Development of Mobile Backhaul and Transport Demands

Maja Kukulovska[1] and Liljana Gavrilovska[2]

Abstract – **Transport demands for migration towards the packet mobile backhaul are one of the most interesting topics nowadays between telecom operators that are planning and investigating the demands for introducing packet backhaul through their network. Broadband access no longer means fixed connection. Recently, broadband services are also offered by mobile operators. Fundamental objective of LTE is to offer higher data rates, with reduced packet latency that delivers more responsive user experience, especially for interactive services. This paper summarizes the implications on transport network of introducing packet backhaul and provides comparisons to available access technologies. This paper presents practical results from measurements using monitoring tools (IP monitor and HP Business availability center).**

Keywords – **LTE, mobile backhaul, transport demands.**

I. Introduction

New services, applications and forms of communication in everyday life are key drivers for implementation of new mobile technology that will enable additional revenue for the mobile operator. New technologies enable mobile systems to become compatible with fixed systems according to the performance, including bit rate to the customer. New generation of mobile networks enable bit rates up to 100Mbps. The scientific communities have been increasingly working on defining the next generation of mobile systems. Possible candidate for next generation are LTE and LTE-advanced, defined by GSM Association. The large number of installed 2G/3G systems drives the need for continued support of legacy TDM backhaul in the years to follow, but on the other hand new technologies require new backhaul that will enable larger throughput. Therefore, smooth migration has to be done in order to lower the total cost of ownership for the operator. LTE offers a smooth evolutionary path to higher data rates and lower latency.

The paper is organized as follows. Section II briefly describes the transformations of the networks, technologies and services. Section III elaborates the consequences and opportunities that arise from introduction of packet networks instead of legacy TDM networks. It covers access technologies, comparing their round trip time and jitter. Finally, section IV provides some strategy guidelines towards the best migration scenario.

[1]Maja Kukulovska is with Makedonski Telekom AD, Kej 13-ti Noemvri 6, Skopje, R. Macedonia; e-mail: maja.kukulovska@telekom.mk

[2]Liljana Gavrilovska is with Faculty of Electrical Engineering & Information Technologies, Ss. Cyril and Methodius University, Skopje, R. Macedonia; e-mail: liljana@feit.ukim.edu.mk.

II. Technologies and Networks Transformation

The mobile networks as primary choice for voice and data communications are looking for new backhaul solutions. Mobile technologies are classified in different generations (2G/2.5G/3G/4G). Every generation brings new services, higher data rates and larger capacity. Different standardization bodies and forums (3GPP/3GPP2/ETSI/ITU) approve standards and recommendations for advanced technical solutions to support every new generation.

The Figure 1 presents the transformation of the cellular concept and the mobile networks during the years.

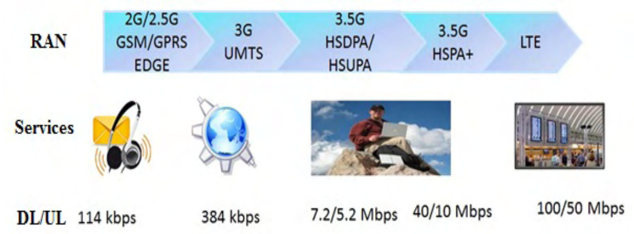


Fig. 1. Networks' transformation

Over the last decades, radio technologies have rapidly progressed and involved. Everything started with simple devices that were used for traditional voice and new service at that time. These services required only 114kbps. But after a process of market saturation from the traditional services mobile operators searched for new advanced services that were supposed to help them in order to increase the revenue.

This evolved into 3G where new sophisticated handheld devices were introduced. These devices brought larger bandwidth requirements for the new services (e.g. web browsing, video streaming). These new services required larger bandwidth and were introduced on the market with new technologies, such as UMTS (Universal Mobile Telecommunications System). UMTS enables up to 384kbps for R99 handsets, 7.2Mbps for HSPA (High Speed Packet Access) devices and up to theoretical data Speed Packet Access) devices and up to theoretical data transfer of 40Mbps using HSPA+ in the network.

With introduction of LTE (Long Term Evolution), next generation of technologies were presented to the market that require packet networks to provide, theoretical data rates up to 100Mbps. Simple SMS and e-mail communications were replaced with faster connections that enable real mobile applications, real time video, music and other multimedia applications. 4G networks are approaching data rates providing by fixed broadband access technologies and customer experience of traditional DSL and cable connections.

III. Packet Backhaul's Implications on Transport Network

Every new mobile technology is opening new revenue and business opportunities for operators to satisfy user's expectations of continuous connectivity. According to the latest estimation from Cisco visual networking index [1], by 2016 global IP traffic will reach 1.3 zettabytes annually with about 3.4 billion Internet users, which is more than 45% of world predicted population. This indicates that number 1 driver for new backhaul technology is traffic. The bandwidth increase primary will be on best effort data user's services.

