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► **To cite this version:**

Oussama Rholam, Mohamed Tabaa, Fabrice Monteiro, Abbas Dandache. Smart Device for Multi-band Industrial IoT Communications. *Procedia Computer Science*, 2019, 155, pp.660-665. 10.1016/j.procs.2019.08.094 . hal-03293401

HAL Id: hal-03293401

<https://hal.univ-lorraine.fr/hal-03293401>

Submitted on 20 Jul 2022

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The International Workshop on the Future of Internet of Everything (FIOE)
August 19-21, 2019, Halifax, Canada

Smart Device for Multi-band Industrial IoT Communications

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Abstract

Data and object connectivity are the key and the critical component of industry 4.0, Connectivity of software, equipment, data ... are all massive data to be processed. Combined with cybersecurity, they become fundamental elements for creating intelligence in an industrial system that can increase the flexibility of production in addition to allocating resources more efficiently. In order to successfully transition to ecosystem 4.0, the industry must examine the new skills that are required and the need for qualified personnel. The fourth industrial revolution corresponds to the widespread use of sensors and intelligent agents to connect machines, components, processes and operators. This is generally called the digital factory or industry 4.0. It suggests a global system of effective communication between the modules of decision-making. World 4.0 will allow interaction between products, machines and even between machines (M2M). The product will also be able to communicate with machines in the production phase. This is called intelligent production, which will allow the modification and customization of products in their production phase.

In this article, we present a communication model based on Modbus and multiband communication using NB-IOT, this communication model allows data to be exchanged between different industrial equipment (PLCs, SCADA systems, etc.) via MODBUS RTU and ASCII, via RS485, or via analog and digital inputs for sensors and actuators.

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Peer-review under responsibility of the Conference Program Chairs.

Keywords: IIOT, Industry 4.0, Multiband, NB-IOT, Industrial communication, Modbus, RS485.

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1. Introduction

By taking a look at the industrial situation, we will certainly identify quite a few improvements made by the Fourth Industrial Revolution or what is called industry 4.0. It is a significant transformation that has been able to radically change the industrial game given its advantages and especially in the industrial field where technological progress is constantly increasing. We cannot talk about industry 4.0 without mentioning Communication, this last one consists of one of the great pillars of digital factories, it is based on the IOT as the vector of communication between machines, sensors etc... The most visionary already imagine machines and factories in which automation components would communicate with each other without using cables. Inventory of the situation, Wireless technologies have already replaced cable networks in many home and office applications. Since they are becoming mass consumption technologies, their cost is changing and potentially attractive to manufacturers. Industrialists also want to benefit from the advantages of wireless technologies. For them, the use of electromagnetic waves for signal transmission potentially eliminates many constraints.

Among other things, the removal of cables leads to the absence of problems related to cable wear, allows complete freedom of movement, and offers the possibility of covering difficult areas for cable installations, if not impossible. In this paper we present a universal IOT device (Industrial Gateway) that allows the collection of data from multiple serial ModBus based devices (ASCII, RTU) on the RS485 link simultaneously, and transfer data without wire between all others industrial equipment's, through the NB-IOT for multiband networks.

This article is organized as follows: in Section 2, we present a state of the art of Industry 4.0. WSN and Cyber physical systems in the industry will be presented in Section 3. In Section 4, we present the main objective of IOT in industrial application. The implementation of the NB-IoT, multiband, the Rs485 and all the discussions will be presented in section 4. Finally, conclusion and perspectives.

2. Smart Factory

The world is in the process of being digitized. There is a real explosion in the number of intelligent devices that are in constant communication with each other and produce huge amounts of data. And this data leads to an evolution in the way companies are managed. The real-time dynamics on which the Internet of Things applied to industry (or IIoT for Industrial Internet of Things), i.e. data analytics, generate both new opportunities and new challenges for business leaders. The category of IIoT devices ranges from tiny environmental sensors to complex industrial robots.

The Industrial Internet of Things, which can lead to new manufactured products and services:

- 3D printing that brings new production technologies.
- Augmented reality to improve the maintenance of industrial equipment.
- Collaborative robots (or Cobots), to increase worker productivity, efficiency and safety.
- Cyber-physical systems (CPS) to improve speed and secure production flows.
- Industrial Big Data, in order to increase the efficiency of companies and offer new services.
- Simulation of virtual plants to improve design and engineering flow.

