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# Intelligent Bus Management and Monitoring System

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## ABSTRACT

*This paper deals with the implementation of an intelligent bus monitoring system based on current challenges and problem. This system would overcome significant drawbacks of wired interfaces, i.e. there would be no interruption of operation owing to physical damage and wireless Bluetooth technology would enable easier access to the device where physical wires and connections may be difficult to install. The result show that the choice of integrated technology used in the system is suitable to monitor and manage a vehicle transportation system.*

**Keywords** –LCD display; microcontroller; traffic monitoring; Intelligent transporation system

## 1. Introduction

Intelligent traffic systems (ITS) hold the promise to improve roadway congestion and transportation infrastructure manage-ment by capitalizing on information derived from traffic mon-itoring. The increasing requirement and public expectation for accurate vehicular traffic information to manage traffic flows has precipitated the deployment of large scale traffic monitor-ing infrastructures. Typically, this has included the use of inductive loop detectors, microwave sensors and relatively expensive video cameras.

The Bluetooth allows data transmission over distance up to 10 meters (100 meters with special amplifier). The ability to communicate over short and medium distances seems to be adequate for the wireless connection of Among available wireless communication technologies the most promising one seems to be the Bluetooth technology sensors, where the sensors are slaves and the DAS is a master. Transmission capacity and the addressing capabilities of the Bluetooth are adequate for the intended autonomous wireless data acquisition system.

## I. BLUETOOTH TECHNOLOGY

Bluetooth is one of several available wireless technologies that to assist in resolving location extracted from a consumer may be employed electronic device (Table I). This survey focuses on classical Bluetooth 2.0 with a range that is well-tailored for monitoring or detecting devices residing in or integrated into vehicles, such as Smartphones, Bluetooth ear-pieces and car audio. NFC and BLE 4.0 are more recent market entries with emphasis on low power and more personal communication or very body-centric networking. WiFi and cellular are intended for wider area networking.

Table I Various wireless proximities

| Technology | Range |
|---|---|
| NFC (RFID) | ~ 20 cm |
| BLE 4.0 | <25 m (estimated) |
| Bluetooth | 1-100 (class dependent) |
| WiFi | 5-100 m (typical) |
| Cellular | km+(cell sector –typical) |

## II. BASICS BLUETOOTH SYSTEM

Bluetooth based system consists of (Fig.1):

a) radio transmitter (2.4 GHz Bluetooth radio) - assures the radio transmission itself,
b) link controller - controls the transmitter,
c) link manager & I/O - takes care of the communication among I/O circuit and provides terminal interface for users.

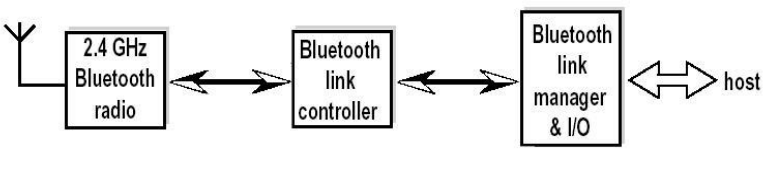


Fig. basic concept of Bluetooth node

The Bluetooth standard defines two different data transmission methods. The first one defines synchronous data channel (Synchronous Connection Oriented - SCO), which is intended mostly for audio transmission, while the second one defines asynchronous data channel (Asynchronous Connectionless - ACL). Both SCO and ACL utilize the same RF line.

The wireless network is built on so called PICONETs , which is the simplest interconnected network that can consist of up to eight nodes [1]. In every PICONET one node acts as a MASTER, the rest of nodes act as SLAVEs. PICONETs form entity of higher- level called SCATERNET. The formation of SCATTERNET allows for more PICONETs in the same location, however there exist some restrictions as for demand for transmission capacity.

