

Sensor Networks in Pervasive Healthcare Computing

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ABSTRACT

Advances in wireless sensor networking (WSN) have opened up new opportunities in distributed informatics. Pervasive healthcare, based on WSN, is an emerging technology area with great potential of future applicability. Small size devices capable of sensing, computing and communicating, enable pervasive platforms; while opening up the large number of technical, medical, social and ethical questions and challenges. Though mostly focused on technical issues, this chapter also addresses some non-technical aspects implied by the technology implementation in medicine. It presents the general philosophy of the pervasive computing and technical design space of wireless sensor networks, mostly highlighting: the energy conservation, communication aspects, security, and software implementation. The state of the art in ubiquitous healthcare, challenges, open questions, as well as the non-technical aspects of the systems implementation are also presented here. As such, this chapter intends to give an insight on most important WSN-based pervasive computing issues, the multidisciplinary application-driven design of these systems, and their position in healthcare pervasive computing.

INTRODUCTION

Pervasive computing, in technological sense, presents a fusion of various geographically scattered devices and software modules integrated into systems, very diverse regarding the purpose, architecture, and the used technology. Ubiquitous computing is one of the most challenging areas of the distributed (medical) informatics today. Instead of the literal meaning of the term *ubiquitous*, which means *everywhere*, the more reasonable definition of ubiquitous computing (based on socio-economic sense) would explain it as a technology which can be available anywhere that it is useful and economically viable to expect to find a sensor (“Ubiquitous Sensor Networks,” 2008). In order to achieve the pervasiveness of the distributed systems in

this context, various computational and communication technologies must be included. The backbone of these information systems are based on well known broadband technologies and, as such, does not present their critical part, hence not included in this paper. On the other hand, long term sensing integrated into the ordinary life activities or scattered into the battlefield, bring up many challenges in scientific society. In this direction, wireless sensor networks are already in use, promising wide range of applicability as in: military, healthcare, environmental monitoring, intelligent home environment, transport systems, industrial systems etc. Small physical dimension of the sensor nodes are one of the musts in these structures, which implies high integration of sensing, computing and communication capabilities into the small size devices while meeting the application-specific characteristics of the system.

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Though sometimes still involving the wired infrastructure, pervasive computing, on the layer of interfacing the physical environment, mostly uses either typical WSN (multi hop, large scaled network of sensor nodes) or some other wireless transmitting structure – special non-typical WSN formations (such as RF, Bluetooth etc.) which contain only one or a few sensor nodes to transmit the sensed data in simple cluster topology. This layer is also technically the most demanding part of the system design. Many constraints here bring up challenges in various engineering fields such as: sensing, energy consumption, communication, security issues etc. These issues are also correlated, which makes the optimization and standardization process more complicated.

Pervasive computing design is a very application specific process. The methodology of proper technology implementation in a specific field involves multi-disciplinary teams which necessarily practices trans-disciplinary education in order to pass through the systematic and optimized project development and implementation phases. These phases often include: a) precise request definition and certain inter-disciplinary education process for both software and hardware engineers; b) development phase with the in-group communications and trans-disciplinary knowledge improvement; c) the in-group cooperation in practical evaluating and the product improvement phase, and d) market interfacing. Regarding its applicability in healthcare, state of the art is mainly focused on: a) minimizing the physical dimensions (making the sensors wearable and as much unobtrusive), while preserving the computational, storing, and communication capabilities; b) communication and mobility issues; c) power management; d) security issues. But, beside the technical limitations, when interfacing human being, there are also many non-technical implications that need to be mentioned. Reducing face-to-face interaction through the use of IT can have impact on social aspects as well. The acceptance of Body Area Networks is, for example, one of the issues in implementation process. Also, the privacy of personal health information, which

belongs to the technical and non-technical aspects of the application design, raises social and ethical issues as well. Other ethical issues like: trust, equity and responsibility for errors; are also concerns of the ubiquitous healthcare computing implementation process.

Human-computer interaction mainly depends on the technological and the application implementation environments. The way the application is designed mostly influences the acceptance and the overall successfulness of the implementation. Therefore, this chapter has three main aims: to present the most important aspects of the pervasive computing while focusing on those which affect the healthcare applications, to present the implementation of this technology in healthcare, and to show social, ethical, and other non-technical implications of the used technology. In the technology-presentation part of this chapter which deals with: pervasive computing, the design, and WSN related issues; during and/or at the end of each section, along with the strict technology-specific material, the relations of the presented subtopics with the healthcare applications and some human-computer interactions are also given.

DISTRIBUTED PERVASIVE COMPUTING

The term *distributed computing*, refers to a computer network where computational entities (i.e. nodes), while distributed within a geographical area, have their own local memory and communicate with each other by message passing.

Typical properties of these systems include:

- Tolerance to failures of the individual computing entities.
- System can be dynamic, not pre-determined in structure, and heterogeneous.
- Each entity has an incomplete view of the system.

While overlapping in some aspects, in contrast to parallel computing, these systems are usually used in (large scale) geographically

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