A Model Of Mpls-Te Based Wireless Mesh And Mobile Global Communications Internetwork System

Eke Vincent O C, Benedict Mbanefo Emewu

Abstract— **Wireless and mobile technology is rapidly gaining in popularity in both home and business networking and has become quickly a promising technology in today's emerging technologies. The advantages of wireless transmission include mobility and elimination of cables while its disadvantages include the potential for radio interference due to weather, other wireless devices, or physical obtrusions such as walls. A new type of broadband access network known as wireless mesh network (WMN) enhances the potentials of wireless and mobile networks by using the wireless mesh routers and wireless mesh clients. The main characteristic of a WMN is that the nodes at the core of the network are responsible for forwarding data to and fro clients, forming thus the Mobile and Ad- hoc Network (MANET). Unfortunately, the inherent shortcomings of WMNs, such as dynamic topology, the limitations of mobile terminals and heterogeneity makes it's end to end QOS become very difficult and challenging. In this work, we propose an MPLS internetworking approach that builds on the capability of traffic engineering in an IP-network by identifying traffic flows by labels and creating explicit routes (label switching paths (LSPs) for various traffic flows to solve these challenges. This approach uses ATM technology to address certain issues of WMNs such as reliable handoff procedure, bandwidth management, distributions of traffics as well as capacity. The theoretical aspects related to this MPLS protocol, its functionality, strengths and weaknesses as well as their implementations were discussed. The unsuitability of WMNs for Traffic Engineering and efficient resource allocation was also discussed.**

Index Terms— **Wireless Mesh Network (WMN), Mobile and Ad- hoc Network (MANET), MPLS internetworking, traffic engineering, ATM technology, End to End QOS.**

I. INTRODUCTION

Wireless and mobile technology is rapidly gaining in popularity in both home and business networking and has become quickly a promising technology in today's emerging technologies. Wireless networks utilize radio waves and/or microwaves to maintain communication channels between computers unlike wired networking that relies on copper and/or fiber optic cabling between devices. The advantages of wireless transmission include mobility and elimination of cables while its disadvantages include the potential for radio interference due to weather, other wireless devices, or physical obtrusions such as walls. Wireless and mobile technologies range from complex systems like Wireless Wide Area Networks (WANs),wireless Metropolitan Area Network (WMAN) and Wireless Local Area Networks (WLANs) to simple devices such as wireless headphones, microphones, and devices using infrared (IR) like cordless computer keyboards, wireless hi-fi stereo systems and remote controls, which require direct line of sight (DLOS) or non-line of sight (NLOS) between transmitter and receiver.

Wireless Mesh Network (WMN) is an advanced form of wireless network [1]. Wireless Mesh Networks have evolved from WLANs, WMANs, and WWANs forming thus the Mobile and Ad- hoc Network (MANET) [2]. For an instance, WIMAX working groups (IEEE 802.11[3], IEEE 802.15 [4], and IEEE 802.16 [5] have since 2004 developed a series of standard protocols that support mesh topology. Besides, the industry has also started to study mesh network technology.

Basically, wireless mesh networks consist of two types of nodes: wireless mesh routers and wireless mesh clients. Each node operates not only as a host but also as a router, forwarding packets on behalf of other nodes that may not be within direct wireless transmission range. The main characteristic of a WMN is that the nodes at the core of the network are responsible for forwarding data to and fro clients, forming thus the Mobile and Ad- hoc Network (MANET) [2]. This advanced feature is able to provide fast and hassle free services to users. Other advanced features are self-organization, self –configuration, self-healing, and automatic connectivity between nodes. These features bring many advantages such as easy deployment, low installation cost, low cost in maintenance, robustness, reliable service coverage and scalability compared with wired networks. In spite of all these, the inherent shortcomings of WMNs, such as dynamic topology, the limitations of mobile terminals and heterogeneity makes it's end to end QOS become very difficult and challenging. The "last mile" problem of the wireless access has become an increasingly widespread concern as well as. Meanwhile if the shortcomings of the WMNs as well as the "last mile" problem of the wireless access are not properly solved, the development of WMNs will be hampered in the future [6].However, it is believed that the WMNs are new type of broadband access network to solve the "last mile" problem as well as the key technology that will better support QOS than any other wireless networks. In this respect, the most common technologies such as desktops, laptops, PDA'S, pocket PCs, phones etc, which are based on conventional nodes equipped with wireless network interface cards (NICs) can connect to wireless mesh routers. Nodes without a wireless NIC can still access wireless mesh networks by connecting to wireless mesh routers through other technologies such as Ethernet. In addition, gateway's/bridge's functionalities in mesh networks enable integration of wireless sensors, wireless fidelity (Wi-Fi) and worldwide interoperability for microwave access (WiMAX)

Eke Vincent O C, Department of Computer Science, Ebonyi State University, Abakaliki. Ebonyi State, Nigeria.
Benedict Mbanefo Emewu, Department of Computer Science, Ebonyi State University, Abakaliki. Ebonyi State, Nigeria.

and routing protocols which do not have enough scalability [7]. We investigate further the possibilities of enhancing the wireless mesh Network functionalities through the necessary: (i) System functional Components modification, (ii) Topological modification, (iii) and protocol modification to tackle the challenges facing the WMNs.

We present an overview of the wireless and mobile Global Communication Internetwork System Architecture in Section 2. Section three discusses the Global Communications Internetwork System modifications and extensions. Section four discusses the theoretical concept of Multiprotocol Label Switching (MPLS) approach, system models for MPLS, and implementation scenarios. Finally, a case study of the traditional IP over ATM Network as well as MPLS-TE Based Global Communications Internetwork System Architecture (MPLS-TE-GCISA) is presented in Section five. We also conclude in Section five.

