

Mobile Backhaul Network

R.G.Kaduskar¹, Aditya D. Kavishwar²

¹Assistant Professor, Department of E&TC, PVG's C.O.E &T, Pune

²Research Student, M.E. E&TC, PICT, Pune

Abstract. Lately advancements in cellular technologies have resulted in significant increase in connection speeds over the air. This paper briefly describes how the mobile backhaul networks have to catch up with all these changes and thus tend to counterbalance the enhancements on the rest of the network. A large number of the existing backhaul networks are based on legacy technologies, incapable of supporting higher speeds or service requirements. Explosion of packet data traffic over voice, unlimited data/voice services, faster download rates have fuelled the demand for higher backhaul network capacity and intelligence. Hence, there is a critical requirement to migrate the mobile backhaul network to technologies that can support quality of service (QoS) to separate traffic streams, timing synchronization, lower packet loss, and high availability (HA) along with maintaining low operational expenditure.

Keywords: Mobile Backhaul, Flat IP Network Architecture, Pure Packet Protocol Stack, Migration Methodologies.

1. Introduction

The backhaul can be considered to be the portion of the network that connects the BTS (and air interface) to the BSCs and mobile core network. The backhaul can consist of a group of cell sites that are aggregated at a series of hub sites. The generic model for the newer backhaul networks consists of a cell, hub sites, or both connected to aggregation devices that in turn can either belong or be connected to a Metro network. Figure 1. shows the different subcomponents of the mobile backhaul network.

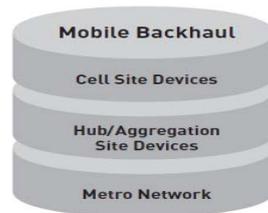


Fig. 1: Subcomponents of mobile backhaul network

Mobile backhaul networks can be Multi-access gateway which supports TDM/ATM or Ethernet connectivity at the cell sites, A Transport type handling data from the different cell sites is carried over pseudo wires which supports circuit emulation, Timing Synchronization type which supports Clocking for the TDM data needs to be synchronized across the network and Aggregation type that performs aggregation of all the incoming connections before they reach the mobile core. Increase in data traffic, increase in number of subscribers, dynamically changing usage patterns, Variation in type of traffic transported across the network, QoS based prioritization of traffic, Timing synchronization are the key drivers behind the demand for a reengineered mobile backhaul network.

2. Backhaul Network Topology

¹ Kaduskar R.G. Tel.:+919823061486; Email address: rgkaduskar@hotmail.com

² Kavishwar A.D. Tel: +918888815686; Email address: adityakavishwar@gmail.com

Backhaul network spans from the Cell Site Transport Gateways, ‘Last Mile’ Domain, Aggregation Domain, through to the Metro Network Domain and ending with the Core Network Transport Gateways. Transport Nodes reside at the border of each of the domains and they provide traffic management capabilities such as switching and performance monitoring. Backhaul network can use a variety of physical transmission technologies including optical fibre, microwave radio, copper DSL and occasionally satellite. There is more variety of physical transmission in the Last Mile and Aggregation domains with microwave radio having a majority share, whilst the Metro and Core networks predominantly employ high capacity WDM optical transmission [5]. The backhaul network topology is shown below in Figure 2.

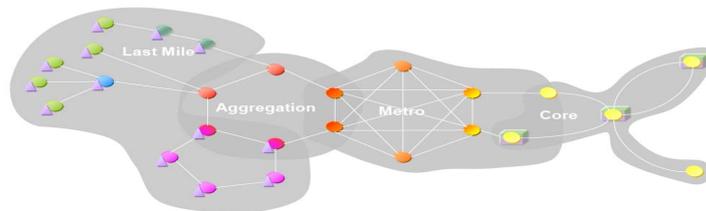


Fig. 2: Backhaul Network Topology.

3. Different Technologies and Backhaul Network Support

The connectivity type offered by the backhaul network is influenced by the technology used in the RAN and factors such as geographical location of the cell site, bandwidth requirements, and local regulations. The amount of available frequency spectrum and spectral efficiency of the air interface influence the bandwidth requirements of a cell site. Hence, the backhaul network can consist of either one or a combination of different physical media and transport mechanisms. Selecting between the different options available depends upon the type of radio technology, applications that are expected to be used, and transport mechanism. Table.1 lists the different technologies and the corresponding base station support.

