Village Telco

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Abstract

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Background

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The Village Telco concept was developed in June 2008 during a workshop at the Shuttleworth Foundation. The main goal was to figure out how to develop an inexpensive system to provide rural and under-served areas with affordable telephone communication [1]. The workshop included participants like open hardware pioneer Dawid Rowe, and Elektra, the developer of B.A.T.M.A.N. [2]. The purpose of the workshop was to develop a business model, as well as a prototype for a Village Telco. Initially the idea was to use low cost VoIP headsets. At that time it was the most viable and convenient way to deliver telephone services to the customers. The wireless VoIP telephones have small antennas, which became a problem. The nodes could not be more than 100 meters away from each other in order to have a reliable connection. This required more nodes in order to cover the desirable area. This factor drastically increased the start-up costs for a village. In order to keep the cost down, it was also important to keep the number of access points (APs) down. A mesh network has a larger range, and one suggestion was to use a small mesh device like an Open Mesh AP and connect a SIP phone to it. This solution would solve a lot of the problems regarding range, antenna and number of access points, but the idea was still an expensive option. The challenge was to create something that would be simple enough to be configured and scaled by local entrepreneurs with limited technical skills. In addition to this it was important to keep the cost down. The two key cost factors that emerged in the scale-up of a Village Telco were the cost of the customer's phone and the power supply. It was clear that the power supply was the most important factor, and that they had to look at other, and cheaper options regarding the customers phones [2]. During the debating, Rael Lissoos took an Analogue Telephone Adapter (ATA) and an Open Mesh AP, held them together and said *"we need these two devices in one"*. This point was the birth

of the Mesh Potato, fully based on customized open hardware and open software design. The name "Mesh Potato" comes from combining the words mesh, POTS (Plain Old Telephone) and ATA. "Patata" is the Spanish word for potato, and hence the name Mesh Potato. The Mesh Potato is a mesh enabled Wi-Fi device, with the possibility to connect any inexpensive regular phone and IP device. [3]

The first generation of the Mesh Potato is shown in Figure 2.1. This device is designed to be used in rural areas. It can be deployed and run anywhere in the world, relying only on a low, but stable, power supply. The Ethernet port, the Foreign eXchange Station (FXS) ports and the power port are robust and designed in order to handle all weather conditions, poor power conditions, lightening and static electricity. In addition to this, the Mesh Potato comes in a waterproof box for outdoor mounting [4].

The Mesh Potato combines the features of a 802.11bg Wi-Fi router with an Analogue Telephone Adaptor (ATA) [5]. The ATA converts the signal from a standard telephone, into the digital signal needed to connect to the Internet and use the SIP protocol [1]. The device is based on the Atheros chipset that is used by OpenMesh, and runs OpenWrt (see section 2.3.1 for more information) and B.A.T.M.A.N. (see section 2.3.5 for more information). Each Mesh Potato provides a single fixed telephone line to the end user. The MPs are connected together via a mesh Wi-Fi network, and configure themselves automatically to form a peer-to-peer network, greatly extending the range of the network over regular Wi-Fi. This enables the phone calls to be made independent of landlines and telephone towers, and creates the basis for the "plug-and-play" solution.

As mentioned, the Mesh Potato is open and based on open hardware, as well as

Figure 2.1: The first generation Mesh Potato, MP01.

open software design. Everything is kept open in order for any third party to test, set standards, and give feedback. Key goals during the development was to minimize the binary blobs (a closed source binary-only driver that has no publicly available source code [6]), minimize closed software and make the hardware open.

The mesh network can be connected via a backbone link to the rest of the world by using VoIP gateways. No cell phone towers, no land lines, and no telecommunication companies are required. A Village Telco is a community owned telephone service, allowing a local entrepreneur to roll out the Village Telco system only needing a server and the wanted amount of Mesh Potatoes. The mesh network is self-healing and self-organizing, meaning if one node goes down, B.A.T.M.A.N. routes the calls through other available nodes in the network [7]. In order to provide internet access, a super node has to be placed in connection with an internet connection. The internet signal enters the server in the Village Telco, this could for example be an existing internet café, with a broadband, link or satellite connection. The signal is transmitted to the super node. The super node consists of three external access points, and is placed high over ground, giving 360 degree coverage, with approximately 1 km range. The internet signal is then carried through the network from one Mesh Potato to another.

