Intelligent Mobile System for Healthcare Based On WSN and Android

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***Abstract*— I-Healthcare can be defined as "intelligent mobile system, medical sensors and android, wireless communications technologies for healthcare." This emerging concept represents the evolution of i-healthcare systems from traditional desktop "telemedicine" platforms to wireless and mobile configurations. The interest in i-healthcare systems (IHS) originates initially from the need to extend health services out of the hospital and monitor patients over extensive periods of time. IHS is integrated systems in contact with or near the body able to sense, process and communicate biomedical and physical parameters. Current and emerging developments in wireless sensors communications integrated with developments in pervasive and android technologies will have a radical impact on future i-healthcare delivery systems. This editorial paper presents a snapshot of recent developments in these areas and addresses some of the challenges and future implementation issues from the i-healthcare perspective. The contributions presented in this special section represent some of these recent developments and illustrate the multidisciplinary nature of this important and emerging concept.**

***Keywords*— android, intelligent healthcare system, wireless medical sensors.**

I. Introduction

The invasion of wireless technology is now more a utopia first represented as the result of the research; the future vision is to remove the wire of transporting information. The first significant illustration for telephony and the exponential growth of Smartphone's. However, major drawbacks remain. First, the exchange of wireless data will be attractive if a minimum security is guaranteed. We see very little transmitting confidential information by air so everyone can enjoy. On the other hand, any device, as small as it is, needs energy to operate and cannot maintain himself needs. The autonomy of some devices such as smart phones is guaranteed by a rechargeable battery periodically. Today there are many standardized wireless technologies. There is no perfect technology; each one represents a balance between different factors (scope, speed ...). Choosing a wireless technology depends upon the needs [1].

However, wireless networks impose own constraints such as:

Mitigation: the network range is limited by the transmitter power and receiver sensitivity. The obstacles encountered by the signal also attenuate the signal. The allocation of frequencies all facilities wishing to communicate must use the same frequency.

Interference: they may be related to simultaneous transmissions (ie collisions) from several sources, sharing the same frequency band. In general, collisions are due to stations waiting for the medium to become idle and start transmitting simultaneously. But some collisions may also occur because of hidden stations [2]. This is the case when a mobile, thinking that the medium is free, begins to transmit data without the presence of a transmission in progress. Further interference is caused by multipath propagation, characterized by random fluctuations of the amplitude and phase of the signal at the receiver.

Reliability: the reliability of a radio channel is often measured by the average bit error rate. Errors on wireless links are much more common than wired links because the channel is constantly changing and moving can be quite moving in a place where the vector sum of the received signals are canceled. Moreover, it is impossible to control or determine the evolution of the electromagnetic environment. To increase the reliability of transmissions, corrupted packets can be transmitted by an ARQ (Automatic Repeat Request) mechanism [3].

Safety: Unlike wired networks, midrange and network access are very difficult to control. A wireless

II. Needs Applications for Intelligent Healthcare System

The physiological signal extraction devices only have to deal with signal extraction and wireless transmission. Since they do not have to do signal processing, their form factor can be further reduced to reach the goal of microminiaturization and power saving. An alert management mechanism has been included in back-end m-health center to initiate various strategies for automatic emergency alerts after receiving emergency messages or after automatically recognizing emergency messages [7]. Within the time intervals in system setting, according to the medical history of a specific patient, our prototype system can inform various healthcare providers in sequence to provide m-health service with their reply to ensure the accuracy of alert information and the completeness of early warning notification to further improve the healthcare quality.

Thus, hypertension and arrhythmia are chronic diseases, which can be effectively prevented and controlled only if the physiological parameters of the patient are constantly monitored, along with the full support of the health education and professional medical care. In this paper, a role-based intelligent m-health system mechanism in chronic care environment is proposed and implemented [8]. The roles in our system include patients, physicians, nurses, and healthcare providers. Each of the roles represents a person that uses a mobile device such as a smart phone to communicate with platform in the care center such that he or she can go around without restrictions. We have developed physiological signal recognition algorithms that were implemented and built-in in the smart phone without affecting its original communication functions. It is thus possible to integrate several front-end mobile care devices with wireless communication capability to extract patients' various physiological parameters [such as blood pressure, pulse, saturation of hemoglobin (SpO2), and electrocardiogram (ECG)], to monitor multiple physiological signals without space limit, and to upload important or abnormal physiological information to healthcare center for storage and analysis or transmit the information to physicians and healthcare providers for further processing[9].

