BACK-END FOR MONITORING MESH NETWORK

By

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B.a.t.m.a.n-Adv

Mesh Potatoes

Network Infrastructure

Backend Application

Software Architecture

Wi-Fi

Wlan

ABSTRACT

Wireless mesh network are complex to monitor and organization or an institution are finding some way to solve the complexity problems. Managing and monitoring remote or local internet connection on university campus and rural area (e.g. Eastern Cape, South Africa) involves high cost of maintenance and the cost of installing physical equipment. Although, some organization believes that wireless technologies are less cost-effective and scalable. Wireless technologies such as access to WIFI network or wireless local area network (WLAN), and remote wireless internet connection on organization network (e.g. UWC free4ALL wireless connection) is becoming easier and accessible by any smart devices (technologies changes). In addition, wireless mesh network require less network infrastructure, as compared to wired network connections. It saves an organization (UWC) the cost of buying expensive network equipment or an infrastructure and, they are scalable, efficient and scalable. Yet, wireless mesh network are complex to monitor. Therefore, this project proposed to create a back-end application that will obtain and store the values of the network parameters, sending the obtained values to a centralized server when low traffic is the least expected on the network, and to minimizing the storage capacity of the mesh devices (Mesh Potatoes) when outputting accounting information from the network (Mesh Potatoes) for the network manager to make decision. This project will further demonstrate the frequency for checking the values and/or mechanisms to compress the data before sending the collected data to the centralize database server. Finally, this project will demonstrate a practical complete system that offers solutions to the complexity, and provide solutions to some key areas of the network problems while carry out network activities and maintenance.

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CHAPTER 1

PROJECT PROLOGUE

A mesh network is a wireless local area network (WLAN) where each node is connected to others nodes. Wireless mesh network are configured to allow wireless connections to be routed around fragmented paths with each signal hopping from node (Source) to other node until it reaches their destination. Wireless mesh networks is self-healing and self-configuring. Yet, they are difficult to manage. Network activity (such as performance) is difficult to manage, and because wireless mesh network operate between layers 1 and layer 3, protocols and services are becoming more complex. Wireless mesh network are packet-switched network with a static backbone [3]. More so, wireless mesh network (i.e. Wireless-Fidelity (Wi-Fi)) nodes comprise of Access point (AP), and clients access (CA). Each nodes support wireless connection that are low cost-effective and a convenient way to setup a mesh mode for campuses (e.g. UWC campus), and in rural area (e.g. Mankosi in Eastern Cape, South Africa) that don't have internet connections. In addition, the each node will operate not merely as a host but also as routing devices (Mesh Potatoes) that will serves as either gateway or remote gateway to assist in Wi-Fi connection. Using this device (Mesh-Potatoes) as a router (Gateway) on the network will provide a secure data transmission and will help to forward packets to other nodes that may not be within uninterrupted wireless transmission range of their destinations [3]. Furthermore, managing a data communications network requires constant network monitoring. The goal of this project will be to create a backend application that will enable the management of data, the configuration of a remote gateway on mesh network, and the rate used with each neighbour on active links (Quality of link). This project will enable wireless network to be integrated with wireless fidelity (Wi-Fi) and other wireless technologies such as WLAN etc. [3, 4].

BACKGROUND

Like other organization (the University of the Western Cape) has seen the usage of wireless technology blowup over the past few years. It was not long that some universities discover the use of wireless technology. Wireless mesh network required proper network database management system for its data transfer or communication. The need for frontend and backend monitoring application system for wireless mesh network is to save the network manager from manually storing and analyzing network accounting information data. Since monitoring mesh network is complex, the project proposes to develop a system that will help the network manager to monitor the network activity (both frontend and backend) system automatically. In other words, the system will help the network manager to minimize the storage capacity of the network device (Mesh Potatoes) when outputting data information for decision making process as well as frequently checking the values or mechanisms to compress the data explored before sending it to the centralized database server, and also to determine the flexibility of packet exchange between each nodes on the network.

Furthermore, because of the growing number of data on mesh devices, this project will develop an application system, particularly backend application for monitoring mesh network activity. More so, this project proposes to use an agile methodology approach. The reason for this approach is to manage changes and reduces risk management at any time anywhere. Therefore, this project finally proposes to help the network manager to solve and evaluate the network metrics, and determine the quality of the links on the network.