Mesh Potato 2.0

The first generation of the Mesh Potato has sold over 2500 copies, and is deployed all over the world. In order to keep up with time, the constant technical development and the demand from the users, a new version of the Mesh Potato was introduced. The second generation became available to users August 2013. This device comes in a smaller box, as shown in Figure 2.2, and is sold to half the price of the first generation. One of the biggest differences is that the second generation has two Ethernet ports and is built on a new, and faster, chipset. It is also operating on new firmware.


Figure 2.2: The second generation Mesh Potato, MP2.

Difference between MP01 and MP02?

Example Mesh network

An example of how to set up a simple network is shown in Figure 2.3. The network consists of two regular telephones connected to each their Mesh Potato. The MP devices has been assigned static IP addresses, these addresses are not part of the LAN address space. The IP addresses are allocated in a predefined default address space 10.130.1.xxx. To administrate the MP devices one can use a workstation linked together with any of the MPs in the network (either by using a Ethernet cable or Wi-Fi). This workstation must be assigned a static address within the same address space as the MP devices. Phone calls may be done between the Mesh Potatoes by dialling the last octet or the whole IP address. See the user guide in Appendix for a more detailed description of how to set up the Mesh Potatoes and how different networks can be built.

2.3   Relevant Technologies

In this section we will go through some of the most relevant technologies used to develop and run the Mesh Potatoes. In order to understand how the Mesh Potato works, it is important to have a certain knowledge about the underlying technology.
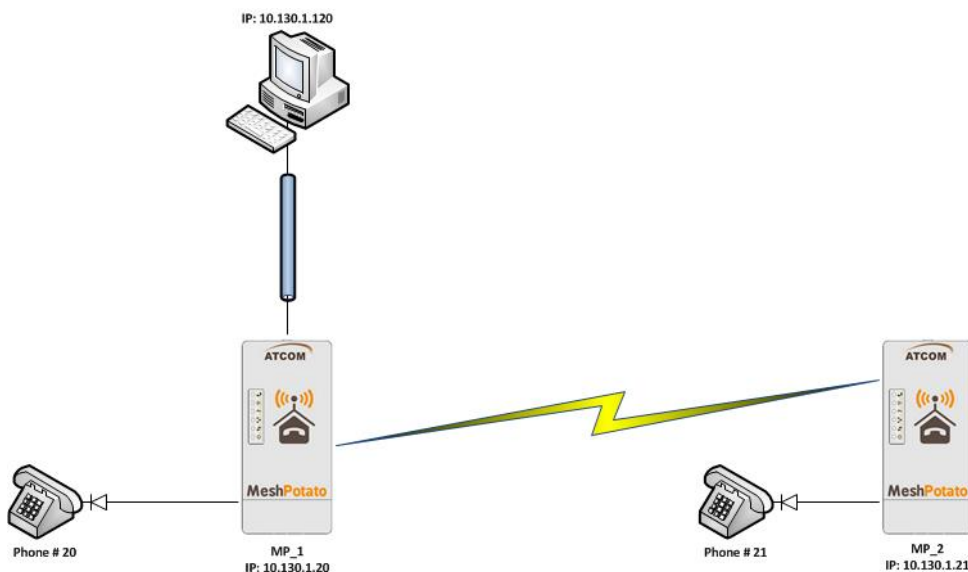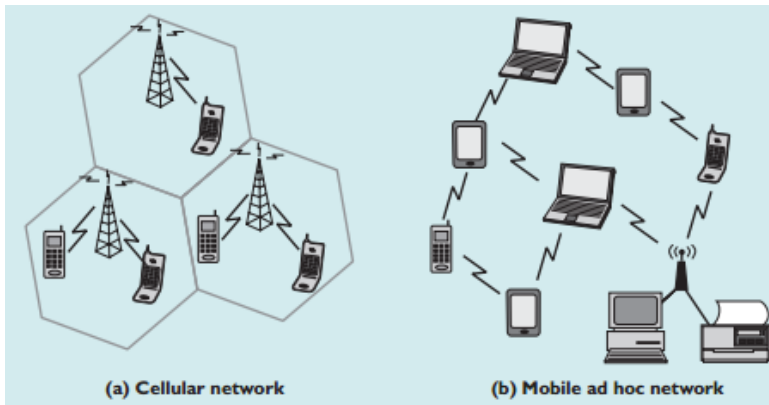

