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Application of Wireless Sensor Networks in Health Care System

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Abstract

Recent, advances in wireless networks and electronics have led to the emergence of Wireless Sensor networks (WSNs). WSNs have been considered as one of the most important technologies that can change the future. These networks consist of small battery–powered motes with limited computation and radio communication capabilities. Each sensor in a sensor network consists of three subsystems: the sensor subsystem which senses the environment, the processing subsystem which performs local computations on the sensed data, and the communication subsystem which is responsible for message exchanges with neighboring sensors. WSNs comprise tiny wireless computers that sense, process, and communicate environmental stimuli, including temperature, light, and vibration.

I. Introduction

Globally, the elderly population is growing and the general population is aging. Life expectancy continues to increase with new advancements in health care. Subsequently, the length of retirement is increasing. Concurrently, more are living with chronic diseases such as heart disease, cancer, Alzheimer’s, and other forms of dementia, placing larger burdens on healthcare systems. Today, more than 850 million people in the world who suffer from chronic diseases are using up to 85% of the healthcare dollars. In the United States, this amounts to more than $1.5 trillion dollars per year. According to the US Centers for Medicare and Medicaid Services (CMS), the national health spending in the United States in 2008 was estimated to be $2.4 trillion dollars. The cost of heart disease and stroke takes around $394 billion. Consequently, the US health care system is facing daunting future challenges.

II. Wireless Sensor Networks

Rapid advances in the areas of sensor design, information technologies, and wireless networks have led the way for the proliferation of wireless sensor networks[18]. A wireless sensor network consists of a large number of wireless-capable sensor devices working collaboratively to achieve a common objective. A WSN has one or more sinks (or base-station) which collect data from all sensor devices. These sinks are the interface through which the WSN interacts with the outside world[22]. The basic premise of a WSN is to perform networked sensing using a large number of relatively unsophisticated sensors instead of the conventional approach of developing a few expensive and sophisticated sensing modules[21]

“WSNs are composed of individual embedded systems that are capable of

1. interacting with their environment through various sensors,
2. processing information locally, and
3. communicating this information wirelessly with their neighbors. “[19]

A sensor node (embedded system) usually consists of three components which are[19]:

- Wireless modules or motes – key components of the network which consists of a microcontroller, transceiver, power source, memory unit, and may contain few sensors. Examples: Mica2, Cricket, MicaZ, Iris, Telos, SunSPOT, and Imote2.
- A sensor board which is mounted on the mote and is embedded with multiple types of sensors. Examples: MTS300/400 and MDA100/300.
- A programming board (gateway board) – provides multiple interfaces including Ethernet, WiFi, USB, or serial ports for connecting different motes to an enterprise or industrial network or locally to a PC/laptop.

These boards are used to program the motes or gather data from them. Example: M1B510, M1B520, and M1B600.

Wireless sensor networks have emerged as a feasible technology for a myriad of applications, including many different health care applications. WSN technology can be adapted for the design of practical Health Care WSNs (HCWSNs) that support the key system architecture requirements of reliable communication, node mobility support, multicast technology, energy efficiency, and the timely delivery of data.

The application of the Wireless Sensor Networks in healthcare systems can be divided into three categories:

1. Monitoring of patients in clinical settings
2. Home & elderly care center monitoring for chronic and elderly patients
3. Collection of long-term databases of clinical data

A wireless sensor network (WSN) is a wireless network consisting of spatially dispersed and dedicated autonomous devices that use sensors to monitor physical or environmental conditions. A usual WSN system is formed by combining these autonomous devices, or nodes with routers and a gateway.

(Figure 1.1: Block diagram of Wireless Sensor Network)

Wireless Sensor Network is different from traditional network.

- Wireless Sensor Network is a Single-purpose design means serving one specific application where as traditional network general-purpose design means serving many applications.

