ELECTRONIC VILLAGE REGISTER (EVR) MESH NETWORK

DESIGN DOCUMENT

Version *1.0*

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Version History

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TABLE OF CONTENTS

1 INTRODUCTION **4**
1.1 Purpose Of The Design Specification Document 4

2 GENERAL OVERVIEW AND DESIGN GUIDELINES/APPROACH **4**
2.1 Network Design Deliverables 4
2.2 Assumptions / Constraints / Standards 5
2.3 Components That Make Up The Network 5

3 ARCHITECTURE DESIGN **6**
3.1 Terminologies 6
3.2 The Layers 8

4 EQUIPMENT TO BE USED **10**

5 TEST PLAN **12**
5.1 Access Layer Test 12
5.2 Mesh Layer 12
5.3 Injection Layer 13
5.4 Performance Test 13

1 INTRODUCTION

1.1 PURPOSE OF THE DESIGN SPECIFICATION DOCUMENT

The Purpose of this Design Document is to show an overview of the Mesh Network Design to support the Electronic Village Registration system Installed at the TA Mtema Area in Lilongwe District. This wireless Mesh Network will provide a means for data transfer from the villages around the TA Mtema to the Lilongwe District Commissioner (DC) office and the National Registration Bureau (NRB) Head Quarters (HQ) through the Baobab Health Trust (BHT) Wide Area Network (WAN). The network should be able to carry http, https and VOIP traffic as the main protocols expected to be used.

2 GENERAL OVERVIEW AND DESIGN GUIDELINES/APPROACH

This report covers a comprehensive Network Design deliverables of the network, the "build-to" network plan covering all components needed to deliver a working system including network diagrams and the equipment to be used.

2.1 NETWORK DESIGN DELIVERABLES

This Mesh Network Design Contains the following Deliverables:

- Full/Partial Mesh Connectivity between the Mesh Nodes
- Provide WIFI Roaming on the Virtual Interfaces on the Mesh Nodes to be used by Peripheral Devices e.g Tablets, smart-phones & Laptops
- Provide Wired access to the network for the Static Devices e.g the Touchscreen Computers(J2`s)
- Provide back-hauls for the Mesh Network to the Baobab Wide Area Network
- Provide ability to carry VOIP traffic

2.2 ASSUMPTIONS / CONSTRAINTS / STANDARDS

The following are the constraints that are expected to have an effect in the implementation of the system:

1. The implementation is expected to provide full mesh capability to connect to multiple villages. However the line of sight between villages will determine the number of villages that will consist a mesh network.
2. The redundancy for the backhaul link may be a challenge as none of the villages involved in the pilot has a line of site to any BHT Point of presence. A 3G connection will be used instead.
3. The mesh network will rely on the availability of power all the time. The assumption is that the solar driven power system that will be managed in a way that adequate power will be available 24 hours.

2.3 COMPONENTS THAT MAKE UP THE NETWORK

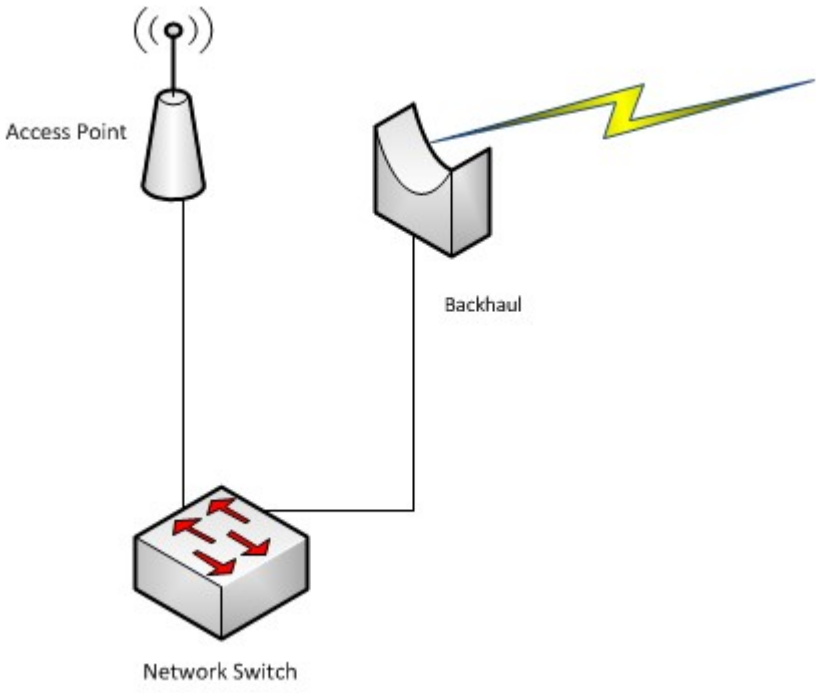
1. **Wireless Access Points** In a wireless local area network (WLAN), an access point is a station that transmits and receives data (sometimes referred to as a transceiver). An access will be used to connect users to other users within the network and will also serve as the point of interconnection between the WLAN and a fixed wire network. The access points will form the nodes for the mesh network. The radio firmware controls the hardware & the routing of traffic between the Mesh nodes.

