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GATEWAY FOR BLUETOOTH AND CAN COMMUNICATIONS PROTOCOLS

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ABSTRACT

In many factory applications establishing communications between devices are traditionally implemented by wired links. The accessibility robustness of interface devices of CAN bus protocol is the mainly feature for its adoption by the automation market. But the wired networks are a disadvantage in installation and maintenance aspects, especially with fixed equipment where wires are in constant danger of breaking. In this paper, we propose a design of gateway to avoid communication between CAN bus and Bluetooth Piconet, with the main goal to provide way to solve and reduce the wired difficulties.

Keywords: *Bluetooth, Control Area Network (CAN), Embedded System, UML, Wireless Network*

1. INTRODUCTION

In recent decades, the increased development of components in factory automation around the world has become into a very attractive research field, especially in the industrial communication area [1]. This area usually incorporates different modern disciplines, as sensors nodes communication and actuators engineering, in an integrated scheme for interconnection purposes. In this way, a factory automation system can be combined with several sensors, controllers, and machines through a message specification [2].

There are many different network types for use in an industrial environment as Control Area Network (CAN), Process fieldbus (Profibus), Modbus, and so on. In this context, the CAN protocol has become a reality in automotive applications (in its early days, CAN was created as a solution for this kind of applications), as well as in industrial control design.

The CAN standard is a very robust protocol including the error detection and signalization, self–checking and fault confinement. The CAN bus is a multi-master broadcast structure that operates at a maximum rate of 1 Mbit/s with an implemented multi-access protocol that detects collision and solves it by analyzing the assigned priority in the identifier field of the message [2]. Although in CAN protocol the data transfer rate depends on distance. For example, 1 Mbit/s can be achieved at network lengths below 40 m, while 250 Kbit/s can be achieved at network lengths below 250 m. The lowest bit rate defined by the standard is 200Kbit/s. Used cables are shielded twisted pairs (see Figure 1).

Figure 1. CAN bus configuration scheme.

Nevertheless, in spite of the increased importance in these areas; the wired network is a disadvantage due to the excessive wire used in its installation and its impact in expensive costs in maintenance. In this sense, the rapid growth of short range wireless networks is an appropriate solution to solve this problem. The wireless networks allow nodes to easily move, adding more flexibility to a devised network solution [3]. Thus, the wireless networks can drastically reduce costs and efforts of installation and configuration systems, as shown in [4].

In applications for industrial control, the wireless networks are an important parameter to consider the robustness related to interference between devices. From this point of view and due the increased usage of Industrial, Scientific and Medical (ISM) band among different networks,

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the traffic becomes an important problem. For example, Bluetooth, Wi-Fi (802.11 b/g), and ZigBee operate in the same frequency spectrum; thus the performance of these devices is adversely affected by the presence of one another, adding to this, the electromagnetic interference from some machines in the vicinity. As consequence, Bluetooth has included Adaptive Frequency Hopping (AFH) algorithm which allows Bluetooth devices to classify channels and use only good channels. AFH considers the channel condition and dynamically changes the hopping frequency [5]. Thus, Bluetooth is a maturity standard based on a wireless radio system designed for short-range and cheap devices to replace cables.

There are 79 Bluetooth channels in the 2.4GHz ISM band; each Bluetooth channel is divided into time slots and the duration of each time slot is 625µs. The Bluetooth devices can communicate with each other using Frequency Hopping Spread Spectrum (FHSS). The Bluetooth topology defines the basic network called piconet, and can form point-to-point (see Figure 2a) or point-to-multipoint links (see Figure 2b). The piconet is a set of two up to eight Bluetooth devices. One device manages the transmission in each piconet, this device is called master, while the others devices are called slaves [5].

Bluetooth devices may create larger structures, where a scatternet is a collection of operational Bluetooth piconets overlapping in time and space. Two piconets can be connected to form a scatternet (see Figure 2c).

Figure 2. Bluetooth topology.

In this paper, we propose an approximation design of a gateway tool that incorporated both, Bluetooth wireless technology and CAN protocol, to solve wired and interferences difficulties. The rest of this paper is organized as follows: Section 2 presents the related work on gateway system based on Short-Range Wireless Networks with CAN protocol. Section 3 describes the hardware and software design of the BlueCAN system. Finally, Section 4 concludes this paper.