Figure 2.3: Simple mesh network. This figure illustrates a simple mesh network with the use of Mesh Potatoes.

2.3.1   OpenWrt

OpenWrt is an embedded open-source operating system for routers distributed by Linux [8]. It is extensible and can easily be modified to suit any application, since it offers a file system with a package manager. OpenWrt provides (1) Free and open-source, (2) Easy and free access, and are (3) Community Driven [8]. This means that the source code is free and available to everyone, and that everyone has the opportunity to contribute to it.

2.3.2   Mobile Ad Hoc Networks

Mobile ad hoc networks (MANETs) are networks that do not rely on an underlying and fixed infrastructure (access points and routers), in other words "infrastructure-less". MANETs acts in a shared wireless media [10]. The structure of these networks change dynamically, and key factors describing MANETs is self-configuration, self-organization, self-discovery, and self-healing [11]. The members of the network are mobile and are free to join or leave the network at any time [9], and therefore these factors are important. MANETs are based on multi-hop forwarding. Each node acts not only as a host, but also as a router. The nodes themselves establish and maintain routes, and forward packets to other nodes if necessary. This enables communication between nodes that are originally not within each other's range [9]. MANETs are suited for use in situations where there is no fixed underlying infrastructure. A MANET can operate as a stand-alone solution, but can also be attached to the Internet. This makes room for numerous of services.


Figure 2.4: Cellular network vs. MANET. This figure illustrates the difference between a regular cellular network and a mobile ad hoc network [9].

2.3.3   Wireless Mesh Networks

A wireless mesh network (WMN) is a type of MANET [11]. The objective of a WMN is to serve a larger number of users with high bandwidth access. As mentioned before, MANETs are "infrastructure-less" and they have self-configuration, self-organizing, self-healing and self-discovering features. WMNs share all these characteristics, except from the infrastructure part. WMNs, on the contrary to MANETs, are often a collection of routers called mesh routers (MRs). These MRs are usually stationary. The MRs can be employed for different use. One MR could for example be connected via cable to Internet, and then become a Internet gateway. Then this MR can provide Internet connectivity to the other MRs in the mesh network. A wireless mesh network consists of two parts [11]; the backbone of the mesh (the MRs) and the clients of the mesh. An example of a WMN architecture is shown in Figure 2.5.

