UNIVERSITI PUTRA MALAYSIA

# SecPath: ENERGY EFFICIENT PATH RECONSTRUCTION IN WIRELESS SENSOR NETWORK USING ITERATIVE SMOOTHING

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# SecPath: ENERGY EFFICIENT PATH RECONSTRUCTION IN WIRELESS SENSOR NETWORK USING ITERATIVE SMOOTHING

**By:**

**WAMIDH JWDAT ABD**

**Thesis submitted to the School of Graduate Student, Universiti Putra Malaysia, in fulfillment of the requirement for the degree of Master of Computer Science**

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# DEDICATION

**This Thesis is dedicated to:**

The sake of Allah. My Creator and my Master.

.My great teacher and messenger, Sazlinah (May Allah bless and grant her).

Who taught us the purpose of life.

My beloved Parents,

My wife, Brothers and Sisters,

And all my friends,

For

Their Endless Patience and Support

Abstract of this thesis is presented to the Senate of Universiti Putra Malaysia, in fulfillment of the requirement for the degree of Master of Computer Science

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By

WAMIDH JWDAT ABD

**Chair: Puan Sazlinah Binti Hasan**

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Wireless sensor networks operate through commonly self-organized sensor nodes to transfer data in a multi-hop approach to a central sink. In order to support fine-grained diagnostic analysis and optimize the performance level of the networks, the reconstruction of per-packet routing path is essential. However, in large-scale networks, the performance levels of the current path reconstruction method decline rapidly, with loss of links. An efficient approach to fully comprehend the complex internal behavior of network is through the reconstruction of the routing path of each received packet at the sink side. One of the most significant study in the field has been conducted on iPath, although the energy efficiency was absent in the study. Thus, the current study proposes SecPath, an energy efficient inference method that enables the reconstruction of the per-packet routing paths of large-scale networks, by providing a stable and efficient route to exchange messages between source and destination in a timely manner. This work uses iterative smoothing algorithm to find an alternative path with less distance and energy consumption. To achieve energy efficiency, it compresses the packet information by using GZIP tools in JAVA. SecPath is evaluated with several variations using 400 nodes in WSN deployments

as well as large-scale simulations. The findings have demonstrated that SecPath surpassed other current approaches such as EEPMM. SecPath has accomplished low transmission overhead which it has reduced 13% of the energy consumption. Besides on the reimplementation also has gained significant reconstruction ratio compared with iPath.

Abstrsk tesis yang dikemukakan Senat Universiti Putra Malaysia sebagai memenuhi

Keperluan untuk Ijazah Komputer Sains

PEMBINAAN KECEKAPAN KUASA DALAM RANGKAIAN SENSOR TANPA WAYAR MENGGUNAKAN ITERATIVE SMOOTHING

Oleh

WAMIDH JWDAT ABD

**Pengerusi: Puan Sazlinah Binti Hasan**

**Fakulti: Computer Science and Information Technology**

Rangkaian sensor tanpa wayar kebiasaanya beroperasi menerusi nod sensor yang diatur sendiri untuk memindahkan data melalui kaedah multi-hop ke sink tengah. Untuk menyokong analisis diagnostik halus dan mengoptimumkan tahap prestasi rangkaian, pembinaan semula laluan setiap paket adalah penting. Bagaimanapun, dalam rangkaian berskala besar, tahap prestasi kaedah laluan pembinaan semula didapati semakin menurun, berserta kehilangan pautan. Pendekatan yang cekap untuk memahami sepenuhnya tingkah-laku dalaman kompleks rangkaian adalah melalui pembinaan semula laluan setiap paket yang diterima di sisi sink. Salah satu kajian yang paling penting dalam bidang ini telah dijalankan ke atas iPath. Walau bagaimanapun, kecekapan tenaga tidak diambil kira di dalam kajian tersebut. Oleh itu, kajian semasa mencadangkan pengaplikasian SecPath, iaitu kaedah inferensi cekap tenaga yang membolehkan pembinaan semula jalur laluan setiap paket bagi rangkaian berskala besar, dengan menyediakan laluan yang stabil dan cekap untuk proses penerimaan dan penghantaran mesej antara sumber, dan destinasi tepat pada masanya. Kajian ini menggunakan algoritma iterative smoothing untuk mencari jalan alternatif dengan jarak dan penggunaan tenaga minima. Untuk mencapai kecekapan tenaga, ia memampatkan maklumat paket dengan menggunakan alat GZIP di JAVA. SecPath dinilai dengan beberapa variasi menggunakan 400 nod dalam penyebaran WSN, serta simulasi berskala besar. Hasil kajian telah menunjukkan bahawa SecPath telah

