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Android in WSN Applications – A Survey

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Abstract: A Wireless Sensor Network (WSN) is used for accessing multiple sensor data at central servers. The advancement in the wireless technology brought with it the evolution in the way the sensors are connected to the system where the data are accumulated and analyzed. Initially for WSN there were simple computing devices used as Base-stations to collect the data and store for analysis. Recently, due to increased use of Smartphones, trend of using Smartphone as base station increased rapidly. Again, the Android OS support in Smartphones boosted the use of Smartphones for various applications using wireless communication. In this paper the review of various applications of Android OS in different scenarios is carried out.

Keywords: Android OS, Wireless Sensor Network, Body Sensor network

I. Introduction

Multiple inaccessible locations are monitored from a system using sensor network. Initially the sensors connected using a wired system was used but the constraint was due to distance from monitoring system as well as cost of wiring. Again, distortion due to noise and attenuation is also prevalent in such wired systems. Managing the wired connections between the sensors and system made it more complex to handle.

A wireless sensor network (WSN) consists of distributed sensors to monitor physical or environmental conditions, such as temperature, sound, vibration, pressure, humidity, motion or pollutants and cooperatively pass their data through the network to main location.

Recently, due to increased use of Smartphones and Android OS support in Smartphones boosted the use of Smartphones for various applications in wireless communication. The main advantage of such system is mobility in monitoring device as well as are compact and handheld. The application portability and device independence are key features behind using Android based device for sensor networking.

II. ANDROID OS

Mobile devices have steadily gained acceptance as a multimedia platform. Current tools offer application developers options to use various technologies—for example, Java, Open C, Python, Flash Lite, XHTML/CSS, JavaScript, and Mobile Ajax—to implement highly functional mobile applications. In [1], the author has compared various available platforms for developing applications to run on mobile devices. The comparison is made between presently available and popular platforms.

Android applications are primarily written in Java and compiled into Dalvik executable (DEX) format, a custom byte code. Developers have full access to all the frameworks and APIs that the core applications use and to Google-developed software libraries. Android is a software stack for mobile devices that includes an operating system, middleware and key applications[2]. Android relies on Linux version 2.6 for core system services such as security, memory management, process management, network stack and driver model. Android ships with a set of core applications including an e-mail client, SMS program, calendar, maps, browser, contacts, and other features. All applications are written using the Java programming language. Android includes a set of C/C++ libraries used by various components of the Android system.

Android has been developed and specifically optimized for ARM microprocessor cores[3]. There are functional equivalents between Linux and Android but modules are not the same, re-coding will be required when moving an application from Linux to Android. Android offers two programming language options, Java and C/C++. Java development utilizes the Android software development kit (SDK) and the Dalvik virtual machine optimized for mobile devices.

In Android, the .dex format files generated by DX-tool, integrate all Java class files and delete redundant information in every Java class files[4]. All non code resources are defined in XML files. Providing resources separate from source code makes it easy to update various characteristics of an application without modifying code and by providing sets of alternative resources enables developers to optimize the application for a variety of device configurations, such as different languages and screen sizes.

There are many operating systems(OS) available for use with mobile applications as well as embedded applications. Amongst all available few of the OS has gained fame and are used widely. In recent trends Android

OS is seen in wide varieties of applications. A comparison between android JAVA performance with Sun embedded JVM on Angstrom linux is made[5]. According to the studies, Android provides better VM designs but consumes more energy due to lack of dynamic compiler in Dalvik JVM which can be eliminated by implementing an optimized dynamic compiler in Dalvik JVM.

On experimental basis, a speaker recognition system was developed in Java and a face recognition system was developed in C++ (native Android code for the Smartphone) using existing open source software libraries. The non-native Java application was found to be about 30 times slower on the phone than on the PC and the native C++ application was about 21 times slower[6]. The difference in processing time was found to be quite large for most algorithms, but still small enough for the implementation of a user-friendly biometric system on the phone.

III. Android Application

Many applications are designed that run on Android platform running on Smartphone or Tablet. In [7], author presented a system using an Android Smartphone that collects, displays sensor data on the screen and streams to the central server simultaneously. Three different sensors transfer sampled data to the MSP430BT5190 which communicate with the NFC tag containing the Bluetooth via UART and sends data to a Smartphone using the Android and Bluetooth system. A Java-based UDP server application is used to collect data sent from the Smartphone via the Internet.