2.3.4   Routing Protocols

Ad hoc networks and mesh networks creates several challenges when it comes to routing protocols. The routing protocols must be able to adapt quickly due to the topology changes. Figure 2.6 shows the different groups of the ad hoc protocols that exist. It is important that a routing protocol do not cause excessive overhead (extensive use of computer resources). Under the category flat routing, there are two types of routing protocols; proactive and reactive. *Proactive routing protocols*
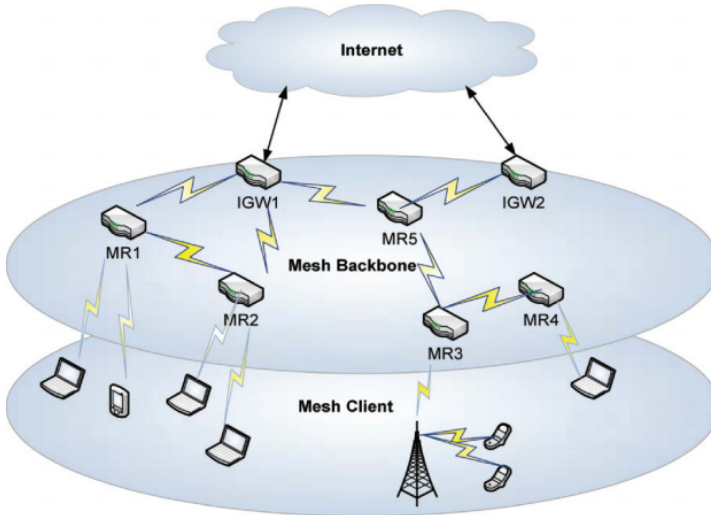
Figure 2.5: Example of a Wireless Mesh Network. This figure illustrates the architecture of a typical WMN [11].
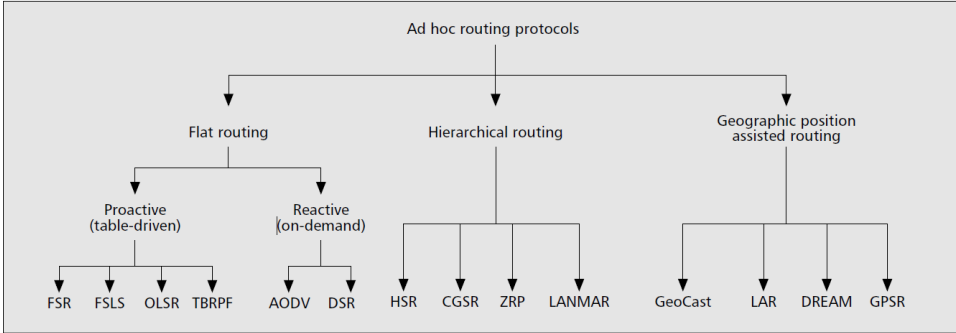
Figure 2.6: Different groups of ad hoc routing protocols [10].

(e.g. OLSR) are table driven [12]. Every network node has a routing table for the forwarding of data. To obtain stability, each node broadcasts and modifies the routing table periodically. Proactive routing protocols are suitable when there are few nodes in the network. The routing table is periodically updated, hence the overhead exceeds the desired value when there are a high number of nodes in the network. In contrary to the proactive routing protocols, *reactive routing protocols* (e.g. AODV) are on demand. Since they are on demand, the overhead is significantly lower. These protocols utilize flooding. The network is flooded with the route request (RREQ) in order to set up the route. The reactive routing protocols do not have a up-to-date routing table like proactive routing protocols [12]. Routes are only set up to nodes they communicate with, and these routes are only kept alive while they are needed [9]. As shown in Figure 2.6, there are several different protocols under proactive and reactive.

2.3.5 B.A.T.M.A.N

Better Approach To Mobile Adhoc Networking (B.A.T.M.A.N) is the routing protocol utilized in the networks formed by the Mesh Potatoes. B.A.T.M.A.N is a proactive routing protocol for wireless ad hoc networks. This includes MANETs [13]. This protocol was developed as an alternative to OLSR (Optimized Link State Routing) [14]. Like mentioned before, routing protocols must be able to adapt quickly to topology changes. B.A.T.M.A.N was made to be a more efficient routing protocol in this area, since it employs a new method for discovering routes. The nodes in the network broadcasts a OGM periodically, like shown in Figure 2.7. A OGM is a Originator Message which contains:

  – The address of the node

– Sequence number

– TTL (Time to live)

The address and the sequence number enables identification of a packet and duplicate detection.

Information about the nodes that are accessible via single-hop or multi-hop are maintained and updated [13]. Every node updates its routing table each time it receives an OGM. The routing table includes information about [14]:

– **Originator Address:** This is the source address of the node that sent the OGM.

– **Current Sequence Number:** The sequence number of the last OGM. This is used to discover if there are any duplicates or any information that is outdated.

– **Sliding Window:** A list of sequence numbers that is stored for each originator and each previous hop, i.e. for the neighbour node that forwarded or originated the OGM, as shown in Figure 2.7. This is used to decide which next hop is best for each destination.