Planning a Mesh Network

For effective communication and information sharing organizations (UWC) are increasingly relying on computer networks and communication tools, such as telephones. This project will set up a mesh mode network that will enable a user (mesh manager computer network) to access remote databases and applications of the same organization or other private or public networks. However, implementing this set up is a complex task. This project will need to consider the goals of the organization while making a decision on which accounting information are needed. This project will also consider the network infrastructure which consists of the physical and logical components that are required to meet the networking needs of an organization. The physical components of the mesh network infrastructure are computers, server, routers (Mesh Potatoes), switches and network

cables. The logical components are the software that will be used to enable the flow of data transfer or communication across the mesh network.

Monitoring of Mesh Network

This project proposes some network parameters, that is, how to use and setup a mesh network with b.a.t.m.a.n-advanced. The idea is to collect and store these network values and use it to monitor the mesh network activity. For instance, batctl holds the commands ping, traceroute, tcpdump that provides a suitable way to configure the batman-adv kernel module as well as showing debug information (such as originator tables, translation tables and the debug log) [4]. This project will further configure interfaces, check the quality of links and performance, nodes connectivity, and rate info. However, this project will limit its discussion on some certain batman-adv commands as the topic is beyond the scope of this project.

CHAPTER 2

REQUIREMENTS DOCUMENT

Overview

This chapter discusses and presents the user requirement for the proposed system. It explains what the user view of the problem is, and briefly describe the problem domain. The chapter further explains what is expected, and what is not expected from the software.

User's (Network Manager) View of the Problem

Monitoring mesh network activities can sometime be complex. This ranges from obtaining and storing network values, different instances of the value, quality of links, and performance. Some network parameters are kept and causes huge amount of data on the mesh network. Currently, the network manager is using a bash scripts on the mesh router by executing it to collect data information on the network and stored them in a text file. The data collected are huge however, the network manager only require less of the data for configuration of remote network. The typical data required by the network manager would be the values outputting from Mesh Potatoes when debugging using the following batman-adv commands: athstats and ifconfig to do some aggregation, and batctl o, wlanconfig, ath0 list, and rate info parameters for doing the dynamic routing that depict link quality and performance. The network manager will want to inject traffic, copy the data and view the information to have a continual awareness and to avoid traffic jam or congestion. In addition, the network manager will want a centralize database server to manage the network values that are collected in order to feed the frontend of the application. The relevant data that are being stored in the backend application will be presented to the frontend application to allow the network manager to monitor the network activity within the internal nodes of the network.

Brief Description of the Problem Domain

A user such as network manager needs a network monitoring system to help manage and monitor mesh network activity. The network manager will execute different network protocol commands to collect data and store them into a centralize database. The used of a configuration files will help the network manager to populate the centralize database server with the most relevant data and to keep track of different parameters used during network debugging. The network manager is finding a way to minimize the time expending on collecting data and to increase the effectiveness of the data transfer between a node and the centralized database servers.

What Is Expected From The Software Solution?

The software solution is expected to establish a remote access network connection between the local organization (e.g. UWC) and the remote site (e.g. rural area) where network activity are taken place. The network values for

connection is expected to utilize low resource storage space of mesh potatoes devices, be secure and reliable, and increase the effectiveness of the data transfer between the batman-adv and the centralize database servers. More so, the network manager is expected the software to manage and monitor mesh network activity in an effective way. The software should investigate the batman-adv routing protocol that will offers an essential diverse approach to route network traffics of each nodes to any destination in the network. Likewise, the software is expected to help the network manager to save time expending on data collection. That is, the more time the network manages requested output from the mesh network activity the better the quality of the information he will get or have to make decision. Therefore, the software is expected to reduce the device storage space (of the mesh potatoes) to a minimum level when populating the centralize database server with the most relevant data information.

What Is Not Expected From This Software?

The software is not expected to override existing system functionality. It is important that this is taking into consideration when planning and designing the software solution. The use of the software should not disrupt the network activity, and connection between each node on the network when sending or receiving packets from source and destination. More so, the software is not expected to consume device space and network resources.

System Users (Network Manager)

The network managers or system administrators are the people who will be using the system to perform administrative tasks. They will be able to efficiently administrate the network with a minimum of personnel and stress. Likewise, they will gain a broad, cost-effective view of what is required to setup an efficient software application for monitoring network activity. In addition, the software developers are fundamental in this project as they are the primary programmer of this particular software. Thus, with this software for monitoring mesh network activity, it will targeted the time the network manger expends collecting and aggregating data by reduces it to a minimal level and also reduces the manually mistakes when computing the most important data for decision-making process.