A new sensor platform is proposed by author in [8], Arkas, which can be easily utilized for various environmental observations. The Arkas sensor platform consist upto 16 sensor node which communicates to the server running Android tablet using Zigbee. The Arkas sensor platform is a server-client type sensor platform, and consists of a centralized server (Arkas server) and all-in-one type sensor nodes (Arkas sensor nodes). The proposed sensor platform, successfully deployed for observing snow using ultrasonic distance sensor in Niigata-prefecture, Japan. Based on the derived values, the administrator of the snow removal decides where the snow blowers should be sent out.

Mobile platforms are used to replace the static stations and server-client setup. Such mobile platforms proves useful when data from region of interest is required to be monitored. In [9] author presented the autonomous/manual traveling Android operating system based robot platform and smart phone operated control and monitoring system. It is implemented on Cortex-A8 series S5PV210 embedded processor. Author has developed the robot control board by integrating Android, Linux kernel, and Boot Loader. In the Android OS (Operating System), the camera image is compressed to JPEG format and the image file is delivered to a smart phone in real time through 802.11x wireless LAN communication which utilizes TCP/IP communication socket programming.

Beyond using the Android platform for acquisition purpose there are application where it is used for controlling. One more such application is depicted in [10] where the author presented a remote control application designed on Android platform. A remote toy car by an android mobile platform with Bluetooth technology. The mobile platform requests to connect with the small car through the BT module then sends instructions to control it by calling the android system Bluetooth API.

So far as the Android platform is concerned, it is mostly used with Smartphone or tablet. As such there are no external I/Os available with such devices. To have such external access in [11] author presented a design to interface the android device with an external world. Here, I/O circuit is designed for working with Android device through USB. The IOIO board fully controllable from within an Android application by using Java API. The IOIO board contains a single MCU that acts as a host and interprets commands from an Android application program. In addition, the IOIO is also able to interact with peripheral devices such as Digital I/O, PWM, Analog Input, I2C, SPI, and UART control can all be employed with the IOIO board.

For accessing some of the devices the ports of processor is required and for this ARM cores are used. Android Platform is used to run on such ARM cores to get access over ports like Ethernet. In [12] author presented one such modular type platform prototype of power efficient, small size, low cost and high performance to meet the requirement for the 3-service. Android (Gingerbread) is used as operating system for the platform running on AM3S94 ARM cortex-A8 processor having different types of interfacing facilities. The three types of services to use are Internet Protocol Television (IPTV) service, Health Care Service and Multiple Fixed Mobile Convergence (FMC) service from that Home Service platform.

For WSN the Smartphone with Android platform is very useful as the mobility of monitoring system is an added advantage. Along with mobility, the secure access make it more safe and useful platform. In [13], the author presented the android based application for a sensor network. This app has functions like user login for restricted access, selective sensor data acquisition and subscribing to sensor data. The sharing of the data through app is provided with IP connectivity on other mobile running the same app.

Remote monitoring of the sensor-nodes from a distant place is desirable in number of applications. Using such networking the area of monitoring increases. In [14], author presented a mobile application to remotely monitor one WSN, installed at a customer's home. The application allows a user to consult sensor states and receive sensor alerts crossing threshold value. The control station browse the list of users associated with the sensor node that detected the event and provide users with the event's data, via SMS and/or email. An Internet connection through 3G or Wi-Fi, allows the user to have a remote access to a server.

In scenarios where human accessibility is an issue the devices like robots with vision sensors are employed. In [15] the author has developed a system with sensors as an alternative to placing soldiers in dangerous situations and make better decisions based on sensor data. Android Smartphone monitor the situation from remote end and Arduino Mega ADK2560 microcontrollers controls the movement of robot in field communicating over wireless adhoc network with Android device. The phone capable of updating the firmware of the Arduino microcontroller to upgrade the functionalities. The FIRMATA library used to bridge the sensors and the Android phone. The Android phones relay information over an ad-hoc, wireless mesh network using the *Barnacle* Android application and the *Gossip* protocol over a network via TCP packets. The USB connection between the phone and Arduino takes about 120 microseconds for 2 bytes of data to be transferred.

