OPTIMIZATION PARAMETER FOR MPEG-4 DATA OVER WIRELESS SENSOR NETWORK

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"I declare that this project report entitled "*Optimization Parameter for MPEG-4 Data over Wireless Sensor Network*" is the results of my own research except as cited as references. This project report has not been accepted for any degree and is not concurrently submitted in candidature of any degree."

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Name of candidate : NORLEZAH BINTI HASHIM
Date : 11 JANUARY 2014

To my beloved parents, husband and my adorable son

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ABSTRACT

Conventional Wireless Sensor Network (WSN) always deals with scalar data such as temperature, humidity, pressure and lights. These types of data are very suitable for low rate and low power networking technology such as IEEE802.15.4. Transmitting a video for IEEE 802.15.4 standard is an interest due to the capability of providing low complexity with low cost but still maintaining the good quality of video in term of Peak Signal to Noise Ratio (PSNR). However transferring video posed new challenges for bandwidth constrained sensor networks like WSN. Furthermore, processing power put a serious limitation on it for any sophisticated processing. Therefore a method needed for reliable video transfer and one way is to compress the video format. A simulation testing has been done to determine the optimal threshold for quantization scale, group of picture and frame per second in order to tailor with the environment of WSN 802.15.4. When these three parameters are changed, the video quality and bandwidth requirement will be affected. Therefore this project aims to create an embedded code in TelG mote according to this concept. Experiment testbeds are conducted for indoor and outdoor to investigate the network performance in term of packet delivery ratio and total packet loss. Results show the packet delivery ratio of optimized MPEG-4 data for Akiyo *cif* file is 36% better than the non-optimized MPEG-4 data, Foreman *cif* file is 12% and Mobile *cif* file is 8%. Thus this project have prooved that optimized parameter of MPEG-4 data has successfully increase the network performance of WSN.

ABSTRAK

Aplikasi Rangkaian Sensor tanpa Wayar *(WSN)* konvensional secara umumnya mengendalikan data yang bersifat skala seperti suhu, kelembapan, tekanan dan cahaya. Data seperti ini amat sesuai untuk teknologi perhubungan rangkaian yang mempunyai kadar data dan penggnaan kuasa yang rendah seperti piawaian IEEE 802.15.4. Penghantaran video untuk standard IEEE 802.15.4 menarik minat kerana kebolehannya menyediakan kerumitan yang rendah dengan kos yang rendah tetapi masih mengekalkan kualiti video yang baik dalam terma nisbah isyarat puncak kepada hingar. Walaubagaimanapun, penghantaran video memberi cabaran baru kepada rangkaian sensor berjalur lebar yang sempit seperti *WSN*. Tambahan pula, kuasa pemproses meletakkan had yang serius untuk pemprosesan yang canggih. Oleh itu satu cara diperlukan bagi pemindahan video yang boleh dipercayai dan satu cara adalah dengan memadatkan format video. Oleh itu ujian simulasi telah diadakan untuk menentukan ambang yang optimum bagi skala pengkuantuman, *group of picture dan frame per second* yang sesuai dengan persekitaran *WSN* 802.15.4. Apabila parameter ini berubah, kualiti video dan keperluan jalur lebar akan terjejas. Oleh tu matlamat projek ini adalah untuk membina kod terbenam di dalam TelG berpandukan konsep ini. Eksperimen telah dijalankan di dalam bangunan dan di luar bangunan bagi menyiasat prestasi rangkaian dalam bentuk nisbah penghantaran paket dan jumlah kehilangan paket. Keputusan menunjukkan nisbah penghantaran paket untuk format video MPEG-4 yang dioptimumkan adalah lebih baik berbanding format video MPEG-4 yang tidak dioptimumkan sebanyak 36% untuk fail Akiyo *cif*, 12% untuk fail Foreman *cif*, dan 8% untuk fail Mobile *cif*. Projek ini telah membuktikan bahawa format video MPEG-4 yang dioptimumkan telah Berjaya meningkatkan prestasi rangkaian dalam *WSN*.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

API	-	Application Programming Interface
BO	-	Beacon Order
CAP	-	Contention Access Period
CSMA-CA	-	Carrier Sense Multiple Access with collision avoidance
CDMA	-	Code Division Multiple Access
CIF	-	Common Intermediate Format
EEPROM	-	Erasable Programmable Read Only Memory
FDMA	-	Frequency Division Multiple Access
FPS	-	Frame per Second
GOP	-	Group of Picture
GTS	-	Guaranteed time slots
HL	-	Hardware Layer
HAL	-	Hardware Abstraction Layer
HPL	-	Hardware Presentation Layer
ISP	-	Internet Protocol
LLC	-	Logical Link Control
LQI	-	Link Quality Indication
MAC	-	Media Access Control
MPEG-4	-	Motion Picture Expert Group
MTU	-	Maximum Transmission Unit
NL	-	Network Layer
OSI	-	Open System Interconnections
PHY	-	Physical Layer of OSI model