CHAPTER 3

REQUIREMENTS ANALYSIS DOCUMENT (RAD)

Overview

This chapter discusses the requirements analysis of the system using the Village Telco device (the Mesh Potato routers) as a key factor for requirement analysis. The chapter further discusses the hardware, software and high level requirements needed to implement the user requirements of the problem domain.

DESIGNER'S INTERPRETATION OF THE USER'S REQUIREMENTS

The following diagram will depict the network design requirement (network infrastructure diagram) for the proposed backend application system. Since a user (Network manager) wants systems that will help him carry out daily network monitoring.

Figure 3.1

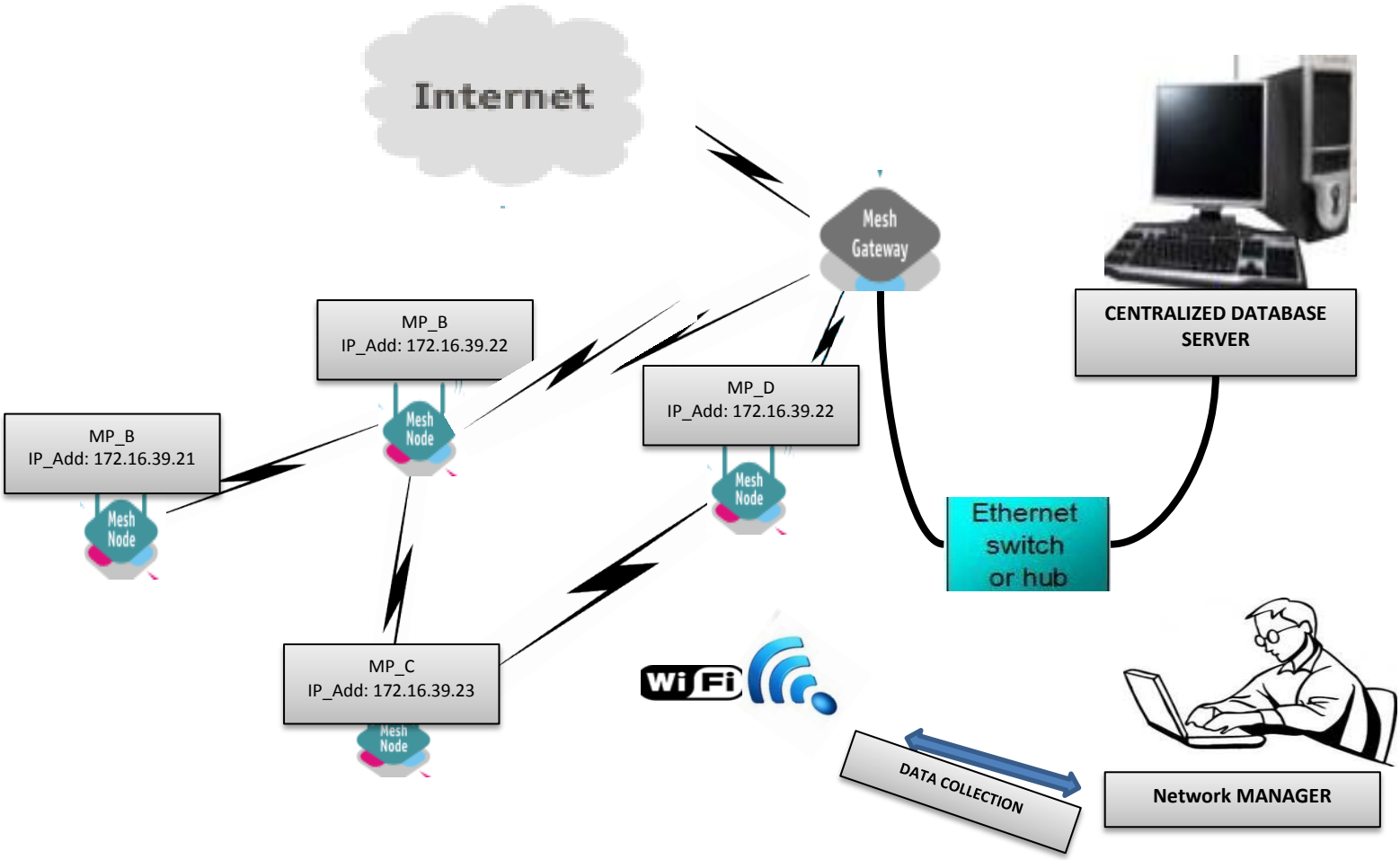

Diagram showing an illustration of designer's interpretation of problem domain.

