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A Proposed Software Structural Design for Instigating Power Management Practices within Intelligent TAGS

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Abstract*— Power consumption has become a serious issue in the development of remote mobile devices such as intelligent tags where charging and recharging of the battery cannot be done frequently. Longevity of the battery has to be increased by power saving. Many existing techniques address the issue of power management in embedded systems. This paper has implemented an efficient method for power management in TAG. In this paper software architecture has been presented for implementing the power management method. Embedded code has been developed and the same is experimented by building an embedded system for the purpose.

***Keywords*— Power management, intelligent tag, embedded system, longevity, low power communication.**

I. INTRODUCTION

Power management is one of the important factors in embedded mobile applications as these are battery driven. The available power must be distributed among the various devices of the application according to their power consumptions all along maintaining the high longevity. The power consumed by the devices controls the overall consumption of the application.Recently the study of the power consumption of various devices is done and many power saving mechanisms have evolved to reduce the power consumption of an embedded device.

Intelligent tag is an embedded mobile device which is placed remotely from the user. So the frequent charging and recharging is not possible. Different challenges like software optimization, low power communication, low power display and low power data management and fault tolerance must be considered to increase the longevity of the battery. An embedded system and a Software architecture is required for implementing the method so that architecture can be used for the development of the software and then moving the software to the Target and conducts various experiments to verify and validate the method. In this paper an embedded system has been designed and presented keeping in view of the above challenges issued by the intelligent tag. The software architecture that meets the requirements of the power management system has been determined and presented. Software has been developed using the software architecture and the same is migrated to the Target system. Experiments have been completed and the same are presented. The Method implemented in the system has been proved to be efficient.

II. RELATED WORK

There are several existing power management techniques in the area of embedded systems. Several modules are proposed which include power manager (PM), device power manager (DM) and application power managers (AM) [1] for managing power at different abstraction levels. All the modules use an abstract model for managing the power, to different parts of the system. Power management techniques in embedded devices can be developed as a part of real time operating systems or its applications. If power management techniques are present in embedded devices, the features and components which are not being used can be placed in low power states. This reduces the power consumption. A power management technique for location estimation is proposed [7]. While a device is not participating in the communication, it is directed to change its state from the active mode to a park mode, so the device will save the battery power. The technique recommended by them falls in the category of Dynamic Power Management (DPM) as it is dealing with the battery power during run time. Dynamic voltage scaling (DVS) is one of the techniques in reducing the power dissipation by lowering the supply voltage and operating frequency. Real-time DVS algorithms are presented to provide power savings while maintaining real-time issues [8]. Power consumption in Bluetooth is high compared to other mobile devices due to continuous monitoring. As the device is small and need to support high throughput, there is a need for power optimization which allows for high throughput with less power consumption. The power consumption in

Bluetooth can be reduced to a certain level using four operational modes which include active, sniff, hold and park modes. The battery lifetime can be increased through these modes [4]. The Bluetooth system architecture consists of device modes, security modes and key management.

Constantly awake (CAM) is one of the techniques which is widely used today where the power saving features are disabled due to reduced performance in terms of throughput when power saving measures are enabled [6]. Power save mode (PSM) is the method in which the mobile device is switched off after a prefixed length of time. The device is wake up periodically whenever any data Power save multi poll (PSMP) is used for multiple radios. Because of the power requirements for Wi-Fi, the Power Save Poll protocol (PS-Poll) was developed to help reduce the amount of time a radio needs to be powered [5]. Rather than having the radio at all the time, PS-Poll allows the Wi-Fi adapter to notify the access point when it will be powered down. While the radio is powered down, the access point will hold any network packets which would need to be sent to it. Of course, the longer the radio is off, the more power you save. Several power management techniques for battery driven tags are supported by energy harvesting devices [2]. Sleep transition protocol-wake up control protocol is the power saving strategy where system is in power saving sate as long as possible. The tag stays in sleep state and shifts to the active state when triggered by a certain event. The additional power can be provided by energy harvesting devices which converts the energy from environment into electrical energy. The lifetime of the battery can be increased. Dr Sastry et. al, [3] proposed an efficient power management system. Battery charge can be preserved through various methods like allowing the central processing unit (CPU) to slow down, suspend or shut down part or all of the system. Tags generally consist of many modules which are integrated. Not all the modules will be active all the time. The unused modules can be shut down or sent to sleep state. Different challenges like software optimization, low power communication, low power display and low power data management and fault tolerance. The proposed technique mechanisms aims at determining the power requirements of the components in the system and to provide the power management techniques to manage the overall power of the system to the lowest level thereby increasing the life of the battery.