- Energy is the main constraint in the design of all node and network components in wireless sensor network where as in traditional network typical primary design concerns are network performance and latencies, energy is not a primary concern.
- Sensor networks often operate in environments with harsh conditions where as in traditional network devices and networks operate in controlled and mild environments.
- In wireless sensor network physical access to sensor nodes is often difficult or even impossible where as in traditional network maintenance and repair are common and networks are typically easy to access

- In wireless sensor network most decisions are made localized without the support of a central manager where as Obtaining global network knowledge is typically feasible and centralized management is possible

III. Characteristics

The general structure of Wireless sensor network consists of a basestation or “gateway” which can communicate with a number of wireless sensors via a radio link. Data is captured at the wireless sensor node, then compressed, and transmitted to the gateway directly or, if required, uses other wireless sensor nodes to forward data to the gateway. The transmitted data is then passed to the system through the gateway connection.

Sensor nodes are likely as small computers, extremely basic in terms of their interfaces and their components. They usually consist of a processing unit with limited computational power and limited memory, sensors, a communication device, and a power source usually in the form of a battery.

The base stations act as a gateway between sensor nodes and the end user and they normally forward data from the WSN on to a server. Other special components are routers, designed to compute, calculate and distribute the routing tables.

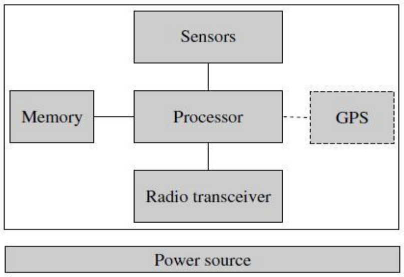
On the basis of functionality of sensor nodes and other element, the major characteristics of WSN are as following :-

- Power consumption constrains for nodes using batteries or energy harvesting Ability to cope with node failures
- Mobility of nodes

- Heterogeneity of nodes
- Scalability to large scale of deployment

IV. Hardware Component

A Wireless Sensor Network (WSN) consists of spatially distributed sensor nodes and each sensor node can perform some processing and sensing tasks independently. In addition, sensor nodes communicate with each other in order to forward their sensed information to a central processing unit or conduct some local coordination such as data fusion. The sensor node consists of several hardware components that include an embedded processor, a radio transceiver, internal and external memories, and one or more sensors, a geopositioning system, a power source.



(Fig 4. Architecture of Sensor Node)

Embedded Processor

The functionality of an embedded processor in a sensor node is to schedule tasks, process data and control the functionality of other hardware components. There are several types of embedded processors available that can be used in a sensor node include Microcontroller, Digital Signal Processor (DSP), Field Programmable Gate Array (FPGA) and Application Specific Integrated Circuit (ASIC). been the most used embedded processor for sensor nodes is the Microcontroller because of its flexibility to connect to other devices and its cheap price[2]. For example, the most recent CC2531 development board provided by Chipcon (acquired by Texas Instruments) uses 8051 microcontroller, and the Mica2 Mote platform provided by Crossbow uses ATMega128L microcontroller.

Transceiver

The responsibility of a transceiver is for the wireless communication of a sensor node. There are different types of wireless transmission media, which includes Radio Frequency (RF), Laser and Infrared. The most used transmission media to fits to most of WSN applications is the RF based communication. The different operational states of a transceiver are Transmit, Receive, Idle and Sleep. Mica2 Mote uses two kinds of RF radios one is RFM TR1000 and other one is Chipcon CC1000. The Mica2 Mote's outdoor transmission range of is about 150 meters.

Memory

Memories in the sensor nodes includes both program memory (from which instructions are executed by the processor), and data memory (for storing raw and processed sensor measurements and other local information). The quantities of memory and storage on board a WSN device are often limited. It include in-chip flash memory and RAM of a microcontroller and external flash memory. For example, the ATMega128L microcontroller running on Mica2 Mote has 128-Kbyte flash program memory and 4-Kbyte static RAM. Further, a 4 -Mbit Atemel AT45DB041B serial flash chip can provide external memories for Mica and Mica2Motes (Hill,2003).