The above figure shows a backend network infrastructure diagram, to the right of the design requirement; the network manager was trying to configure a router on the wireless mesh network using the Linux as the based operating system. And on the left of the diagram, a wireless mesh network was setup to allow wireless local area network (WLAN) or Wi-Fi connectivity so that the network manager that want to configure, monitor or query all nodes on the network for their connectivity information can configure the router (Mesh Potatoes) locally or remotely using the remote access gateway. Each node MAC address will be marked with their hostname to enable easy node identification and for easy lookup of the IP address (e.g. 172.16.*.*). More so, the network manager will want to examine and monitor the quality of the link, node connection and signal strength. This setup can be seems to be a complex network setup however, this project propose a solution to solve the network complexity. The network set up will be break down and will be analyze. After breaking down the problem, the information (Network values) from the network will be computed into database management system to assist the frontend application system. This suggested solution will best suit the operation and running process of the wireless mesh network. That is, organization will be able to increase the number of routers as per the requirements and increased the network traffic. Each node will learn routes using a very stigmeric approach [1]. This project primary concerned is to help develop a backend application system for monitoring mesh network activity and to help gather the necessary accounting information to make available to the other project components (frontend application).

SYSTEM ARCHITECTURE

The system architecture for this project (backend application for monitoring mesh network activity) will comprised of two main components namely; the hardware configuration and the software configuration package. These two components will be outlined and then broken down into more defined sub-components at a later stage of the software development life cycle. This project will employ the concept of data mining using Extract, Transform, and Load (ETL) for its database management system. Each sub-component will be responsible for the remote or local configuration for mesh network. The hardware component will further discusses the hardware of the mesh devices (Mesh Potatoes) and the software necessary for the data collection for storing into the centralize database server. Likewise, the software component will be used to gather require necessary network accounting information that the network manager wants to see on the frontend application. This project projected to help and make available information needed to supply the front end monitoring system for easy access, nodes visualization, and monitoring. However, to gather the required network information, it is important to ensure that the mesh devices (Mesh Potatoes), computers system, and switches are part of the network and have the right configuration setup properly. Therefore, nodes on the network will communicate with each other network. More so, a java program script will be used in this project to help queries the entire mesh node on the network for

relevant data information. Such information will include network of the next neighbors, link quality on the mesh network and connection strength to neighbors, network traffic, and rate info for maximum and minimum throughput of the nodes on the network. The following figure show sample of a system architecture to be implemented for this project:

Figure 3.2

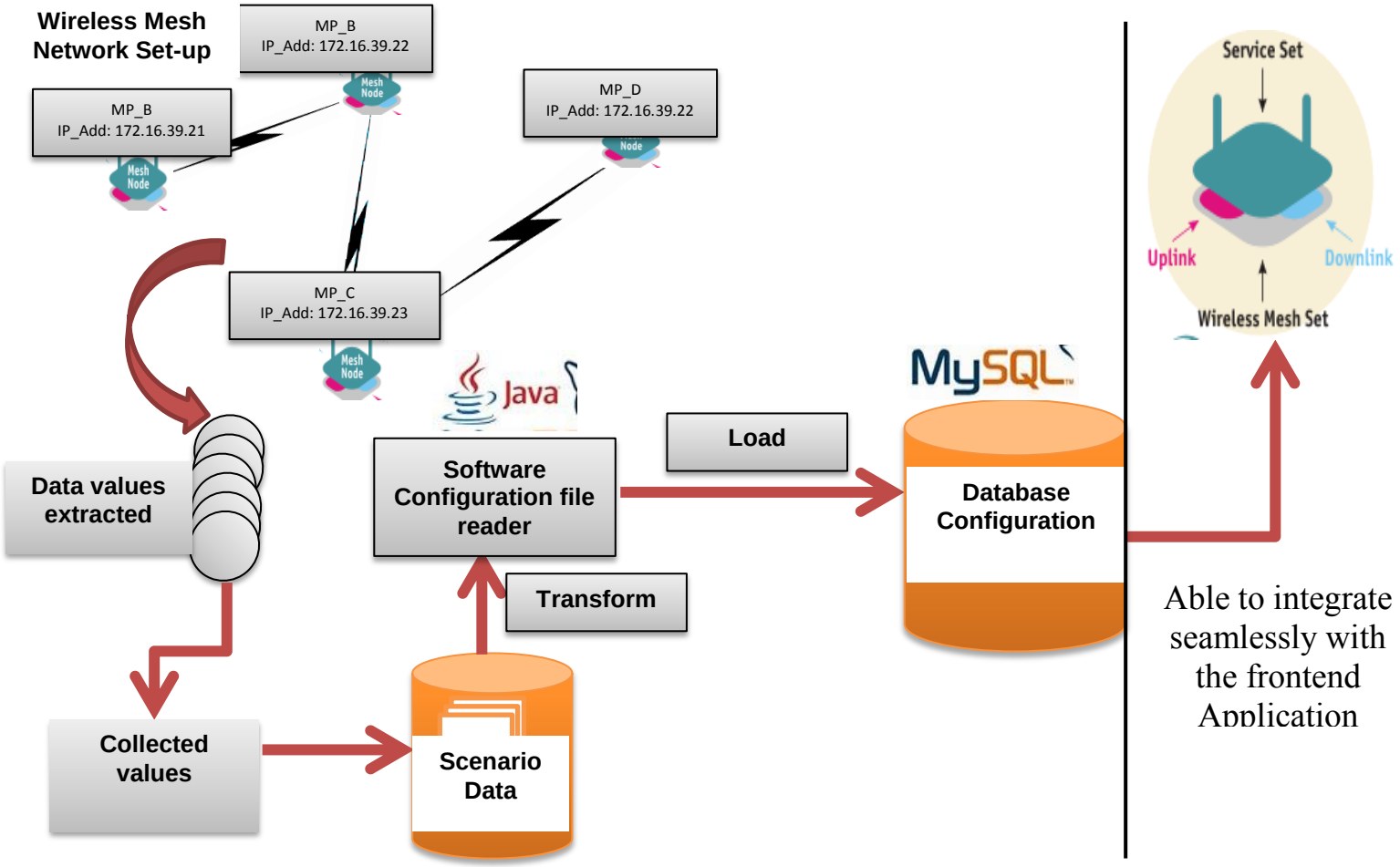

Diagram showing an illustration of System Architecture for Requirements Analysis

Hardware Configuration Component

The hardware configuration component will include the mesh potatoes device, switches, network cable, and computer system. This part of the project will be implemented incrementally to tackle the network manager view of the problem. The fundamental sub-components in this project include mesh potatoes and the backend hardware's.

Mesh Potatoes (MP)

The mesh potatoes (MP) which is a wireless router will be connected to the switch, and the computer system will be part of the network to form an ad hoc mesh network. This ad hoc mesh network will enable the execution and evaluation of the back end application for monitoring the network activity. The diagram illustrated in the table 3.1 show each network nodes and their main contribution to the ad hoc wireless mesh network. Furthermore, the mesh potatoes (MP) devices utilize an Open System Interconnection (OSI) Layer 2 protocol, even layer 1 of the OSI protocol and will basically act as one main router (Gateway), transparently connecting all the attached devices together. Mesh Potatoes have the Village Bus module installed, which act as an interface for all the data stored on them, such as their accounting information and connection to neighbors. The hardware specifications of the Mesh Potatoes routers are given below in the table 3-1:

Table 3-1: HARDWARE SPECIFICATIONS OF THE MESH POTATOES ROUTERS

Hardware	**Details**
Processor	MIPS 4k 180 MHz
Memory	16Mb Ram 8Mb flash EEPROM
Wireless LAN, WiFi	IEEE 802.11b/g 2.4 to 2.462 GHz frequency band Omni directional Antenna
Wireless network configuration	Ad hoc mode
Firmware	Linux kernel 2.26.3 Small Campus Enterprise Network software (SCEN) or Customized OpenWRT B.A.T.M.A.N-Advance routing potatoes