III. HARDWARE DESIGN DESCRIPTION

The interconnection between hardware devices forms the hardware design related to intelligent tag power management system. Figure 4.1 shows the interconnection diagram. ARM 7 acts as main controller to which most of the devices are interfaced directly through various busses. To the main bus which is AHP Bus, VLSI Peripheral bus and Local bus are connected. To the VLSI bus GPIO bus and I2C bus are connected. All the devices are connected to one of the mentioned busses. External memory which is EEPROM is connected Via I^2C Bus. Three devices are used for establishing communication in different communication modes. While Bluetooth module is connected through USB (Universal serial bus) to the microcontroller through VLSI bus. Similarly the Wi-Fi is connected to the microcontroller through URT01 and VLSI bus.GPS is connected to microcontroller URT02 and VLSI bus. Pressure senor is connected to controller through a native ADC and VLSI bus.LCD, LED's, Keypad, Buzzer, Beeper, reset gate are connected to the Micro controller through GPIO and VLIS Bus LCD is used for displaying the environmental changes taking place in and around the intelligent TAG with the mobile phone. LCD, LED's are used to alert local operator about the power status and the HOST is informed of the power status of the battery through Wi-Fi or Bluetooth communication modules.The microcontroller is loaded with ES application that runs the power management system. The ES application keep tracks of the power consumption by various devices and also optimizes the power consumption by various devices based on the state of the operations at any point in time. The ES software keeps updating the status of the battery through implementation of various communication modules.

IV. SOFTWARE ARCHITECTURE

The system developed in this paper is responsible for the power management of an intelligent tag. The power management system developed consists of different hardware modules interfaced with each other. The hardware modules that are directly interfaced with the microcontroller are driven by their related software components defined through a class structure.. Defining the functionality of each class and relationships among different classes form software architecture. ARM7 being the main controlling device for power management system, is defined as a main class which is associated with a power management class. The power management class has the functionality to control the power supply to various devices. The power manager performs several operations like calculation of power consumed by various devices that include ARM7, peripheral IO, GPIO, and to various communication devices such as Wi-Fi and Bluetooth. The power management module keeps tracks of the battery position and communicates the position of the same to remote mobile device so that corrective actions can be taken. Peripheral IO bus is responsible for interfacing external modules like Bluetooth, Wi-Fi, GPS. So the peripheral IO power manager class maintains information regarding the power consumed by the external modules. GPIO PM connected to the peripheral IO PM controls power consumed by beeper and pressure sensor.Tag communicates with mobile device using communication protocols.