III. Classification of wireless sensors networks

Wireless communications and networks have been one of the major revolutions of the last three decades. We are witnessing a very fast growth in these technologies where wireless communications and networks have become so ubiquitous in our society and indispensable our daily lives. The demand for new services to support high speed wideband Internet access and advanced high quality real-time video applications push the researchers to investigate new technologies in wireless communications and networks.

Sensing is a fundamental function in wireless sensor networks. Researchers have built WSN platforms with a wide spectrum of sensors, ranging from simple thermistors to micro power impulse radars. They provide flexible sensing capability with a large number of low-power and inexpensive sensor nodes. Nontrivial as it is, the selection and integration of sensors on a WSN platform is often a manageable task given a certain amount of engineering effort. The situation is, however, completely different above the physical sensor and computing hardware layer the acquisition and processing of sensor data impose great challenges on WSN design because of strict resource constraints. Moreover, a sensor node must be energy efficient [10, 11, 12]. As a result, the raw sensor data is often of low quality they are not always reliable, not always repeatable, usually not self-calibrated, and often not shielded to environment and circuit board noise. Obviously, it is necessary to use signal processing algorithms to filter, process, and abstract sensor data with software to provide precise, reliable, and easy to use information to applications.

IV. WSN for monitoring parameters of healthcare system

In this section we present an overview of the key principles and general methodology in the deployment of wireless sensor networks in the solution of i-healthcare system problems.

1) Key Principles: The following key principles should be kept in mind throughout the process:

- This is an i-healthcare problem, not a technology problem. At the center is the patient, not the technology.
- There is often more than one way to achieve a clinical or care objective the first technology solution that appears may not be the best.
- The simpler the technology, the better.
- WSNs for i-healthcare are mission critical; reliability is of paramount importance.
- It has to work in the home, not just in the laboratory.

2) Methodology: The following methodology is valid for any WSN in i-healthcare system:

- Understand the problem. A clinician may already have analyzed the problem, and have come up with a technology outline for the engineer to develop. However, further analysis may pay dividends. At-home i-healthcare means that the appropriate environment to formulate any technology solution is not the clinic or the laboratory, but the home.
- Ethnographic observation of user behavior, where an understanding of how people live and why they live as they do, their constraints and their priorities day to day, can be very beneficial and has informed many of the solutions in which the designers are involved.
- Understand the end user. Who will use the solution in the longer term? What are their constraints or priorities? How do they feel about the type of solution envisaged? Usage modeling, where multidisciplinary teams use personas to explore the user experience from several perspectives, can be useful here.
- Understand what data must be collected. In order to test a clinical hypothesis or to achieve a care objective, some information about the activity or health state of the patient must be collected. It is important that a clear understanding of what data will be collected by the sensor network is shared by the clinician and the engineer, from the start. The information that the clinician needs is important, not the data that the sensor has the technological capability to collect. Focus on what is needed, rather than on what the technology allows.
- Understand the environment. Many WSN deployments do not achieve their objectives because they failed to take into account the differences between the laboratory/clinical environment and the home environment. Building methods and materials vary from location to location; these may impact on the technology. Other equipment in the home may interfere with the sensor technology.
- Consider sensor location. Are sensors to be worn, to be held, to be embedded in walls, floors, beds, or furniture? Keep in mind that the sensor network must be as unobtrusive as possible solutions that require the patient to change his or her day-to-day behavior or which impact on comfort, privacy, or dignity are unlikely to be successful on a long-term basis. Almost all at-home solutions aim to be long-term.
- Select sensors and actuators. Take into account the data, the environment, and the placement. What impacts have these on power consumption, size and weight, form factor, radio communications, antenna type, and computational capability? Where at all possible, use components which are available off the shelf, avoiding experimental or prototype technology. Remember this is an i-healthcare problem, not a technology research project. Aim for a low-cost, light-touch solution.
- Specify and build the aggregator. The aggregator receives data from all the sensors in the network, and may transmit it to an analysis engine or data

visualization system. Alternatively, it may itself process the data and trigger responses by actuators or by communications with caregivers, doctors, and so forth. Commonly, actuators take the form of local PCs or mobile devices such as smart phones [13].