The Mesh Potatoes hardware configuration and software management show in the table above in this project will be accessible via browser or Linux terminal sessions with an access to the core Linux operating system kernel, OpenWRT or the Small Campus Enterprise Network software (SCEN). Mesh potatoes uses B.A.T.M.A.N-Advance (as seen above in the table) for its mesh network routing protocol. A collection of this device will be used in this project to provide data for the network activity. Each MP device will provide a Wi-Fi Access Point for remote data collection and for data analyses. An Ethernet cable will be used to sometime connect the Mesh Potatoes (nodes) to flash the device for the wireless local area network (WLAN) configuration setup. In addition, a personal computer (PC) and network cable with a network switch will be connected together using

the Ethernet port of the Mesh Potatoes node (router) to gain access to the availability of the Wi-Fi to allow the network manager connecting anytime anywhere. One key factor that is essential to take note in this project is that once a Mesh Potatoes device is connected via Ethernet cable to a LAN router (MP), then devices on LAN will gain access to local or internet connection as well as gain access to the LAN resources to help the network manager or a system developer to connect to any of the port on the network.

Backend Database server (MP_DB server)

The backend database server is a central component of to this backend application system and it will have the storing capability which will allows the network manager to query nodes that are on the ad hoc mesh network [chuck, Theodore, 2010]. A computer system will be setup to cater for the operation and running of the mesh network. The backend database server will have the following specifications: IBM Sun Solaris Ultra 20 Workstation, AMD Opteron 64bit, 1800 +CPU, 1GB RAM and 80GB SATA2 hard drive. This database server will be able to manage a very large data communication on the mesh network and also requires constant network monitoring. Although, research study show that IP networks are difficult to manage (a side effect of their decentralized nature); protocols and services are becoming more complex. However, with this back end database servers its primary goals are to minimize data storage during the local or remote configuration set-up. Analysis of network traffic, performance log file during monitoring and debugging will also be kept at a minimum storage capacity on the Mesh Potatoes. In addition, this project foreseen the need for a structure query environment and adaptability which is most evident to the network manager. One significant problem with mesh network is the high rate of data generating per day. Furthermore, if the analysis of data could be done on-the-fly, this project will offer capabilities that current methods cannot provide. This project therefore decided that the backend database server should be lightweight stream query processing systems that will at least as fast a hand-written system and which will allows the user (network manager) to by-pass the query system as needed.

Software Configuration Package Component

This project will implement Software Application for downloading and collecting the mesh network data. This collected data will be analyze and store into the backend database server for easily accessibility for the frontend application. How this will be achieved will include the following sub-components lists namely: Small Campus Enterprise Network (SCEN) or OpenWRT, Application File Extractor module, Better Approach to Mobile Ad hoc Networks (B.A.T.M.A.N-ADV), and MySQL Database Application Software. Brief description of the sub-component lists is as follows:

Mesh Potatoes Small Campus Enterprise Network (SCEN) or OpenWRT Firmware

This project will use the Small Campus Enterprise Network firmware that is designed to allow a collection of Mesh Potato (MP) devices to provide a data and internet network for a small campus. The intended use will typically for a small/medium size organization which needs to set up mesh network for a geographical area. This

will help the network infrastructure wirelessly without the use of conventional LAN cabling. The meshed MP devices will utilize an OSI Layer 2 protocol and act as one large switch that will obviously connect all other network devices together. In this project, each MP device will provides an Ethernet cable connection, and a Wi-Fi Access Point. PCs and other network devices will be connected to the Ethernet port of a Mesh Potatoes, or they will be connected wirelessly to the Wi-Fi Access Point of each Mesh Potatoes.

Application File Extractor module

An Application File Extractor module will be programmed by using Java Programming Language. This will help load data into the database server. It will also extract the relevant data from the Mesh Potatoes devices (configuration files) to minimize the Mesh Potatoes space capacity. The file extractor will help to collect relevant accounting information from the mesh network activity and load them in the back end database to help the network manager for making decision based on the quality of link (QoS) getting from the ad hoc mesh network.