## 2. METHOD AND SYSTEM

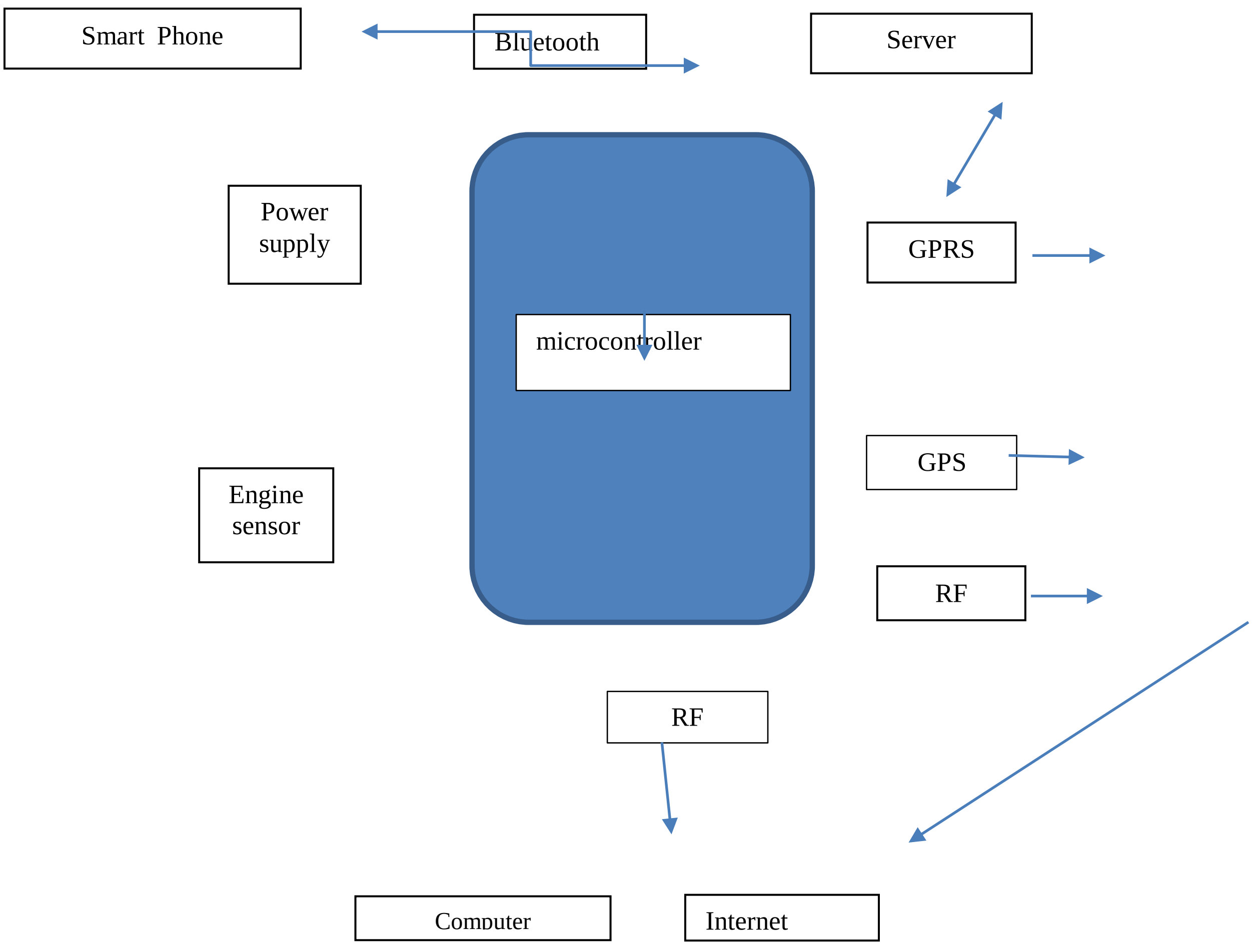



FIG. Architecture of bus identification and monitoring system

Eliminating the physical cabled connection between a data acquisition system and the data processing unit brings flexibility and robustness to every system, especially when this system is located in an industrial environment.

This project investigates the possibility to build a small-sized, low-cost wireless data acquisition system with improved power saving capabilities. The aimed computational platform is the SERVER while the chosen wireless communication standard is Bluetooth. Data acquisition, storage and communication are implemented in microcontroller architecture with integrated A/D converter and UART interface and an external non-volatile memory chip.