II. OVERVIEW OF THE WIRELESS AND MOBILE GLOBAL COMMUNICATIONS INTERNETWORK SYSTEM ARCHITECTURE

We take the case of the wireless and mobile Global communications Internetwork system architecture (WMGCISA) that was designed in [8] as our reference Communications System Architecture. The system architecture has the following functional modules: The users and cellular/mobile network module, Telecommunications network providers' module, Network carrier' module, and Web-based systems and applications (Web-Apps module) as shown in figure 1.

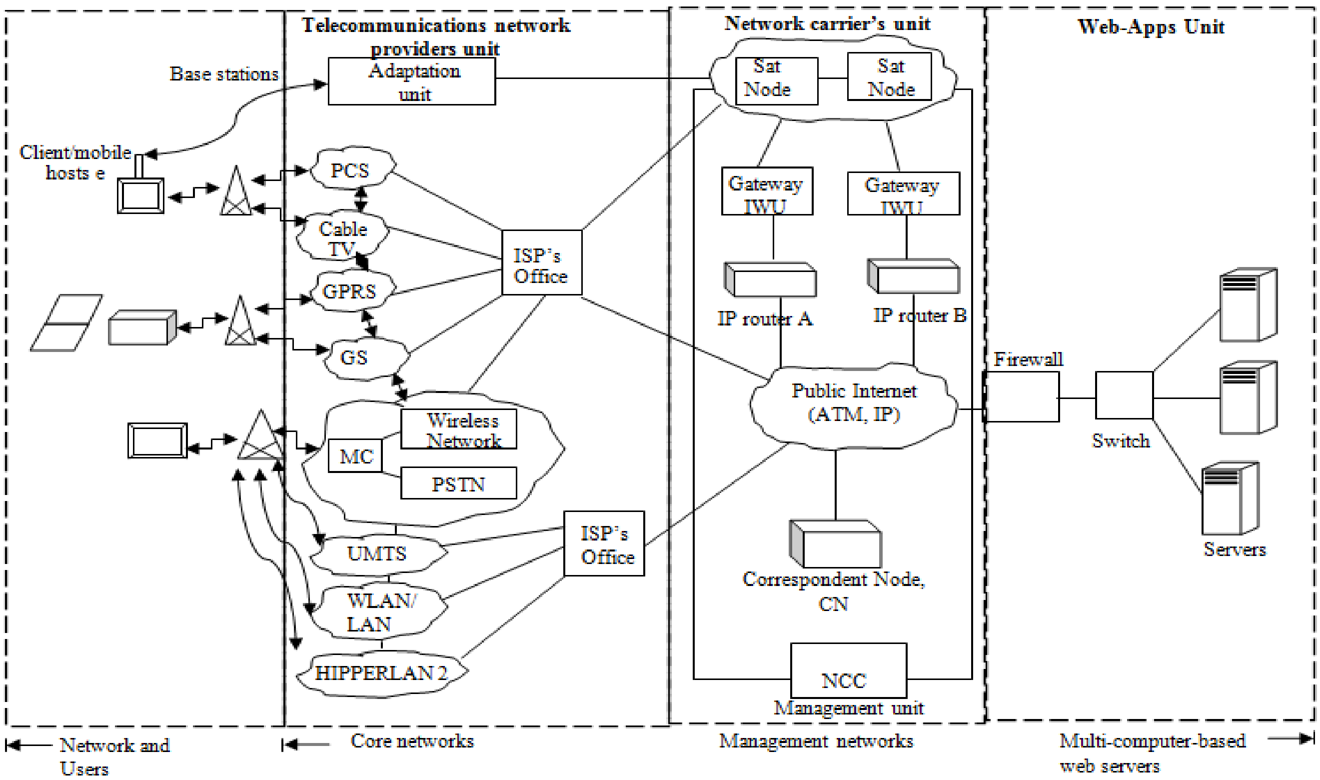

Figure 1: Global communications internetwork system architecture (GCSIA) in wireless and mobile networks [8].

The users and cellular/mobile network module**:**

In this module, the air interface connects the user's components (desktops, laptops, PDA'S, pocket PCs, phones etc.) to the radio base stations. Wireless networks utilize radio waves and/or microwaves to maintain communication channels between user's components and the radio base stations. With this arrangement, there will be greater flow of the traffic between the user's components and the radio base stations. This traffic includes fixed internet traffic (refers perhaps to traffic from residential and commercial subscribers to ISPs, cable companies and other service providers), as well as Mobile/Internet Traffic (refers perhaps to backhaul traffic from cell phone towers and service providers) [9].

Telecommunications network providers' module

In this module, a highly integrated wireless access platform is formed. The communications between the base stations and the Internet has to pass through the Telecommunications network providers unit and be of multi-hop and multi-path nature. It has been observed that Internet traffic data from the public peering points can give an indication of Internet volume and growth, but these figures may exclude traffic that remains within a single service provider's network as well as traffic that crosses private peering points.

Network carrier's module

In this module, it is either that the satellite broadband ATM network is integrated with the Internet or that the satellite IP network is integrated with the Internet to form a wireless overlay network. Consequently, the wireless overlay network can use either the IP protocol or the ATM protocol to handle the transfer of traffic between the terrestrial network users. In this case, the Internet uses routers rather than the PSTN switches to interconnect data terminals (computers) around a large geographical area.

Web-based systems and applications (**Web-Apps)** module

This module consists three units: the satellite Network, the terrestrial Public Network, and the Network management unit (NMU). This module comprises the firewall connected to the LAN typically an Ethernet, and the Multi-computer-based web servers to deliver a complex array of contents and functionality to a broad population of end users. As a consequence, most computers nowadays are connected to a network of networks (or the Internet). Multi-computer-based web servers have computing environments for web-based applications. They have application gateways in the application layer which translate message semantics. As an example, gateways between Internets e-mail (RFC 822) and x.400 e-mail must parse the e-mail messages and exchange various header fields.

