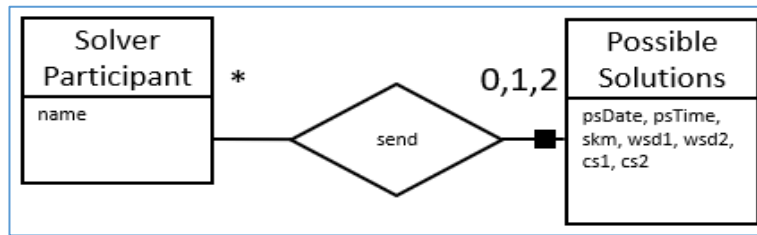
## Class IdeaCards

```
Public class IdeaCards{
    String icTitle;
    String icDesc;
    String icScenery;
    String icPrioCli;
    String icAdvant;
    String icRisk;
    Blob icDraw;
    Date icDate;
    Time icTime;
    Boolean icImprv;

    void Idea(String title_Ic, String desc_Ic, String scenery_Ic, String prioCli_Ic, String advant_Ic, String risk_Ic,
    Blob draw_Ic, Date date_Ic, Time time_Ic, Boolean imprv_Ic)
    {
        icTitle = title_Ic;
        icDesc = desc_Ic;
        icScenery = scenery_Ic;
        icPrioCli = prioCli_Ic;
        icAdvant =advant_Ic;
        icRisk = risk_Ic;
        icDraw = draw_Ic;
        icDate = date_Ic;
        icTime = time_Ic;
        icImprv = imprv_Ic }
}
```



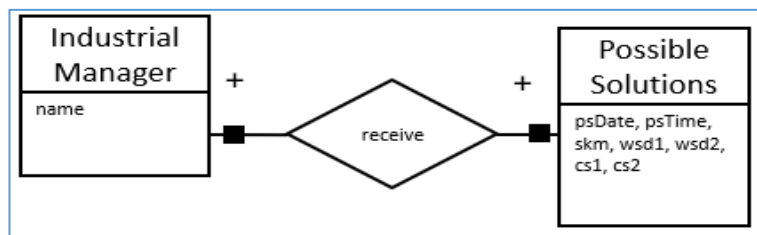
### Relation Solver Participants-Possible Solutions



### Class PossibleSolutions

```
Public class PossibleSolutions{
    Date psDate;
    Time psTime;
    Boolean skm;
    Float wsd1;
    Float wsd2;
    Float cs1;
    Float cs2;
    void Idea(Date date_Ps, Time time_Ps, Boolean skmPs, Float wsd1Ps, wsd2Ps, Float csPs1, csPs2)
    {
        psDate = date_Ps;
        psTime = time_Ps;
        skm = skmPs;
        wsd1 = wsd1Ps;
        wsd2 = wsd2Ps;
        cs1 = skmPs;
        cs2 = skmPs; }
}
```

### Relation Industrial Manager-Possible Solutions



# Abstract

## **Design of information and technology tools to support the process of creativity and innovation.**

This research thesis is focusing in creativity, innovation and collaborative creative process. There is a need to build new technical and innovative systems that can emulate a valuable human behavior consisting of visualizing and giving life to their ideas. This approach involves creativity ability and involves, as a process, many concepts such as discovery, creation, sociability, refinement and communication.

This research's missions to design informatics and technological tool to support creativity during the creative phases in a creativity workshop. To achieve the design of this tool, there are several objectives to achieve during the time requested for this research. The research context is a creativity workshop "48H", mobilizing students, professors, industrials, experts working with ideas by mean of exploratory combinatory, and transformational techniques and collaborative creative methods.

To build a tool for that kind of creative event, we need research how to consider the Human Knowledge Sharing Model and how a proposed System can develop a Semantic Approach to compare Idea Cards in 48H Creativity Workshop.

The main purposes of this research are to understand the knowledge sharing during a creativity workshop and to study the human organization in a creativity workshop and its general process, particularly. We study the event 48 Hours of creativity (48H) as a creative and innovative process where ideas are the final product. This event is performed in Nancy, France at the University of Lorraine (ERPI Laboratory). We design an intelligent system based in multi-agents (MAS) also to develop and annotation system. We propose a semantic approach to manage ideas and the global design system.

The practical implications of our model permit to use creativity, collaborative creative methods and new technologic modern methodologies, as new tools designed to build creative and innovative systems.

Some pertinent fields and models take part on this research such as multi-agent system (MAS), semantic web, ontology, organizational model to highlight knowledge and knowledge reuse organizational model KROM.

### **Keywords**

Creativity, Organizational Creativity Workshop, Semantic Approach, Ontology, Multi-agent Systems.

# Résumé

## **Conception d'outils d'information et de technologie pour soutenir le processus de créativité et d'innovation.**

Cette thèse de recherche aborde les champs de la créativité, de l'innovation et du processus créatif collaboratif. Il est nécessaire de construire de nouveaux systèmes techniques et innovants qui peuvent imiter le comportement humain précieux consistant à visualiser et à donner vie à leurs idées. Cette approche fait appel à la créativité et implique, en tant que processus, de nombreux concepts tels que la découverte, la création, la sociabilité, le raffinement et la communication.

L'objectif de cette recherche est de concevoir des outils informatiques et technologiques pour soutenir la créativité au cours des phases de création dans un atelier de créativité. Pour opérationnaliser cet outil, il y a plusieurs objectifs à atteindre pendant le temps requis pour cette recherche. Le contexte de la recherche est un atelier de créativité «48H», mobilisant des étudiants, des professeurs, des industriels, des experts travaillant avec des idées au moyen d'une combinatoire exploratoire, de techniques de transformation et de méthodes de création collaborative.

Pour construire un outil pour ce genre d'événement créatif, nous avons besoin d'étudier comment prendre en compte le modèle humain de partage des connaissances et comment un système proposé peut développer une approche sémantique pour comparer les cartes d'idées dans un atelier de créativité de 48 heures.

Les principaux objectifs de cette recherche sont de comprendre le partage des connaissances lors d'un atelier de créativité et d'étudier l'organisation humaine dans un atelier de créativité et son processus général, en particulier. Nous étudions l'événement 48 Heures de créativité (48H) comme un processus créatif et innovant où l'idée est le produit final. Cet événement a lieu à Nancy, en France, à l'Université de Lorraine (Laboratoire ERPI). Nous concevons un système intelligent basé en multi-agents (MAS) également pour développer et annoter le système. Nous proposons une approche sémantique pour gérer les idées et le système de design global.

Les implications pratiques de notre modèle permettent d'utiliser la créativité, les méthodes créatives collaboratives et les nouvelles méthodologies technologiques modernes, comme de nouveaux outils conçus pour construire des systèmes créatifs et innovants.

Quelques domaines et modèles pertinents participent à cette recherche tels que le système multi-agent (MAS), le web sémantique, l'ontologie, le modèle organisationnel pour mettre en évidence les connaissances et le modèle organisationnel de réutilisation des connaissances KROM.

## **Mots-clés**

Créativité, Atelier de créativité organisationnelle, Approche sémantique, Ontologie, Systèmes multi-agents.