With the advent of the new low-cost wireless technologies, the functionality of data acquisition systems can be enhanced eliminating the burden of cabled connection between the system itself and the data processing unit. Especially in the industrial environment, where every supplementary plug implies design and financial efforts, a wireless link between a data acquisition module (sensor with signal conditioning and digital conversion) and a data processing unit (PC, Laptop or SERVER) brings flexibility and robustness to the entire design. The goal of this work was to investigate the possibility to build a small-sized, low-cost wireless data acquisition system with improved power saving capabilities. The aimed

computational platform was the SERVER while the chosen wireless communication standard was Bluetooth (IEEE 802.15.1).

# 3. System Design

## 3.1 Wireless Communication

The aim to build a wireless low-cost communication system implies using wireless communication standards already since a certain time on the market, offering low-cost hardware and good performances. The two suitable standards for the current research topic were WLAN (IEEE 802.11) and Bluetooth (IEEE 802.15.1). Using both the same frequency band, the standards differ mainly in terms of through output, power consumption and network architecture. WLAN offers in the 802.11b version a maximum transmission rate of 11 Mbps, more than ten times higher as the Bluetooth transmission rate of 1 Mbps. This advantage is eclipsed by the high power consumption of the WLAN hardware which offers power saving modes only in the infrastructure mode, implying the existence of an access point.

Bluetooth was designed from the beginning as peer-to-peer low power communication standard, offering various power saving modes without additional hardware such as access points. Based on this main advantage and taking into consideration also the simple interfaces offered (serial connection), Bluetooth was preferred as wireless communication standard.

## 3.2 Bluetooth

Commercial Bluetooth hardware is available in the form of transceiver modules which are small shielded subsystems designed to be used as add-on peripherials. They feature an embedded CPU, around 1 Kbyte of memory and the baseband and radio circuits. Depending on the product, one or more upper layers of the Bluetooth Protocol Stack are also implemented, like Link Controller and Manager, Host Controller Interface, Logical Link and RFCOMM. Modules that have implemented also the RFCOMM layer are called Cable Replacement modules and are emulating one or more serial connection (RS 232) based on the ETSI TS 07.10 standard. The RFCOMM layer offers to the upper application layers a Serial Port Profile (SPP), which is a virtual serial interface. The maximum baud rates for the Cable Replacement modules vary from 115 kbps to 960 kbps and the featured transmission range varies from 10 to 100 m. Both internal and external antennas are available. Successful serial communication up to 960 kbps has been tested for Bluetooth modules produced by Connect Blue based on an Infineon (former Ericsson Microelectronics) chipset and also for modules produces by Amber Wireless based on a National Semiconductors chipset. The latter module is smaller (3 cm X 1,5 cm) and requires less external components and has been used for advanced prototyping.

## 3.3 Microcontroller architecture

The tasks of data acquisition, storage and communication have been implemented in a microcontroller architecture consisting of an Analog Devices Microcontroller with integrated A/D converter, integrated UART interface and an external non-volatile memory chip. The