III. THE DESIGN MODEL OF THE MPLS-TE BASED WIRELESMESS AND MOBILE GLOBAL COMMUNICATIONS INTERNETWORK SYSTEM

The goal of any system model design is to build a system that is effective, reliable and maintainable. A system is effective, reliable and maintainable if it is well designed, flexible and developed with modifications in mind. These modifications are necessary to correct problems, to adapt to challenging user requirements, to enhance the system, or take advantages of the changing technology [10]

A: System Design Considerations

In our effort to design a model of the MPLS-TE based wireless mesh and mobile global communications internetwork system, we consider the following issues of WMNs:

Bandwidth The cells closer to the base stations would receive a high bandwidth. A client that is one hop away from a WHS tends to receive a higher throughput than a client that is four hops away from the same WHS. This is because all traffic that is relayed to and from the base stations is done through the single WHS. Then there is an uneven share of bandwidth. So the position of a client in the WMNs directly influences the throughput received [11,12]. For cells which cannot be connected directly to the wireless hot spot (WHS), a possible connection path can be done using access nodes (see figure 2). These would then result to a lower bandwidth because of distance[13]. Since all clients pay the same amount of money for services, it is only appropriate that they receive an equal share of the bandwidth.

Scalability – the configuration capability of mesh networks could be used to extend coverage area and to increase the available bandwidth [14].

Reliability The WMN topology has a distributed style. As the Architecture becomes more distributed, the reliability of the network increases. If we increase the number of nodes or access points, the reliability of the network increases automatically. This is because packets will get more paths to reach the destinations.

Security The WMN topology has a distributed style. As the Architecture becomes more distributed, the security issue in the network increases. Increase in the number of nodes or access points will increase the security risks.

We can classify these issues into two categories of criteria: the functional and architectural. The functional criteria basically should enforce the system standard and functionality to satisfy the system requirements while the architectural criteria (i.e. interoperability) should define how the system should be constructed.

B: System Functionality

We consider restructuring the wireless and mobile Global Communications Internetwork System Architecture of figure1 with a view to adapt it to WMN in order to deal with the problems which plague wireless and mobile Networks. Our new network Architectural configuration will focus on the integration of the ATM broadband satellite, the terrestrial PCS network, the Internet and the wireless LAN/LAN only. This will reduce the complexity of the networks as well as such large volume of traffics that could be generated in figure 1. However, our simplified system Architecture can still take care of the traffic data from residential and commercial subscribers to ISPs, cable companies and other service providers, Mobile/Internet Traffics from cell phone towers and providers, and Internet traffic data from the public peering points are inclusive [9]. The new Network Architecture consists of:

(i)Teledesic Satellite model and **Terrestrial PCS Networks:** The Teledesic satellite model designed in [15] uses 200 LEO satellites in the connectionless-oriented constellation. This can provide a complete world data communications system above the surface of the earth using fiber-optic cables on satellites, instead of on the earth's surface. It uses wideband data links, on-board processing, and ISL links. Any user can access any other user or ISP [Internet Service Provider] independent of location and the existing telecommunications infrastructure. The Teledesic model employs ATM-based model with adaptive routing protocol. An ATM technique permits the use of Application Specific Integrated Circuit (ASIC) chips to be employed for ATM networks as well as user terminals. Direct access to ISP is available via optical fiber where the satellite Internet access can concentrate its services on less well populated and rural areas [16].

(ii)The Internet and WLAN/LAN

The Internet uses routers rather than the PSTN switches to interconnect data terminals (computers) around a large geographical area as shown in the middle of fig. 2.It uses point-to-point primary link protocol over the point-to-point lines. PPP is a multiprotocol framing mechanism suitable for use over MODEMS, SONET and other physical layers, The bridges and switches in the data link layer can accept frames, examine the MAC addresses and forward the frames to a different network while doing minor protocol translation in the process, for example, from Ethernet to FDDI or to 802.11. At the physical layer of the WLAN/LAN, the Application Points (APs) are required in the BSSs to constitute a distribution system which can be any of this IEEE 802.11: (802.11a, 802.11b, 802.11 infrared, 802.11 FHSS, 802.11 DSSS, 802.11 OFDM, 802.11b HR-DSSS, 802.11g OFDMA) WLANs. To achieve true mobility, the use of short-range radio waves (or infra-red) is required [17].

The development of satellite constellation such as Teledesic has led to the consideration of dynamic and adaptive routing algorithms for communications across ISLs between multiple satellites, on-board routing support, and on-board switching. In this case, the satellite constellation itself is a true network; in conjunction with the terrestrial switched WAN and LAN, it forms an autonomous system considered to be a wireless mesh and mobile global communications internetwork system as shown in figure 2.