- Identify and deploy analysis and visualization capability. Ensure that the technology is in place to convert the data from the WSN into clinical information, and to allow the clinician to access this information in an appropriate manner. This may be out of the scope of a purely sensor-network project, but it is important that in such a case the precise nature of the interface between the network and the back-end data analysis/clinician system is clearly defined.
- Build the solution in the laboratory and verify that all elements work as planned. Discuss with clinicians and end users.
- Build the solution in a friendly environment, such as in the home of an older person who has agreed to act as tester.
- Deploy the solution in the "real world." Continue to engage with end users to detect and correct any issues that may lead to failure to use the solution as planned.

V. THE FUTURE OF ANDROID IN PLATFORM I-HEALTHCARE SYSTEM

Android was geared for smart phones and tablets. With its open-source flexibility, powerful content delivery system, and consumer device ubiquity, Android is a tempting choice for platform designs, but presents significant challenges for designers. This section discusses these benefits and challenges, highlighting the importance of android in healthcare field. Android provides standardized interfaces for accelerated graphics, audio, wireless networking, Bluetooth technology, USB, and more, enabling applications to easily harness the power of these hardware facilities. OEMs see Android as a means of leveraging consumers' familiarity with mobile devices to improve the i-healthcare system.

Another advantage of Android is its open-source licensing model. While closed source operating systems publish APIs for app developers, they do not allow the base frameworks to be modified and expanded. Android's frameworks and hardware abstraction layer employ the flexible Apache license, which permits modification of the source code without requiring the developer to release those code modifications or their associated intellectual property rights. The availability of the Android open-source infotainment platform comes at a time when OEMs are taking more control in the i-healthcare system. Challenges with Android given the inflow of consumer complaints about monitoring health system, the designers are justifiably concerned with the reliability, stability, and security of Android. Android's extremely large source code base coupled with its open source development model results in extreme churn literally thousands of edits per day across Android and its underlying Linux kernel. This guarantees a steady flow of vulnerabilities.

VI. ARCHITECTURE AND I-HEALTHCARE SYSTEM SPECIFICATIONS

1) ECG System Functionality and Evolution: Basic functions of an ECG machine include ECG waveform display, either through smart phone screen or printed paper media, and heart rhythm indication as well as simple user interface through buttons. More features, such as patient record storage through convenient media, multiple levels of diagnostic capabilities are also assisting doctors and people without specific ECG trainings to understand ECG patterns and their indication of a certain heart condition. After the ECG signal is captured and digitized, it will be sent for display and analysis, which involves further signal processing.

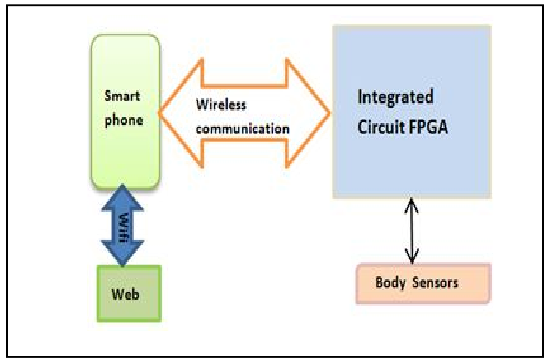

Fig.1 Block diagram of I-healthcare system

2) Signal Acquisition challenges:

- Measurement of the ECG signal gets challenging due to the presence of the large DC offset and various interference signals. This potential can be up to 300mV for a typical electrode. The interference signals include the 50-/60-Hz interference from the power supplies, motion artifacts due to patient movement, radio frequency interference from electro-surgery equipment's, defibrillation pulses, pace maker pulses, other monitoring equipment, etc.
- When a low resolution (16 bit) ADC is used, the signal needs to be gained up significantly (typically 100x - 200x) to achieve the necessary resolution. When a high resolution (24bit) sigma delta ADC is used, the signal needs a modest gain of 4 - 5x. Hence the second gain stage and the circuitry needed to eliminate the DC offset can be removed. This leads to an overall reduction in area and cost. Also the delta sigma approach preserves the entire frequency content of the signal and gives abundant flexibility for digital post processing.
- With a sequential approach the individual channels creating the leads of an ECG are multiplexed to one ADC. This way there is a definite skew between adjacent channels. With the simultaneous sampling approach, a dedicated ADC is used for each channel

and hence there is no skew introduced between channels.