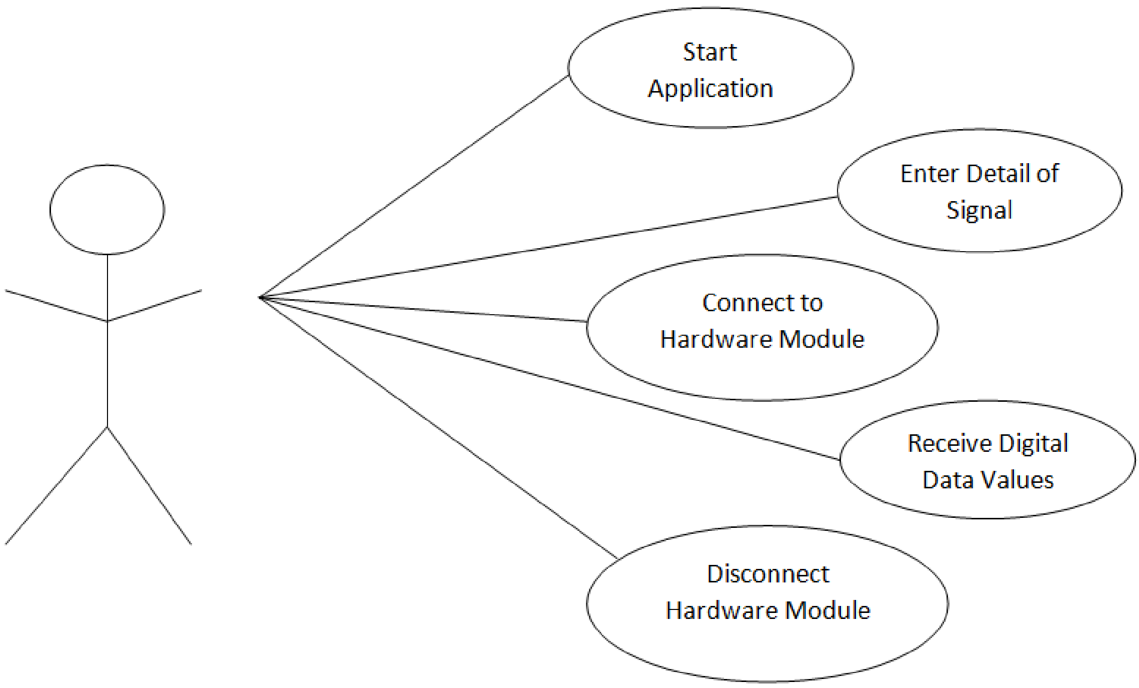
ADuC812 from Analog Devices is a versatile and powerful microcontroller having an integrated, self-calibrating A/D converter with a maximum sampling rate of 200 kHz and ½ LSB precision. The core is an 8 bit 8051 compatible core operating at frequencies up to 16 MHz. A very useful feature of this microcontroller is the possibility to make continuous data acquisition via DMA (Direct Memory Access) into an external memory with a maximum capacity of 16 Mbytes. The access to external memory is done using two external latches. Communication with the external circuits is done by the integrated UART interface with two lines (Rx/Tx).

## 3.4 Device overview

The overall architecture of the data acquisition system is presented in figure 1. The core of the system is the ADuC812 microcontroller that receives the conditioned signals, converts them into digital samples and writes them to the external memory. The ADuC812 monitors also the power management circuits and communicates full duplex with the Bluetooth module. The system is programmed to have two operational modes: “continuous sample” and “single shot”. In the “continuous sample” mode the incoming data is sampled, each sample is formatted into the RS232 standard (1 start bit, 8 data bits, no parity, 1 stop bit) and sent directly to the Bluetooth module where it is transmitted wireless further to the computational platform. The maximal sampling frequency is directly proportional to the baud rate at which operates the Bluetooth module (maximum 960 kbps). Practical tests have revealed a maximal sampling frequency of ca. 100 Hz. Further improvements in the programming of the microcontroller will raise this limit. This operational mode is useful in systems where the data received from sensors is needed in real-time but consequent accuracy is not the main item. For future developments, data pre-processing (for example threshold detection) could be done directly in the microcontroller. In the “single shot” mode the microcontroller fills the external memory by using DMA, working at maximal sampling rate (200 ksps – in practice 160 ksps). Once the memory filled, its content is read incrementally and sent via the Bluetooth Module. This operational mode is useful when working with sensors generating signals at higher frequency. There is the drawback of not receiving real-time data, but the high sampling frequency is a price worth paying. The “single shot” mode was successfully tested with a sensor measuring the tension forces in a filament yarn (textile industry).

# 3.5 System software

**Programming Details:-** The programming of hardware module that is Atmega8 microcontroller is done using the embedded C. The data_acq.apk is written using JAVA and XML codes. XML code is use to design the layout of the activity and JAVA code is use to design the functionality of the system i.e. to save signal information, making Bluetooth connection and saving received values.