Sensors

Due to limited bandwidth and power , Wireless Sensor Network devices primarily support only low- data-rate sensing. There are various applications call for multi-modal sensing, as a result each device may have several sensors on board. The specific sensors are used according to the requirement of the application.For example, they may include temperature sensors, light sensors, humidity sensors, pressure sensors, accelerometers, magnetometers, chemical sensors, acoustic sensors, or even low-resolution imagers.

Geopositioning system

It is important for all sensor measurements to be location stamped In numerous WSN applications. To obtain positioning you need to pre-configure sensor locations at deployment, but this may only be possible in limited deployments. Mainly for outdoor operations, when the network is deployed in an ad hoc manner, such information is most easily obtained via satellite-based GPS. The Global Positioning System (GPS) is a space -based global navigation satellite system (GNSS) which provides location and time information in all weather, anywhere on or near the Earth, where there is an clear line of sight to four or more GPS satellites.

Power Source

In deployment of the WSN device is likely to be battery powered. power is consumed by sensing, communication and data processing by a sensor node. . Batteries are the main source of power supply for sensor nodes. For example, Mica2 Mote runs on 2 AA batteries. While some of the nodes may be wired to a continuous power source in some applications, and energy harvesting techniques may provide a degree of energy renewal in some cases, the finite battery energy is probable to be the most critical resource bottleneck in most applications.

V. Wireless Sensor Network Architecture

The entire system can be described as consist as two subsystems depending upon the operation performed by the entire system(Figure 8.1),such as :-

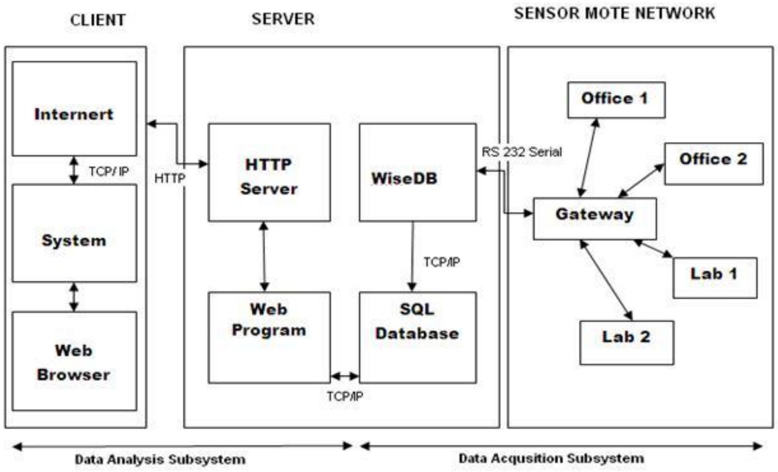
- Data Analysis
- Data Acquisition

Data Analysis

Data Analysis subsystem is software-only . It relied on existing Internet and web (HTTP) infrastructure to ensure communications between the Client and Server components. The main use of this subsystem was to selectively present the gathered environmental data to the end user in a graphical manner.

❖ Data Acquisition

Data Acquisition subsystem is used to collect and store environmental data for later processing by the Data Analysis subsystem. This subsystem is consists of PC , embedded system software and also embedded system hardware. In the other word you can say ,it is composed of both the Server and Sensor Mote Network components.



(Figure. Wireless Sensor Network Architecture)

➢ Client

The Client component is external to the development of wireless sensor network.That means, any computer with a web browser and Internet access could be a Client. It served only as a user interface to the Data Analysis subsystem (Figure 6.1).

➢ Server

The Server plays a significant role between the Data Acquisition and Data Analysis subsystems.In case of Data Analysis ,in this side, an web (HTTP) server hosting a web application. When a page request came in, the web server executes the web application, which retrieved data from the database, processes it, and returns a web page that is transmitted to the Client through the web server.In case of Data Acquisition system, there is a daemon (WiseDB) running to provide the fascility to establish the communication with the Sensor Mote Network.