The growth of mobile data traffic surprises the mobile operators. In their predictions, data traffic volume is growing, while in same time the revenue per megabyte declines, due to increased competition and offers for flat prices. In order to be more competitive on the market, mobile operators have to be prepared not only for new transport and backhaul demands but also for the new technology. Correspondingly the growth in traffic should be translated into an opportunity for new revenues.

New data rates and capacities introduce problems in the mobile backhaul networks for the providers. This will require not only bigger capacities in the transport network, but also fundamental shifting from legacy TDM transport to packet transport necessary for 4G. The impact of 4G to mobile backhaul transport is important for development of efficient and cost-effective transport solution that will satisfy expectations of mobile operators for performances (delay, jitter, and synchronization), availability and costs.

Ethernet/IP technology is the most suitable solution for upgrade of existing mobile TDM backhaul between base stations and core networks.

A. Packet backhaul implications on transport network

Although there are advantages from using of Ethernet, it is necessary to define changes that need to be done on transport network in order to be prepared for new demands. It is necessary to fulfill following functionalities in order to have competitive packet backhaul:

Capacity: the required throughput to the base station these days is around 30-40Mbps, but it is expected that with LTE introduction it will be at least 100Mbps. Therefore, the adopted solution has to be scalable in order to support flexible extension of the capacity;

Latency: The solution has to support low latency. For LTE e2e latency has to be up to 10ms;

Quality of service: Services offered by mobile networks are treated on an end to end basis. Therefore, the mobile network, transport as well as backhaul, have to be able to mark different CoS (classes of services) and perform prioritization of packets. This prioritization will decrease the packet loss in the network. Mobile technology standards define classes that can be used for traffic classification, but do not define how many classes should be used. The total number of classes depends of network implementation as well as traffic profile. A common implementation uses 4 classes (high, medium, low and best effort);

Synchronization: With traditional legacy TDM backhaul, frequency synchronization is obtained via SDH/PDH transmission networks. Basic difference between traditional legacy networks is that they are synchronized, while the new IP network is non-synchronized. Ethernet is not intended for transport of synchronization that is crucial for existing applications, especially in cases where there is need for emulation between TDM and backhaul network. Migration to all-IP packet network means loss of existing traditional clock source. Real time content, especially voice has to be synchronized in order to maintain mobile voice quality, enable handoffs and prevent possible dropped calls. Loss of synchronization will result in bad user experience, problems with billing and usage of extra frequency spectrum. Several standard solutions have been designed to deliver synchronization over packet based backhaul and transport network: Network Time Protocol, Precise Time Protocol – IEEE 1588v2, Synchronous Ethernet. Each of these has its own capabilities, strengths and weaknesses. Time accuracy to the base station should be around 50ppb (parts per billion) according to the G.8261 [2, 3].

A. B. Packet based enabling access technologies

For the existing 2G/3G systems there are few available access technologies that can be used for packet backhaul. The type of connection that will be used in the backhaul network depends of the RAN technology and other factors such as base station, throughput requirements etc. Therefore, backhaul network consists of one or combination of physical mediums and transport mechanisms, as illustrated on Figure 2.

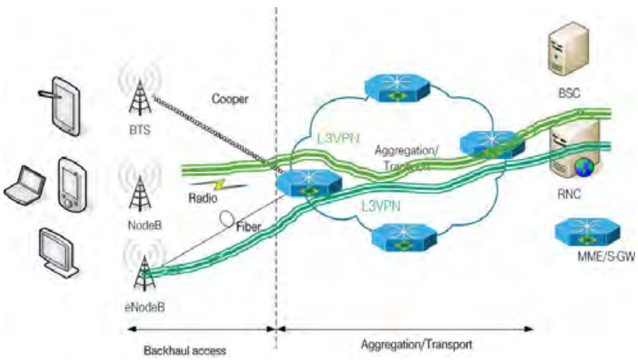


Fig. 2. Backhaul access and transport network

Nowadays, there are three available access technologies that can be used in mobile backhaul: copper, fiber and microwave. On the global market, more than 50% of the installed capacity is radio technology based. [4]

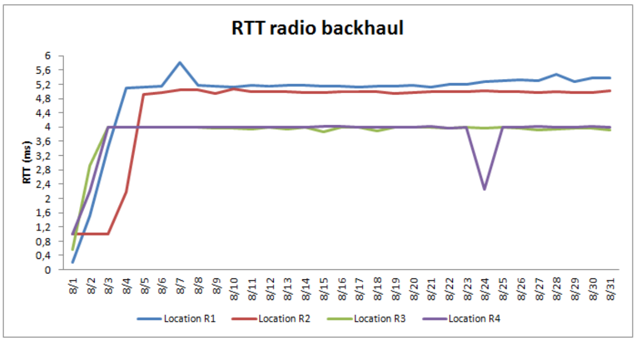
Copper. It is envisioned as migration access technology due to the fact that is capacity limited, since E1/T1 leased lines can offer up to Nx2Mbps, DSL technology can offer up to 20Mbps, while EFM (Ethernet in the first mile) can offer up to 60Mbps. Disadvantage of EFM solution is that it consumes large amounts of existing copper, and the performance varies with copper plant quality. This technology will be useable until 2014, due to the fact, that it is not scalable. After this period, its usage will significantly decrease since the base stations will require much higher throughput than this technology can offer.

