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Development of Wireless Sensor Network as an Application in Aerostats

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Abstract: This paper presents wireless sensor network (WSN) for health monitoring system of Aerostats. The paper discusses Aerostat and its health monitoring system; requirements and significance of wireless sensor network for the purpose of data monitoring and control. It also discusses the implementation methodology of such a network. System has been designed using Zigbee based transceiver with various types of sensors. Detailed description of the design & the components used for system implementation is presented in the paper.

Index Terms: Aerostat, Ballonet, WSN, Zigbee.

I. INTRODUCTION

Wireless Sensor Technology has been listed as one of the "10 Emerging technologies that will change the world" by MIT Technology Review. Applications of WSN extend to vast and diverse areas such as Security and Intrusion detection, Asset Tracking, Fleet Management, Industrial monitoring, Building Automation, Health Care and many more [1].

A remote sensor system is a gathering of hubs sorted out into an agreeable system. Every hub comprises of handling ability (one or more microcontrollers, CPUs or DSP chips), may contain different sorts of memory (project, information and glimmer recollections), have a RF handset (for the most part with a solitary omni directional recieving wire), have a force source (e.g., batteries and sun oriented cells), and oblige different sensors and actuators.

The hubs convey remotely and regularly self-sort out in the wake of being sent in a specially appointed manner. Frameworks of 1000s or even 10,000 hubs are foreseen. Such frameworks can change the way we live and work.

At present, remote sensor systems are starting to be sent at a quickened pace. It is not outlandish to expect that in 10-15years that the world will be secured with remote sensor systems with access to them through the Internet.

This can be considered as the Internet turning into a physical system. This new innovation is energizing with boundless potential for various application ranges including ecological, medicinal, military, transportation, entertainment, crisis management, homeland defense, and smart spaces.

In this paper, one of the applications of the Wireless Sensor Network for the Aerostat is discussed. An overview of the technology behind WSN, basics of the Aerostat and the usefulness of WSN for the Aerostat is presented.

II. TECHNOLOGY BEHIND WSNS

Wireless Technologies

The potential applications of wireless data communication are seemingly limitless; although some wireless technologies can provide reliable, standards oriented data transmission, they are not particularly suitable for applications with low bandwidth requirements [2]. As well, the energy consumption of devices employing these protocols is extremely high, often requiring large batteries or a fixed power supply. With these shortcomings and limitations being addressed, another protocol has recently emerged - the Zigbee wireless protocol.

What is Zigbee?

Zigbee is a standards based technology that facilitates wireless communication with design emphasis being placed on low cost, low power consumption, and interoperability between all Zigbee compliant devices.
A typical Zigbee node can be configured as a network Coordinator, router, or end device. With this type of organization, mesh, cluster tree, and star network topologies are possible. A network coordinator is required in all Zigbee networks as it is responsible for network formation, administration, and security management. In addition to the coordinator, a router device can be defined to relay messages across the network to various end-nodes. The coordinator and router devices are considered full function devices (FFD's), while the end-nodes are reduced function devices (RFD's). Being a more complex entity, a FFD requires the entire protocol stack, while only a 'skeleton' version of the stack is needed by a RFD [3].

The Zigbee standard defines the Networking and Application layers of the wireless network; it is built upon a robust physical layer implementation commonly referred to as the IEEE 802.15.4 standard. This existing standard allows Zigbee to be structured in a manner conducive to low power operation. IEEE 802.15.4 is an open standard that is designed for low data rate- wireless personal area networks (LR-WPAN).

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III. ROLE OF WSN FOR AEROSTAT

Aerostat Basics

Aerostat system comprises of an aerodynamically shaped balloon which can be designed to be raised to an altitude of specified kms or so, depending upon the application requirements. Volume of the balloon is governed by various factors like payload weight, altitude of operation, etc. Balloon is having two compartments [4]. He filled compartment called Hull and Air filled compartment called ballonet. Hull provides the lift to the Aerostat, while smaller compartment, Ballonet is used to maintain the required differential pressure inside the ballonet using the Ballonet Pressure Control System. As the system is used for applications like surveillance, advertisements, weather monitoring, it is required to be at that altitude, in raised condition, for days together. Ballonet Pressure Control System is expected to maintain the required pressure throughout its flight.