2. RELATED WORK

According to our literature review, there are early approximations incorporating wireless technology with CAN protocol. For example, Castro and dos Reis Filho [6] described and evaluated a system which implements the communication between a controller area network bus and wireless Bluetooth networks. In this work, the authors measured the latency from the end of Bluetooth reception to the start of CAN transmission, and they observed that for high baud rates, average latency is less than 10ms and jitter is less than 2ms, thus showing that the dual media network is a competitive solution for industrial automation. Zhang et al. [7] designed a monitoring system of power cable joints temperature based on the combination of CAN wired transmission and ZigBee wireless network, and by monitoring and analyzing the temperature of power cable joints, it can give an early alarming of cable joints accidents and will be very significant to the safe and reliable operation of power system. Ren et al. [8], gives a kind of design of CAN bus network based on Bluetooth technology, they indicated that the system could operate reliably and steadily and CAN-Bluetooth nodes could deliver the data correctly transmitted from the Bluetooth wireless sensor nodes in real time to the upper computer to process through CAN bus intelligent controller.

Our proposal is different of these studies, since the implementation of our Bluetooth-CAN gateway system is based on UML design to achieve, in a more easy way, the migration of the target device. Also our approach give an example for designing the interaction between actors and functions involved in a gateway system to manage the functionality between communication protocols.

3. DESIGNING THE BLUECAN NODE

The BlueCAN node is a gateway tool that converts data from CAN bus to Bluetooth data and vice versa. Also can read data from CAN bus and converts the packets to UART data to send them to Bluetooth devices in the vicinity (see Figure 3).

3.1. Hardware Design

In the hardware design, the BlueCAN node consists of two main modules to manage the system activities: DCE Module and DTE Module (see Figure 3).

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Figure 3. Block diagram of BlueCAN system.

Through the DTE Module the user configures the node and displays the messages that are sent between devices. The DTE Module is composed by the following components:

- Graphic Liquid Crystal Display (GLCD): Through the GLCD, the user will see the different options of the system and can view CAN packets in real-time.
- Keyboard: Through the keyboard matrix, the user can select different options of the functionality.
- DSPIC30F4013 Microcontroller: The dsPIC 30F4013 MCU contains a CAN module controller implementing the CAN 2.0 A/B protocol, as defined in the BOSCH specification [9].
- RS232 transceiver: The RS232 transceiver converts the RS232 voltage levels (-12V and 12V) to UART voltage levels (5V and 0V).
- CAN transceiver: The CAN transceiver is the MCP2551 device, which is a high-speed CAN, fault-tolerant device that serves as the interface between a CAN protocol controller and the physical bus.
- Reset button: In some situations it is necessary to restore the BlueCAN node settings to its default values. The reset button is responsible for restarting the DTE module.

The DCE module establishes the connections according to the Bluetooth protocol in serial format, and this module consists of the following components:

- Bluetooth module: The Bluetooth module is the OEM serial port adapter OBS433i that is a long range Bluetooth 2.1+EDR module (class 1), with support for the Serial Port Profile (SPP) for fast and secure transparent serial data transmissions, and the Personal Area Networking Profile (PAN) released by connectBlue signature (see Figure 4a).
- OEM RS232 adapter: The OEM module adapter RS232 is a development tool designed for easy interfacing the OEM serial port adapter products from connectBlue signature (see Figure 4b).

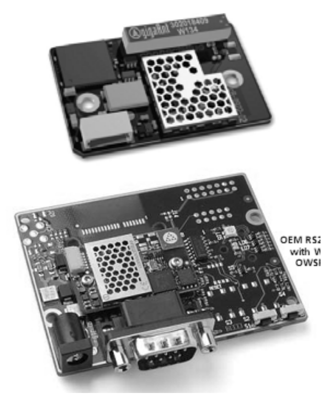

Figure 4. Bluetooth device.

The hardware design and integration of these components are represented by the block diagram of the Figure 5.

Figure 5. Block diagram of BlueCAN node integration.

3.2. Software Design

With the UML diagrams, we established a design to represent the functionality of the BlueCAN system. In this way, the BlueCAN node operates in two main modes: the configuration mode and the data mode. These main operating

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modes are managed by the operation management and data management respectively (see Figure 6).

The user can explore the several functions of the BlueCAN system through the keyboard, and choosing options in the menus.