Fiber. It is the most reliable transport medium that has almost unlimited capacity (up to NxGbps). Optical connections are smoothly replacing copper connections. They are mainly available in urban areas, since the deployment in rural areas incurs large cost. This alternative is usually time consuming and does not provide the necessary flexibilility required by LTE.

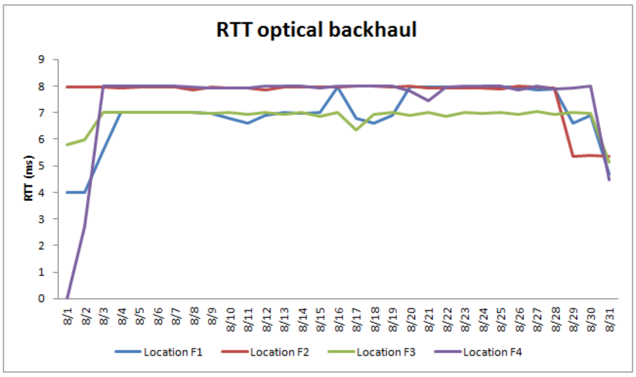
Microwave technology. The most adequate alternative since it enables maximum capacity and smaller operational expenditures. Microwave technology can offer different mechanisms for optimization like redundant links, number of hops, adaptive modulation, CoS, etc. Since the installation of the microwave-based technology is relatively easy, implementation is fast. One of the main advantages of using microwave in backhaul is that it uses the frequency spectrum more effectively with lower costs. Operators use the licensed and expensive, lower frequency spectrum in order to interconnect mobile devices with base stations, while using higher frequencies, for interconnection of base stations among each other and with core network. By using microwave technology the operators can also deploy infrastructure on locations where neither fiber nor copper is available like roofs, mountains and other inaccessible locations. However, this alternative has some disadvantages like varying weather-dependent network capacity and line of site requirements.

A combination of access technologies is necessary to implement in order to interconnect some base station with central office. On the other hand, while high costs of fiber deployment and low terrain availability in rural areas are significant barriers for optic. The experience has shown that for the Greenfield location for base stations, optical connection are more cost effective for short distances up to 500m, while in rural areas microwaves are more cost effective for distances around 1,6km. After 2,5km optic connection is costly solution. The latest practical tests have shown that microwave is faster than fiber that is illustrated in the Figure 3.

These tests were done on real telecom provider network with topology presented on Figure 2. Two different L3VPN services implemented through IP/MPLS packet core network but different last mile technology were analyzed. The tests were performed using shadow routers and monitoring tools, HP Business availability center and IP monitor. The shadow routers were used instead of existing provider edge routers since they are used for other customer services. Using of shadow routers also enables better flexibility in changing of IP SLA (service level agreement) probes without interrupting all other services in the real network. During the phase of testing following parameters were analyzed: source and destination delay, round trip time delay and jitter. In order to have more real pictures different scenarios regarding last mile technologies, distance from central office, urban vs rural environment, throughput of the links were analyzed. In general the received results can be divided in two main scenarios a) microwave and b) fiber.