As mentioned in the beginning, the computational platform for which the entire system was initially designed was the SERVER. Although small, SERVERs offer enough power to handle some Mbytes of data, to process and display it. The most important feature of the used SERVER (HP iPAQ product family) was the integrated Bluetooth interface with selectable baud rates up to 960 kbps and the integrated SPP (Serial Port) Bluetooth Profile. This profile allowed a simple software approach, which basically consists of serial port readings and writings. This software was written in Embedded Visual C++. The program detects the remote Bluetooth module and establishes a radio link with it. Then the user has the possibility to select the operational mode of the system and to initiate data acquisition itself or to wait for an external trigger signal.

Basic devices:-

**1) ADuC812 uC**

**a. Memory**

**2) BT Module**

**3) Power Management**

**4) Signal**

**5) Conditioning**

Data is received and displayed in real time for the "continuous sample" mode or is written in the SERVER memory and displayed afterwards as a curve for the "single shot" mode.

A mobile operating system, also referred to as mobile OS, is the operating system that operates a smartphone, tablet, PDA or other digital mobile devices. The main requirements of the mobile OS for this project are:

- Bluetooth Support
- Openness
- Accessibility
- Low complexity

Bluetooth support is one of the main requirements of this project. Mobile OS should allow the third party applications to install and access the mobile resources. For the research purpose, it should be low cost and well documented. Android has powerful APIs, excellent documentation, a thriving developer community, and no development or distribution costs. In addition to this, it has following advantages:

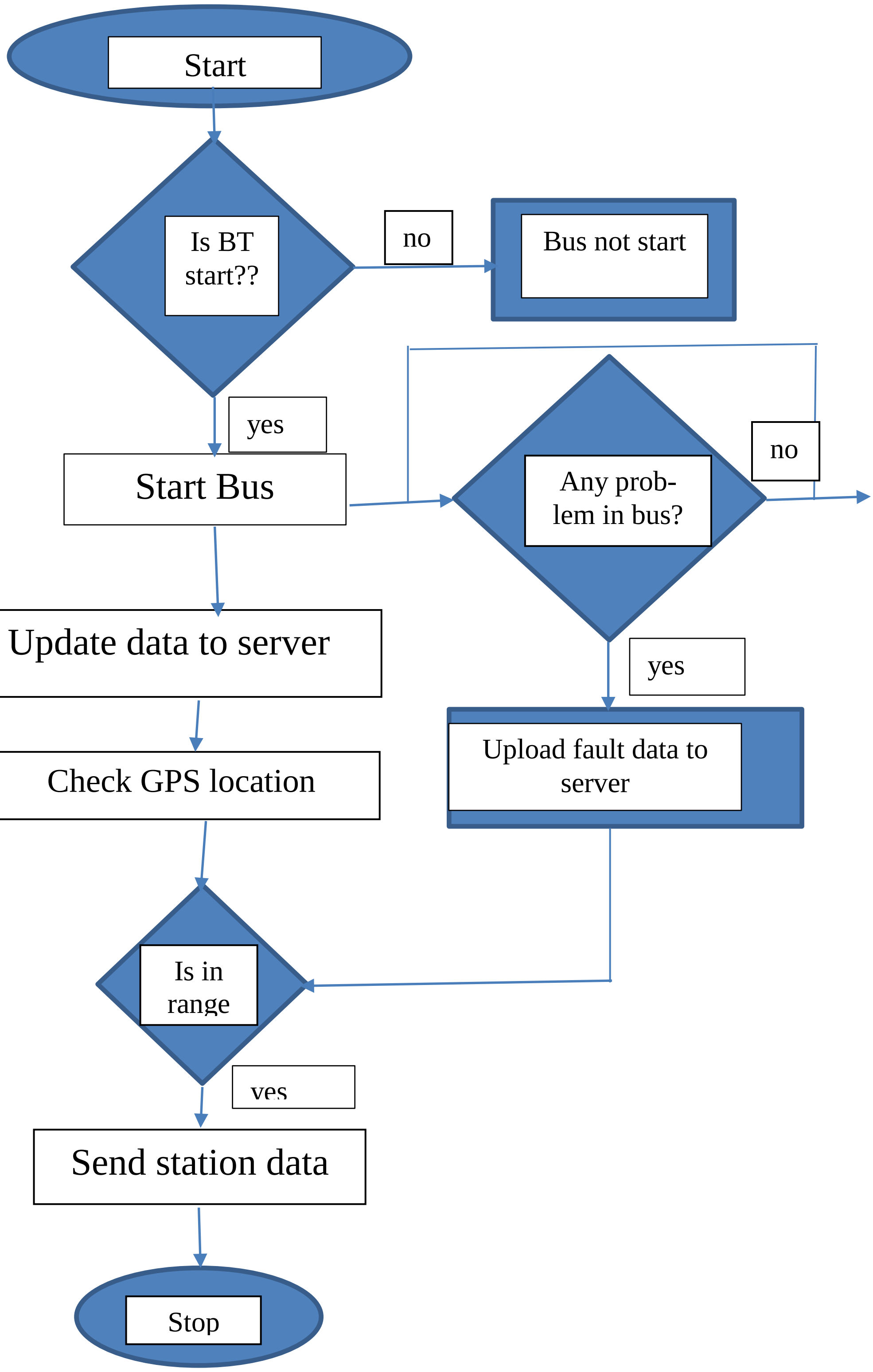
- Open source and free
- There is no approval process for application distribution.