Better Approach to Mobile Ad hoc Networks (B.A.T.M.A.N-ADV)

In this project, the B.A.T.M.A.N-ADV routing protocol will be in the form of a Linux kernel module operating and it is ISO/OSI layer 2 level [2,6] protocol. This routing protocol will proactively maintain information about the existence of all nodes on the network that will be accessible via single-hop or multi-hop communication links. The main purpose of routing protocol in this project is to help determine for each destination on the mesh one single-hop neighbor or multi-hop links. This links (neighbor IP address) will be utilized as best gateway to communicate with the destination node. However, how the batman-adv routing protocol will be achieve or work in this project will be all nodes will periodically broadcast packets that are known as originator messages to its neighbors. The originator messages will consist of an originator address, sending node address and a unique sequence number. Each neighbor will changes the sending address to its own address and re-broadcast the message. While at the receiving end of the mesh node, the originator does a bidirectional link check to verify that the detected link can be used in both directions. BATMAN-ADv will optimize data flow through the mesh potatoes when injecting traffic or correcting forward errors.

MySQL Database Application Software

This application will help the project implementation of the database server. This means that the application file extractor module (Java Module) will directly be connected to the MySQL database to help in the frontend application implementation of this project. All relevant data values will be collected and load into MySQL database to facilitate the frontend application system for monitoring the mesh network activity.

HIGH-LEVEL DESIGN OF THE SOLUTION

The network manager will interact with the backend system to troubleshoot, configure and manage the Mesh Potatoes (MP) router. The network manager will further collect the necessary values to store in the centralize database. This part of this project will show the internal overview of the routing protocols for mesh-node with BATMAN-ADV configuration snippet on Small Campus Enterprise Network. The high-level configuration design will include the key data collection design, key routing protocol functions and the expected behaviors of wireless mesh network.

Data Collection Design

This sub-part of this project will include collecting the values that are relevant to the managing and monitoring of the mesh network activity. This will help the network manager to facilitate easy network communications and the quality of wireless links in each network node. However, this data collection design will be an open arena for possibilities with regard to the distribution of data on the database. Whenever possible and appropriate, the database designs structures will be consider and allow direct access of the system to collect data from remote locations.

Routing Protocol functions

The following figure illustrates routing scenario using an asymmetric routing when setting up B.A.T.M.A.N-ADV routing concept [2]. This project will use this concept to design wireless mesh network of each nodes such as; if node A, B and C are connected via asymmetric links. Then every node will have a good transmitting power (Tx) connection to one neighbor and a good receiving connection (Rx) from the other node on the network. Hence, the routing protocol that this project will use is to discover the best neighbor towards any of its destination. Also the routing protocol will helps with the node to find the best path on the mesh network.

Figure 3.3

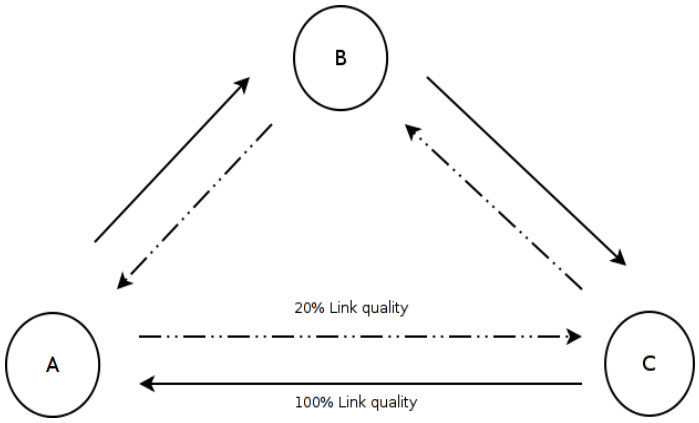

Diagram of Asymmetric routing for Mesh Network

Behaviors of Wireless Mesh Networks.

This project will ensure that the rate used on individual Mesh Potatoes (with each neighbor) will allow easy data communication and better quality of service (wireless links). This project will also allow the network manager to keep track of expected time to send packet to remote network on another region (e.g. rural area) during remote accessibility as well as avoid traffic congestion during working hour.

CONCLUSION

Having analyzed the proposed system requirements, this design requirement will help and allow the system developer to build and implement a complete system. The requirement analyses will help this project to focus on the system and software required or needed to implement the system. Moreover, the requirement analysis documents have helped to maps the domain of propose system onto the user requirements.

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Appendix

Project Plan

Term1	Understanding the problem facing Organization e.g. UWC Interview with Mr. Carlos Rey-Moreno Gather the user requirements Meeting with the supervisor Reading the specifications of the Mesh Potato and SECN firmware Installation of MySQL database, and Java database driver Still leaning towards MadWifi and Batman-adv routing protocol.
Term 2	Designing and preparing the prototype
Term 3	Implementation and coding
Term 4	Testing and Evaluation