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ABSTRACT

The past several years have witnessed a rapid development in the wireless network area. So far wireless networking has been focused on high-speed and long range applications. However, there are many wireless monitoring and control applications for industrial and home environments which require longer battery life, lower data rates and less complexity than those from existing standards. What the market need is a globally defined standard that meets the requirement for reliability, security, low cost and low power. For such wireless applications a new standard called ZigBee has been developed by the ZigBee Alliance based upon the IEEE 802.15.4 standard.

The goal of this thesis is to investigate the suitability of ZigBee devices in monitoring and control applications. A light monitoring system has been developed using ZigBee products. The developed system is based on Delphi 5 programming language and Oracle 10g database. Also Toad for Oracle 8.0 interface is used to manage the Oracle database. The developed system measures the light intensity using a light sensor connected to a ZigBee device. A dynamic program has also been developed in real-time to plot the variation of the light intensity with time.

The study showed that because of its extremely low-power consumption, the large network capability and the ease of use, the ZigBee protocol is more suitable in applications such as remote data collection, remote data monitoring, and multi-node control than most of the other wireless communications protocols, such as Bluetooth, Infrared or Ultrasound.

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ACRONYMS

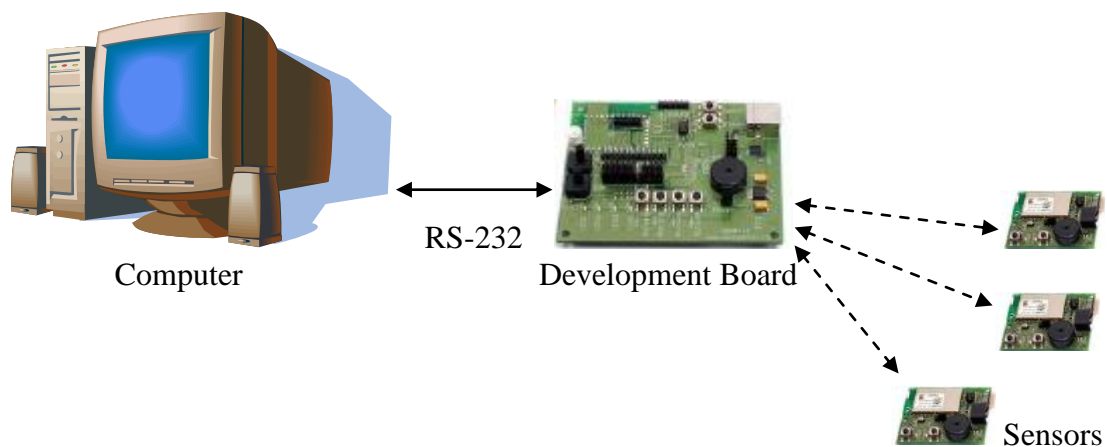
AES	Advanced Encryption Standard
AMI	Advanced Metering Infranstructure
AMR	Automatic Meter Reading
AODV	Ad-Hoc On Demand Distance Vector
AT	Attention Terminal
BAN	Body Area Network
BSN	Beacon Sequence Number
BPSK	Binary Phase Shift Keying
CCA	Clear Channel Assessment
CE	Consumer Electronics
CFP	Contention Free Period
CID	Cluster ID
CLH	Cluster Head
CSMA-AC	Carrier Sense Multiple Access with Collision Avoidance
DCE	Data Communications Equipment
DD	Designated Device
DOA	Direct Oracle Access
DSR	Dynamic Source Routing
DSSS	Direct Sequence Spread Spectrum
DTE	Data Terminal Equipment
ECM	Electrically Commutated Motor
ED	Energy Detection
EVB	Evaluation Board
EVM	Error Vector Magnitude
FCS	Frame Check Sequence
FFD	Full Function Device
GUI	Graphical User Interface
GTS	Guaranteed Time Slot
HAN	Home Area Network
HVAC	Heating, Ventilating, Air Conditioning
HDR	Header
IR	Infra-Red
ISP	In-System Programmer
LLC	Logical Link Control
LQI	Link Quality Indication
LR-WPAN	Low Rate-Wireless Personel Area Network
MAC	Medium Access Control
MACT	Multicast Activation
MCB	Module Carrier Module
MEMS	Micro Electro-Mechanical System
MFR	MAC Footer
MHR	MAC Header
MIC	Message Integrity Code
MLME	MAC Layer Management Entity