## 4. Working:-

The first prototype of the data acquisition system was built around the ADuC812 evaluation kit, adding external memory, control logic, a signal conditioning circuit based on operational amplifiers and a power source. The used Bluetooth module was The Connect Blue Serial Cable Replacement. Due to the specific requirements of the used sensor (strain gage), there was the need to generate +/- 12 V for the sensor itself and for the signal conditioning circuit. This was accomplished by using two cascaded DC – DC converters, one for generating stabilized 5 V for the digital circuits (microcontroller, Bluetooth) and the second for raising the voltage to +/- 12 V. Both DC – DC converters operate as switching devices, inherently generating electromagnetic interference. These periodic interferences interfered with the output of the conditioned signal, and, more critical, with the functionality of the Bluetooth modules, restrained the radio coverage area and lead to packet loss in the radio transmission. Apart these inconveniences, data acquisition was possible in both operational modes, demonstrating the viability of the chosen design. The second prototype (figure 2) contained all components on a single custom-made double layer PCB with carefully designed ground planes to eliminate the interferences encountered at the first prototype. The PCB was designed modularly, for debugging purposes but also for measuring power consumption for each functional block. The Bluetooth module, this time the National Semiconductors module, can be seen in the lower right part of the picture.

A 3,7 V Li-Ion rechargeable battery was used and first tests showed a lifecycle of more than 2h of uninterrupted functionality. The SERVER software was extended with a graphical module that allowed visualizing the recorded curves. Zoom and pan functionality was also implemented. Figure 3 presents the visualization screen of the software. The curve represents a cardiac signal generated by a function generator at a frequency of 50 kHz. Higher frequency signals up to 80 kHz have been sampled successfully. The noise level of the entire circuit was kept low due to the extensive grounding measures undertaken for the second prototype and the precision of the A/D converter was in the range of ½ LSB, as specified in the converter's datasheet.

# Flow chart:




**Conclusion and future works**:

The intelligence implemented in the bus monitoring and management system can be achieved by compiling and feeding all the proposed theories and algorithms for Bluetooth and other sensing technologies into the system. The ability of the system to act on its own can reduce the manpower required at the monitoring center. Bus drivers will also be more punctual to the bus schedules that have been established , resulting in a more efficient bus circulation system. The experimental results show the system is intelligent enough and able to provide important information to the authorities for monitoring and management of the bus system.

We can propose to use intelligent bus monitoring and management system for public transportation services. The information about the current location of the buses can be provided on mobile so that the user can adjust her/his schedule accordingly.

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