2. **Omni Antennas** An omni directional antenna is a wireless transmitting or receiving antenna that radiates or intercepts radio-frequency (RF) electromagnetic fields equally well in all horizontal directions in a flat, two-dimensional (2D) geometric plane. The radio signals from the antenna can be received by any node within its line of sight and reach. The omni directional antenna will be used for all nodes participating in the mesh network.

3. **Ethernet Cables** These will provide wired access to the mesh network for the static Devices. They will also carry power from the power adapters to power the radios using Power Over Ethernet (PoE) approach.

4. **Point to Point Radios** will be used for linking the mesh networks to the Baobab wide area network through the nearest point of presence.

5. **Network Switch** will will be used where multiple devices will need to be connected on Ethernet. One use case may be where the mesh gateway will connect to the back haul link to the Baobab Wide area network.



3 ARCHITECTURE DESIGN

The Design Is Comprised of three tiers or layers each using a different connection technology

3.1 TERMINOLOGIES

1. **Mesh Networks**: A mesh is a network topology in which devices are connected with many redundant interconnections between network nodes. In a true mesh topology every node has a connection to every other node in the network.

2. **Mesh Node**: These nodes contain a Wi-Fi radio Main Interface that participates in a local mesh network and a Virtual WIFI interface that acts as an access Device. The primary functions of a mesh node include the provision of 802.11 access point capabilities and the forwarding of local and relaying of remote user traffic from other mesh nodes to and from the Wide Area Network via the injection and back haul layers.

3. **Full Mesh**: Full mesh topology occurs when every node has a circuit connecting it to every other node in a network. Full mesh yields the greatest amount of redundancy, so in the event that one of those nodes fails, network traffic can be directed to any of the other nodes.

4. **Partial Mesh**: With partial mesh, some nodes are organized in a full mesh scheme but others are only connected to one or two in the network. In a partial mesh topology, at least one node connects directly to every other node while others may only connect to those nodes they exchange data with on a frequent basis.

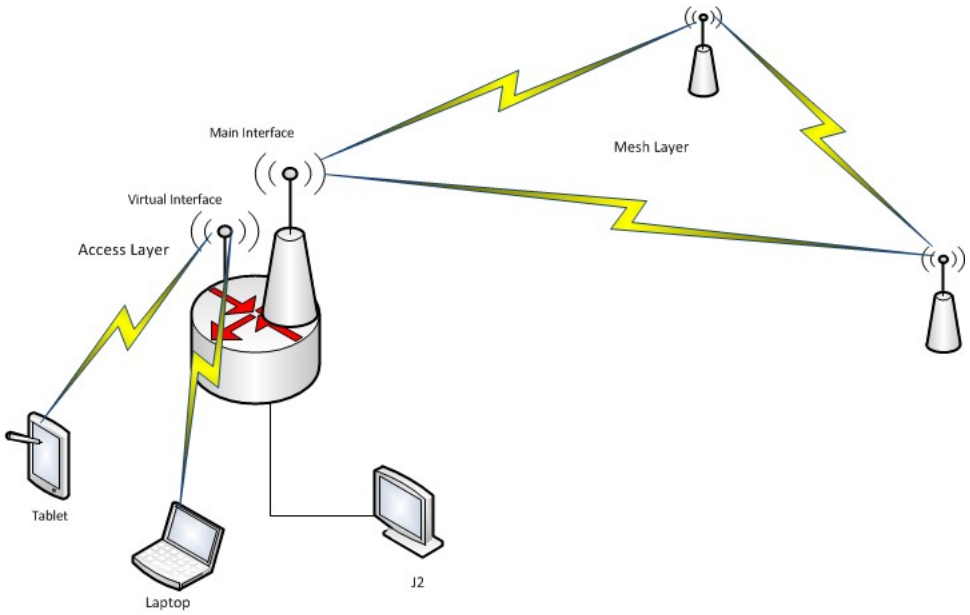
5. **Mesh Gateway:** This device is responsible for passing traffic between a collection of mesh nodes and the backhaul network, serving as the single egress point for these nodes. A mesh gateway role is assigned to a standard mesh node upon deployment; however, mesh nodes dynamically select their mesh gateway based on shortest routing path. This approach allows mesh nodes to re-select an alternate gateway if the current one becomes unavailable.
6. **Mesh Neighborhood:** A mesh neighborhood is comprised of a number of mesh nodes that are logically and functionally controlled by and associated with a single mesh gateway. At a minimum, a mesh neighborhood consists of one mesh node and an associated mesh gateway, although in practice the number of mesh nodes is expected to be much larger in order to extend the reach and coverage of the wireless network and reduce the number of injection layer links.
7. **Point Of Presence (PoP):** In the context of this network architecture, a PoP is a point that has connectivity to the Baobab Wide Area Network