When a node receives an OGM it will decrease the TTL, and then forward it to the neighbour nodes. The same OGM can arrive to a node, but from different paths. In this case, only the first copy is preserved.

RO.B.IN

RO.B.IN (Routing Batman Inside) uses the B.A.T.M.A.N routing algorithm. It is a project based on open source, and is intended for wireless mesh networks. It runs on Atheros AP51 routers running OpenWrt. RO.B.IN has the ability to spread wired internet (e.g. DSL) throughout a specific area, for example a village or a school [15].
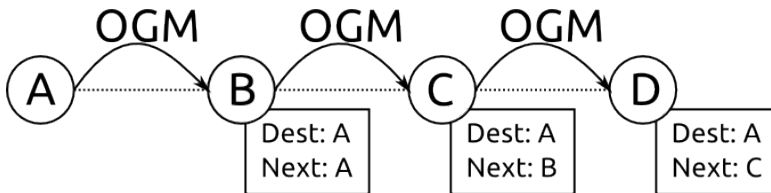
Figure 2.7: Originator Message used in B.A.T.M.A.N [14].

Simple Unified Dashboard for mesh networks

Simple Unified Dashboard (SPUD) for mesh networks is a tool for visualization made for B.A.T.M.A.N mesh networks, and for the users of the networks [16]. The Simple Unified Dashboard is, like the name insinuates, a dashboard based on PHP which is designed to be simple. It communicates with the B.A.T.M.A.N visualization server. The dashboard makes it possible to monitor the link status of the networks, by displaying real time wireless link status. Other features are client management and customization. The software is written in CakePHP and for visualization SPUD uses Google Maps API 1.3 [16].

2.4   The Cost Structure and Revenue Model(s) of Village Telco Today

2.5   Comparison of Village Telco and other Telecommunication Companies

Chapter 3

Refugee Camps

3.1 Refugee Camps

Women are in general in a more vulnerable position when living in a camp, especially if they are single mothers. They may be solely responsible for taking care of the children in addition to sick and elderly family members, maintaining the household, preparing food, acquire water, and securing firewood. Collecting firewood for cooking is a necessity, but it forces women to walk far away, hence making them vulnerable for sexual assault. they have to turn to sex and other unhealthy and dangerous means in order to survive. [17]

The means of communication vary greatly in the different camps. Some have internet connection and satellite TV, other barely have access to a radio. Even though radios are the most common media for communication, it is not given that all citizens in a camp have access to one. Often people would gather around the few radios that exists in a camp. One issue that limits the usage is the batteries. They are very expensive and hard to acquire. The women were interested in news regarding their place of origin.

Information walls and word of mouth is often used in order to spread practical information within the camp and about camp activities. Word of mouth is also used in order to retrieve information about the world outside the camp. People visiting the camp were used as sources for information. Earlier studies have shown that social connections with neighbours works as an important medium to transport information, resources and services between individuals. These kind of networking have been used to find lost family members in big camps, as well as get financial help from abroad. [17]

Cell Phone The use of cell phones are increasing. Even though the prises are extremely high it does not stop people from calling relatives in Europe and other places in the world.

[17]

3.2   Dadaab Refugee Camp

Dadaab is the largest refugee camp in the world, and is located in Daadaab, Kenya [18]. It was created in 1991 [19]. In April, 2013, there were 423,496 registered refugees in the Dadaab camps. 51 % of these were female and 58 % were younger than 18 years old. The lead agency for this camp is the UN High Commission for Refugees (UNHCR) [18]. In addition to UNHCR, major international humanitarian agencies like Care, Save the Children and the International Rescue Committee are active helpers in the Dadaab refugee camp. These agencies provide the refuges with critical services (e.g. food, housing, sanitation and medical help). This is an extremely challenging task in refugee camps, especially when they reach this size. During the recent years, the terror group Al Shabaad (Somali-based) have intensified their misdeeds in and around the Dadaab refugee camps. This has made the situation even tougher for the refugees and the relief agencies.

