Building an Overlay for Wireless Mesh Network

Santika W.P.¹, M.Ghifary², Adi Indrayanto³, Iping Supriana⁴

¹Sekolah Teknik Elektro dan Informatika, Institut Teknologi Bandung
Jalan Ganesa 10 bandung, Indonesia 40132

#santika@informatika.org, #mghifary@gmail.com,
#adi@sysapp.itb.ac.id, #iping@informatika.org

Abstract— The research and development of the wireless mesh networks (WMNs) now still popular. P2P was an old technique, but it is coming back for building an virtual overlay network on top of physical network. Open Chord as varian of Chord is a tool based on distributed hash table that can be used to build overlay. In swarm intelligence presented the particle swarm optimization (PSO) algorithm. One application of the algorithm named SensorPSO for square area sensor network. We had modified this application for free rectangle area network. In this paper we report a study how to build an overlay network based on Open Chord. The objective of our study is to use overlay network to efficiently find the resources currently available in the WMNs. Our application firstly read the output of SensorPSO for square area sensor network. We had modified this application to build an overlay network, then built a virtual overlay on top of the underlay. The virtual overlay network resulted can be used for routing simulation.

Keywords— WMNs, overlay, Open Chord, SensorPSO, routing.

I. INTRODUCTION

The wireless technology grew fastly throughout the world after the first wireless local area network (WLAN) developed in 1970 at University of Hawaii. In 1985 wireless fidelity (Wi-Fi) technology presented to the public in the USA, for which many universities, companies and volunteer groups could deploy any wireless networks such as mobile ad-hoc networks (MANETs) and WMNs [1]. MIT Roofnet is the first WMN for academic community which can access the Internet [2]. Look at the success of MIT Roofnet, Humboldt University at Berlin built the similar system named Berlin Roof Net (BRN) [3]. Until now WMNs still popular research area for the use of low cost off-the-self devices. The wireless mesh architecture provides very easy configuration, high reliability, and a cheap solution to extend network coverage. The WMNs are different from other wireless networks, it is composed of stationary access points and mobile clients.

At the software technology, Chord is one of the distributed hash table (DHT) algorithm based on key-value pair which can make a virtual network ring topology [4]. Key and value will represent the identity of each node of the network. Each node in the Chord networks has predecessor and successor nodes as neighbour, adding or deleting a node will change neighbouring states. Open Chord is an open source software as the implementation of application programming interface (API) for Chord which treats keys as points on a circle. The circular keyspace is split into contiguous segments whose end points are the node identifiers. Open Chord developed in Java by Distributed and Mobile System Group team at Otto-Friedrich-Universitat Bamberg, Germany. This software distributed via GNU-GPL which can be freely downloaded [5]. Overlay network is a virtual network above one physical / underlay network. It is an old technique for P2P and begins as the Internet born as an overlay of the telephone network in connecting to LAN. Telecommunication transport networks and IP networks are all overlaid with at least an optical layer, a transport layer and an IP or circuit layers [6]. Our question is how to use this technique for routing efficiently in the WMNs.

In the other side of computing technology, at the end of 1990 Beni and Wang declared the swarm intelligence (SI) in the context of cellular robotic system. This research then developed in the context of ants as ant colony optimization (ACO) algorithm by Dorigo and in the context of birds as particle swarm optimization (PSO) algorithm by Kennedy and Eberhart [7]. Borgelt has developed the PSOpt application which updated by Stabeler as an optimum coverage for 500x500 sensor area named SensorPSO [8]. We had modified the SensorPSO for a free rectangle area with a 2D text output named Report.

In this paper we consider the challenge that can be used to solve efficiently finding the resources currently available in the WMN with P2P application. Firstly we run an application of PSO algorithm which we had modified, the SensorPSO, to produce a virtual coordinate text file. Secondly we developed an application based on Open Chord which reads that text file to build an underlay network and an overlay network too. The objective of this research is to build a virtual overlay network that can be used for routing simulation in the WMN.

II. RELATED WORKS

Reliable overlay networks (RON) architecture designed by Andersen et al was a distributed system where many nodes deployed at various locations on the Internet form an application layer overlay to cooperatively route packets for each other. The clients interacts with RON uses an API to send and receive packets. The entry node receives and classifies a packet to determine the type of path will use before it forwarding by next subsequent nodes based on the destination address. The exit node delivers the packet to RON application [9].
Touch designed an application named X-Bone architecture that creates IP tunnel-based Internet overlays that supports concurrence, recursion and revisitation. This system allows different applications on the same end host or router to be associated with different overlay networks through its application deployment mechanism [10].

