Realisation of Ubiquity in Body Area Networks for Healthcare Systems

Thesis by

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Declaration of Authorship and Originality

I, Jan Szymanski, declare that I am the sole author of this thesis and that I have not used material in part or whole from other sources without proper acknowledgment. All theories, results, and designs of others that I have incorporated into my report have been properly referenced, and that sources of assistance have been acknowledged appropriately.

Signature of Doctoral Candidate:

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Abstract

The world today is facing many health-related problems. Obesity-related health issues, often attributed to unhealthy lifestyle, represent one of the most serious global problems of the 21^{st} century. Despite significant progress in the field of medicine, the level of chronic diseases is still on the rise.

These health issues are further exacerbated by a growing pressure on the healthcare system caused by a rapid growth of an aging population and a falling number of people of workforce age.

Physical and mental health is of prime importance to every individual and to society as a whole. There is a growing interest in new ways to support and maintain an overstressed healthcare system, and there is an expectation for solutions that come from the areas of science and technology. One of the main ideas offered is to move some of the traditional functions of clinicians, health centers and hospitals into the patient's home environment.

The Internet of Things (IoT) and Big Data domains are rapidly evolving. From the initial concepts of connecting things to the Internet for monitoring, control and collecting data, the technology extends into Big Data analytics in a ubiquitous and pervasive computing environment. The number of healthcare applications is becoming a core part of the IoT world, with all its benefits and challenges.

This research focuses on IoT solutions related to personal health monitoring and health-aware mobile devices, seen as an integrated system. The application of ubiquitous communication for plug-and-play, IP protocols, for interoperable low-power sensor networks are investigated together with research into effective resource management into Body Area Networks. The aim is to contribute to an area of health technology that can be available *"everywhere, anytime and to anyone"*.

Contents

List of Figures

List of Tables

Glossary

A

Actuator - An actuator is a device converting energy from electrical to another form.

Agent - An agent is a program construct that acts on behalf of a user or other program, designed with a binding agreement to operate within a set of pre-defined rules and outcomes.

AI - Artificial Intelligence is the branch of computer science that seeks to approximate intelligence exhibited in nature.

API - Application Programming Interface is a defined set of interface rulesets to allow extensible functionality of software code.

AR - Augmented reality (AR) is a live view of real-world in which a view of reality is modified by a computer.

Architecture - The Architecture of a system is the conceptual model defining the structure and behaviour and views of the system

B

BAN - formally defined by IEEE 802.15 is a communication standard optimized for low power devices and operation on, in or around the human body

Bluetooth - Bluetooth is a wireless technology standard also known as IEEE 802.15.1

C

Cloud - a set of scalable server infrastructure performing Cloud Computing by processing and storage of data from devices or other sources, and enabling the creation and integration of software systems and applications

Cloud Computing - A model of network computing performed on connected servers rather than on a local computers.

CoAP - Constrained Application Protocol (CoAP) is a software protocol for the Internet of Things able to run on devices with limited resources

Configuration - BAN mote interface enabling a set of configuration properties to be read and modified through it.

Contiki - Operating system including IP protocol stack for WSN.

D

Discovery - BAN motes interface enabling publishing of capabilities in the network/group and dynamical search for motes based on certain criteria.

Distributed Systems - A Distributed System is a software system consisting of multiple autonomous components communicating through a common network and interacting in order to achieve a common goal or objective.

E

Energest - a software module in Contiki OS used to estimate the energy consumption

F

Framework - A System Framework provides a reusable set of development libraries or classes for a software system or subsystem.

G

Github - Both Git and GitHub refer to this as a repository, or repo for short, a digital directory or storage space where the project, its files, and all the versions of its files are stored

H

I

IDE - An Integrated Development Environment is a software application that provides complete development tools including source code editor, build automation tools and code debugger.

IEEE - The Institute of Electrical and Electronics Engineers is a non-profit professional association involved among others in a development of communication standards

IETF - Internet Engineering Task Force is the group of people producing technical documents and new ideas related to Internet

Internet of Things (IoT) - New Internet paradigm being the extension of the Internet into low power intelligent objects (Things) for the purpose of monitoring and control

IP for Smart Object or 6LowPAN - 6LowPAN (IPv6 over Low power Wireless Personal Area Networks) is a protocol defining IPv6 packets over IEEE802.15.4 wireless networks.