PSNR	-	Peak Signal to Noise Ratio
QCIF	-	Quarter Common Intermediate Format
QS	-	Quantization Scale
QoS	-	Quality of Service
SO	-	Superframe Order
SSCS	-	Convergence sub layer
SHR	-	Self Healing Ring Network
TDMA	-	Time Division Multiple Access
UART	-	Universal Asynchronous Receiver/Transmitter
USART	-	Universal Synchronous Asynchronous Receiver/Transmitter
XBee	-	Zigbee
WSN	-	Wireless Sensor Network

LIST OF SYMBOLS

P_r	-	Received power
P_t	-	Transmitted power
G_t	-	Gain of transmitting antenna
G_r	-	Gain of receiving antenna
h_t	-	Height of transmitter
h_r	-	Height of receiver
d	-	Distance from transmitter
L	-	System loss

LIST OF APPENDIX

TABLE OF CONTENTS

CHAPTER 1

INTRODUCTION

This chapter gives the overall idea of this research. It discusses the background of research, the problem statements, research objectives and the scope of work.

1.1 Introduction

Nowadays, we can see wireless sensor network is used in many applications such as disaster prevention and relief and environmental monitoring. The importance of wireless sensor networks arises from their capability for detailed monitoring in remote and inaccessible locations where it is not feasible to install conventional wired infrastructure. More interest is given to the wireless sensor network (WSN) for IEEE 802.15.4 standard due to its advantages in providing low data rate transmission, low energy consumption, ease to deploy in the network and low cost with the small size of the sensor. However, the transmission of data especially video

for IEEE 802.15.4 standard is more challenging due to large amount of bandwidth is required. Furthermore, WSN IEEE 802.15.4 standard only allowed the maximum of 250 kbps data rate.

One way to overcome the issue of bandwidth is by compressing the video format, for example MPEG-4 video. The Researcher in [1] has developed the benchmark for the settings of video encoding which can provide better video quality suitable for WSN application. The researcher mentioned three parameters namely quantization scale, group of picture, and frame per second that are important in determining the quality of a received video. Therefore this project aims to conduct an experiment to investigate the network performance of optimized MPEG-4 video format proposed by [1] over WSN for IEEE 802.15.4 standard using TelG sensor node.

1.2 Problem Statement

Conventional WSN always deals with scalar data such as temperature, humidity, pressure and lights. These types of data are suitable for low rate and low power networking technology such as IEEE802.15.4. However, transferring video data posed new challenges for bandwidth constrained sensor networks like WSN. Furthermore, processing power puts a serious limitation on it for any sophisticated processing. Therefore a method is needed for reliable video data transfer.

Transmitting a video for IEEE 802.15.4 standard is an interest due to the capability of providing low complexity with low cost but still maintaining the good quality of video in term of Peak Signal to Noise Ratio (PSNR). The MPEG-4 video is already proven suitable to be transmitted over IEEE 802.15.4 standard. Therefore this project aims to conduct an experiment to investigate the network performance of MPEG-4 video data over WSN for IEEE 802.15.4 standard using TelG sensor node. However, due to limitation of power and memory in WSN; the encoding and decoding process is done outside TelG. This also can reduce the hardware complexity. Encoding and decoding process consumes a lot of power huge memory so the complexity will increase.

1.3 Research Objectives

The research objectives are stated as follows:

i. To develop an algorithm to transfer MPEG-4 data in WSN using TelG devices.

ii. To perform experiments based on the algorithm and analyze the network performance.

1.4 Scope of Work

This research is limited to several scopes. First, the development of optimized parameter for MPEG-4 is done using TinyOS operating system and network embedded systems C (nesC) programming language. Then the developed code is uploaded into TelG mote before the testbed is deployed. The testbed network used 2 sensor nodes and the XTerminal[1] software will be used to view the result obtained from testbed. Performance of test bed and simulation will be compared.

Second, the encoding and decoding process is done manually outside TelG. The reason for this is due to the limitation of TelG and WSN where the processor inside TelG puts a serious limitation for any sophisticated processing and WSN only allowed a maximum data rate of 250 Kbps. Decoding and encoding process needs a huge memory. Thus, in order to save the internal memory of TelG, the encoding and decoding process is done outside TelG devices.

[1] It is a window terminal emulator for displaying client applications.

1.5 Thesis Outline

There are five chapters included in this thesis. Chapter I is the Introduction which covers the project overview, problem statement, objectives and scope of work.

Chapter II presents the Literature Review on related theories and previous related work to this project. The theories part discusses on the overview of the WSN, the MPEG-4 format, the optimized MPEG-4 data, and TelG software and hardware architecture.