mendahului kaedah-kaedah semasa yang lain seperti EEPMM. SecPath berjaya mencapai overhead penghantaran rendah yang mana ia telah mengurangkan 13% daripada penggunaan tenaga. Selain itu, pelaksanaan semula juga telah memberikan nisbah rekonstruksi yang signifikan berbanding dengan iPath.

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# APPROVAL

This thesis was submitted to the Faculty of Computer Science and Information Technology of Universiti Putra Malaysia and has been accepted as partial fulfillment of the requirement for the degree of Master of Computer Science.

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# DECLARATION

I declare that the thesis is my original work, except for the quotation and citations, which have been duly, acknowledge. I also declare that it has not been previously, and is not concurrently, submitted for any other degree at Universiti Putra Malaysia or any other institution.

______________________________

WAMIDH JWDAT ABD

Date: ---------------------------------

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# LIST OF ABBREVIATION

| | |
|---|---|
| WSN | Wireless Sensor Networks |
| SN | Sink Node |
| MNT | Multi hop Network Topology |
| PathZip | Packet path tracing in wireless sensor networks |
| iPath | Inference Path |
| DEGRA | A Density-based Energy-efficient Game-theoretic Routing Algorithm |
| EEPMM | An Energy Entropy-Based Minimum Power Cost Multipath Routing in MANET |
| EC | Energy Consumption |
| Et | The energy spent by a sensor node in transmit. |
| Er | The Energy spent by a sensor node in Receiving |
| $\lambda$ | Ratio of Stable Period without packet loss |
| NW | North west |
| NE | North east |
| SE | South east |
| SW | South west |

# CHAPTER 1

# INTRODUCTION

## 1.1 OVERVIEW

Currently, there are numerous uses in wireless sensor networks (WSN) that need knowledge of the relative or real locations of the sensor nodes, running from observing (such as buildings health, precision agriculture, pollution prevention, and structures), to occasional identification (such as fire/ flood emergencies, and intrusions), and targets following, for instance the surveillance (Di Francesco et al., 2011) . A WSN refers to a group of sensor nodes possessing limited supply of power as well as limited computational abilities. Furthermore, limited communication range and a large density of sensor nodes lead to packet forwarding in sensor networks, typically via multi-hop data transmission. Consequently, WSN routing has recently received much attention from the research community within the 21st Century (Radi et al., 2012).

Routing within WSN determines the path, starting from the source of data transmission and finishing with the sink. In the case of multi-hop networks, source nodes do not typically connect sink nodes immediately. Instead, intermediate sensor networks (SNs) transmit the data via packets. Routing paths are able to provide a solution to the problem, thus leading to reconstruction of routing paths as an important field of study, with regards to routing algorithms. Many sensors are required to transmit messages effectively from the source to the sink. In order to achieve effective transmission and maximize network lifetime, message delivery assurance for the routing protocol is crucial. This denotes that the protocol should search for routing paths even if the particular route in question is not present ( Nida Afreen et al.,2016).

With regards to network performance, routing paths for packets serve as important guide for comprehension. The metrology of routing dynamics requires per-packet routing paths to check and determine the frequency of path alterations occurring. Furthermore, the metrology of packet losses requires path information to extrapolate the location of packet loss.  To add to this, network diagnostic tools require information for the routing path in order to determine the main cause of network disturbances. Information on the path of packets enable enhancement of detection and flow control.

While reconstructing routing paths for the received packet constitutes an efficient method for comprehending the complex internal network behavior, the routing path of each packet requires diagnostic tools, which are capable of executing effective management and protocol optimizations for WSNs in deployment. These WSNs are also characterized by a high number of unsupervised sensor nodes.

