Implementation of a CAN/IEEE 802.11b WLAN/CAN internet working system using a wireless interface unit

[1]Cuneyt Bayilmis, [1]Ismail Erturk, [1]Celal Ceken, [2]Ibrahim Ozcelik, [3]Ahmet Karaca

[1]University of Kocaeli, Department of Electronics and Computer Education, Turkey
[2]University of Sakarya, Department of Computer Engineering, Turkey
[3]University of Sakarya, Department of Electronics and Computer Education, Turkey

This paper presents a sample design and implementation of a CAN/WLAN/CAN interworking system using Wireless Interworking Units (WIU) that are capable of connecting remote CAN 2.0A nodes over IEEE 802.11b WLAN. This provides a straightforward solution to extend the size of distributed area of CAN networks and enables the CAN networks to communicate with other LANs utilising a low cost technology with high data rates.

1 Introduction

The Controller Area Network (CAN) is mainly employed in distributed real–time control applications. Increasing use of several CAN networks in modern industrial plants results in need for interworking between CAN networks as well as between CAN and other major public/private networks [1-4]. There may be certain difficulties in some industrial scenarios where a traditional wired backbone is deployed to provide this type of required interconnection functions. Instead, having a wireless backbone as an alternative in such environments to interconnect CAN networks would be exceptionally valuable [1-3].

One wireless network which currently provides the features needed in an industrial control environment, that is, easy integration with several communication systems and capability to ensure critical time constraints, is the IEEE 802.11 standard.

This work presented includes a sample design and implementation of a CAN/WLAN/CAN interworking system utilising Wireless Interworking Units (WIU) proposed in [2, 3].

The organization of this paper is as follows. Section 2 briefly introduces CAN and IEEE 802.11b WLAN. Section 3 describes the WIU and its structure employed in interconnection of the CAN segments using IEEE 802.11b WLAN. The CAN/IEEE802.11b/CAN prototype is presented in Section 4. Section 5 introduces a sample application using this prototype.

2 Background: CAN and IEEE 802.11 WLAN

[5] and [6] supply a detailed overview of the CAN features that can be summarized as high speed serial interface, low cost physical medium, short data lengths, fast reaction times and high level of error detection and correction. CAN utilises the Carrier Sense Multiple Access with Collision Detection (CSMA/CD) as the arbitration mechanism to enable its attached nodes to have access to the bus. As CAN employs a priority based bus arbitration process, the node with the highest priority will continue to transmit without any interruption. There are two versions of CAN exist and they only differ in the size of identifier. The identifier field serves two purposes: assigning a priority for the transmission and allowing message filtering upon reception. Figure 1 shows the CAN 2.0A message format utilised in the WIU.

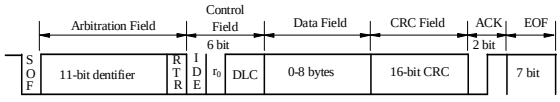

Figure 1: CAN 2.0A message format

IEEE 802.11 WLAN is a local area network implemented without wires. The

main advantages of WLAN are mobility and cost–saving installation. Any WLAN aims to offer all the features and benefits of traditional LAN technologies (e.g., Ethernet and Token Ring) but without the limitations of being tethered to a cable [7-8]. IEEE 802.11 employs Carrier Sense Multiple Access/ Collision Avoidance (CSMA/CA) as the channel access method and operates in the 2.4 GHz unlicensed ISM (Industrial, Scientific and Medical) band. Figure 2 shows IEEE 802.11b frame that consists of a PLCP preamble, PLCP header, and MAC Protocol Data Unit (MPDU), utilised also in the WIU. [7].

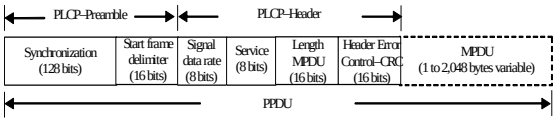

Figure 2: IEEE 802.11b DSSS PCLP packet format

3 CAN/IEEE802.11b/CAN Wireless Internetworking Unit

The Wireless Internetworking Unit (WIU) interconnects two CAN2.0A networks communicating through IEEE 802.11b. The WIU has two ports. Each port of WIU has a different protocol, frame/message format, and frame reception/ transmission mechanism. Thus, the processes to be performed at each port of the WIU are different. Therefore, both the translation and forwarding processes are required [2, 3].

The WIU contains the worst-case translation that requires creation or loss of fields representing unmatched services. The unmatched services can be solved by a transparent-translating local bridge used to interconnect different LANs. Figure 3 shows the process model of transparent-translating local bridge. [2] and [3] supply a detailed design stages and computer modelling of the Wireless Interworking Unit using OPNET Modeler.