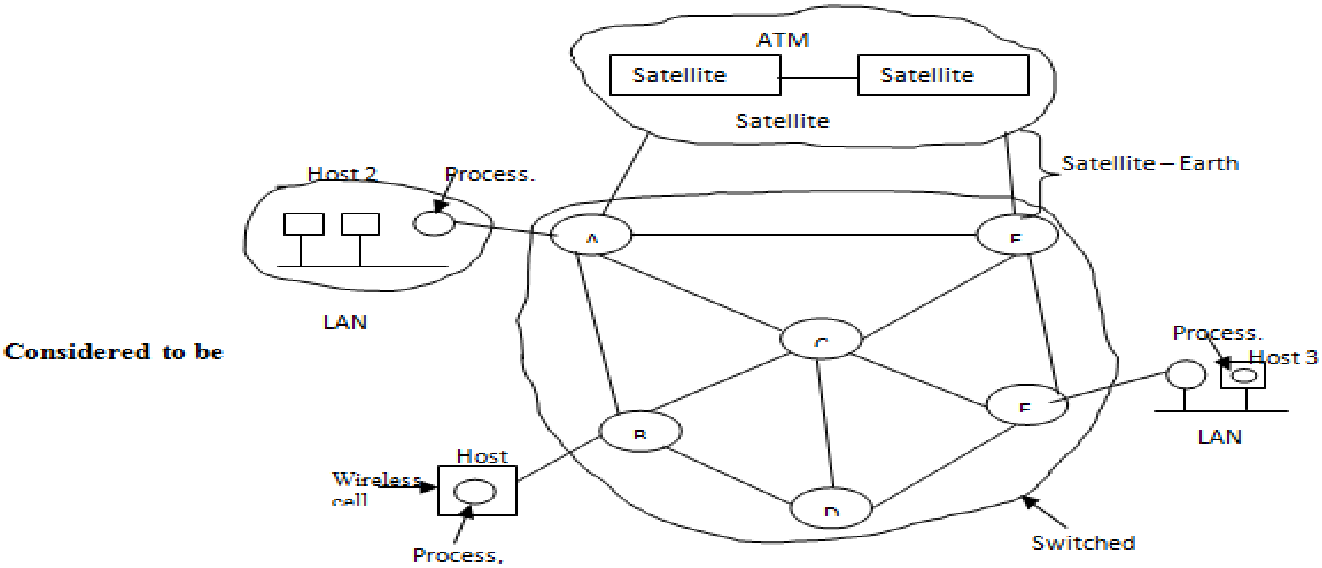

Figure 2: A model of Wireless Mesh Global Communications Internetwork System Architecture (WMGCISA).

C: Architectural Criteria

In order to provide interoperability to the existing terrestrial ATM Network, the LEO infrastructure must support on-board satellite LASER communication system (LCS) that uses concatenated switched virtual circuit approach of internetworking. A Satellite LASER communication subsystem (LCS) must then implement ATM's user to network interface (UNI) [18], and private network to network interface (PNNI) [19] where UNI is a signaling protocol for connecting end users, and PNNI is a routing as well as a signaling protocol for connecting ATM switches. The ATM switches, on either end of a point-to-point link exchange their identities during the initial handshake, and therefore, can proceed to exchange routing and signaling messages, using reserved ATM Virtual Circuits, without ambiguity regarding the source, except when the link is connecting multiple ATM switches. As such, the ATM technology will have to rely on the packets source hardware address, in addition to the reserved ATM Circuit to transfer data, so that PNNI and UNI protocols can perform properly. This allows terrestrial ATM devices to extend their connections over this infrastructure. The PNNI signaling protocol completes a connection request by generating a source-route using the PNNI routing and resource information if it is the original switch, or by executing a call admission control (CAC) algorithm to allocate or deny the requested resources if it is a transit switch. These Connections have hard states which require memory for storage so that these connection states will be maintained until explicitly released by the end users. This requires that the procedure for handoff between satellites must provide reliable transfer in order to prevent disruptions to connectivity. A reliable handoff procedure requires yet another protocol to help handle the bandwidth management, distributions of traffics as well as capacity. ATM technology cannot do the job by itself, but needs the network layer addresses and the services of the IP signaling protocol to make a connection request by using the network layer addresses of the two endpoints [20].

IP technology must integrate with the ATM Technology in order to provide interoperability of the ATM on-board support to the existing terrestrial IP Network. IP technology

uses datagram approach of internetworking that uses destination based routing which determines the forwarding tables based on various routing algorithms (RIP or 0SPF). The hop-by-hop processing for determining the next hop gives an IP network its robustness [19] [.However, IP technology only provides half-way solutions to our problems at hand due to the following limitations [20] : The datagram service is best effort, therefore, QOS cannot be guaranteed; all datagram tend to follow the best route when a link goes down. Consequently, this causes congestion on the best route even though alternative paths may be lying unutilized in the network; some applications (e.g. digital voice and video) have the property that their IP packets follow the same path. Therefore, traffic engineering, which deals with mapping traffic flows along desired paths, is not possible; the routing and forwarding mechanism of datagram is slower compared to other technologies based on virtual circuit approach (ATM, X.25 etc); IP packets were not designed for virtual circuits. There is no field available for virtual circuit numbers within the IP header. IP delivers variable size packets that can range from 64 bytes to a maximum transfer unit (MTU) of the packet's originating link (e.g. 1500 bytes for Ethernet and 4352 bytes for FDDI) to perform segmentation and reassembly (SAR) at the ground station to satellite interface. However, we are motivated by the fact that this technology is similar to ATM technology in this respect, but can accommodate variable length packets that are typically larger than 53 bytes. Similarly, the receiving ground stations will need the packets source route in addition to the source ground station's hardware address as the identifier for the reassembly queue.

In [21], it was established that both IP and ATM can be integrated to support on-board processing but can be compute and memory intensive. Due to the strict payload constraints imposed by the LCS technology, the authors proposed the "Wire in Space" Approach that uses a lightweight, link layer, source-based routing protocol to extend the LEO infrastructure to the fast growing terrestrial IP over ATM networks. Therefore, our satellite constellation acts as a "wire extension to on-board ATM support and has the innovative feature of multi-access support. This "Wire in Space" Approach protocol relies on the ground stations to calculate source routes based on a position-dependent addressing scheme and a fixed constellation topology, thereby allowing satellites to simply forward fixed size packets. Moreover, a 64-byte packet size can simultaneously accommodate IP and ATM packets, by encapsulating 53 bytes of payload within an 11 byte protocol header. Hence, segmentation and reassembly (SAR) in the IP case will be performed at the ground station to satellite interface, using technology similar to ATM to accommodate variable length packets that are typically larger than 53 bytes. Furthermore, the fixed-sized, 64 byte packets will simplify both the VLSI implementation and the memory management of the onboard packet switching equipment [21].