3.2 THE LAYERS

3.2.1 Access Layer:

This layer uses 802.11b/g technology to provide wireless access to end user devices. Figure 3.2a below shows the access layer.

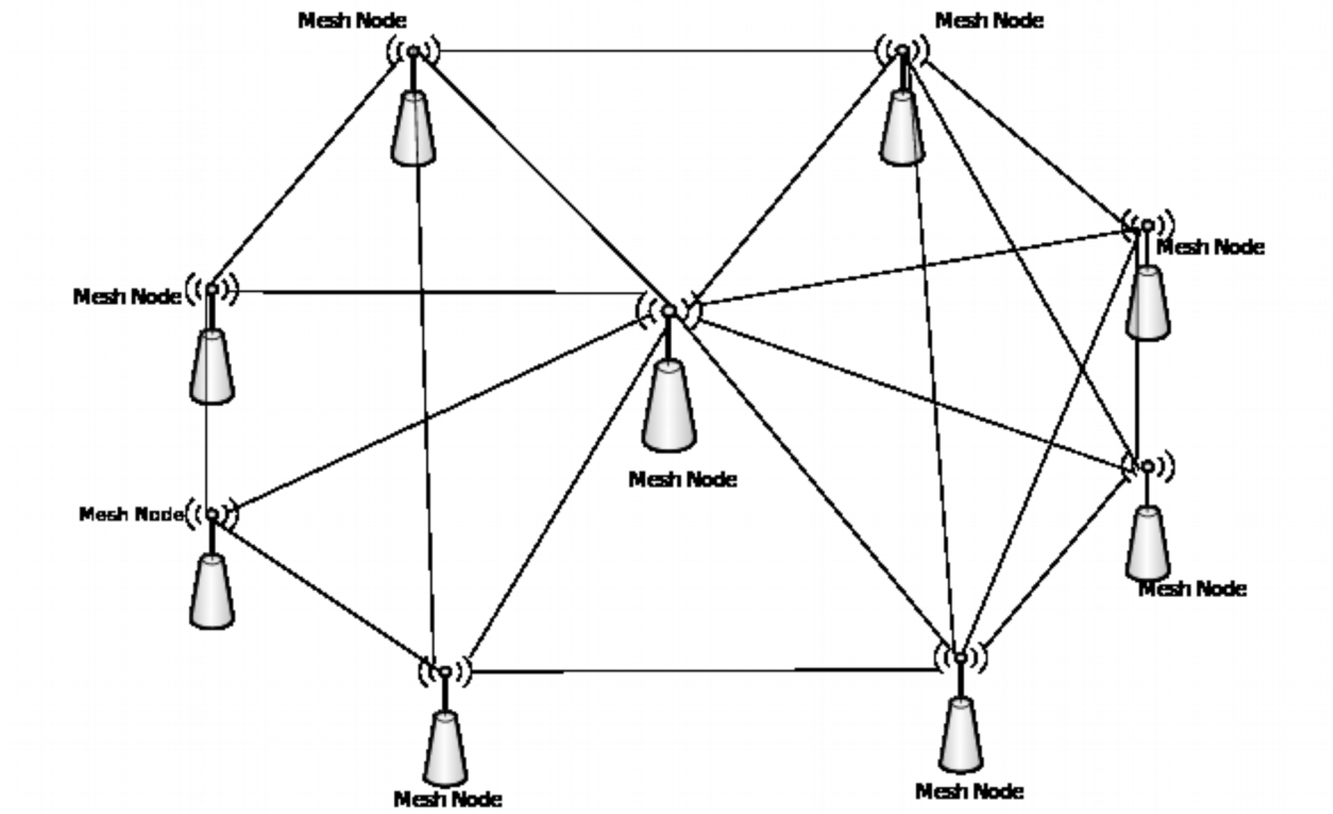
Figure 3.2a: Access and Mesh Layers



3.2.2 Mesh Layer:

The mesh layer is a self-forming, self-healing multi hop ad-hoc network based on 802.11b/g radio technology. The mesh layer's purpose is to connect the 802.11 access points of a collection of mesh nodes to the wireless injection layer, or directly to the wired back haul network. The self-forming capability refers to the ability of mesh nodes to discover their neighbors and establish efficient paths across the mesh to the Internet. The self-healing