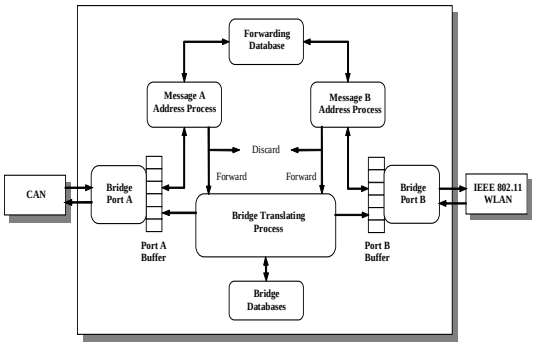

Figure 3: Process model of transparent-translating local bridge

Main function of the Wireless Internetworking Unit is that the Protocol Data Units (PDU) of the CAN messages are encapsulated within those of the IEEE 802.11b DSSS frames to be carried over wireless channels. Since a CAN 2.0A message is 108 bits, it can easily be fitted into one IEEE 802.11b frame MPDU (Figure 4). Thus, neither segmentation / reassembly of CAN messages nor data compression is necessary for carrying a CAN message in one IEEE 802.11 frame. At the destination WIU, preamble and header parts of the IEEE 802.11b frames are stripped off, and the CAN messages extracted from the IEEE 802.11b MPDUs can be processed [2, 3].

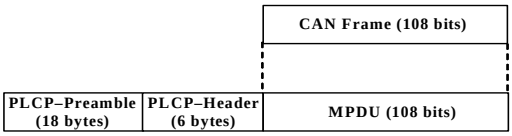

Figure 4: Encapsulation of a CAN2.0A message into an IEEE 802.11b frame

4 CAN/IEEE802.11b/CAN WIU prototype

Figure 5 shows a picture and block diagram of the WIU prototype. The WIU prototype consists of a CAN development kit, a IEEE 802.11b WLAN unit and an LCD.

The CAN development kit provides all functions of CAN protocol and connection between CAN bus and WIU. It contains following parts:

- T89C51CC01 CAN controller: The T89C51CC01 is the first member of the CANary™ family of 8-bit microcontrollers that provides all the features required to implement CAN

serial communication protocol as defined by Bosch GmbH. The CAN controller supports both CAN 2.0A and CAN 2.0B. The CAN controller has 15 independent communication channels that each channel can be programmable for reception, transmission and as receive buffer. T89C51CC01 can be programmed by serial mode via the CAN bus or UART. It also allows ISP (In-System Programming) [9].

- PCA82C251 CAN transceiver: It provides communication between CAN controller and CAN physical bus.
- RS-232 transceiver: It is used as serial interface between the microcontroller and computer as well as between the microcontrollers.

IEEE 802.11b WLAN unit provides all functions of IEEE 802.11b and CSMA/CA protocol. It supports both ad-hoc and infrastructure topologies. IEEE 802.11b WLAN unit also contains an embedded web server. Therefore, it can be wirelessly accessed and controlled over a network or the internet. IEEE 80211b WLAN unit generally establishes wireless networking with any electronics device over serial port or Ethernet [10].

The LCD shows operations of the WIU such as reception and sending CAN messages.

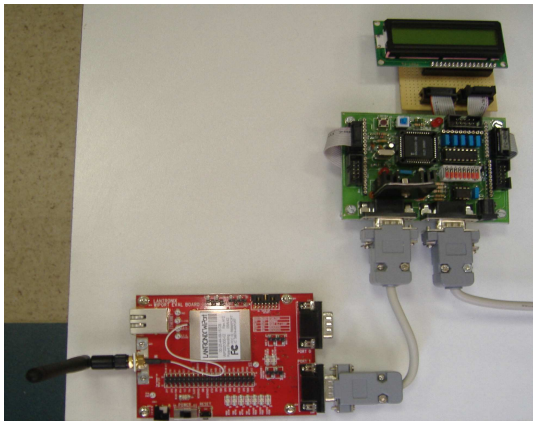

Figure 5.1: Prototype

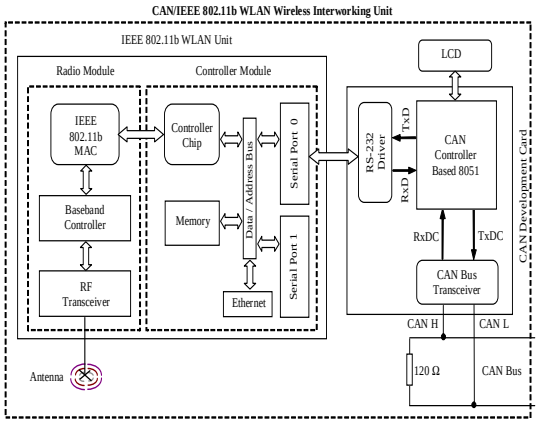

Figure 5.2: Block diagram of WIU

5 A sample application using the CAN/IEEE802.11b/CAN WIU prototype

Figures 6 and 7 show the block diagram and a picture of the CAN/IEEE802.11b/CAN internetworking application prototype, respectively. The system designed and implemented consists of two independent CAN segments each with two CAN nodes and a WIU. Every CAN node produces a remote CAN message and a local CAN message carrying data entered using the keypad. The local message is destined to the other CAN node in the same CAN segment while the remote message is destined to a CAN node in the other CAN segment. The CAN messages used in this sample application are given in Table 1. The flowchart of operation of the WIUs and flowchart of operation of the CAN nodes in this application prototype network are shown in Figures 8 and 9, respectively.