NB:" Big data is the high volume, high speed, and/or high variety of information that requires new forms of processing to enable us to improve decision making and optimization of processes".

Industry 4.0, factory of the future, smart factories, connected factories..." all these terms are used to describe this new factory model born of the 4th industrial revolution, succeeding the 3 major phases of evolution called revolution: mechanization, industrialization and automation. This concept, which was highlighted for the first time at the Hanover Fair in 2011, represent a new way of organizing the means of production: setting up "intelligent" factories, where everything is done through interaction between products, machines and machines each other's, linked in a network that is itself connected to the outside world (instant and continuous communication). We are at the heart of a global interconnected system and all companies are now involved. It is a technological revolution, bringing many innovations and creating a new dynamic market. Inside the plants, information technologies, communicating sensors, IIoT (Industrial Internet of Things), software tools for simulation (Analysis Platforms), information processing, piloting, machines with the highest performance gradually make the plants more

and more agile, more and more efficient, more and more competitive... [1, 5, 7]

3. Industrial IOT

3.1. Wireless Sensor Network (WSN)

The increased use of IoT will also have an impact on the presentation model of the future factories with more and more sensors implemented as a wireless sensor network (WSN) [9,10], which confuses the electronic and computer world in the manufacturing lines to monitor the condition of the machines. Using wireless sensor networks connection will generate a very large database on the different statuses of the production lines of the different physical measurements instrumented to transmit them and process them. This very large number of nodes which make industrial processes managers able to monitor and visualize the different performance indicators and even create a virtual plant This will make it possible to monitor everything that is happening in value chains, and to allow managers to take better decisions by accessing to more information, they need it. All this will lead to virtualization (a digital twin of everything we have in physics and also making a link or even join the physical world to the digital world)

3.2. Cyber Physical Systems (CPS)

Cyber physical system is a combination of a software component and mechanical or electronic entities, via the Internet. Cyber Physical Systems (CPS) is the structure that links the IIOT, it is the essential technological link to merge the real world to the virtual world.

Cyber physical systems are a key of the generic concept industry 4.0, CPS are usually used whenever complex physical systems need to communicate with the digital world to optimize their performance and increase their efficiency. They play an increasingly important role in industrial processes and in production control in the form of sensors and actuators communication that allow the movement and the control of the mechanism [6] to the outside world (linking the CPS). Sensors allow systems to acquire and process data. This data is then made available to the various services connected to the network that use these actuators to directly impact the measurements taken in the real world. This leads to the fusion of the physical world and virtual space in the Internet of Things.

CPS's are mainly used in industrial production to develop architectures built on the Internet that can facilitate the remote control of autonomous production systems. CPS's are useful tools in many other application areas: such as medical equipment, driving safety and driver assistance systems for automobiles, industrial process control and automation systems, assistance systems for controlling the power supply in terms of optimized use of renewable energies.

4. Discussions

4.1. Narrow Band IOT (NB-IOT)

NB-IoT (Narrowband Internet of Things) is a wireless communication technology. Applied to date mainly to Smart Home, Smart Cities, Smart Buildings, Smart Metering, Consumer, Agriculture/environment sectors

It is a wireless protocol that is promoted by telecom operators and mobile phone equipment manufacturers (Huawei and Vodafone in particular). Indeed, it relies on existing mobile telephony infrastructures to convey messages over long distances. This protocol is standardized by 3GPP, the standardization body that writes cellular standards, i.e. GSM, 3G, 4G mobile technologies and their evolution. [11]

NB-IoT competes directly with solutions such as Lora and Sigfox. Like the latter, it is characterized by a very good indoor and outdoor coverage, low latency, very low connectivity costs, low power consumption and optimized network architecture. However, it is not a private initiative because it is developed by several people.

From the outset, the latest NB-IoT technology has been developed to enable effective communication while ensuring long battery life for devices distributed in homes or in mass across the Smart City. This is a Low-Power Wide-Area (LPWA) technology: low power consumption for a wide area of radiation.

Another advantage of NB-IoT over other protocols that exist in the house (and in the connected house) is that he doesn't need a box to play the smart house driver. No need for a gateway or Wi-Fi router to communicate over the network and even to communicate with the data collection and monitoring components to the outside. Telephonic communications antennas will do the trick. That is, on the traditional 4G network, NB-IoT can be used with a simple software update of the existing network software.