Data Monitoring System for Aerostats

Ballonet Pressure Control System controls the pressure inside the ballonet with the help of pressure sensors, ballonet valves and blowers. As pressure inside the ballonet increases beyond a specified limit, valves are opened to push the air out of the ballonet. On the other hand, if pressure decreases below a specified threshold, blowers are switched on to fill the air inside the ballonet. Apart from maintaining differential pressure of the ballonet, it also monitors data of various sensors mounted on the aerostat. Sensors used include weather sensor (for monitoring ambient pressure, relative humidity, ambient temperature, wind speed, wind directions), RTD (for monitoring Hull temperature), Load cell (for monitoring tether tension), pressure sensors (for hull and ballonet pressure) and AHRS (for attitude and tri- acceleration measurement) [5]. Based upon the data received from the sensors or the commands received from the ground station, the ballonet pressure control system also controls various actuators like ballonet valve, emergency deflation valve and strobe lights. The sensors are mounted at various locations on the aerostat. Figure 1 pictorially depicts the mounting locations of various sensors. Weather sensor and one strobe light is mounted on the top fin of the Aerostat. One strobe light at the tail and one at the bottom of the balloon. EDV is located on the top near the nose, GPS on the topside of the balloon, somewhere near the fins. RTD and pressure sensors are mounted at the bottom of the Balloon. Ballonet Valve is located at the bottom (on the ballonet) near the Control and Monitoring Unit (CMU). CMU houses main controller, attitude and heading reference system, power converters, relays and modems. CMU is powered from the power supply unit installed close to the CMU. Power supply unit provides rectified DC to the Control and Monitoring Unit (CMU). It also houses battery and charging circuitry. The battery powers the Control and Monitoring Unit (CMU) when AC power is not available. Shielded cable runs from the CMU to various sensors and actuators all over the balloon [6]. This not only adds weight to the airborne electronics, it also poses significant difficulty during integration and routing of the cables and sensors on the Aerostat. The weight of the cable loon itself is approx. 40 kg.

Data Monitoring System using WSN

Wireless sensor network provide an alternative to the cable loom requirement of the Aerostat. Cable loom is replaced by the sensor nodes. Balloon is 32 m in length and 11 m in diameter. Zigbee modules have ranges of the order of 100 m. Also, since the sampling frequency of the data is low, the data rate requirement is not high. Hence Zigbee radios suit very well to the data monitoring requirement of the Aerostat.

Zigbee RFD modules are placed with every sensor – Weather, Load Cell, GPS, RTD and pressure sensors. Zigbee coordinator is placed at the CMU. RFDs send the data periodically to the Coordinator. Coordinator further transfers the data to the Main Controller which does further processing on the data received.

IV. IMPLEMENTATION SCHEME OF WIRELESS SENSOR NETWORK FOR AEROSTAT

Configuration

Without making wholesome changes and retaining basic configuration, the proposed scheme incorporates wireless sensor network for Aerostats. The proposed scheme involves following modules:

- Zigbee Gateway-to act as Coordinator and installed near the master controller in CMU.
- Zigbee Radio-to act as RFD and it is installed with each sensor.
- Sensor: Existing sensors to be used.

The configuration of the network of sensors on the Aerostat is depicted in figure 2.

All the sensors will send their data via Zigbee module to the Zigbee Gateway which forwards this data to the main controller for transmission to the ground control unit [7]. Weather sensor and GPS module are interfaced using the RS232 port. RTD and load cell output are connected to the analog ports.

Reduced function device (RFD)

RFDs proposed for these applications are Libelium's Waspmotes. Waspmote is designed around ATmega1281 MCU. It runs at 8MHz, has SRAM of 8KB and EEPROM of 4KB in addition to FLASH of 128KB. It also has a provision to use SD Card of 2GB capacity. It uses xbee 802.15.4 Zigbee transceivers for communication [8]. Waspmote is shown pictorially in figure 3. Waspmote can communicate with other external devices through using different input/output ports. Waspmote has 7 accessible analog inputs in the sensor connector. Each input is directly connected to the microcontroller with 10 bit successive approximation analog digital converter (ADC) [9]. There are total 6 serial ports, two are accessible to the user.In addition, there are digital I/Os, I2C, USB ports which are used for various applications.

Solar Power

As Aerostats remains in flight for day's together, solar panels are provided for these sensor nodes to recharge the

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battery used for the radios [10]. Waspmotes themselves consume very low power and hence the batteries they use can last for long time [11]. However, localized flexible solar panels are proposed to be integrated with each sensor because of its obvious advantages [12]. Aerostats being flexible structure, flexible solar panels are proposed.

Algorithm

When Waspmote is first connected, the boot loader is started which loads the program into memory [13]. Code has two segments-Setup and Loop. Setup runs only once when the code is initialized, while loop runs continuously, forming an infinite loop [14]. Interruptions are used in this loop to perform actions with Waspmote [15]. To save energy, program blocked until some interrupt is generated.