Means of Communication   To improve the situation in Dadaab, communication is crucial. In 2011, a group consisting of people from NetHope, Inveneo and the USAID Global Broadband and Innovations Program gathered to discuss ways to improve the means of communication in Dadaab [18]. NetHope is a consortium of over 30 international Non-Governmental Organizations (NGOs) [20]. NetHope works with improving connectivity, with the help of information technology, among relief agencies. The aim of this project, called DadaabConnect, was to bring forward more reliable Internet, and find ways for agencies to communicate better internally [18]. The group put together teams that travelled to Kenya to investigate the conditions in the refugee camps, and to find out what they could implement. It was clear from the feedback they got that a better communication system was needed, and that it would make the humanitarian work much easier. It would improve the coordination and the security in the camps. Improvements of these aspects gives the humanitarian agencies better working conditions, and makes it easier for them to help the refugees with critical services. Inveneo started working with Cisco's Tactical Operations (TacOps) to install and configure a local high-speed network [21]. They also entered a partnership with a local Kenyan mobile and landline telecommunications service provider called Orange. The reason for this was that they wanted to extend the Dadaab compound with new data services. This could be done by using Inveneo's long-distance Wi-Fi solutions. The data services that were added included services requested from the Dadaab aid community. "DadaabNet", a high-speed network, was created in cooperation between Inveneo and TacOps. This network connected the NGOs locally, and made it possible for the agencies to easier communicate internally (VoIP telephony, file sharing etc.). Following this, in March 2012, they

started the training of technicians. These technicians were people from Orange, from the technical staff of the NGOs and from Inveneo's staff. The training took place both in classrooms and in the field, in order to give the technicians a wide understanding. The results from DadaabConnect has been great. The humanitarian agencies has gotten better working conditions, due to the improvements in means of communication. Other positive outcomes is that the network is more reliable and cost effective.

3.3   Challenges

3.3.1   General Challenges

3.3.2   Communication Challenges

Main Work

4

Make a best practice for quick roll out, by the use of a MultiBox.

4.1 MultiBox

Table 4.1: The components of MultiBox

Component	Description and purpose
Mesh Potato	
Suitcase/box	
Power supply	
Plain old telephone	
Junction box	

4.2 Up-Link

In 2011, UN declared Internet access a Human Right [22]. This says something about the extent of the Internet, and the importance of connectivity. To provide Internet to the mesh network formed by the Mesh Potatoes, an uplink is necessary. An uplink connects a device or a LAN to a larger network [23]. There are several ways of connecting to the Internet. In the following sections, we will look at some of the uplinks available, and how Internet access can be provided.

4.2.1 Landline

The most common way of getting Internet access is via a landline.

Telephone Line

Internet Service Provider

4.2.2   Mobile Network

UMTS - 3G

WiMax - 4G

4.2.3   Satellite

Internet from satellites are offered by a satellite Internet provider [24]. The satellite are orbiting the Earth, and get signals from a land based Internet connection. To get Internet access via satellite you need a satellite dish. The main advantage of using satellite is that it provides an universally available Internet access [25]. Since it is universally available, it is fitted for use in rural regions where there exists no landlines or other options for connecting to the Internet. But like with everything else, there also exists disadvantages with satellite-Internet. Since it is a shared medium, privacy concerns arise, and the speed are dependent of simultaneous use. Another disadvantage is that the connection can be affected by bad weather, unlike for a wired connection.

4.3   Different Scenarios Where a Quick Roll-out is Necessary

4.3.1   Natural Disasters

4.3.2   Blackouts

4.3.3   Temporary Refugee and IDP camps

4.3.4   Breakdown of Mobile Towers

4.3.5   Mountain Areas - Avalanches

4.3.6   Festivals

4.3.7   Differences/relation between different scenarios

References

[1] J. Dempsey, "The mesh potato network," 2008. http://ictupdate.cta.int/en/Feature-Articles/The-mesh-potato-network, accessed 26.02.2014.

[2] Village Telco, "Village telco workshop," 2008. http://villagetelco.org/2008/07/village-telco-workshop/, last accessed 24.02.2014.