NB-IoT or Narrowband IoT or called LTE-M2 is a low power and long-range technology (LPWAN) validated in June 2016 that can operate in three different ways: - In the 200 kHz frequency band formerly the GSM network
 - With the LTE network which reserves resources for NB-IoT
 - Within an independent network

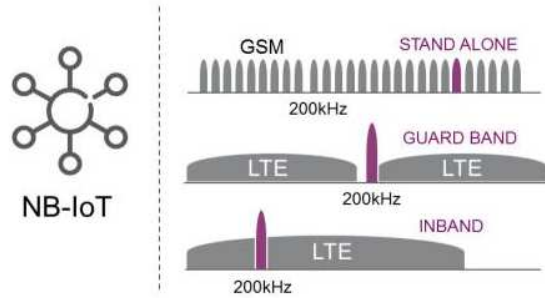


Fig.1.Multiband NB-IOT

To date, Huawei, one of the major technology promoters, estimates that 5 million connected objects and sensors are discussing in NB-IoT, include sensors in factories, water meters, gas meters, connected streetlights, bicycles, and sensors in car parks... This NB-IOT technology ensures a better integration of connected objects in a noisy industrial rea via a narrow band 180 KHz, a rate of 250 Kbits but also a low energy consumption. The NB_IOT is already in place in logistics could bring the smart city, agriculture, but also now the smart home and the household appliance sector in line... [12]

NB-IoT or Narrowband IoT is a new communication standard Low Power Wide Area Network (LPWAN) specially designed for the Internet of Things developed by 3GPP (Third Generation Partnership Project, the organization behind the standardization of cellular networks).

4.2. Proposed Device (RS485 to SaRa-N2)

With this article, we are particularly interested in the application of the Internet of Things in the industrial field especially for wireless communications of smart factories. We aim to replace all heavy wiring in factories with an intelligent and agile system based on smart things and intelligent communication for control and monitoring. we present in this part of our paper an industrial communication based on the IOT and multiband communication using the Nb-Iot technology and the RS485.

NB-IoT is a global industry open standard, sustainable and scalable, based on 3GPP, and benefits from its powerful ecosystem of manufacturers and mobile operators around the world.

This communication solution, based on a licensed radio spectrum offer an optimal quality of service. NB-IoT eliminates usage limitations, interference and congestion, which are often the biggest problems in unlicensed radio spectrum applications.

With extensive radio coverage, NB-IoT based on 4G, benefits from existing infrastructure. In addition, the frequency band used makes it possible to improve penetration inside buildings or underground (so-called "indoor" or "deep-indoor" coverage), for example to ensure a periodic connection with industrial boilers installed in the basement, places that are considered too difficult to use without wires without any problems, without signal interruption and without loss of data.

In the industrial communication space, the use of communication technologies is based on several criteria (range, speed, reliability of communication in difficult environments, etc.), i.e. there is no single solution for all

possible connectivity requirements. It must be dimensioned to meet the specifics of each use case, for example, wireless sensor-actuator networks that operate in real time and include several industrial Internet of Things loops for future installations.

This industrial gateway is a universal IOT device that allows data collection from several ModBus-based serial devices (ASCII, RTU) on the RS485 link simultaneously, and transfer of this data to industrial applications, using multiple bands, to use a well-defined bandwidth for each level of the CIM pyramid (WSN, Machines, SCADA, ERP and EMS) via the NB-IOT network..

NB-IOT will provide global coverage, as it is an update of the 4G/LTE network. In addition, the amount of data that can be transferred (uplink and downlink) is higher the other LPWAN technologies. LORAWAN and SIGFOX which are indeed limited compared to NB-IOT.

The major factor in the Internet of Things ecosystem is the availability of good Sensors, Actuators, PLC's, Variable Speed Drives, operating on efficient data communication networks. It is within this framework that we are implementing a new communication device an industrial gateway, which operates on the NB-IOT network.

The NB-IOT will not replace LORAWAN or SIGFOX. It will complement it for projects that require truly global coverage or higher data rates. This communication model based on wireless industrial communication between different industrial equipment is a universal module for data collection and transfer, based on the NB IOT network. It is suitable for connecting PLCs and industrial equipment's (PLCs, variable speed drives, HMI, etc.)