	Source Node	Message Type	Priority	Data (bytes)	Destination Node
Segment 1	1	Remote	1	8	3
		Local	2	8	2
	2	Remote	3	8	4
		Local	4	8	1
Segment 2	3	Remote	5	8	1
		Local	6	8	4
	4	Remote	7	8	2
		Local	8	8	3

*CAN Bus rate: 500 Kbit/s

**IEEE 802.11b WLAN rate: 11 Mbit/s

Table 1: CAN messages used in the CAN*/IEEE802.11b/CAN internetworking application prototype**

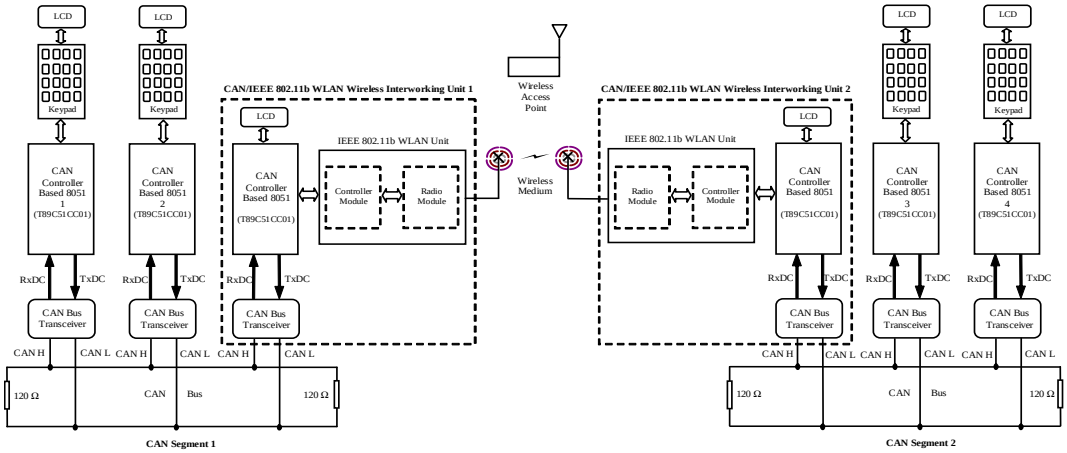

Figure 6: Block diagram of the CAN/WLAN/CAN internetworking application prototype

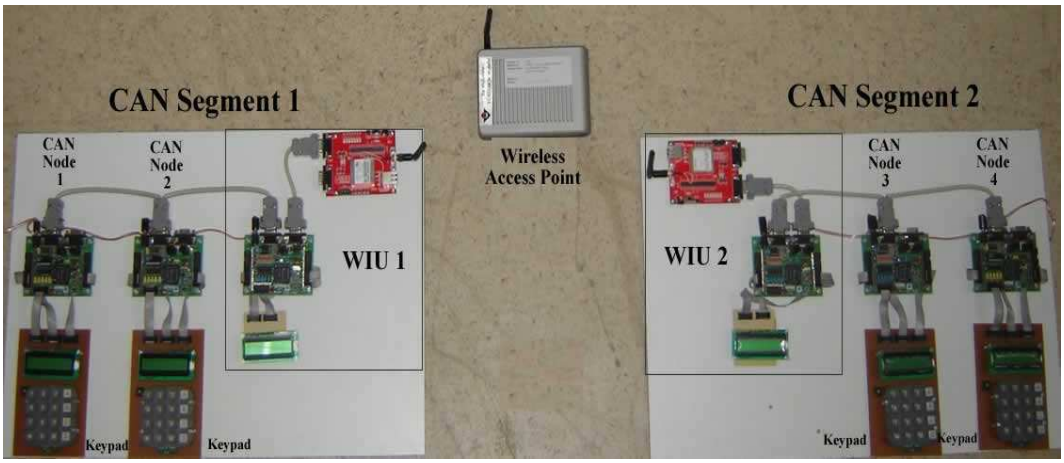

Figure 7: Picture of the CAN/WLAN/CAN internetworking application prototype

6 Conclusions

The aim of this work presented has been to design and implement a sample CAN/WLAN/CAN interworking system using Wireless Interworking Units (WIU). The WIUs employed provide a service to achieve the wireless interconnection of two CAN2.0A segments using an IEEE 802.11b WLAN. Considering their easy and widespread usage in many industrial areas, CAN nodes emerge inevitably to need this type of wireless internetworking for greater flexibility for their applications to be controlled remotely. And this study shows that it can be well achieved by using the proposed application and/or its FPGA based examples.