Amir et al designed SMesh architecture, a transparent wireless mesh network that offers seamless fast handoff supporting realtime application traffic. The logic procedure do solely by the access points, and therefore connectivity is attainable by any 802.11 mobile device, regardless of its vendor or architecture, uses only standard network protocols. The entire mesh network is seen by the mobile clients as a single, omnipresent access point, giving the mobile clients the illusion that they are stationary [11].

Ding et al proposed OverMesh Networks, a generic overlay architecture as a parallel edge/access internetworking strategy positioned for novel use scenarios. The overlays are built over an IEEE 802.11s wireless mesh network pre-standard prototype. The platform enables development and deployment of concurrent distributed experiments. Based on this platform, they introduce a cross-layer searching algorithm, which combines traditional overlay searching with ad hoc network routing so that a physically short searching route is facilitated [12].

III. OVERLAY NETWORK DESIGN

We design a desktop application based on Open Chord for building an virtual overlay network. Three steps that must be done are building of virtual underlay network, virtual overlay network and routing table. Figure 1 show an interface we had developed for it.

A. Classes Design Strategy

Open Chord has six principal functions/procedures of application programming interface, that are:

1) CREATE
   Is the procedure for building new Chord network.

2) JOIN
   Is the procedure for adding one new peer in the available Chord network.

3) LEAVE
   Is the procedure for deleting / crashing one peer in the available Chord network.

4) INSERT
   Is the procedure for storing key and value in the available Chord network.

5) RETRIEVE
   Is the procedure to look for and retrieve a value in the network based on input key.

6) CRASH
   Is the procedure for simulating a crash atu atau failed against one peer in the available Chord network.

Java is the language for object-oriented programming, for the easy in developing and maintaining the network, we modeled the classes based on Model-Control-View paradigm. There are three classes, such as:

1) Model Class which contains four modules: NodeModel, VNodeModel extends NodeModel, ArrowModel, and many classes of Open Chord API.

2) Control Class which contains two modules: NetworkReader and NetworkUtil.

3) View Class which contains two modules: NetworkCanvas and OverlayNetView.

B. Virtual Underlay Network Building

The first step is activing the SensorPSO application which can produce a PNG figure and 2D text output named Report. Figure 2 show an example of a PNG figure for 16 sensors/hot spots in 400x500 pixels, in our application we assumed in m².

### Fig. 1 User Interface

![User Interface](image1.jpg)

### Fig. 2 Example of 16 Sensors which Covers 400x500 m² area.

![Example of 16 Sensors](image2.jpg)

When the application activated it will read Report.txt to take the nodes coordinate data. File is reading by an object that instantiated in NetworkReader module as a parser. The object will search the data if it identify the Best Position phrase. After that action NodeModel module will arrange the position of the nodes with unique decimal number series identity in a square icon begins from zero which be shown on the Java 2D canvas.
Click View icon at up left of Figure 1 and tick the facility to show Figure 3, an underlay network that catch from Report.txt.

The circle viewed in Figure 3 is coverage area of each node, the red line represent node-to-node physical network link that formed if the coverage area of one node cut off other node. In our simulation only coverage area we look at, other parameters such as the distance and the transmission quality were ignored. All nodes assumed have same coverage area.

C. Virtual Overlay Network Building

After the virtual underlay network built, we can build the virtual overlay network. At this step Open Chord will help to build the finger table and successor-predecessor list for each node. The arrangement of successor-predecessor nodes will make a ring-like green links. The contents of the list will periodically updating for correctness and stability of virtual network if suddenly adding or deleting / crash one or several of the nodes. It is important if the data of the nodes always be validated any time.

Click icon View at up left of Figure 1 and tick a selection facility to show Figure 4, an overlay network for underlay/physical network that shown in Figure 3. Figure 4 shown the link between each node in overlay network with the same series number of underlay network.

Figure 5 show an example of finger table and successor-predecessor of node 3, if we click node 3 in the canvas. The content of the table will change if the virtual network change.

The result of Open Chord represent two DHT characteristics, at each node only store the neighbours information and the finger table don’t have enough information to know other successors and predecessors.

Each node will contribute to fix the route at the time there are an insertion and retrieval of the value to the network. Figure 6 show the insertion example of key = t for value = test, the result shown at Figure 7.

D. Virtual Routing Table

Virtual Routing Table module won’t work if virtual underlay and overlay networks didn’t definitively exist. This table will lookup the value in the network if the user give a key input. Just click Update Routing Table icon to build new virtual routing table. Table 1 is an example of virtual routing table for node 3 on those underlay and virtual network.