nature of the mesh layer indicates the ability of a mesh node to select a new path towards the intended destination in the event of individual mesh nodes failing along the original route (e.g. due to equipment failure or power outage).

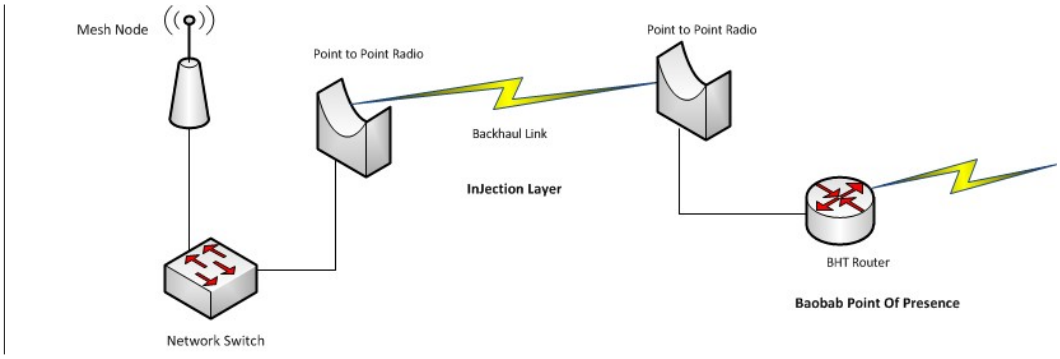
Figure 3.2b: *EVR Mesh Layer*



3.2.3 Injection Layer:

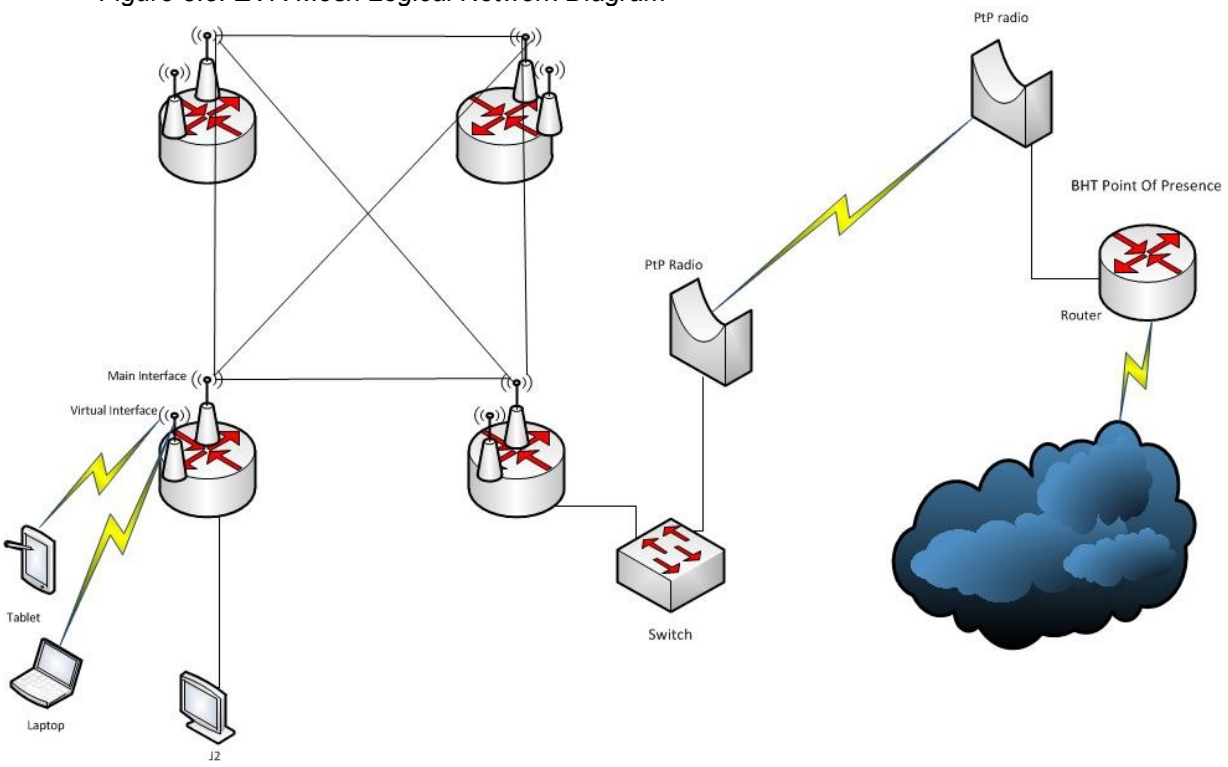
This layer provides a broadband wireless link to mesh neighborhoods by connecting a mesh gateway to a PoP as shown in Fig 3.2c. The injection layer will provide High Bandwidth link between the Mesh Network and the Baobab Network Point of presence. Where possible, Radios operating in 5 GHz range will be used to provide high bandwidth.