Generation	Technology	BTS Support	Backhaul Support
2/2.5G	GPRS/TDMA/CDMA	Channelized TDM	PDH/SDH
3G(Rel99)	UMTS	ATM	ATM
3G/4G	EVDO,UMTS WiMAX, LTE	Ethernet/IP	IP/MPLS/ Ethernet

Table1. Different technologies and corresponding base station support

4. Mobile Backhaul for Long Term Evolution

Existence of different strategies for the rollout of Radio Access Network and corresponding backhaul deployment strategies may at first suggest divergent set of requirements that will be difficult to address with a common approach to backhaul transport. However, backhaul requirements are consistent between the two evolutions strategies described. This convergence of requirements is due to the fact that regardless of the starting point today, all operators have the same end objective which is a LTE based network for mobile broadband. Related network evolution steps will be common and the difference will lie in whether all operators will experience all of the transformation stages or whether some can accelerate or side step one or two of the stages. The challenge lies in the complexity of managing the transition to packet backhaul whilst maintaining existing high quality of legacy services [3].

With today’s hybrid approaches packet data traffic is either carried encapsulated into TDM transport or alternatively it is transported separately over a public internet. Hybrid approaches of tomorrow will reverse the hierarchy by carrying TDM traffic encapsulated over packet based transport. And eventually 2G networks will be turned off allowing for the pure packet transport network for Mobile Broadband. The gradual transition from hybrid architecture to pure packet protocol architecture as shown in Fig.3 is the driving force behind key trends in Mobile Backhaul transport evolution [4].

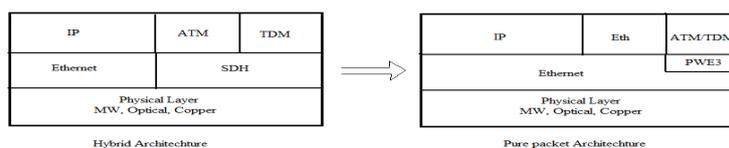


Fig.3: Migrations from hybrid architecture to pure packet protocol stack.

5. Flat IP Network Architecture

To support multi-service traffic with cost effectively, to increasing transport bandwidth capacity for data services by widening frequency band of carriers, maximizing efficiency for bandwidth utilisation, providing carrier grade manageability and survivability and architectures like Flat IP network architectures are the main requirements in mobile backhaul network.

The term flat IP architecture can be applied to a network where all the nodes can reach each other via IP connectivity. A flat IP architecture can be applied to a network where the radio and routing functionality is pushed to the edge of the network. The end-to-end connectivity is achieved through a packet-based core network. Technologies such as LTE are based on a flat IP architecture. One of the main advantages of using IP-based networks is the capability to transport different traffic types over a common IP/MPLS-based infrastructure in addition to providing QoS guarantees and security requirements, low latency, low cost thus reducing total volume of equipment used [3].

6. Design Considerations for IP Based Mobile Backhaul Network

Following are the designed considerations for IP based mobile backhaul network.

6.1. VLAN Models

The traffic in the backhaul can be separated either based on services or location into tagged frames and untagged frames. Tagged frames can be location and service tags (Q- in- Q) or only location based tags. Considering untagged frames, the BTS is not capable of tagging the frames with the appropriate location or service information. The appropriate location and service VLAN tags are added on the cell site device.

6.2. CoS

In general, services signalling, user plane transport, and management traffic can be classified, prioritized, and scheduled using CoS. The mobile backhaul network needs to be capable of recognizing the CoS settings, doing any re-marking of packets if required, prioritizing between the packets, and applying CoS rules to the different traffic streams. Backhaul networks need to be able to support the main traffic types—voice, video, network signalling/management, and best-effort data and also be able to providing low packet loss.