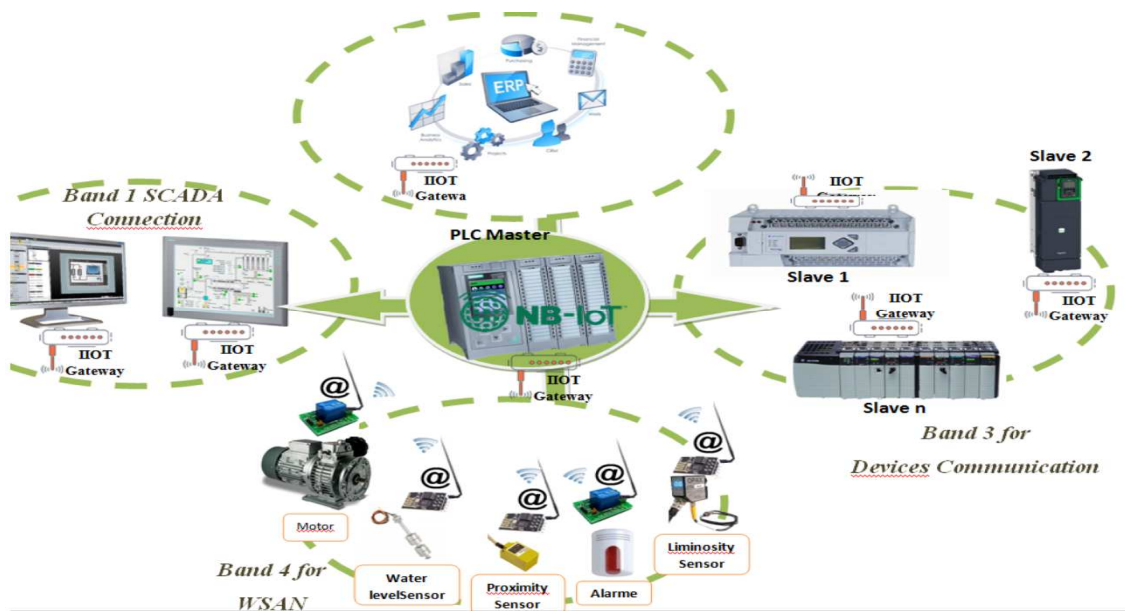


Fig. 2. Gateway Implementation Architecture in the CIM Pyramid

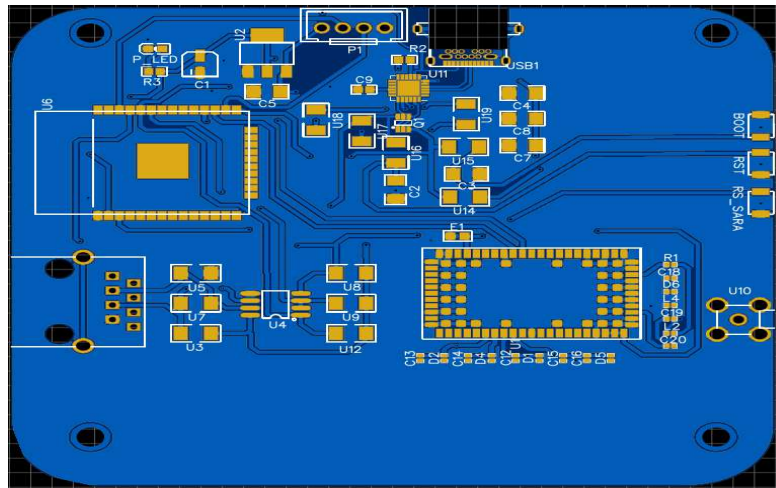


Fig. 3. Top Side View of the PCB

5. Conclusion

In the process industry, for example, where the collection of sensor data frequently requires the deployment of long lengths of cables and the crossing of various obstacles in a harsh environment, wireless technologies can save significant amounts of time and money. However, provided a number of conditions are met: Ensuring high transmission reliability, a range from a few meters to several kilometers.

Industry 4.0 presents a technology in full growth given the fruits it brings to good management of the industrial sector. Its proper functioning is due to the Internet of Things, which in turn is a vital element for its development and improvement. Certainly, the proper conduct of this protocol requires communication between a set of industrial equipment using data frames adaptation techniques using protocols such as Modbus RTU (RS485) and NB-IoT.

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