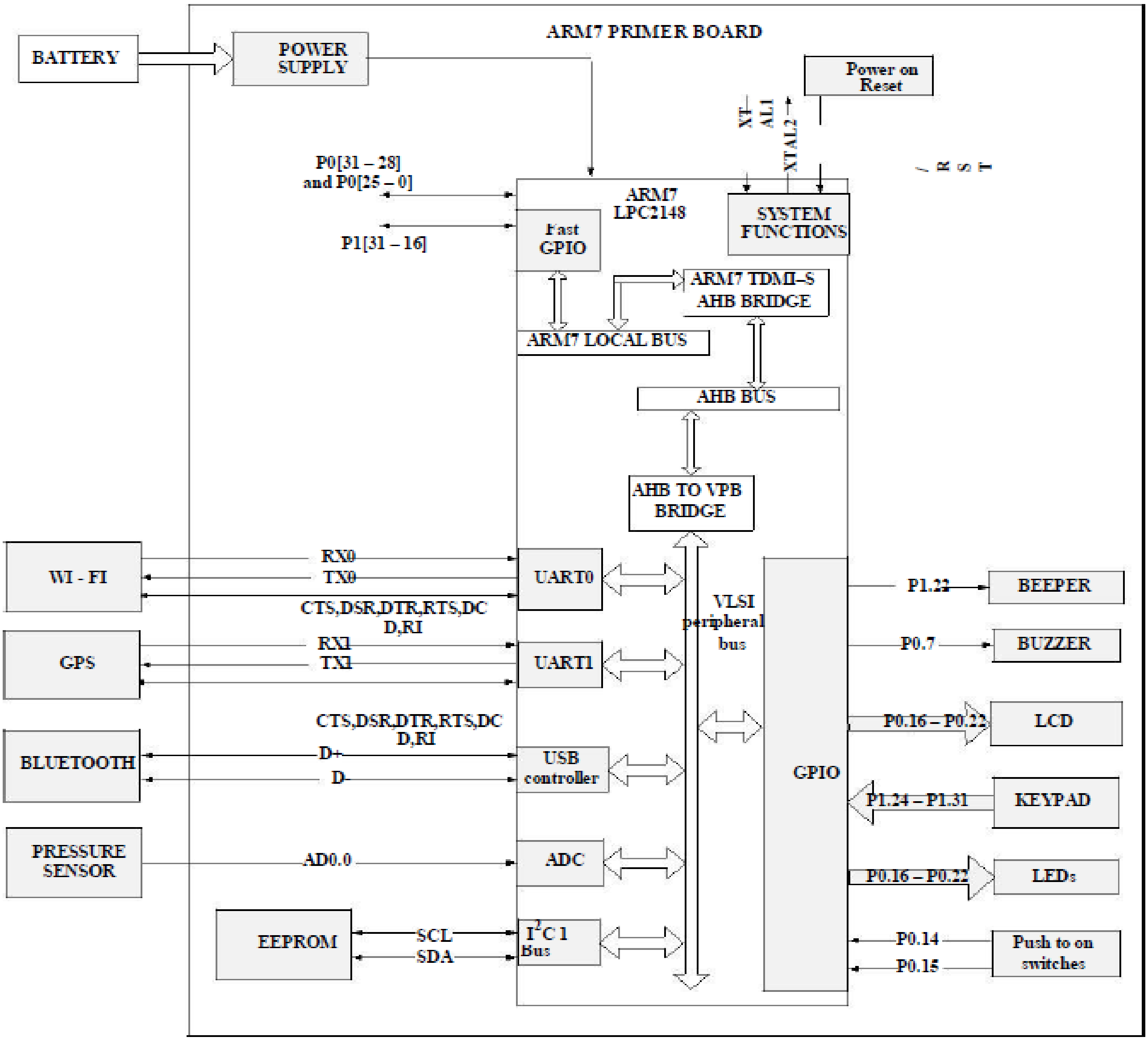

Figure 4.1: Hardware Interconnection diagram for power management system

Communication protocol class is used for tracking the devices using a range of frequencies. Communication protocol classes of the tag are dependent on the communication protocol classes of the mobile device. The application developed provides the identification and authentication between Host and Intelligent tags. Power manager maintains constant communication with the communication modules of the mobile phone to notify the power status of the battery. The specific functions of the individual modules can be maintained in special class diagrams. The Bluetooth PM, Wi-Fi PM and GPS PM classes specify the special power saving operations of the individual modules to reduce the power consumption of their respective components. Figure 5.1 shows the class diagram of the overall power management system built as a part of intelligent tag Application. The software architecture for implementing power management module related to intelligent tag is implemented using 3 tier architecture as shown in the figure 5.2. In tier I all modules related to intelligent tag application shall be made to be resident. The overall task execution is implemented within the main control logic which is resident in the tier II. The main task is designed to incorporate all functions which are real time oriented using real-time operating system (µCos) in this case. The software components through which communication is effected either through Wi-Fi or Bluetooth are situated in tier II but invoked through main controller logic. The communication modules related to remote mobile HOST are situated in tier III. Communication modules which are in tier II and III communicate with each other especially for alerting, power shortages and breakdowns at the tag side to the remote host which in this case is the mobile phone. The power management modules resident in tier II are invoked through main controller logic. The power management modules shall have the components that monitors the power consumption by different devices and also optimizes the power consumption by various devices based on type of operations taking place within overall application execution. Power management modules if implemented in future can be located within the tier II along with other components and thus the system can be extended.