D: The Traditional **IP over ATM Networking and Implementation**

Most ATM networks are expected to be implemented as backbone networks within an IP based Internet where edge devices separate IP networks from ATM networks. In the traditional IP network, each router performs an IP look up ("routing") and determines a next hop based on its routing table and forwards the packet to the next-hop, Rinse and repeat for every router, each making its own independent routing decisions until the final destination is reached. In a worst-case scenario where layer 2 (L2) may be different from layer 3 (L3) topology, L2 and L3 do not overlap. L2 devices have no knowledge of L3 routing information. The virtual circuits are manually established. The result is that there may be suboptimal paths and link utilization. Even if the two topologies overlap, the hub-and-spoke (star) topology is usually used because of easier management.

This scenario is shown in fig.4; where there are three switches and three routers. A single packet could be propagated with 7 hops instead of 3 as shown. This is because L2 devices have static information about how to interconnect L3 devices. Routers use a routing protocol to propagate routing information through the intermediary router. Even in the star topology where the forwarding to the hub router was more optimal, the packet forwarding from the downstream router to the upstream router would still require unnecessary hops. Thus, the only possible solution to get the optimal forwarding from any router to any other router would be to have a full mesh of virtual circuits. However, this is rarely used because of its complexity 20[Prakash].

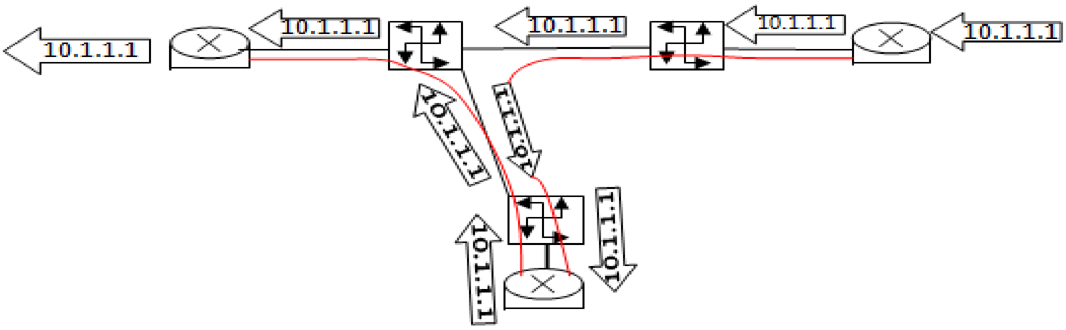

Figure 4: IP over ATM [22]

From all the issues of WMNs, the functional and architectural modifications discussed above, we argue that it is possible to adapt the wireless and mobile Global communications Internetwork system Architecture to WMNs but the issue of its end to end QOS has not been resolved. Thus, we investigate further into the system Architecture thus formed with a view to find out how its end-t-end QOS could be solved. We then discuss the applications of MPLS-TE Based wireless mesh and mobile Global communications Internetwork system Architecture next.

IV. THE APPLICATIONS OF MPLS-BASED TE TO WIRELESS MESH GLOBAL COMMUNICATIONS INTERNETWORK SYSTEM ARCHITECTURE

In this section, we first explain the MPLS Concept in 4-1 followed by the MPLS System models in 4.2, MPLS-Based Traffic Engineering protocols in 4.3, network boundaries of the satellite MPLS network in 4.4, after which we discuss the implementation scenarios of the satellite MPLS networking concept in 4.5, and finally we compare the non- Traffic Engineering routing with Traffic Engineering routing with an illustration in 4.6.

4.1: The concept of MPLS

MPLS stands for "Multiprotocol label switching". It is best summarized as a layer 2.5 Networking protocol. This is because it sits between the two traditional layers: data link layer 2 and Internet protocol layer 3, providing additional features for the transport of data across the network. In this approach, a router performs two basic functions: routing and switching. Routing function is based on IP addresses while the switching function is based on MPLS labels that are attached to IP packets. Labels are just like logical channel identifiers of ATM and x.25 networks. MPLS enabled IP network consists of Label Edge Routers (LERs) and Label Switching Routers (LSRs) as shown in Fig 5.

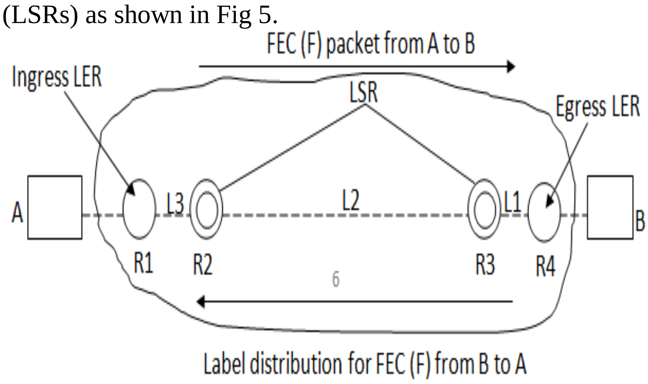

Fig. 5: MPLS enabled IP network [15]

LER adds labels to the incoming IP packets from the customer to the incoming ports of the router while these Labeled IP packets are sent over virtual paths called label-switched paths (LSPs) in MPLS and are finally switched to the outgoing ports by an LSR. Label switching table is used for this purpose. The IP address is required only at the LER where a label is attached to the IP packet for the first time. MPLS requires exact matching of labels rather than finding the longest match of destination address of an IP packet and the entry in the forwarding table. Therefore forwarding action is faster in MPLS protocol than forwarding in IP Protocol. A group of packets treated in the same way is called forwarding equivalence class (FEC). A set of FECs can use one single label for this set. This procedure is known as aggregation. Hence, assignment of an IP packet to an FEC is done just once by the MPLS edge router at the ingress to the MPLS network.