6.3. Transport and Services

MPLS and pseudo wires are used as the transport mechanism in both the IP/Ethernet and hybrid types of mobile backhaul networks. The advantage of using MPLS for transporting pseudo wires is that it is agnostic to the transport media and more scalable than pure Layer 2 networks. Loops and flooding can be avoided. A Layer 3 network can solve such an issue since the routing information is obtained from the control plane, thus making it more deterministic. Layer 3 networks offer reliability, convergence of services (2G/3G traffic), QoS, OAM, inherent security and synchronization. MPLS (and pseudo wires) can support transport of multiple technologies such as ATM, TDM, and Ethernet over the same physical links. MPLS protection schemes ensure faster convergence and failure detection times.

6.4. Synchronization

Clock synchronization in a mobile backhaul network is an essential requirement for handoff support, voice quality, and low interference. Loss of timing synchronization can result in poor user experience, service disruptions, and wastage of frequency spectrum. Hence, timing in a mobile network can be distributed by using GPS or a legacy TDM network that is external to the IP-packet based network, Packet-

based dedicated streams (IEEE1588- or NTP-based), using Synchronous Ethernet over the physical layer, adaptive clocking, DSL clocking. Thus clock synchronization is obtained.

6.5. Reliability and Fault Detection

Fault detection mechanisms need to be in place at different levels of the network. OAM can be used to detect failures at both Ethernet physical and link layers. MPLS protection schemes offer options such as make-before-break, and link- and node-level failure detection with better convergence times. All these schemes enable faster detection, notification, and recovery from failures; thus increasing the reliability of the network.

6.6. Network Configuration and Monitoring

It is essential to use software tools that provide ease of network provisioning, management, and monitoring. The tools need to be able to maintain a database of the network node information in order to support configuration and monitoring.

7. Methodology

It is nothing but the migration steps from legacy backhaul networks towards carrier Ethernet technology along with maintaining backward compatibility. There are scenarios considered under two cases when migrating from existing legacy networks to Carrier Ethernet. The initial scenario mainly depends upon the extent of Ethernet support available on the BTS. Irrespective of the level of Ethernet support, the migration path involves an intermediate step of a TDM/ATM/ Packet hybrid backhaul. This is shown in Fig.4. The hybrid nature of the backhaul will depend upon either using an interworking function between the BTS and BSC or running a dual TDM/Ethernet stack on the BTS and BSC [1] [3].

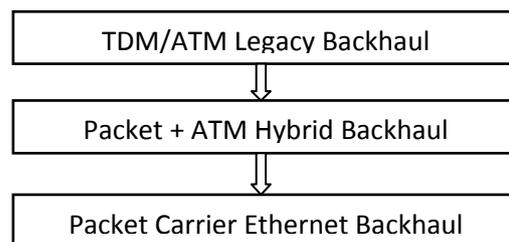


Fig. 4: Migration from legacy backhaul network to packet carrier Ethernet backhaul.

7.1 Case I: BTS with no Ethernet Support

In this scenario, both the BTS and RAN NC in the mobile core do not have native Ethernet interface support and so cannot be directly connected to the Carrier Ethernet network. An interworking capability is required to be able to connect the TDM/ATM interfaces on the BTS and RAN NC to the Ethernet network. This scenario mainly pertains to the migration step where both legacy and Ethernet technologies need to be supported [1].

Option 1: Run IP/Carrier Ethernet in Parallel to TDM/ATM Backhaul.

In this scenario, low-priority high-bandwidth traffic can be offloaded from the legacy TDM/ATM network to the Carrier Ethernet IP network for scalability purposes. For example, the IP packet portion of the network can be used for data transport while 2G/3G voice traffic can be sent over the TDM portion of the backhaul. In this case, an interworking function between the legacy technology on the BTS, such as TDM/ATM, and the Carrier Ethernet is required in the RAN.

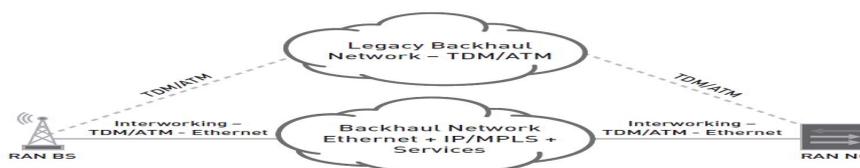


Fig. 5: BTS with no Ethernet support: Run IP Ethernet in parallel to carrier TDM/ATM Backhaul.