Figure 3.2b: *EVR Mesh Injection Layer*



1.1 LOGICAL NETWORK DIAGRAM

Figure 3.3: EVR Mesh Logical Network Diagram



4 EQUIPMENT TO BE USED

This section describes and outlines the specifications for the main equipment that is going to be used for the project.

4.1 WIRELESS ACCESS POINTS

- **Router Board Metal 2SHPN**

Is a waterproof, rugged, and super high powered RouterBOARD Metal. This serious outdoor access point is powered with an amazing 1600mW tx power radio.

Specifications

CPU Frequency	400 MHz
Wireless standards	802.11b/g/n
Max Power consumption	11.5W

Supported input voltage	8V – 30V
Transmit Power	1600mW
RAM	64mb

- **BaseBox 2**

The BaseBox2 is an outdoor 2.4 GHz wireless device, fitted with two SMA connectors for antennas, and a cable hood for protection against moisture. Also available are three additional places for antenna connectors, in case you wish to use the BaseBox miniPCIe slot for one more wireless interface to make a dual band device, or a 3G/4G modem.

The case can be opened with one hand, and is protected against the elements. USB, Ethernet and a Grounding wire exits are provided on the bottom, behind a protective door.

Comes with a mounting loop for tower/pole mounting

Specifications

CPU Frequency	600 MHz
Wireless standards	802.11b/g/n
Max Power consumption	10W
Supported input voltage	8V – 30V
Transmit Power Ram	1000mW

4.2 ANTENNAS

- **TP-LINK TL-ANT2412D**

Specifications

Frequency	2.4Ghz
Weight	1.4Kg
Dimensions	1480mm*80*80mm
Gain	12dbi
Connector	Integral N-Female

- **L-COM HG2415U-PRO**

Specifications

Frequency	2.4Ghz
Weight	1.5Kg
Connector	Integral N- Female
Gain	15dbi

5 TEST PLAN

5.1 ACCESS LAYER TEST

- Ability of Mobile devices to connect to the network
- Ability of Static devices to connect to the network on Ethernet.
- Functional DHCP Server
- Ability to authenticate devices that can connect to the network
- Ability of Mobile devices to connect to Server at Ngoni of Lilongwe

5.2 MESH LAYER

- Mesh functionality test. Check that nodes are able to make multiple concurrent connections. (The ability of mesh nodes to discover their neighbors and establish efficient paths across the mesh to the Intendend destination).
- Pass traffic through the mesh network
- Switch off one intermediate node and see if traffic will automatically redirect to another path. (the ability of a mesh node to select a new path towards the

intended destination in the event of individual mesh nodes failing along the original route).

5.3 INJECTION LAYER

- Check Ability to back-haul the mesh network

5.4 PERFORMANCE TEST

- Check bandwidth between nodes as read from the Access Points themselves.
- Use Iperf to determine Bandwidth from Node to BHT Lilongwe.
- Test VOIP capability of the network. (From Node to node, From Node to BHT Lilongwe Office).

5.5 TEST WITH EVR APPLICATION

- Register a record or update an outcome if there is any.
- Sync the data with the remote server through the mesh network.
- View the data from the TA office.