V. CONCLUSIONS

Wireless Sensor Network has been proposed to be integrated with the Ballonet pressure control system of an Aerostat. The scheme provides an alternative of various cables running across an Aerostat [16]. Use of localized solar panels enables the modules to work for long durations, unattended. So far, actuators are not involved in the network because the power requirement of these actuators can't be sufficed by the proposed solar panels. However, experiments are being tried out to explore this aspect. Further, use of this technology for Airships is likely to be very beneficial and will be investigated.

VI. ACKNOWLEDGEMENT

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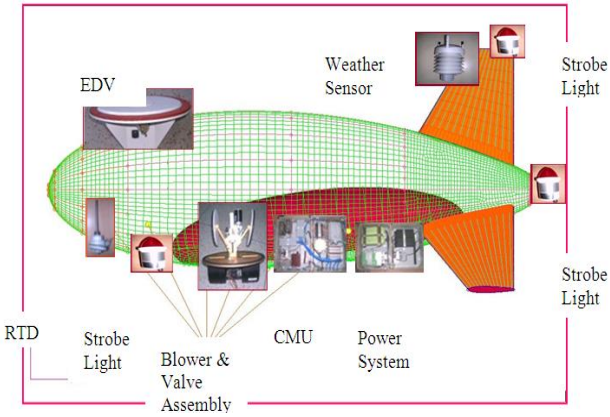

Fig. 1 Aerostat with various transducers

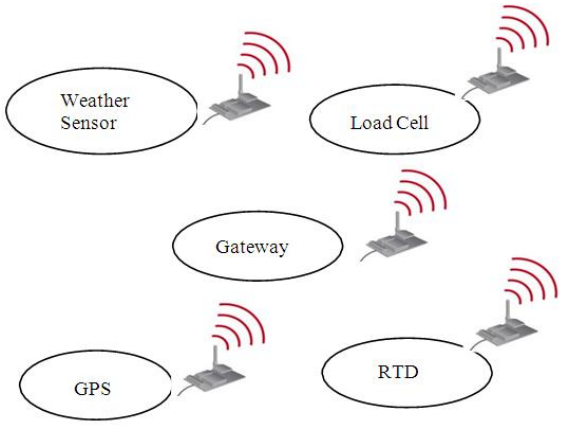

Fig. 2 Wireless Sensor Network Configuration

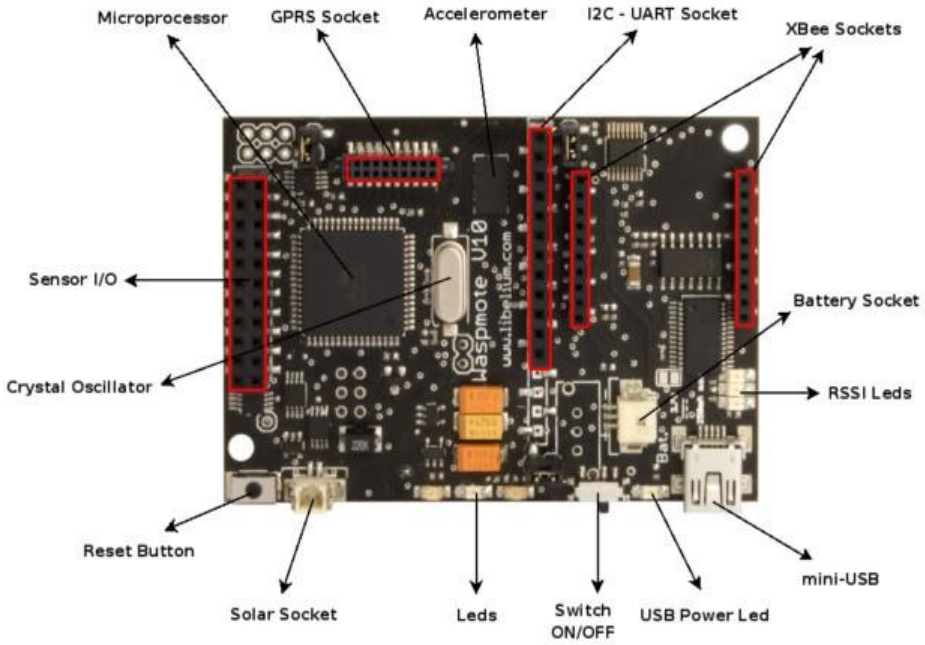

Fig. 3 Reduced Function Device

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