An MPLS internetworking approach builds on the capability of traffic engineering in an IP-network by identifying traffic flows by labels and creating explicit routes (label switching paths (LSPs) for various traffic flows. It is a data carrying mechanism that emulates some properties of the virtual circuit switched network (like ATM Network) over a datagram switched network (IP Network). It is a switching mechanism that imposes labels (numbers) to packets and then uses them to forward packets etc. This can distribute Internet traffics to more than one host over multiple paths and simultaneously at a cost effective manner. This is a better packet forwarding infrastructure than concatenated virtual-circuit and datagram internetworking models. The first device does a routing lookup, just like before, but instead of finding a next-hop, it finds the final destination router, and finds a pre-determined path from "here" to that final router; the router applies a "label" (or "shim") based on this information; future routers use the label to route the traffic

4.2: MPLS System models.

On-demand protocols are known as reactive protocols. The route path is made only when a node got data packets ready for transmission. However, they do not maintain route information update and they do not maintain the route path on which there is no traffic. Hence, the routing overhead is less because routes are maintained only when there is a need to transmit packets. The major disadvantage is that these protocols have very high response time as the source node has to wait until the destination node has been discovered. This on- demand protocols are not efficient in this regard. Hence, this gives room for further modifications. There are two system models for this approach. [20]: Solicited and Unsolicited Downstream on Demand MPLS. They are based on the Two-way store and forward principle. The forwarding procedure (forwarding plane) is completely decoupled from the MPLS control plane, which gives service providers a lot of possibilities to influence the networks behavior. The control plane itself can be divided into two parts: the label distribution protocol (LDP) which is responsible for distributing labels to all LSRs along an LSP and the control plane which consists of mechanisms which gather network state information and compute routes for LSPs.

A. Solicited Downstream on Demand MPLS

In this case, the ingress LER (R1) requests for a label from its downstream neighbor LSR (R2) for a specified destination. The request is further passed onto the next downstream neighbor LSR until the egress LER (R4). The egress router (R4) sends its label binding to the upstream LSR (R3), which in turn, sends its binding to the next upstream LSR till the last binding reaches the ingress LER (R1) that originated the request. Thus, within the MPLS based network, LSRs have label bindings to an FEC that are created as follows: Downstream router R4 selects a label L1 for FEC (F) to the flow of packets to B. it advertises this binding to its neighbors. The neighbor R3 takes note of this binding and selects a label L2 for this FEC (F). It advertises this binding to its neighbors. R2 repeats the above process and conveys its selected label L3 with the FEC (F) to its neighbors that include MPLS edge router R1. Thus, an LSP from R1 to R4 for the packets meant for destination B gets created. Hence, it is clear that labels on IP packets enable their transport on defined paths from R1 to R4. LSPs for the destination B get created in the similar manner from all the other MPLS edge routers that receive these advertisements. The label distribution is always from the downstream router to the upstream router.

B. Unsolicited downstream on Demand MPLS.

In this case, the downstream routers initiate this process on their own. The LSRs have label bindings to an FEC that are created as in the case of solicited downstream on Demand MPLS.

4.3: MPLS-Based Traffic engineering protocols. There are three MPLS-Based Traffic Engineering protocols namely [23]:

(i) OSPF-TE [24], this is the traffic engineering extension to open shortest path first for use with MPLS.

(ii) CR-LDP [25].CR-LDP] is the constraint-based routing label distribution protocol that is defined by the internet engineering task force (IETF) .It is an extension to label distribution protocols (LDP). The label distribution process makes use of the forwarding table for sending IP packets containing the label and FEC bindings. Therefore, the LSPs that are created are based on the shortest paths as dictated by the routing protocol. It is not suited for such applications that would likely be defined along a specified path that may not be the shortest path between the two points. CR-LDP implementations are, however, very few in the industry. Therefore, we shall not discuss this further.

(iii)RSVP-TE: RSVP-TE [26] is the traffic signaling extension for MPLS to the resource reservation protocol (RSVP). Once we have a specific route for a flow of traffic data, it becomes possible to reserve resources (e.g. bandwidth, buffer space, and CPU cycles per second) along that route to make sure that the needed capacity is available. RSVP allows multiple senders to transmit to multiple groups of receivers, permits individual receivers to switch channels freely, and optimize bandwidth use while at the same time eliminate congestion [27].

Generally, MPLS builds on the capability of traffic engineering in an IP network by identifying the traffic flows by the labels and creating explicit routes (LSP) for various traffic flows. An LSP is a "tunnel" between two points in the network that uses RSVP-TE to reserve bandwidth across the network [27]; Under RSVP, each LSP has a bandwidth value associated with it; If a LSP has been reserved for a particular user and there is no traffic to send, the bandwidth of that LSP is wasted. It cannot be used for other traffic. From the system wide perspective, the tradeoff is between guaranteed service and wasting resources versus not guaranteeing service and not wasting resources [27]. However, Using constrained routing, RSVP-TE looks for the shortest path with enough bandwidth to carry a particular LSP; If bandwidth is available, the LSP is signaled across a set of links; The LSP bandwidth is removed from the "available bandwidth pool"; Future LSPs may be denied if there is insufficient bandwidth. Consequently, they will ideally be routed via some other paths, even if the latency is higher, Existing LSPs may be "preempted" for new higher priority LSPs. This means that we can create higher and lower priority LSPs, and map certain customers or certain traffic onto each one, unlike traditional way of ensuring QOS; no packets are being dropped when bandwidth is not available, and we are simply giving certain traffic access to shorter paths.

4.4 MPLS BACKBONE NETWORK BOUNDARIES

The MPLS backbone network can be completely placed to the ISL space network, which has a permanent topology and could thus be operated without stringent LSP rerouting requirements. This means that the Label Edge Router (LER) can be placed in the "sky" which does onboard processing. This causes the earth- satellite link to fall inside the space MPLS network which is involved in frequent handovers, since this implies continuous rerouting decisions and computations for the LSP. Alternatively, we could place the LERs (and the network boundaries) on the ground to keep the satellites simple to avoid such onboard processing. However, there are no worthwhile advantages to implement LER functionalities onboard. Rather, two advantages of having LERs placed on ground are dominating [21]: there is no need to restart a QOS negotiation or admission control for rerouting of an LSP due to satellite handover. Secondly, expensive and complex onboard processing for advanced routing functionality is avoided. Thus, we propose to apply this scheme in this paper.