This daemon collects raw data packets from the Sensor Mote Network. Then these packets are then processed and then convert the raw data into meaningful environmental data.Then this processed data is then inserted into the database. Thus the database is the link between the Data Analysis and Data Acquisition subsystems.

➢ Sensor Motes

The main focus of wireless sensor network is the development of the Sensor Mote Network component . Wireless Sensor Networks are collections of motes. Motes are the individual computers that work together to form networks. It is the component responsible for collecting and transmitting raw environmental data to the Server. The requirements for motes are extensive. They must be small, energy efficient, multifunctional, and wireless.

The component consists of two parts. Such as:-

- The sensor mote
- The gateway mote

The sensor mote is developed to collect and transmit raw environmental data. When not doing this, it went into a low-power idle mode to conserve energy. It also have some other feature involved adhoc networking and may be for multi-hop routing; The second part of the Sensor Mote Network is the gateway mote .The gateway mote is responsible for serving as the liaison between the Server and the Sensor Mote Network and transport all the data packets to WiseDB. It is possible to implement both sensor and gateway motes on the same hardware PCB and with the same software .

VI. Monitoring of Patients in Clinical Settings

Wireless medical sensor networks are becoming increasingly important for monitoring patients in the clinical setting. There exists an overwhelming need for continuous and benign monitoring of more and more physiological functions in a hospital setting. Sensors today are effective for single measurements, however, are not integrated into a “complete body area network”, where many sensors are working simultaneously on an individual patient. Mobility is desired, but in many cases sensors have not yet become wireless. This creates the need for the implementation of new biomedical personal wireless networks with a common architecture and the capacity to handle multiple sensors, monitoring different body signals, with different requirements. The type and number of sensors must be configured according to monitoring needs related to different diseases, treatment, and the patient treatment life cycle.

At the Interventional Center, Oslo University Hospital, they have developed, implemented and tested a biomedical wireless sensor network (BWSN). The BWSN allows simultaneous use of six different sensors. The following six different sensors were integrated:

- Millicore - DigiVent Pulmonary Air Leakage
- Novosense - CardioPatch ECG sensor
- Novelda - Medical UWB-IR radar
- VTT - Heart Monitoring Accelerometer
- SINTEF - SpO2 & Temperature sensors

Their BWSN matched performance of the state of the art wired advanced medical monitoring platforms. Their new wireless system facilitated more aggressive and early patient ambulation and unrestricted mobility. This applies to post procedure monitoring of patients, as length of hospital stays are shortening due to minimally invasive procedures.

At University of Texas at Dallas, they have designed a BWSN for monitoring patient vital sign data in a hospital setting. They are using Crossbow MICAz motes to design a mesh network that routes the patient data to a remote base station within the hospital. A hospital care giver can access the patient’s data at any point in time and doesn’t have to be present in the patient’s room to examine the readings. The nodes of the network are self-powered and get its energy from overhead 34 W fluorescent lights using solar panels. The network nodes can be interfaced to different vital sign sensors like electrocardiograms (ECGs), blood pressure (BP), and pulse-oximeters. They have tested their system by interfacing a commercial BP/heart-rate monitor (BPM) to a node. The sensor node controlled the BPM to initiate a reading and collecting data and forwarded the data to the base station. They also designed a graphical user interface (GUI) to store and display data on the base station PC.

VII. Collection of Long-Term Databases of Clinical Data

Sensors link the physical with digital world by capturing and revealing real-world phenomena and converting these into a form that can be processed, stored, and acted upon. The data that is gathered by the sensors in a WMSN can be used in two ways:

1. Healthcare applications that leverage wireless sensor networks analyze the data gathered by sensors to infer and make decisions about the state of a patient's health and wellbeing. By improvement in monitoring consistency, continuous monitoring enhances data quality and precision for decision support leading to better titration of therapeutic interventions.
2. The continuous gathered data can be analyzed utilizing computational intelligence techniques to find solutions to the unsolved problems in the healthcare system.