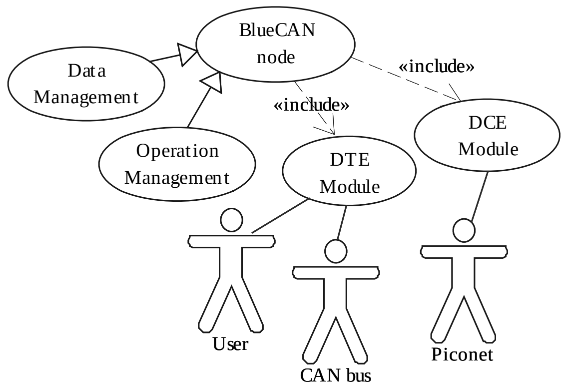

Figure 6. Use case diagram for BlueCAN node.

The Figure 7 shows a statechart diagram that represents the dynamic model in which the user has interaction with the methods and functions of the BlueCAN system.

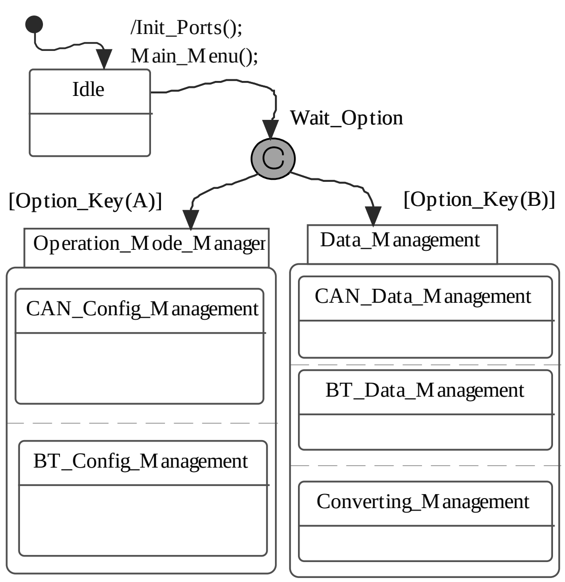

Figure 7. Statechart diagram of choice operation mode.

In the configuration mode, the CAN and Bluetooth modules are set up with the support of the Bluetooth configuration management and CAN configuration management subsystems respectively.

In the Bluetooth configuration management subsystem (see Figure 8), the Bluetooth mode method enables or disables the Bluetooth characteristics of the BlueCAN node (i.e., it can work in a discoverable and non-discoverable mode). The Bluetooth name mode method is useful to change the friendly name of the Bluetooth module. Finally, the pairing mode method is used for performing searches for Bluetooth devices and allow to establishing a security link connection with the BlueCAN node.

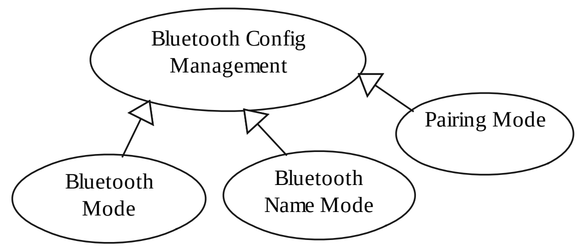

Figure 8. Use case diagram for Bluetooth configuration.

The Bluetooth connections of the BlueCAN node are based on the Serial Port Profile (SPP). Thus, is very important that the devices (BlueCAN node and Bluetooth device) have the same profile to establish the link and establish the communication between them.

In the other hand, the CAN configuration management determines the operation mode of the CAN module with the support of the CAN operation mode method (see Figure 9). The operation mode method includes: initialization mode, disable mode, normal operation mode, listen only mode, loopback mode, and error recognition mode.

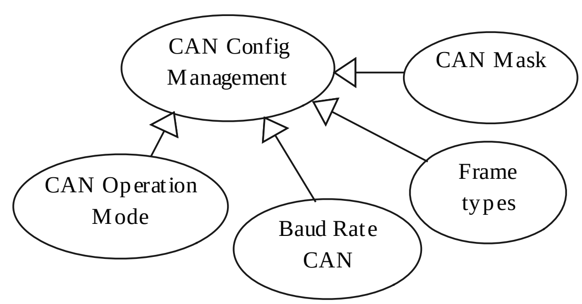

Figure 9. Use case diagram for CAN configuration.

All nodes on any particular CAN bus must have the same nominal bit rate. In order to set the baud rate, the CAN baud rate method is responsible to set up parameters as: synchronization jump width,

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baud rate prescaler, propagation segment bits, and so on.