Table 1: Virtual Routing Example for Node 3.

If we look at three first lines in the table there are links to the next virtual neighbours for overlay and underlay of node 3. The data in the table may be change if user click Update
Routing Table button. If we look at Table 1, the first row and the second row are links to successor while the third row link to predecessor and the fourth row link to nearest underlay neighbour. In this case node 3 is the source node.

The general algorithm how to update the virtual routing table for each node is:

```plaintext
// Define:
// - VSet_Successors_Path = List of {endPointA, sucNode, null, nextHopB}
// - VSet_Predecessor_Path = List of {endPointA, predNode, null, nextHopB}
// - PSet_Path = List of {endPointA, pNeighborNode, null, pNeighborNode}
// - sucNode, predNode, pNeighborNode are the endPointB
// - nextHopB is the next/neighbor node of endPointA which is the member of shortest path towards endPointB

empty(node.routingTableEntry)
FOREACH node in the network
    Set VSet_Successors_Path to node.routingTableEntry
    Set VSet_Predecessor_Path to node.routingTableEntry
    Set PSet_Path to node.routingTableEntry
END FOREACH

If there is not enough information in application to go to next neighbour of a node, we design a recursive algorithm as:

```
FUNCTION findMinNextHop(src:Node, dest:Node) -> Node
    FOREACH neighbor IN src
        IF neighbor is the 'dest'
            Number of path of neighbor = 1
        ELSE
            Number of path of neighbor = 1 + countNumPath(neighbor[i], src, dest)
        END IF
    END FOREACH

RETURN neighbor IN 'src' which has the minimum value of number of path among other neighbors
END FUNCTION

FUNCTION countNumPath(current:Node, src:Node, dest:Node) -> Integer
    FOREACH neighbor IN current
        IF neighbor is the ever-passed node
            // assign 'number of path' with the arbitrary-biginteger if neighbor has ever been passed on previous recurrence
            Number of path of neighbor = 100000000
        ELSE
            IF neighbor is the 'dest'
                Number of path of neighbor = 1
            ELSE
                // recursively count number of path of current neighbour to 'dest' if neighbor hasn’t passed or doesn’t equal with 'dest'
                Number of path of neighbor = 1 + countNumPath(neighbor[i], src, dest)
            END IF
        END IF
    END FOREACH

RETURN minimum number of path of current’s neighbors
```

END FUNCTION

Neighbour nodes identifying of a node in the pathway from source node to destination node will complex if we designed conventional iteration algorithm. It is because of the specific characteristics of distributed hash table that a node has not complete information about it successor-predecessor node.

IV. CONCLUSIONS

In this paper we have presented an application based on Open Chord software for building virtual overlay network from virtual underlay network.

When modified SensorPSO application activated it will produce 2D coordinate file report which would be read by our application that should build a virtual underlay and then a virtual overlay network. Our application that can be used for any rectangle area of WMN is an advantage.

Virtual overlay network built can be used for virtual WMN routing simulation.

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The heading of the Acknowledgment section and the References section must not be numbered.

REFERENCES

Dear Santika W.P.,

It is our pleasure to inform you that your paper no. 611 titled “Building an Overlay for Wireless Mesh Network” is accepted to ICEEI2011 conference. The acceptance may be subject to re-review and attached reviewer comments must be addressed in your full paper. Please prepare your final paper to follow the Final Paper Submission instruction in the ICEEI2011 website (http://stei.itb.ac.id/iceei2011/).

Full paper with more than 6 pages will have an extra charge of US$30/page for maximum 8 pages. You have to submit your paper both in
(1) PDF format to icesi2011@gmail.com, by May 30, 2011 and
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Best regards, ICEEI2011 Secretariat

----------------------- REVIEW 1 -------------------

PAPER: 611
TITLE: Building an Overlay for Wireless Mesh Network
AUTHORS: Santika W.P., M.Ghifary, Adi Indrayanto, Iping Supriana and Carmadi Machbub

This paper develops an application that modified the SensorPSO for a free rectangle area, with SensorPSO was for square area sensor network development.

The authors spend most of the efforts on the design of the presented overlay network.

But the motivation of the paper is not clear, i.e., what is the significance of this change?
What’s so special about the presented application?
Basically, what’s the problem that authors try to address?
The contribution of the paper is not clear.

Typo:
Abstract: has table --> hash table

----------------------- REVIEW 2 -------------------

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This may be accepted only if the research objective are clearly defined and its proposed solution is highlighted with expected its advantages and disadvantages.