3) *Heart rate measurement:* Cardiograph is an application which measures heart rate. You can save your results for future reference and keep track of multiple people with individual profiles, figure2.

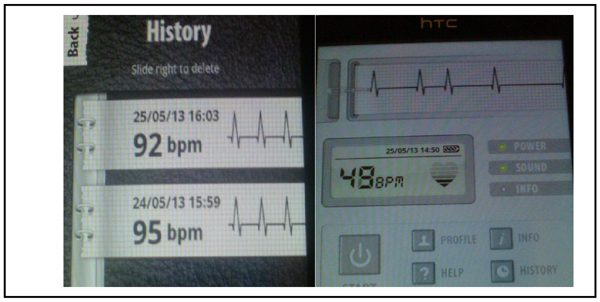

Fig.2 Cardiograph and history

This application has access to the following:

Network communication, Full network access, allows the app to create network sockets and use custom network protocols. The browser and other applications provide means to send data to the internet, so this permission is required to send data to the internet.

Bluetooth, pair with Bluetooth devices allows the app to view the configuration of Bluetooth on the device, and to make and accept connections with paired devices. Access Bluetooth settings, allows the app to configure the local Bluetooth device, and to discover and pair with remote devices.

Network communication, view network connections allows the app to view information about network connections such as which networks exist and are connected.

VII. COMMUNICATION PROTOCOL

The complexity of the communication systems and protocols is increasing constantly, while the communication products' time-to-market is becoming shorter. Afterthoughts communication system redesign due to lack of performance is financially and time expensive, and it is unacceptable. This chapter proposes a method for improving the telecommunication systems, by means of enhancement the performance of the protocols they rely on. The proposed engineering of communication systems is based on a formal method and it provides an early phase performance evaluation of the underlying communication protocols. The methodology is illustrated through a hands-on case study conducted on an existing wireless communication system [15, 16, 17]. Two nodes communicate directly if they are within the transmission range of each other; else communicate via a multi-hop route. Routing protocols can be divided into proactive and reactive. Proactive routing approach attempts to maintain routing information to all nodes in the network in the form of routing tables even before it is needed. They require periodical update, which causes overhead. In contrast to this, in reactive protocols routes are built as and when required. Two routing schemes are available in ZigBee networks, namely mesh routing and tree routing. The ZigBee standard defines only the networking, application, and security layers of the protocol and adopts IEEE 802.15.4 PHY and MAC layers as part of the ZigBee networking protocol.

One advantage of custom proprietary networking/ application layers is the smaller size memory footprint required to implement the entire protocol, which can result in a reduction in cost. However, implementing the full ZigBee protocol ensures interoperability with wireless solutions and additional reliability due to the mesh networking capability supported in ZigBee.

1) Zone Routing Protocol (ZRP):

This is a hybrid protocol with the advantages of both the reactive and proactive protocol. Each node proactively maintains route to the destination with a local neighborhood called routing zone. The size of the zone depends on the zone radius.

2) Inter Zone Routing Protocol (IERP):

This is responsible for reactively discovering routes to the destination beyond the routing zone. It is used if destination is not available within the routing zone. The route request packets are transmitted to all the border nodes which again forward the request if destination is not found in the routing zone. It is different from the standard flood search algorithm that it uses broadcasting. Here broadcast Resolution Protocol is used for the packet delivery.

3) Dynamic Manet On-demand Routing Protocol (DYMO):

The basic operation of DYMO is Route Discovery and Route Maintenance. The route discovery is responsible for identifying the appropriate route, including Route Request (RREQ) and Route Reply (RREP). The route maintenance is responsible for maintaining an established route, including Route Error (RERR) the path accumulation function of DYMO includes source routing characteristics, thereby allowing nodes listening to routing messages to acquire knowledge about routes to other nodes without initiating route request discoveries themselves. As a result, this path accumulation function can reduce the routing overhead, although the packet size of the routing packet is increased [14].