[3] Village Telco, "The origin of the mesh potato," Last edited: 2013. http://villagetelco.org/2008/06/the-origin-of-the-mesh-potato/, accessed 21.02.2014.

[4] Village Telco, "Background village telco," Last edited: 2013. http://wiki.villagetelco.org/Background, accessed 20.02.2014.

[5] Village Telco, "Mesh potato," 2013. http://store.villagetelco.com/mesh-potatoes/mesh-potato.html, last accessed 20.02.2014.

[6] Wikipedia, "Binary bolb," Last modified December 2013. http://en.wikipedia.org/wiki/Binary_blob, accessed 05.03.2014.

[7] D. Rowe, "The mesh potato part 1," 2008. http://www.rowetel.com/blog/?p=70, accessed 26.02.2014.

[8] OpenWrt Wiki, "About openwrt." http://wiki.openwrt.org/about/start, accessed 03.03.2014.

[9] J. Hoebeke, I. Moerman, B. Dhoedt, and P. Demeester, "An overview of mobile ad hoc networks: Applications and challenges," 2004.

[10] X. Hong, K. Xu, and M. Gerla, "Scalable routing protocols for mobile ad hoc networks," *IEEE*, 2002.

[11] J. Wang, B. Xie, and D. P. Agrawal, *Journey from Mobile Ad Hoc Networks to Wireless Mesh Networks*, pp. 1–30. Springer London, 2009.

[12] B. D. Shivahare, C. Wahi, and S. Shivhare, "Comparison of proactive and reactive routing protocols in mobile adhoc network using routing protocol property," *International Journal of Emerging Technology and Advanced Engineering*, 2012.

[13] A. Neumann, C. Aichele, M. Lindner, and S. Wunderlich, "Better approach to mobile ad-hoc networking (b.a.t.m.a.n.)," 2008. http://tools.ietf.org/html/draft-wunderlich-openmesh-manet-routing-00, accessed 21.02.2014.

[14] Freie Universität Berlin, "Better approach to mobile ad hoc networking (b.a.t.m.a.n.)." http://www.des-testbed.net/content/better-approach-mobile-ad-hoc-networking-batman, accessed 24.02.2014.

[15] P2P foundation, "Robin." http://p2pfoundation.net/ROBIN, accessed 05.03.2014.

[16] Village Telco, "Spud – simple unified dashboard for mesh networks." http://villagetelco.org/2011/06/spud-simple-unified-dashboard-for-mesh-networks/, accessed 26.02.2014.

[17] M. Maasilta, "Outsiders or active citizens? the role of oral amd mediated ommunication in african refugee camps," ?

[18] Inveneo, "How better connectivity can help dadaab, the world's largest refugee camp," 2012. http://www.inveneo.org/2012/06/how-better-connectivity-can-help-dadaab-the-worlds-largest-refugee-camp/, accessed 10.03.2014.

[19] Care, "Dadaab refugee camps, kenya." http://care.org/emergencies/dadaab-refugee-camp-kenya, accessed 11.03.2014.

[20] Wikipedia, "Nethope," Last edited: 13 May 2013. http://en.wikipedia.org/wiki/NetHope, accessed 11.03.2014.

[21] Inveneo, "Dadaabconnect." http://www.inveneo.org/projects/dadaabconnect/, accessed 11.03.2014.

[22] D. Kravets, "U.n. report declares internet access a human right." http://www.wired.com/threatlevel/2011/06/internet-a-human-right/, accessed 14.03.2014.

[23] B. Mitchell, "What is an uplink(port)?." http://compnetworking.about.com/od/homenetworking/f/uplink-port.htm, accessed 14.03.2014.

[24] A. Chianis, "Cable vs. satellite — which internet connection serves your business best?." http://www.businessbee.com/resources/news/technology-buzz/cable-vs-satellite-internet-connection-serves-business-best/, accessed 14.03.2014.

[25] E. S. Cohen, ed., *Broadband Internet: Access, Regulation and Policy*, pp. 80–81. 2007.