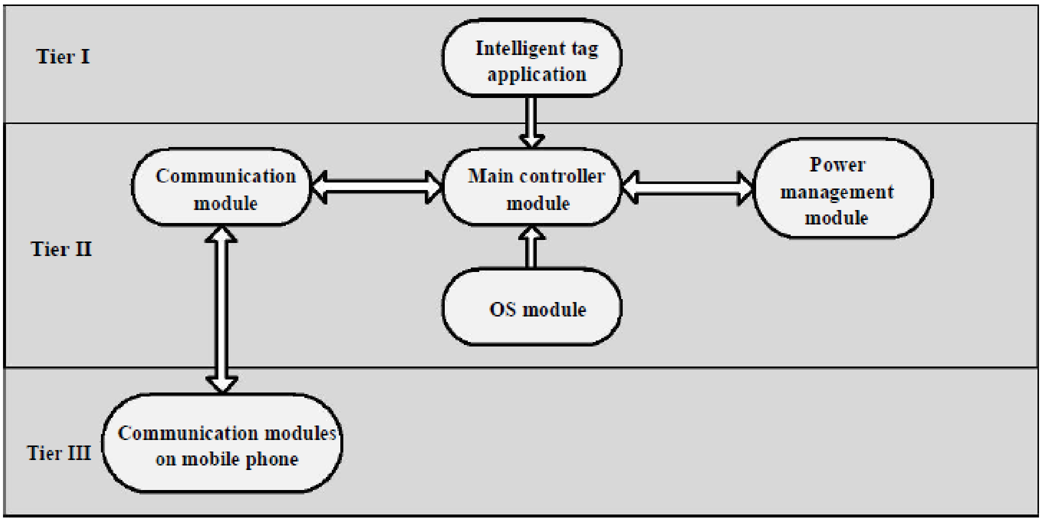

Figure 5.2: Software architecture of intelligent tag

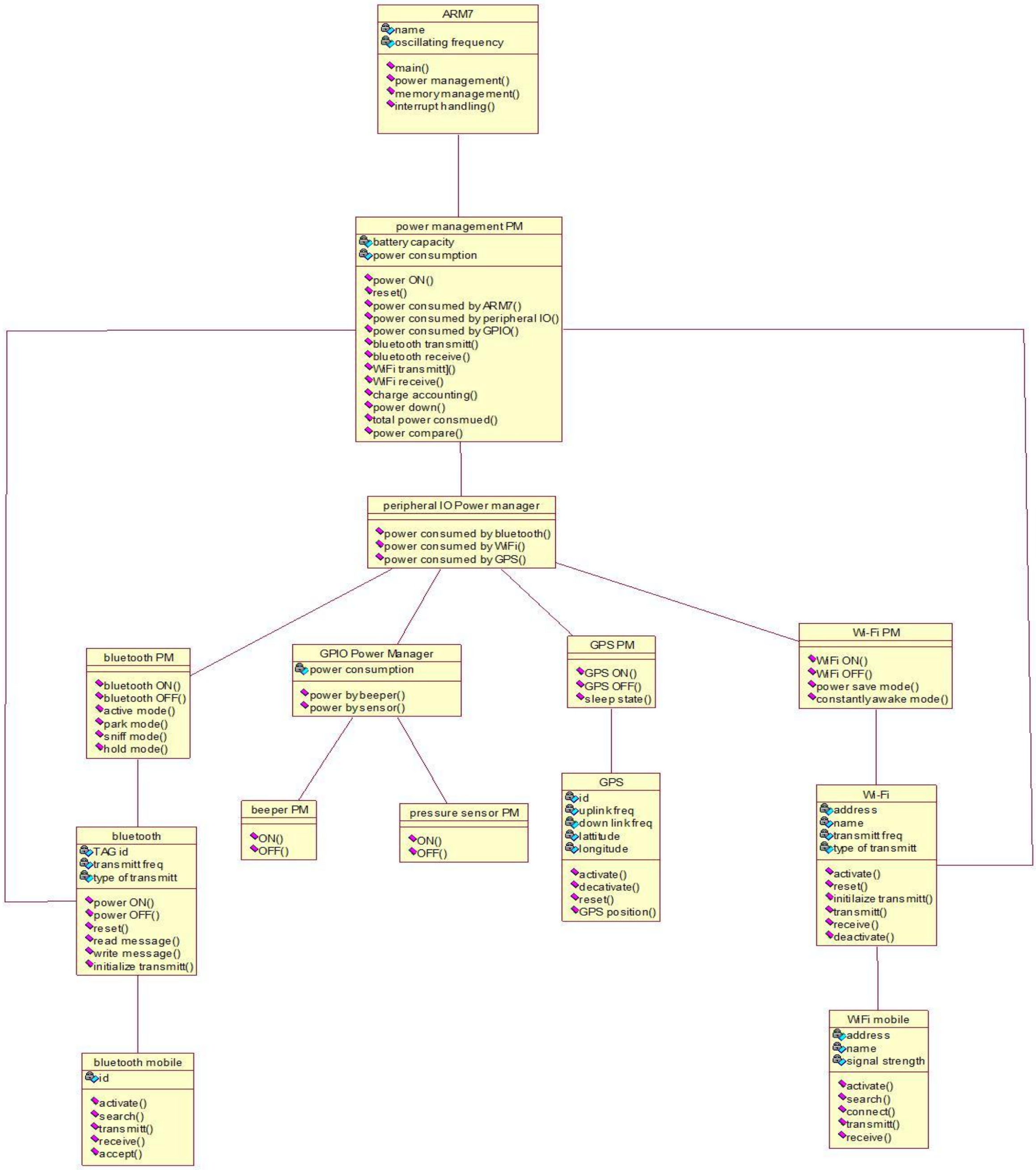

Figure 5.1: class diagram of power management system

V. EXPERIMENTAL RESULTS

The power consumptions by various devices from time to time have been recorded as they are displayed on the LCD and the messages that have been transmitted to the remote HOST also have been displayed on the LCD and the same are recorded. The rate of discharge of battery is decreasing as the time of usage of the TAG is increasing. This is because of efficient power management of the devices and routing every operation to the devices through power management module. The experimental results as recorded are shown in the Table 6.1

VI. CONCLUSION

In this paper, software architecture for implementing an efficient method for power management in TAG has been presented. The architecture clearly revealed the decrease in the discharge of the battery as the improvement in the performance of the operations takes place by way of optimizing the operations which are carried related to different devices. The architecture is efficient that any of the embedded