When reliable data transmission is required than the error correction protocol is embedded in application. The author presented a smartphone-based reliable multimedia transmission system with packet-level forward error correction scheme using Reed- Solomon code[16]. The system shows the average packet delivery ratio between 90% and 95% regardless of interference strength. It consists of a multimedia streaming server on windows PC in C++ developed on Microsoft Windows platform reads a multimedia data file and generates streaming data and a client on the Android platform implemented using java. Processed packet recorded in a temporary file which is generated in 10- second intervals. Clients play temporary files after 10 seconds the first packet arrives and new temporary file played with 10-second intervals. Android player can reliably play received packets on real time by using this method.

A similar application for video streaming is presented in [17]. Here video captured from mobile camera or laptop camera encoded in MPEG4. The MJPG video captured is streamed through the WiFi connection to the VLC Media Player in the same network using Android Based Webserver customized and configured to work as Media Server for mjpg Video. The system can be used as video surveillance and monitoring application.

In WSN various wireless standards are used to match the requirement. In [18], author presents a sensor network system with integration of ZigBee and Wi-fi for security system. The XBeeSeries2 from the Digi Company is employed as the ZigBee nodes. The node sends the Zig Bee sensor messages to a cloud database through the TCP/IP protocol to network containing the physical network and wireless network device lines. This system consists of two parts: home intelligent control and outside access control. The door entry management uses the real-time handwriting recognition system using a Smartphone. The Android and Java programming languages are used to write the Smartphone and Server recognition programs.

The control applications with brain are developed to implement controlling functions over wireless network. In [19], author proposed a way to control robot through brain by a Brain-computer interfacing platform to remotely control a mobile robot through the Internet. From the Smartphone, the command is transmitted by the Android platform via Bluetooth to a robot. The Android Smartphone transmits video stream to the server for the feedback to the user. The Android platform controls the LEGO robot via Bluetooth based on the command received from the server, and transmits camera view through the Internet as a visual feedback.

Health related applications are tremendously used with Smartphone. One such application where Heart rates are monitored is presented in [20], where author discusses an Android application Developed and compare HRs derived from a Motorola Droid to electrocardiograph (ECG) and Nonin 9560BT pulse Oximeter readings during various movement-free tasks. Variable levels of opacity are illuminated by the camera light and measured by the camera's five-megapixel photodetecting lens, as it passes through the pulsating capillary tissue beneath the surface of the finger. Measurements are tracked overtime and analyzed until a pulsatile signal is properly detected. An nv21 YUV planar frame format was used to allow for efficient processing of both light and color intensity changes.

Biomedical signal processing over Smartphone add ons the feature of mobility. Such applications is very useful to the doctors to monitor the patients health on Smartphone. In [21], author proposed a case of utilizing tablet computer for processing biomedical signals with a specially designed wireless platform for sensing biomedical signals. It transmit up to 16 channels of biomedical signals simultaneously, and maximum transmit 20 times per second through TI MSP430 Bluetooth Platform by TI, as the Bluetooth solution for proposed platform with the Xilinx XC3S1500FG320 FPGA chip for data processing center in platform. A specialized Android application is designed for collecting, processing, analyzing, displaying and storing the received biomedical signals on tablet computer.

Other such application using photoplethysmography method is described in [22]. The biosignal is first extracted via photoplethysmography (PPG) principle into electric signal to C8051F930 and transmitted through RF module. The sampling frequency of the ADC is set to be 250 Hz. The Bluetooth APIs of Android supports the cable replacement protocol RFCOMM which provides serial port (RS-232) emulation. An open source pure Java API, AndroidPlot, used to create dynamic PPG chart.

Applications targeting human health and wellness is also developed using Android running Smartphones due to its advantage of mobility and handheld feature. One such application is depicted by the author in [23]. This paper describes a method to monitor driver safety by analyzing information related to fatigue using two distinct methods: eye movement monitoring by video sensor and bio-signal processing using bio-signal sensor. Android-based smartphone receives bio signal sensory data via wireless sensor network - Zigbee connected through MSP430F1611 and Video sensor data through USB, further processes the data to indicate the current driving aptitude of the driver. A dynamic Bayesian network framework is used for the driver fatigue evaluation.