MSK	Minimum Shift Keying
MPDU	MAC Protocol Data Unit
MSDU	MAC Service Data Unit
NWK	Network Layer
O-QPSK	Offset-Quadrature Phase Shift Keying
PAN	Personel Area Network
PHR	Physical Header
PHY	Physical Layer
PLME	Physical Layer Management Entity
PN	Pseudorandom Noise
POS	Personel Operating Space
PPDU	Physical Protocol Data Unit
QoS	Quality of Service
RDBMS	Relational Database Management System
RERR	Route Error
RF	Radio-Frequency
RFD	Reduced-Function Device
RREP	Route Reply Packet
RREQ	Route Request
SAP	Service Access Point
SFD	Start of Frame Delimiter
SHR	Synchronization Header
SMT	Surface Mount
SSCS	Service Specific Convergence Sublayer
TOAD	Tool for Oracle Application Developers
URC	Universal Remote Control
WPAN	Wireless Personel Area Network
Z-URC	ZigBee based User Remote Control

INTRODUCTION

ZigBee is the name of a specification for high level communication protocols using small, low-power digital radio, based on the IEEE 802.15.4 standard for wireless personal area networks (WPANs), such as wireless headphones connecting with cell phones via short-range radio. The technology is intended to be simpler and less expensive than other WPANs, such as Bluetooth. ZigBee is targeted at radio-frequency (RF) applications that require a low data rate, long battery life and secure networking.

ZigBee protocol based devices can be connected to wireless sensors which can monitor physical quantities such as the temperature, light intensity, humidity, pressure, force, acceleration, speed and so on. The ZigBee technology has been developed for use in low-power automation and remote control applications. The following figure shows how a ZigBee protocol based automation or monitoring system can be developed using a PC and a ZigBee development kit.



Block diagram of remote monitoring & automation based zigbee

The aim of this thesis is the investigation of the feasibility of using ZigBee protocol based products in monitoring and control applications. A light intensity monitoring system has been developed as an example system in order to assess the suitability of ZigBee devices in wireless monitoring applications. A ZigBee development kit (telegesis ETRX2DVK) is used with a main board and a remote sensor board. The main board is connected to the RS-232 serial port of a PC and a light intensity sensor is connected to the sensor board. Under the control of the PC, the main board receives the

measured remote light intensity values from the sensor board. The received data is stored in the Oracle database on the PC and is also plotted dynamically in real-time. It is shown that the ZigBee protocol based control and monitoring has many advantages such as long battery life, fast response, and large number of nodes compared to using other communication protocols such as the Bluetooth, Infrared or the Ultrasound.

This thesis consists of an introduction, three chapters and a conclusion.

Chapter 1 gives an overview of ZigBee. It includes information about ZigBee and its history, how it is compared with other wireless standards and how it can be marketed. It also includes the relationships between IEEE 802.15.4 and LR-WPAN standardization.

Chapter 2 gives a general information about wireless personal area Networks (WPAN) and their components and topologies. Also describes the physical layer, the medium access control layer of IEEE 802.15.4, the routing mechanisms and algorithms that will be used in the ZigBee protocol. ZigBee's security is described too in this chapter.

Finally, Chapter 3 describes the advantages of using ZigBee in remote control, automation and monitoring applications. The design of a ZigBee based remote light intensity measuring device and the details of the program used to collect remote measurement readings are also given in this chapter.

The conclusion chapter contains the conclusions, based on the findings and results obtained in the study.