VIII. HEALTHCARE APPLICATIONS

Wirelessly networked sensors enable dense spatio-temporal sampling of physical, physiological, psychological, cognitive, and behavioral processes in spaces ranging from personal to buildings to even larger scale ones. Such dense sampling across spaces of different scales is resulting in sensory information based healthcare applications which, unlike those described in Section II-A, fuse and aggregate information collected from multiple distributed sensors. Moreover, the sophistication of sensing has increased tremendously with the advances in cheap and miniature, but high quality sensors for home and personal use, the development of sophisticated machine learning algorithms that enable complex conditions such as stress, depression, and addiction to be inferred from sensory information, and finally the emergence of pervasive Internet connectivity facilitating timely dissemination of sensor information to caregivers.

At-home and Mobile Aging: As people age, they experi-ence a variety of cognitive, physical, and social changes that challenge their health, independence and quality of life . Diseases such as diabetes, asthma, chronic obstructive pul-monary disease, congestive heart failure, and memory decline are challenging to monitor and treat. These diseases can benefit from patients taking an active role in the monitoring process. . Such data can also be correlated with social and environmental context. From such "living records", useful inferences about health and well-being can be drawn.

IX. TECHNICAL CHALLENGES

In the paragraphs that follow we describe some of the core challenges in designing wireless sensor networks for health-care applications. While not exhaustive, the challenges in this list span a wide range of topics, from core computer systems themes such as scalability, reliability, and efficiency, to large scale data mining and data association problems, and even legal issues.

A. Trustworthiness

Healthcare applications impose strict requirements on end-to-end system reliability and data delivery. For example, pulse oximetry applications, which measure the levels of oxygen in a person's blood, must deliver at least one measurement every 30 seconds [36]. Furthermore, end-users require measurements that are accurate enough to be used in medical research. Using the same pulse oximetry example, measurements must devi-ate at most 4% from the actual oxygen concentrations in the blood [36]. Finally, applications that combine measurements with actuation, such as control of infusion pumps and patient controlled analgesia (PCA) devices, impose constraints on the end-to-end delivery latency. We term the combination of data delivery and quality properties the trustworthiness of the sys-tem and claim that medical sensing applications require high levels of trustworthiness.

A number of factors complicate the systems' ability to pro-vide the trustworthiness that applications require. First, medi-cal facilities, where some of these systems will be deployed, can be very harsh environments for radio frequency (RF) com-munications. This harshness is the result of structural factors such as the presence of metal doors and dividers as well as deliberate effort to provide radiation shielding, for example in operating rooms that use fluoroscopy for orthopedic pro-cedures. In fact, Ko et al. recently found that packet losses for radios following the IEEE 802.15.4 standard is higher in hospitals than other indoor environments [41]. Moreover, devices that use 802.15.4 radios are susceptible to interference from WiFi networks, Bluetooth devices, and cordless phones all of which are heavily used in many hospitals.

B. Privacy and Security

Wireless sensor networks in healthcare are used to deter-mine the activities of daily living (ADL) and provide data for longitudinal studies. It is then easy to see that such WSNs also pose opportunities to violate privacy. Furthermore, the importance of securing such systems will continue to rise as their adoption rate increases.

The first privacy challenge encountered is the vague spec-ification of privacy. The Heath Insurance Portability and Ac-countability Act (HIPPA) by the U.S. government is one at-tempt to define this term [1]. One issue is that HIPPA as well as other laws define privacy using human language (e.g., English), thus, creating a semantic nightmare. Nevertheless, privacy specification languages have been developed to specify privacy policies for a system in a formal way. These requests should be evaluated against the predefined policies in order to decide if they should be granted or denied. This framework gives rise to many new research challenges, some unique to WSNs, as we describe in the paragraphs that follow. Fortunately, many solutions with different tradeoffs are pos-sible for this type of physical layer attack. Such solutions in-clude (i) attenuating the signal outside of the home to increase the packet loss ratio of the eavesdropper, (ii) periodically trans-

Fig. 1. The SHIMMER wearable sensor platform.