4.5 MPLS IMPLEMENTATION SCENARIOS

In this sub section, we discuss, three implementation scenarios of the MPLS networking concept. Three implementation scenarios were identified in [21] as follows: scenario 1: Distributed routing and LSP distribution management; scenario 2: centralized routing – distributed LSP management; and scenario 3: centralized routing and centralized LSP management. From the analysis done on the three scenarios, we can infer as follows: In scenario 1, the ground stations only need information about visibility and distance of satellites for determining alternative LSPs and the time to switch to the new path. Scenario 2, however, offers two possibilities regarding the time of rerouting: either the central Link State Data Base (LSDB) offers one or several alternatives for Edge Routers (ERs) and the decision when to start the rerouting is completely up to the ground station (like in scenario 1), or the ground station has to take new route directly after reception of the ER from the central CLSDB. The first option does not require detailed position information and is suitable for satellite constellations with several visible satellites at the same time (satellite diversity), out of which the best one is chosen, and the latter option is more appropriate for small number of visible satellites, but then the LSDB needs very accurate information about the ground stations locations to avoid routing errors. In scenario 3, the ingress points of the network do not set up LSPs anymore; all nodes of the network get their tables for label swapping directly from the central database via logical links. Any decision about traffic engineering driven rerouting or handover events is up to the LSDB, but this approach has only little remaining commonalities with terrestrial use of MPLS, including for instance the label swapping mechanism.

One advantage of the scenario 3 approach is the faster installations of LSPs. The central LSDB distributes label swapping tables among the satellites directly after the reception, of course, due to request from one of the LERs, and of course due to the origin of the connection request and this may immediately start to use the already existing LSP without having to set up one itself. A major drawback of this scenario is the design of a new signaling protocol to distribute labels among the LSRs. This is a critical point and is, therefore, addressed in the concept of MPLS RSVP-TE routing protocol used for setting up an LSP along a specified path. This research paper adopts scenario 3 for its obvious advantages.

4.6 MPLS-TE

Traffic engineering routing takes a metric (or Cost) per link and shortest path first algorithms to find the shortest path and adds additional constraints. For example, TE finds the shortest path that also has available bandwidth. This is also called constrained routing; using a constrained shortest path first algorithm (CSPF).The principle of the TE is simple, it is better to take an uncongested path even though the delay may be higher, than to congest the shortest path link while leaving available bandwidth unused on another link.

When the network operators are detecting the situation with an over utilized primary path and underutilized alternate path, they want to move some traffic volume or the over utilized to the underutilized path. When using traffic engineering to perform this operation, a traffic engineering tunnel is configured from the ingress router, to the egress router. This tunnel is engineered to take the underutilized path as an alternate path. We illustrate the scenario in Fig. 6:

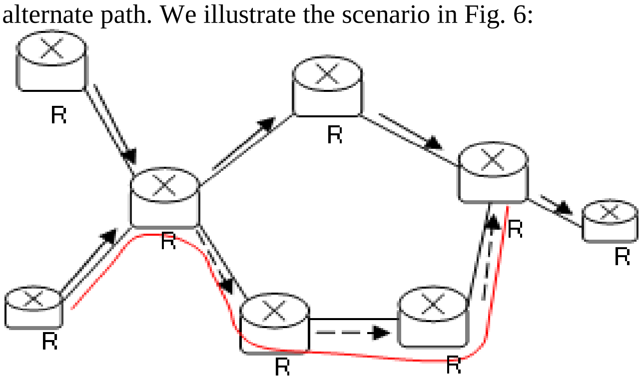

Fig. 6: MPLS-TE configuration

Legend: → the solid arrow denotes an over utilized primary path, ⇢ the dashed arrow denotes an underutilized secondary path, while the red solid line denotes Traffic Engineering Tunnel.

The operation of the IP-traditional forwarding would take the following steps in fig.5: **Step 1**, Traffic flows from both R1 and R2 towards R7 takes upper path via R3. This is the result of the destination-based forwarding in R2. **Step 2**: R3 does not make any difference if the packets arrive from R1 or from R1. R3 only cares about the destination. As a result, the upper path may become over utilized while the lower path (via R4 and R6 may become underutilized. When using traffic engineering to perform this operation, a traffic engineering tunnel is configured from R1 to R7. This tunnel is engineered to take over the lower, underutilized, path. Traffic from R1 to destinations behind R3 can now be directed by R1 into the tunnel. This moves a subset of the volume of traffic that use to take the upper path to now take the lower path. The traffic from R2 is not injected into any tunnel and still takes the upper path.

V. Conclusions and Recommendation

In our design, two network backbones were integrated: The satellite backbone which uses the optical fiber cable and serves as the backup, and the terrestrial Internet backbone and the terrestrial Internet backbones. The satellite Optical fiber cable is often found in backbone networks because of its wide bandwidths that are cost effective. The terrestrial Internet uses IP routers at the periphery and optical fiber cable at the core. Therefore, the satellite and terrestrial IP Internet can use a hybrid technology of ATM-IP-OPTIC-FIBER (or ATM-IP-ATM) which warrants the use of Multi-protocol Label Switching techniques as an enhancement.