systems can implement the same. The Software has been developed using the architecture and the same is implemented within separately designed and implemented embedded systems.

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Table 6.1: experimental results for power management in intelligent tag

Date	Time	Power Consumed in Millie watts in 24 Hours						Total power consumed/day	Battery Power In watts	Left over Battery Power	Rate of discharge	Message sent	Device to which message is sent
		ARM 7	WIFI	Blue Tooth	GPS	Pressure Sensor	Beeper						
15-05-2012	10.00	2.400	1.440	0.72	2.16	0.24	0.24	7.200	1000.000	992.800	0.720	#@& POW 992800	Wifi
16-05-2012	10.00	2.328	1.436	0.717	2.156	0.238	0.237	7.112	992.800	985.688	0.716	#@& POW 985688	Wifi
17-05-2012	10.00	2.302	1.421	0.703	2.142	0.235	0.234	7.037	985.688	978.651	0.714	#@& POW 978651	Bluetooth
18-05-2012	10.00	2.209	1.417	0.709	2.138	0.233	0.232	6.938	978.651	971.713	0.709	#@& POW 971713	Bluetooth
20-05-2012	10.00	2.195	1.369	0.702	2.125	0.229	0.230	6.850	971.713	964.863	0.705	#@& POW 964863	Wifi
25-05-2012	10.00	2.185	1.309	0.649	2.135	0.223	0.223	6.744	964.863	957.342	0.699	#@& POW 957342	Bluetooth