VIII. I-HEALTHCARE SYSTEM INTEGRATION

The most comprehensive coverage so far of VHDL and its applications to the design and simulation of real, industry-standard circuits. It does not focus only on the VHDL language, but also on its use in building and testing digital circuits. In other words, besides explaining VHDL in detail, it also shows why, how, and which types of circuits are inferred from the language constructs, and how any of the four simulation categories can be implemented, all demonstrated by means of numerous examples. A rigorous distinction is made between VHDL for synthesis and VHDL for simulation. In both cases, the VHDL codes are always complete, not just partial sketches, and are accompanied by circuit theory, code comments, and simulation results whenever applicable. The fundamental concepts of digital electronics and digital design, resulting in a very practical, self-contained approach.

Recent advances in FPGA technology have enabled these devices to be applied to a variety of applications traditionally reserved for ASICs. FPGAs are well suited to data path designs, such as those encountered in digital applications. The density of the new programmable devices is such that a nontrivial number of arithmetic operations such as those encountered in wireless communication may be implemented on a single device. The advantages of the FPGA approach to digital filter implementation include higher sampling rates than are available from traditional DSP chips, lower costs than an ASIC for moderate volume applications, and more flexibility than the alternate approaches.

IX. Results

Wireless communication is established between the ECG block and the smart phone android Application, for transferring information. This environment allows the implementation of wireless communication system on programmable circuits, the use of FPGAs circuits offer the advantage of the possibility of re-programming circuits. This improves the application performance in coming from tests. The synthesis results show the complexity of system design and performed by imposing constraints to minimize the propagation delay or integration area. The delay can be optimized to improve the performance of wireless communication system in terms of speed or rate of operation. The synthesis results are established in the development environment Xilinx ISE 14.4 Suite.

TABLE 1 SYNTHESIS RESULTS

function generator (FGs)	*703*
Ports (I/O)	*581*
CLB Slices	*401*
D flip-flops	*344*

Synthesis module provides the following reception results: 581 ports (I/O), D flip-flops 344 and sub modules called function generator (FG) which are the numbers of 703 table1. These characteristics depend much on the target technology. The synthesis results of the emission are given in the following table, we can see that the clock frequency is moderately high (366.8 MHz), which helps at the right flow of data from one area to another. The synthesis step was performed using the Xilinx ISE 14.4 Suite tool to evaluate the performance of the circuit in terms of function generator, operating frequency. Xilinx ISE 14.4 Suite is a design environment that enables simulation and synthesis of a complex so that its projection on a target system technology figure3.

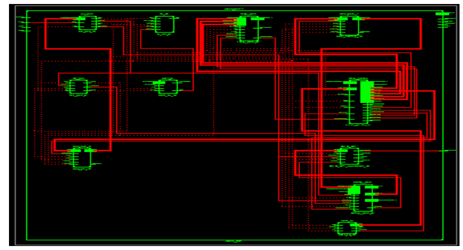

Fig.3 Synthesis RTL schematic

X. Conclusions and Future Works

This work is the contribution to the specification and design of wireless communication for m-health system. Indeed, the work has done in this paper represent a basic building block in the design of a wireless interconnection between ECG block and an android application. This paper demonstrates an intelligent system for m-health. Smart sensors offer the promise of significant advances in medical treatment. Networking multiple smart sensors into an application-specific solution to combat disease is a promising approach, which will require research with a different perspective to resolve an array of novel and challenging problems.

References

[1] A. Paier, D. Faetani, and M. C.F, “Performance evaluation of IEEE 802.11p physical layer infrastructure-to-vehicle real-world measurements,” in 3rd International Symposium on Applied Sciences in Biomedical and Communication Technologies (ISABEL), pp. 1–5, 2010.

[2] Li Y., Chen C. S., Song Y.-Q., Wang Z., Sun Y., « A two-hop based real-time routing protocol for wireless sensor networks », (2008) 7th IEEE International Workshop on Factory Communication Systems - WFCS’08 Dresden (Germany), May 2008.