The BlueCAN node supports two message formats which are managed by the frame types method: standard format (with 11 identifier bits) and extended format (with 29 identifier bits). Finally, the CAN mask method establishes advanced filtering and sets mask for listen messages.

Once the modules are configured, it is possible that the BlueCAN node converts CAN packets to Bluetooth packets and vice versa. The Figure 9 shows a scenario where the user accesses to operation mode and first establishes the configuration of both Bluetooth and CAN modules, then changes to data mode and enters to BlueCAN convert data subsystem. The BlueCAN node listens packets from CAN bus (always with the previously configuration of the mask and identifier bits for filtering messages) and convert to Bluetooth data, and then send data to other Bluetooth device (both devices have been previously paired). The firmware of the BlueCAN node was programming in C, with the mikroC compiler demo for Microchip dsPIC30 family. The final implementation of the BlueCAN node is shown in the Figure 11.

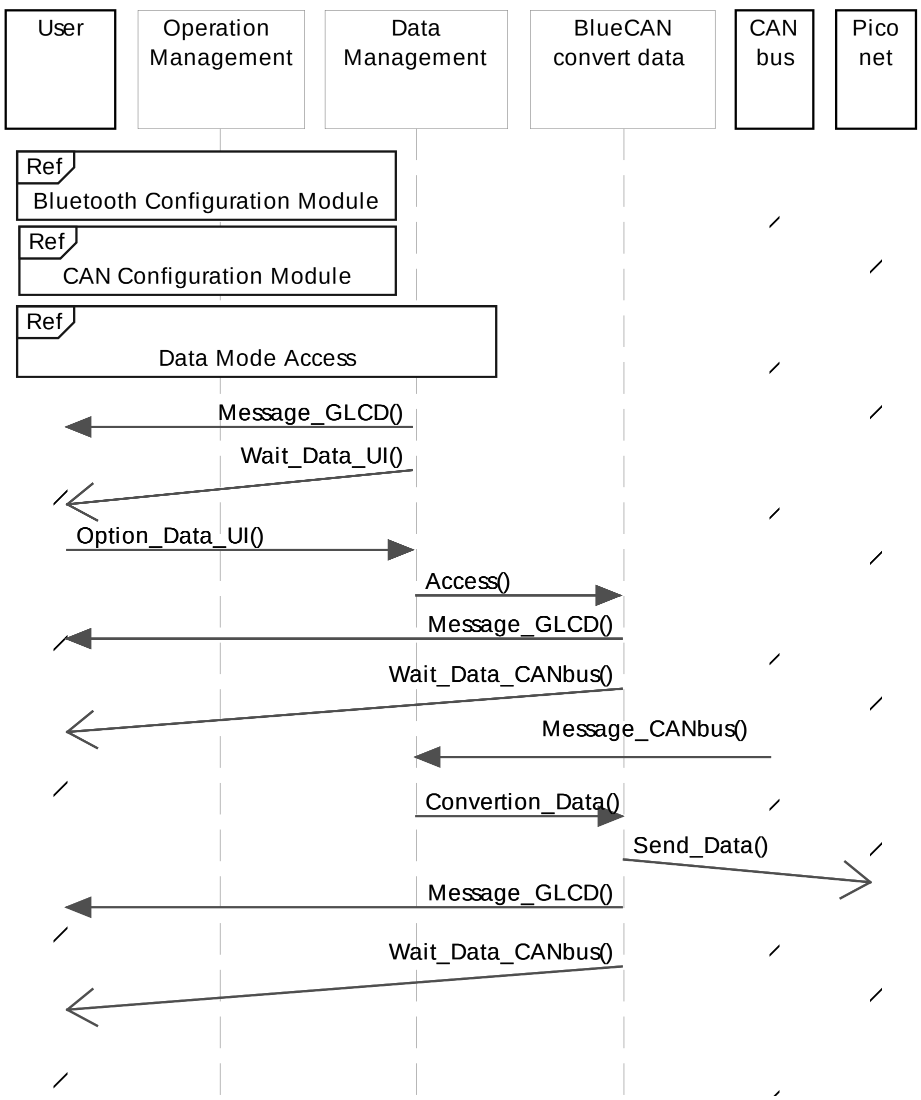

Figure 10. Sequence diagram for Bluetooth to CAN data conversion.