SHIMMER incorporates a TI MSP430 processor, a CC2420 IEEE 802.15.4 radio, a triaxial accelerom-eter, and a re-chargeable Li-polymer battery. The platform also includes a MicroSD slot supporting up to 2 GBytes of Flash memory.

Unfortunately, an adversary can combine information avail-able from many (external) sources with physical layer infor-mation to make inferences even more accurate and invasive. New solutions that are cost-effective, address physical layer data, protect against inferences based on collections of related data, and still permit the original functionality of the system to operate effectively are needed.A related fundamental problem, yet unsolved in WSNs is dealing with security attacks. Security attacks are especially problematic to low-power WSN platforms because of several reasons including the strict resource constraints of the devices, minimal accessibility to the sensors and actuators, and the unreliable nature of low-power wireless communications. The security problem is further exacerbated by the observation that transient and permanent random failures are common in WSNs and such failures are vulnerabilities that can be exploited by attackers. For example, with these vulnerabilities it is possible for an attacker to falsify context, modify access rights, create denial of service, and, in general disrupt the operation of the system.

C. Resource Scarcity

In order to enable small device sizes with reasonable battery lifetimes, typical wireless sensor nodes make use of low-power components with modest resources. Figure 1 shows a typical wearable sensor node for medical applications, the SHIM-MER platform . The SHIMMER comprises an embedded microcontroller (TI MSP430; 8 MHz clock speed; 10 KB RAM; 48 KB ROM) and a low-power radio (Chipcon CC2420; IEEE 802.15.4; 2.4 GHz; 250 Kbps PHY data rate). The to-tal device power budget is approximately 60 milliwatts when active, with a sleep power drain of a few microwatts. This de-sign permits small, re-chargeable batteries to maintain device lifetimes of hours or days, depending on the application’s duty cycles.

The extremely limited computation, communication, and energy resources of wireless sensor nodes lead to a number of challenges for system design. Software must be designed carefully with these resource constraints in mind. The scant memory necessitates the use of lean, event-driven concurrency models, and precludes conventional OS designs. Finally, application code must be extremely careful with the node’s limited energy budget, limiting radio com-munication and data processing to extend the battery lifetime. While smartphone-based systems typically enjoy more pro-cessing power and wireless bandwidth, the fact that they are less flexible compared to customizable mote platforms, limits their capability to aggressively conserve energy. This leads to shorter re-charge cycles and can limit the types of applications that smartphones can support.

X. SYSTEMS

Next, we present several wireless sensing system prototypes developed and deployed to evaluate the efficacy of WSNs in some of the healthcare applications described in Section III. While wireless healthcare systems using various wireless tech-nologies exist, this work focuses on systems based on low-power wireless platforms for physiological and motion moni-toring studies, and smartphone based large-scale studies.

A. Physiological Monitoring

In physiological monitoring applications, low-power sensors measure and report a person’s vital signs (e.g., pulse oxime-try, respiration rate, temperature). These applications can be developed and deployed in different contexts ranging from disaster response, to in-hospital patient monitoring, and long-term remote monitoring for the elderly.

Therefore, systems that automate patient monitoring have the potential to increase the quality of care both in disaster scenes and clinical environments. Systems such as CodeBlue , MEDiSN, and the Washington University’s vital sign monitoring system target these application scenarios.

Fig. 2. Medical information tag

The miTag is a Tmote mini [52] based patient monitor that includes a pulse oximetry sensor with LEDs, buttons and a LCD screen. The miTag is powered using a re-chargeable 1,200 mAh 3.7 V Li-Ion battery and external finger tip sensors are used to make the pulse oximetry measurements.