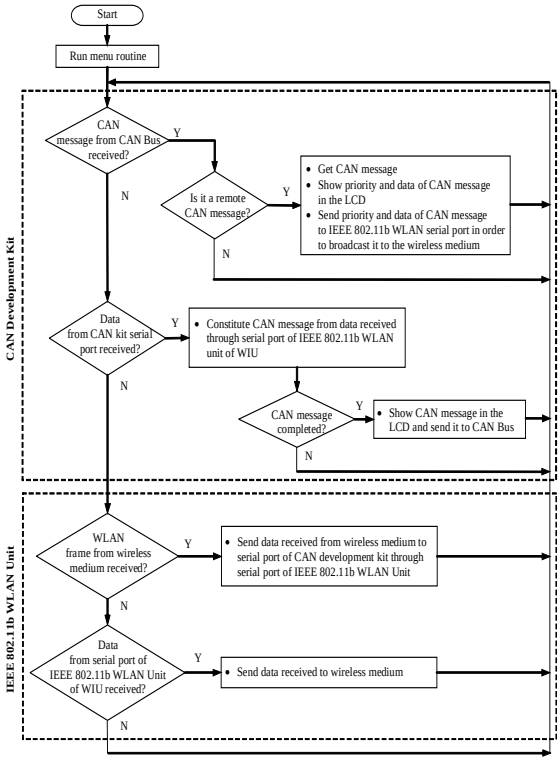

Figure 8: Flowchart of operation of the WIU process

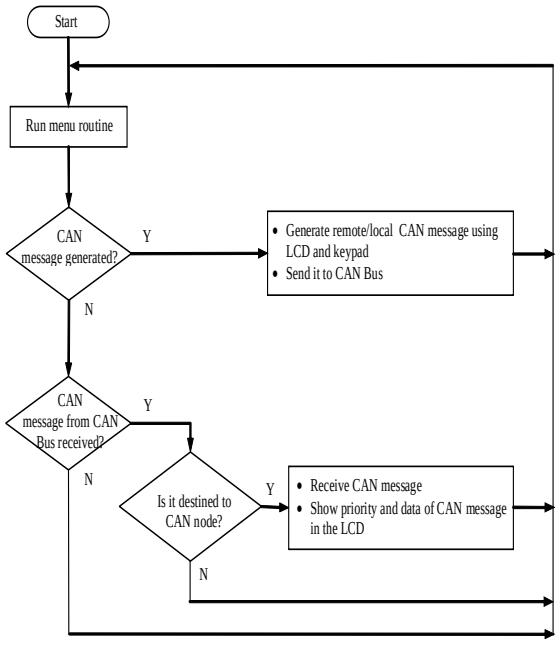

Figure 9: Flowchart of the operation of the CAN nodes

7 Acknowledgment

This research has been supported by TUBITAK (Scientific & Technological Research Council of Turkey) under contract EEEAG/105E059.

8 References

[1] Erturk, “A new method for transferring CAN messages using wireless ATM”, Journal of Network and Computer Applications, vol. 28, pp. 45-56, 2005.

[2] C. Bayilmis, I. Erturk, and C. Ceken, “Wireless Interworking Independent CAN Segments”, Lecture Notes in Computer Science, LNCS 3280, pp. 299-310, 2004.

[3] C. Bayilmis, I. Erturk, and C. Ceken, “Extending CAN Segments with IEEE 802.11 WLAN”, The 3rd ACS/IEEE International Conference on Computer Systems and Applications, AICCSA-05, Egypt, 2005.

[4] H., Ekiz, A., Kutlu, E., T., Powner, “Design and Implementation of a CAN/Ethernet Bridge”, Proceedings of the ICC’96 3rd International CAN Conference, France, pp. 1117–1126, 1996.

[5] W., Lawrenz, “CAN System Engineering: from Theory to Practical Applications”, Springer-Verlag, New York, pp. 1-289, 1997.

[6] M., Farsi, K., Ratckiff, M., Babosa, “An Overview of Controller Area Network”, Computing and Control Engineering Journal 10 (3), pp. 113–120, 1999.

[7] Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications, IEEE Standards 802.11, pp. 195–200, 1999.

[8] I., Aad, C., Castelluccia, “Priorities in WLANs”, Computer Networks, Vol. 41. pp. 505–526, 2003.

[9] Atmel T89C51CC01 Data Sheet, http://www.atmel.com

[10] Wiport Guide, 2006, Documentation – Embedded Device Servers [online], http://www.lantronix.com/support/documentation.html