In practice, Network implementations deviates considerably from the abstract or physical Network Analysis and Design theory. A network must be able to meet a certain number of criteria. The most important of these are: performance, reliability and security. Many Network performance problems abound such as Network Traffic congestion, structural resource imbalance, overloads (e.g., bad parameters and electrical failures) and lack of system tunings (e.g., Insufficient allocation for memory buffer space, high scheduling algorithms to processing incoming packet data units(PDU), setting time-out correctly). Consequently many of the network providers are faced with the challenges of providing the Telecommunications services to mobile (satellite and terrestrial) users with “anywhere, anytime” access to “anybody” in a cost effective manner and with a good quality of services (QoS). In the context of Internet traffic engineering, the Network congestion problem is caused by inappropriate or inefficient allocation of available network resources to traffic streams, thus causing some parts of the network resources to become over utilized while others remain underutilized. Hence, the objective of this paper which is to minimize the maximum resource utilization of the network resources due to insufficient resource allocation can be achieved by forcing the load to be spread as evenly as possible and carrying out load balancing policies. We have demonstrated that the MPLS protocol has the capability to solve the problems of Network traffic congestion as well as guarantee QOS with cost efficiency. In the next paper we will discuss how good the network is by investigating the performance of the proposed MPLS-based traffic engineering in wireless and mobile global communications network system.

REFERENCES:

[1] S.G. Glisic, Advanced Wireless Networks,: 4G Technologies, Wiley Publishing,2005.

[2] Akylldiz and Kasimoglu,(2004), “Wireless Sensor and Actor Networks Research Challenges, Ad-hoc Networks”.

[3] IEEE 802.11 standard Group, IEEE802.11 [EB/OL], 2007, http://www.ieee802.org/11.

[4] IEEE 802.15 standard Group, IEEE802.15 [EB/OL], 2007, http://www.ieee802.org/15/.

[5] IEEE 802.16 standard Group, IEEE802.15 [EB/OL], 2007, http://www.ieee802.org/16/.

[6] Zhiyuan L, Ruchuan WANGi, “A Multipath Routing Algorithm Based on Traffic Prediction in Wireless Mesh Networks”, Communications and Network,2009,1,82-90, Sourced at: http:/www.scirp.org/journal/cn.

[7] Poor (200) Wireless Mesh Links Everyday Delivery Electronic Engineering Times.

[8] Eke Vincent O. C. and Benedict Mbanefo. Emewu (2016), A Framework for Wireless and Mobile Global Communications Systems Integration: Architectural and Implementation Issues, International Journal of Engineering and Applied Sciences, volume3. Issue 7, July, 2016.

[9] William E.; Gilbert, P.; Chun, B. G.; Cox, L. P.; Jung,J.; Mc-Daniel, P.; and S. Heth, A. N. (2010), Taint Droid: An Information-Flow Tracking System for Real-time Privacy Monitoring on Smart-Phones. In 9th USENIX Symposium on Operating Systems Design and Implementation.

[10] Gary B. Shelly, Thomas J. Cashman, and Harry J. Roseenblatt, System Analysis and Design, Fourth edition, Course Technology,Thompson Learning,U.S.A.,2001,Pg.6.27.

[11] Movement uscb(edu,2006),”Wireless Communications Technology Routing,” http://Movement.cs.ucsb.edu/AODV.html

[12] Mitola (2000), “Software Radio Architecture, Object-Oriented Approaches to Wireless System Engineering”, Wiley Inter-science, New York.

[13] IEEE 802.11b-1999, IEEE Standard for Local and Metropolitan Area Networks Specific Requirements-Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications High Speed Physical Layer Extension in the 5 GHz Band, September 16,1999.

[14] Draves, Padhye and Zill (2004) Routing in Multi-Radio, Multi-hop Wireless Networks, ACM Mobicom.

[15] O. C. Eke Vincent and A.N.Nzeako, Development of Global Geographical Coverage Area for Terrestrial Networks with Leo Satellite Network, International Journal of Communications and Network, Published online November,2014 in SciRes. http://www.scirp.org/journal/cn doi

[16] Pratt,T., Bostian,C., and Allnut, J.(2003) Satellite Communications, Second Edition, John Willey and Sons Inc.,New York Pg 246 -248.

[17 IEEE 802.11 Standard Group Web Site (2006), http://www.ieee802.org/11/

[18] The ATM Technical Committee, “ATM User Network Interface (UNI) Specification Version 3.1,” Prentice Hall, 1995,pp151-294.

[19]The ATM Technical Committee, “Private Network- Network Interface (PNNI) Specification Version 1.0,” af-pnni-0055.000, March, 1996.

[20] Prakash C. Gupta, Data communications and computer networks, PHI learning private limited, New Delhi-110001, 2009.pg 660

[21] [37] H. Y. Chen, Jim Hutchins, and Bruce Mah. A light weight, link layer, source-based routing protocol for LEO satellite networks.

[22] www.cisco.com/

[23] Anton Donner, Matteo Berioli, and Markus Wermer, “MPLS-based satellite constellation networks” IEEE Journal on selected areas in communications, vol. 22, pp. 438-448, April, 2004.

[24] D. Katz, D. Yeung,and K. Kompell, “Traffic Engineering Extensions to OSPF,Versin2” Internet Draft-Katz-Yeung-OSPF-Traffic-09.Ext., work in Progress,2000.

[25] B.Jamoussi, L. Anderson, R. Callon, R.Daanta, L. Wu, P. Doolan, T. Worster, N. Feldman, A. Fredette, M. Girish, E.Gray, J. Heinanen, T. Killy, and A.Mallis, “ Constrained-based LSP Set up Using LDP,” IETF, RFC 2205, Sept. 1997.

[26] D. Awduche, M. Networks, L. Berger, T.L.D. Gan, V. Srinivasan, and G. Swallow, “ RSVP-TE. Extensions to RSVP for LSP tunnels, “IETF, RFC 3209, Dec. 2001.

[27] Andrew S. Tanenbaum, Structured Computer Organisation,5th edition, Pearson Education, Inc.,Upper Saddle River, New Jersey 07458 pp151,410