Two currently available methods for path reconstruction in WSN's include multi-hop network tomography (Keller et al., 2012) and PathZip (Lu et al., 2012). For the first method (MNT), for each individual packet, a reliable packet set is computed to attempt reconstructing the path. Consequently, no packet loss or packet reordering occurs. Furthermore, the set entails that the routing path to be carefully reconstructed with regards to the computer utilized. The second method (PathZip) attempts to reconstruct the packet path by assigning compressed path information, as a hash value, to the individual packet. An effective math is sought for the path by employing a comprehensive search across neighboring nodes by the sink. In summary, the two methods provide an effective means of reconstructing paths in events of low loss rates and non-severe routing dynamics.

A direct method, which solves the problem, entails sticking the whole routing path to each individual packet. An issue arises with this method, however, in that the message overhead may be too huge for packets with longer routing paths. Because WSNs tend to be deployed with limited resources, the method is impractical in many cases.

In light of the aforementioned information, the present study proposes SecPath, which is an energy efficient inference method that enables the reconstruction of the per-packet routing paths of large-scale networks. This approach constantly searches for longer paths rather than shorter ones.  An iterative smoothing algorithm is also employed to find the longest unknown path based on the known shortest path.

## 1.2 PROBLEM DEFINITION

In the WSN, all sensors nodes produce and transfer bundles to the sink along with some routing ways. In the sink, a recreation technique way is needed to recover the routing way every packets travel. One bundle way is an ID sequence of the input of the packets to the sinks, involving IDs of every middle of the road nodes handing-off this packets, and its hop numbers also.

There are many numerous endeavors made to addressing the path recreation issue. Two techniques have been used, MNT (Keller et al., 2012) and Pathfinder (Yi Gao et al., 2013), successfully used MNT recreates per-parcel way via exploiting between bundle connection, such as a handed-off bundle, and its nearby parcels privately produced at any node I are typically sent to the same next hop. These local packets fill in as stays of the transferred packets in hub I. In the primary hop, recipient is recorded in packet; the way of packets could be retrieved via connecting the principal hop collectors of every one of its anchors. Enhancing MNT, Pathfinder endures certain inconsistency in between packets connection, through unequivocally recording inconsistency in the packet. The reconstruction disappointment happens once the inconsistency surpasses the resilience limit. To precisely find stays, Pathfinder additionally forces the parcel age rate of every hub to be indistinguishable and settled. Both MNT and Pathfinder require stable networks topology, with the end goal that between packets connection can be caught.

## 1.3 OBJECTIVE

There are several approaches have been discussed in the literate review over years regarding the reconstruction path for large- scale network in WSN's. Many researches have emerged to solve this issue of reconstruction of the track, the most important of which is Pathfinder and MNT But failed in large-scale networks. Recently, the top approach in reconstruction path is iPath (path inference in wireless sensor network). The primary goals of this study are:

1. To reimplement iPath inference by adapting the iterative smoothing from large-scale WSN and achieve greater reconstruction proportion under diversified system settings against the conditions of the workmanship.

2. To reduce energy consumption by compressing the data for the transmission between nodes and sink node.

## 1.4 PROJECT SCOPE

As mentioned in the thesis chapter, this project is reimplementation of iPath. However, iPath scope is quite huge for a 1-year project. iPath consists of three main modules, network scale, routing dynamic and network density. It is decided that the scope of this study is focusing on network scale because this metrics is the most important in Reconstruction ratio. iPath will be simulated using iterative smoothing in large-scale WSN through numerous system settings against the conditions of the workmanship.

## 1.5 MOTIVATION

In wireless sensor networks, existing path reconstruction algorithm consumes more energy, take high message overhead, and takes more time for packet transmission. We enhanced the iPath to consume energy; these problems are what motivate to generate SecPath.

## 1.6 ORGANIZATION OF THESIS

The first chapter gives the overviews of the path reconstruction problems in wireless sensor networks, motivation, problem definition, project scope and objectives. The second chapter introduces the literature survey of Path Reconstruction in wireless sensor network. It also discusses various algorithms for path generation and reconstruction. Besides that, chapter three provides methodology of proposed SecPath Algorithm, with evaluation metrics and implementation details. Next, chapter four presents results and discussions. The final chapter, which is chapter five, includes conclusion and suggestions for future enhancement.

## 1.7 SUMMARY

This chapter has explained the overview of path reconstruction and its problems statement in wireless sensor networks, motivation, problem definition, project scope and objectives. Followed by it presents thesis organization and its summary.

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