[3] Chen C. S., Li Y., Song Y.-Q., « An Exploration of Geographic Routing with k-Hop Based Searching in Wireless Sensor Networks », (2008) 376-381, Third International Conference on Communications and Networking in China - ChinaCom 2008 Hangzhou Chine.

[4] I.F. Akyildiz et al., “Wireless Sensor Networks : A Survey” Journal of Computer Networks, 38 (2009), 393-422.

[5] Li Y., Chen C. S., Song Y.-Q., Wang Z., “Real-time QoS support in wireless sensor networks : a survey”, 7th IFAC International Conference on Fieldbuses & Networks in Industrial & Embedded Systems - FeT’2007, France (2007)

[6] T. He et al., “SPEED : A Stateless Protocol for Real-Time Communication in Sensor Networks”, International Conference on Distributed Computing Systems ICDCS 2003, pp. 46-55.

[7] Takamura, J., and B. Williams, “Informal Caregiving: Compassion in Action,” Informal Report, U.S. Dept. Health and Human Services, 2007.

[8] D. Malan, T. Fulford-Jones, M. Welsh, and S. Moulton, “CodeBlue : An Ad Hoc Sensor Network Infrastructure for Emergency Medical Care”, International Workshop on Wearable and Implantable Body Sensor Networks, April 2008

[9] Boughanmi N., Song Y.-Q., « A New Routing Metric for Satisfying Both Energy and Delay Constraints in Wireless Sensor Networks », The Journal of Signal Processing Systems for Signal, Image, and Video Technology, Springer, Volume 51, Number 2, pp. 137-143, may 2008.

[10] Herman, W. A, "The Last Word: Health Technology Is Coming Home—and How!," FDA Consumer, May, 2001.
[11] Jovanov, E., "Wireless Technology and System Integration in Body Area Networks for m Health Applications," Proceedings of the 27th Annual International Conference of the IEEE Engineering in Medicine and Biology Society, Shanghai, China, September 2008.
[12] Jovanov, E., Milenkovic, A., Otto C. and de Groen, P., "A wireless body area network of intelligent motion sensors for computer assisted physical rehabilitation," Journal of NeuroEngineering and Rehabilitation, 2005, vol 2, no. 6, 2005.
[13] Patel, S., Lorincz, K., Hughes, R., Huggins, N., Growdon J. H., & Welsh, M., "Analysis of Feature Space for Monitoring Persons with Parkinson's Disease With Application to a Wireless Wearable Sensor System," Proceedings of the 29th Annual International Conference of the IEEE EMBS, 2007, pp. 6290–6293.
[14] Hongliang R, Meng, M. Q.-H. and Chen, X., "Physiological Information Acquisition through Wireless Biomedical Sensor Networks," Proceedings of the IEEE International Conference on Information Acquisition, June 27–July 3, 2009, Hong Kong and Macau, China, pp. 483–488.
[15] Penders, J. Gyselinckx, B. Vullers, R. De Nil, M., Nimmala, V., van de Molengraft, J., Yazicioglu, F., Torfs, T., Leonov, V., Merken, P., and Van Hoof, C., "Human++: From technology to emerging health monitoring concepts," Medical Devices and Biosensors, 2008, ISSS-MDBS 2008, 5th International Summer School and Symposium on, 2008, pp. 94–98.
[16] Lymberis, A., "Smart Wearables for Remote Health Monitoring, From Prevention to Rehabilitation: Current R&D, Future Challenges," Proceedings of the 4th Annual IEEE Conference on Information Technology Applications in Biomedicine, April 2003, pp. 272–275.
[17] I. C. Msadaa, P. Cataldi, and F. Filali, "A Comparative Study between 802.11p and Mobile WiMAX-based V2I Communication Networks," in Proc. Fourth Int Next Generation Mobile Applications, Services and Technologies (NGMAST) Conf, pp. 186–191, 2010.
[18] Shue Chen C., Shing Wong W., Song Y.-Q., « Constructions and Analysis of Robust Protocol Sequences for Wireless Sensor and Ad-hoc Networks », IEEE Transactions on Vehicular Technology, vol. 57, no. 5, pp. 3053-3063, Sept. 2008.