Option 2: Emulate Native Service over Ethernet Using PWE.

This option requires the use of an interworking function but all the traffic between the BTS and RAN NC is carried over the Carrier Ethernet network. The native TDM/ATM service can be carried over Ethernet using pseudo wires for circuit emulation. Figure shows a logical representation of the TDM/ATM traffic and Ethernet traffic being carried over the Ethernet backhaul required in the RAN.



Fig. 6: BTS with no Ethernet support: Emulate native services using Ethernet using PWE.

7.2 Case II: BTS Supports Ethernet in Addition to Legacy Technology

In this scenario, the BTS and RAN NC are capable of supporting both Ethernet and the legacy technology. This leads to the options of either using the legacy network in conjunction with Ethernet or just the latter [1].

Option 1: Using both Packet/Ethernet and Legacy Technologies

In this case, the RAN nodes are equipped with dual stacks to support TDM/ATM and packet traffic. The legacy technology is used alongside with the Ethernet network. Figure illustrates this option. Low-priority high-bandwidth traffic can be offloaded from the legacy TDM/ATM network to the Carrier Ethernet network for scalability purposes.

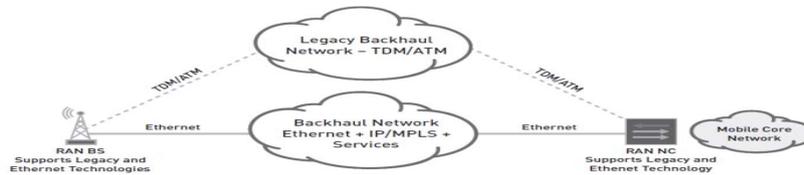


Fig. 7: BTS with Ethernet support: using packet/Ethernet technologies and legacy technologies in parallel.

Option 2: Use Packet/Ethernet All Through Backhaul

In this case, the BTS and RAN NC can support Ethernet and are directly connected to the Carrier Ethernet network. All traffic is carried over the Ethernet network.

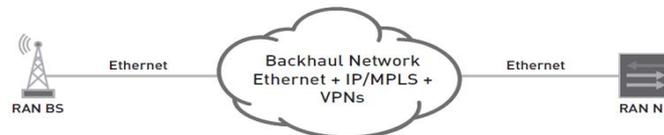


Fig. 8: BTS with Ethernet support: use packet/Ethernet all through backhaul

8. Conclusion

A few years after the deployment of HSPA, the volume of mobile packet data traffic has exploded to the point where it has now exceeded circuit-switched traffic. Furthermore, with the coming deployment of LTE and 4G mobile systems, it is expected to increase even more. To cope with the changed traffic composition, operators need to migrate their legacy TDM networks to packet-switched backhaul networks capable of supporting high volumes of packet traffic while maintaining low OPEX. Inspection of the different migration options shows that there is no silver bullet solution or single migration path that fits all types of networks. Operators need to make careful analysis of their deployed networks, present and future traffic demands, link technologies, and capability to support TDM, packet, and hybrid traffic.

9. References

- [1] Zere Ghebretensaé, Janos Harmatos, Kåre Gustafsson. "Mobile Broadband Backhaul Network Migration from TDM to Carrier Ethernet"- *IEEE Communications Magazine*, October 2010.
- [2] Peter Briggs, Rajesh Chundury, Jonathan Olsson, "Carrier Ethernet for Mobile Backhaul" *IEEE Communications Magazine*, October 2010.
- [3] Orawan Tipmongkolsilp, Said Zaghloul and Admela Jukan, "The Evolution of Cellular Backhaul Technologies: Current Issues and Future Trends" *IEEE communications surveys & tutorials*, accepted for publication 2010.

- [4] .Sherif R. Sherif et al“On the Merits of Migrating From Legacy Circuit-Switched Cellular Infrastructure to a Fully Packet-Based RAN Architecture” *Journal of Light wave technology*, vol. 27, no. 12, June 15, 2009
- [5] S. Chia et al., “The Next Challenge for Cellular Networks: Backhaul,” *IEEE Microwave*, Aug.2009.