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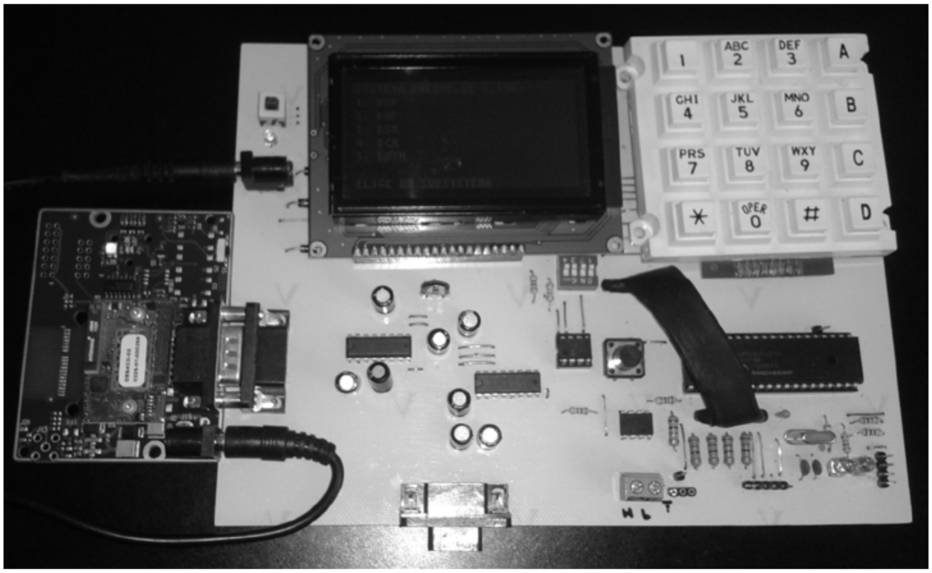

Figure 11. BlueCAN node final prototype.

4. CONCLUSIONS AND FUTURE WORK

In order to allow the communication between a wired CAN bus and a Bluetooth piconet, the design of the BlueCAN gateway system was proposed. We summarized a design under UML approach to enable the expansion of system functionality, and understand in an easy way, the interaction between user and system. Other contribution of this work is related to research on the fusion of short range wireless technology with the industrial communication. The results of remove wire connection between machines, and supported by a robustness wireless protocol as Bluetooth technology, made very suitable for many industrial automation applications since Bluetooth includes the AFH mechanism to mitigate environment interferences.

As limitations of our work, at the moment our system does not support with other wireless technology. As future work, we will expect to design a system for improving the application experiments, including WiFi technology and giving a formal architecture for the construction of a refine gateway tool.

REFRENCES:

[1] R. Zurawski. "Guest editorial of special section on factory communication systems," *IEEE Trans. Ind. Electron*, Vol. 49, No 6, 2002, pp. 1186-1188.

[2] Dominique, P. Multiplexed Networks for Embedded *Systems*, John Wiley & Sons Ltd, 2007.

[3] Jin-Shyan, L., Yu-Wei, S., Chung-Chou, S. "A Comparative Study of Wireless Protocols: Bluetooth, UWB, ZigBee, and Wi-Fi" *Proc. of the 33rd Annual Conference of the IEEE Industrial Electronics Society*, IEEE Computer Society, 2007, pp. 46-51.

[4] Miorandi, D., Uhlemann, E., Vitturi, S., Willig, A. "Guest Editorial: Special Section on Wireless Technologies in Factory and Industrial Automation, Part I," *IEEE Transactions on Industrial Informatics*, 3(2): 95-98.

[5] Bluetooth SIG, Bluetooth Spec. v4.0, 2009.

[6] Castro de Almeida, L., dos Reis Filho, C. "Latency evaluation in a Bluetooth-CAN dual media sensor network," *2010 IEEE International Conference on Industrial Technology (ICIT)*, IEEE Computer Society, pp.247-251, 2010.

[7] Zhang, L., Sun, L., Lu, W. "A Temperature Monitoring System of Power Cable Joints Based on the Combining of CAN Wired Transmission and ZigBee Wireless Network," *2nd International Conference on Information Engineering and Computer Science (ICIECS)*, IEEE Computer Society, pp.1-4, 2010.

[8] Li, Y., Yu, L., Yan, J., Li, H. "The design of ZigBee communication convertor based on CAN," *International Conference on Computer Application and System Modeling (ICCASM)*, IEEE Computer Society, 245-249, 2010.

[9] "CAN Specification 2.0", Bosch, Stuttgart, 1991.