IPSO - IP for Smart Object Alliance is a global forum serving the goal to establish the Internet Protocol (IP) as the network for the connection of Smart Objects

J

Java (software platform) - The Java Platform is a software runtime environment developed by Sun Microsystems, providing a system for developing application software and deploying it in a cross-platform computing environment.

Java Script - High-level, dynamic, untyped, and interpreted programming language

jQuery - jQuery is a JavaScript library

jQuery UI - jQuery UI is a JavaScript library for user interfaces

K

L

Layer - An layer provides a way to abstract the implementation details of a functionality in a system architecture.

LLN - Low-Power and Lossy Networks (LLNs) described in RFC 6550 is a network of resource constrained devices

M

Monitoring - Supervising activities in progress to ensure they are on-course and on-schedule in meeting the objective and performance targets, in BAN mote interface providing a mechanism to monitor the various properties or parameters of a mote.

MQTT - MQTT (MQ Telemetry Transport or Message Queue Telemetry Transport) is an ISO standard (ISO/IEC PRF 20922) publish-subscribe-based lightweight messaging protocol for use on top of the TCP/IP protocol.

MTU - In computer networking, the maximum transmission unit (MTU) is the size of the largest network layer protocol data unit that can be communicated in a single network transaction

N

Neural Networks - Neural Networks are biologically inspired models of computations, capable of machine learning and pattern recognition.

Node.js - JavaScript framework using an event-driven, non-blocking I/O model for speed and efficiency.

O

OSI - The Open System Interconnection model is a model that characterizes and standardizes the internal functions of a communication systems.

P

Pervasive - Pervasive means permeated into environment.

Pervasive Healthcare - Pervasive Healthcare (or the European Union term: ambient assisted living) is a paradigm and a vision for the future of healthcare.

Q

Quality of Service - The Quality of Service (QoS) refers to the networking of components that enable the transport of traffic with specialized or prioritized requirements or service demands.

R

Replica - Replica is an exact reproduction of the object. In computing Replication is the use of redundant resources to improve reliability, fault-tolerance, performance or substitute original hardware components.

Repository - software repository is a place where software is found and organized, can be local or online

Responsive Web Design Responsive Web Design is a design method using CSS and HTML to resize, hide, shrink, enlarge, or move the content to make it look good on any screen.

RPL - IPv6 Routing Protocol for Low power and Lossy Networks

S

Sensor - A sensor is a transducer converting various physical types of energy into electrical energy

Service Discovery and Publishing - service discovery protocols used to discover services present in a network.

Sink - In WSN Sink is a special node where data collected (sometimes, already aggregated data) is sent

Smart Dust - Smart Dust was originally a concept for miniature wireless sensor networks and a project undertaken at University of California Berkeley.

Smart object - Smart object is an item equipped at least with a form of sensor and/or actuator, a microprocessor, a communication device (radio transceiver) and a power source. Additionally, smart object might contain other modules, for example data storage.

SOTA - State of the Art is the currently highest level of development of a device, scientific field or technique.

T

TinyOS - Operating system including IP protol stack for WSN

Transducer - A transducer is a device converting energy from one form into another

U

Ubiquious - Ubiquitous is something that is available anywhere, anytime

Usability - Usability is the ease of use and learnability of anything a human interacts with. Typical example is the elegance and clarity with which the interaction with a computer program or an electronic hardware is designed

V

W

Web Server - A web server is a computer system processing requests and serving resources

WSN - Wireless Sensor Network (WSN) is a network made of number of small intelligent devices called motes having capabilities to sense, control and communicate wirelessly

WSN-HEAP Acronym for Wireless Sensor Networks Powered by Ambient Energy Harvesting

X

Y

Z

ZigBee - ZigBee is a standard using small, low-power digital radios based on the IEEE 802.15.4 standard for WSN