A Smartphone application can also be used as personal gait rehabilitation device based on wireless transmission of ambulation data for real-time sensory feedback for assistive healthcare[24]. The insole sensor system made use of force sensitive resistors to sample plantar pressure data at 1000 Hz by an Arduino Pro Mini microcontroller, using the ATMEGA168 16-MHz microprocessor. The Arduino board is in turn connected to a BlueSMIRF Gold Bluetooth serial pipe for data transmission to the Android smartphone. The ARTISTIC ANDROID application layout makes use of a tabbed design in which each feedback method is quickly available via clicking on the corresponding tab with facilities like Data Logging, Visual Feedback, Audible Feedback and Vibro-tactile Feedback

Apart from Heart Rate monitors body sensor networks also use Smartphones the reason being the same – mobility and compact handheld. UAHealth is an integrated mobile health application developed for iPhone for monitoring physical activity, weight, and heart activity[25]. WBAN uses low power ANT+ wireless standard and Digifit Connect ANT+ transceiver adapter for iPhone. mUAHealth monitors Internet connectivity to determine when to submit health related information to the remote medical server.

In a smart walker a microwave Doppler radar, a 3D accelerometer, and piezoresistive sensors used for measuring the force applied by the walker-user during the gait recovery sessions[26]. A 16F673 PIC microcontroller with 16bit ADC (ADS8344) communicating through the SPI bus converts data to digital which is communicated over Bluetooth with the smart phone. The HTC Desire runs on Android 2.2 mobile OS is used as Smartphone.

A Smartphone-based fall detection system monitors the movements of patients, recognizes a fall, and automatically sends a request for help to the care-givers[27]. Detection of falls should be carried out using only acceleration-based information. The system uses a HTC Google Nexus One Smartphone, on which the application is made consisting of four major components: Background Service, Classification Engine, Notification System and Graphical User Interface. Data coming from the sensor is forwarded to the Classification Engine by Background Service which turn by turn reaches Notification System which is responsible for alerting the caregivers whenever a fall is detected. The different activities like sitting, walking, jumping, etc. are differentiated using approaches like Acceleration magnitude threshold and median filtering, Vertical velocity estimation, Acceleration thresholds plus timeouts and Combining use of orientation with the previous approaches.

A personal assistance device that provide autonomy and health monitoring capabilities for wheelchair users such as the patients with neuromuscular disorders, stroke victims, elderly and others who are currently with limited mobility is developed[28]. The wheelchair smart sensors are able to unobtrusively extract the ballistocardiography (BCG), plethysmography, skin conductance (SC) and electrocardiogram signals of a subject seated on a wheelchair. Using data from the real-sensors embedded on the wheelchair and advanced processing algorithms based on uses DWT, CWT, EMD and/or artificial neural network architectures virtual measurement channel is implemented using DSP. The data from the DSP are sent to mobile device running on android where it is displayed and analyzed.

The ongoing research on intelligent Tele-rehabilitation Assistants for in home rehabilitation of post stroke patients is summarized in [29]. The system is expressed by a set of smart sensors including a microwave FMCW Doppler radar that are connected to an embedded computing platform based on digital signal processor (DSP). This platform assures advanced data processing and wireless data transmission to a human machine interface (HMI) Android OS compatible device expressed by a tablet or by a smart phone as part of a health care intelligent ambient. The information from the health status and motor activity smart sensors is added to the patient localization given by a radar RFID device. Additionally, well-established neuron-rehabilitation instruments are used to evaluate the results obtained by the proposed architecture implemented in a ubiquitous and pervasive manner.

IV. Conclusions

Android platform on Smartphones have gained tremendous fame in field of wireless applications. Android platform running on Smartphone or tablet or MCU can be used to make various applications. The portability of the application on other platforms makes it more useful. The access to core of ARM with C/C++ can be implemented using Native Development Kit(NDK). The performance can be enhanced with Native coding compared to Java coding. For Embedded applications ARM core proves to be more efficient than Smartphones as there are no external interfaces available with Smartphones. Different wireless protocols are used for creating wireless network such as Wifi, Zigbee, Bluetooth or RF. There are many research wings open in this field to explore more advanced ways to get better outputs.

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