Chapter III is the Methodology which includes planning and implementation process of the project. Under planning, the state diagram and the flow chart are elaborated in detail. Implementation includes the discussion on the testing methodology used in this project.

Chapter IV consists of result and discussions. It covered the experimental results from the project. This chapter will also discuss the findings observed from the results.

Chapter V is the conclusion and future work. This chapter concludes the thesis and suggestions of future development.

CHAPTER II

LITERATURE REVIEW

This chapter can be categorized into three major parts. First part explained the overview of Wireless Sensor Network (WSN) and its functionality. Next, literature review on MPEG-4 data used in this research is introduced briefly. The software and hardware architecture of TelG is presented in detail. At the end of this chapter, few related researches were prepared for readers.

2.1 Overview of WSN

A wireless sensor network is defined as a wireless network consisting of spatially distributed autonomous device that use sensors to monitor physical or environmental conditions [7]. A combination of autonomous devices with routers and a gateway will form a typical WSN system. Figure 2.1 shows how WSN is

connected from sensor nodes to the end user. A base station is needed to control the operation from sensor node to the end user and vice versa. The total number of sensor node needed in any application is related to the size of the area. Huge area required more sensor node to route information from source to destination compared to a smaller area.

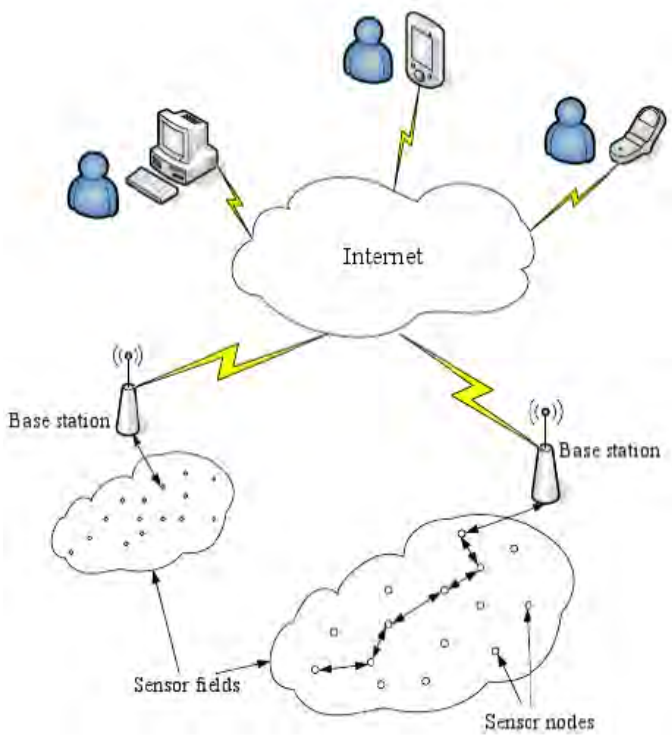

Figure 2.1: Accessing WSN through the internets

2.1.1 WSN architecture

Most commonly WSN architecture follows OSI model [2, 3]. Each layer in OSI is responsible for one part of the standard and offers services to the higher layers. The interfaces between the layers are used to define the logical links that are described in this standard. A WSN device comprises a physical layer (PHY), which contains the radio frequency (RF) transceiver along with its low-level control mechanism, and a medium access control (MAC) sub layer that provides access to the physical channel for all types of transfer [3]. Figure 2.2 shows the graphical representation of WSN architecture where the upper layer consists of a network layer

and application layer. An IEEE 802.2 type 1 logical link control (LLC) can access the MAC sub layer through the service specific convergence sub layer (SSCS).

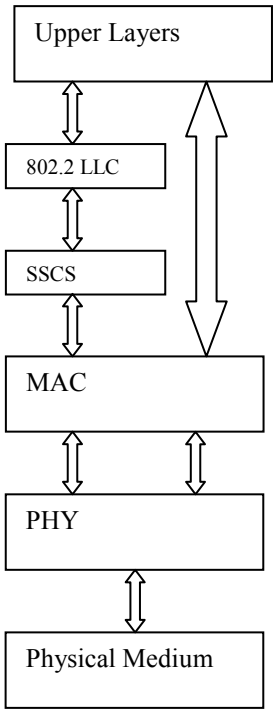

Figure 2.2: WSN architecture

2.1.2 WSN general description

A WSN is a simple, low-cost communication network that allows wireless connectivity in applications with limited power and relaxed throughput requirements. The main objectives of a WSN are ease of installation, reliable data transfer, short-range operation, extremely low cost, and a reasonable battery life, while maintaining a simple and flexible protocol.

Some of the characteristics of WSN are:

i. over-the-air data rates of 250 kb/s, 40 kb/s, and 20 kb/s
ii. star or peer-to-peer operation
iii. allocated 16 bit short or 64 bit extended addresses