The systems described above were deployed in disaster sim-ulations and hospital pilot studies. These studies showed that wireless sensing systems can in fact over-come the challenging RF conditions that exist in these envi-ronments to meet the applications' stringent trustworthiness requirements.

While the systems introduced above deal with improving the quality of patient care in hospitals or disaster scenarios, researchers and practitioners noticed that the coming world-wide silver tsunami , where a large number of retiring el-ders overload the capacity of current hospitals, is stressing the traditional concept of healthcare which is focused on clinical and emergency medical service (EMS) settings. Specifically, it is economically and socially advantageous to reduce the burden of disease treatment by enhancing prevention and early detection while allowing people to stay at home for as long as possible.

B. Motion and Activity Monitoring

Another application domain for WSNs in healthcare is high-resolution monitoring of movement and activity levels. Wear-able sensors can measure limb movements, posture, and mus-cular activity, and can be applied to a range of clinical set-tings including gait analysis , activity classifica-tion , athletic performance, and neuromotor disease rehabilitation . In a typical scenario, a patient wears up to eight sensors (one on each limb segment) equipped with MEMS accelerometers and gyroscopes. A base station, such as a PC-class device in the patient's home, collects data from the network. Data analysis can be performed to recover the patient's motor coordination and activity level, which is in turn used to measure the effect of treatments.

In contrast to physiological monitoring, motion analysis in-volves multiple sensors on a single patient each measuring high-resolution signals, typically six channels per sensor, sam-pled at 100 Hz each. This volume of sensor data precludes real-time transmission, especially over multihop paths, due to both bandwidth and energy constraints. The SHIMMER platform incorporates a MicroSD interface, permitting up to 2 GBytes of storage — enough to store up to a month of continuously-sampled sensor data. While the energy consump-tion of flash I/O is non-negligible, it is about 101 th the energy cost to transmit the same amount of data over the radio.

C. Large-Scale Physiological and Behavioral Studies

The final application of WSNs in healthcare that we dis-cuss is their use in conducting large-scale physiological and behavioral studies. The confluence of body-area networks of miniature wireless sensors (such as the previously mentioned miTag and SHIMMER platforms), always-connected sensor-equipped smartphones, and cloud-based data storage and pro-cessing services is leading to a new paradigm in population-scale medical research studies, particularly on ailments whose causes and manifestations relate to human behavior and living environments.

One example of such systems is AutoSense, in which objective measurements of personal exposure to psychosocial stress and alcohol are collected in the study participants nat-ural environments. A field-deployable suite of wireless sen-sors form a body-area wireless network and measure heart rate, heart rate variability, respiration rate, skin conductance, skin temperature, arterial blood pressure, and blood alcohol concentration. From these sensor readings, which after initial validation and cleansing at the sensor are sent to a smartphone, features of interest indicating onset of psychosocial stress and occurrence of alcoholism are computed in real time.

XI. FUTURE DIRECTIONS

Driven by user demand and fueled by recent advances in hardware and software, the first generation of wireless sen-sor networks for healthcare has shown their potential to alter the practice of medicine. Looking into the future, the tussle between trustworthiness and privacy and the ability to deploy large-scale systems that meet the applications' requirements even when deployed and operated in unsupervised environ-ments is going to determine the extent that wireless sensor networks will be successfully integrated in healthcare practice and research.

➢ Conclusion

Today, there is an increasing interest in developing technical solutions, by academia and industry alike, to address problems with healthcare delivery.. In fact, the future of healthcare in our increasingly aging world will oblige ubiquitous monitoring of health with minimal physical interaction of doctors with their patients. Low-cost technologies are expected to aid in the delivery of services while simultaneously reducing costs. Wireless sensor networks have the potential to assist in meeting some of these future challenges, by simplifying use of medical equipment, advancing at-home medical care, and displaying health and wellness information to both providers and patients. The design of better wireless medical sensor networks seems to be a good solution to part of the problem. As a result, wireless sensor networks are becoming increasingly important for monitoring patients both in the clinical settings as well as home.

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