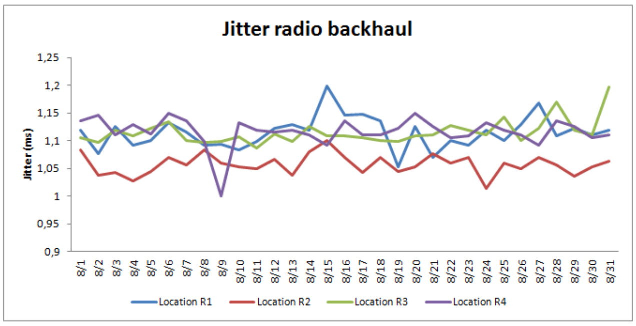


(a) Microwave

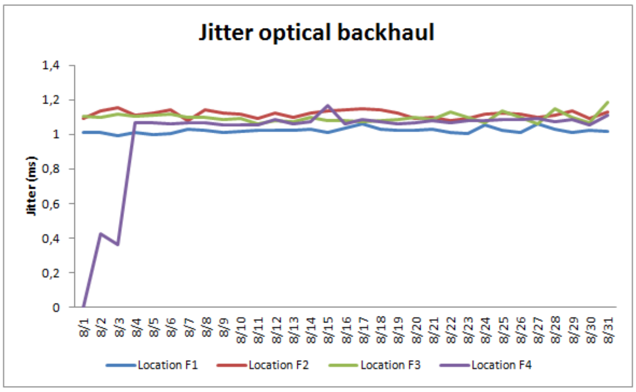


(b) Fiber

Fig. 3. Round trip time for a) microwave b) fiber access technology



(a) Microwave



(b) Fiber

Fig. 3. Jitter for a) microwave b) fiber access technology

These tests are illustrating the performance of the transport network and different access technologies since it is measured starting from the access where demarcation point is located and interconnected to aggregation network using microwave or fiber through transport/core network and vice versa. The microwave is almost 50% faster than fiber and there is smaller variation in the delay (jitter) compared to the fiber. The results demonstrate that the observed transport network is satisfying the necessary criteria related to round trip time delay and jitter.

IV. Migration Scenario

There is no single migration path that can fit to all different operators' requirements [5, 6, 7]. Transport technology should follow all requirements as mobile backhaul migrate from legacy TDM to packet infrastructure described above. There are two main scenarios for migration from legacy networks to Ethernet. Which of these scenarios will be used depends mostly on the type of base station and the availability of Ethernet interfaces.

The hybrid backhaul offloads data traffic originating from new data services that require large bandwidth into a separate dedicated data transport network, while continuing to use existing transport network (PDH/SDH) for voice traffic.

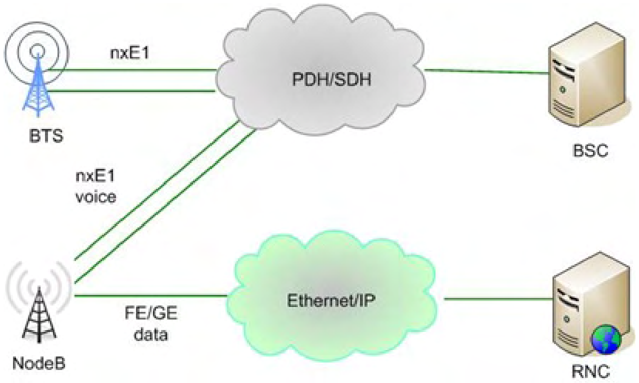


Fig. 4. Hybrid backhaul scenario

The full packet backhaul creates unified, converged transport network that is equally suitable for transportation of new data services and existing voice services.

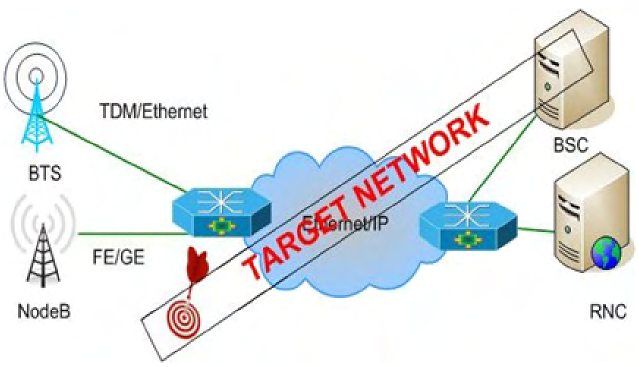


Fig. 5. Full packet backhaul scenario

The full packet backhaul is future proof and preferable solution from provider's perspective. This network design is target for all operators. But this scenario requires support of synchronization through packet network. In terms of synchronization, most suitable solution is a combination of both, SyncE and 1588v2. Since SyncE requires each node in path to be SyncE enabled and at the moment almost more than 50% of installed equipment in service providers do not support SyncE, It is recommended SyncE to be used in the core network while 1588v2 to be used in access network.

After enabling SyncE equipment (which will require some time and money), service providers can implement end to end SyncE as future proof solution for synchronization through packet networks.

In the first stage, capacities up to hundreds Mbps will be enough to satisfy the demands per base station, but in near future these demands will increase, thus it is recommended to implement access network with 1Gbps interfaces in order to be scalable and flexible for implementation of new services and meeting new customer demands.

V. Conclusion

Driven by the development of data services, network convergence as well as need for new services, migration to IP base stations i.e. IP backhaul started even though LTE is still not implemented by most of the mobile operators. Evolution to packet backhaul seems to be ideal way for going forward, since Ethernet has lower costs and optimized operational costs.

Fixed operator has to offer less expensive and scalable backhaul alternatives for mobile operators than the traditional E1/T1 connections. To be more flexible in rollout of new services, to meet new requirements, especially with migration of mobile voice traffic into packet networks, service providers need to evolve their infrastructure, implement new features and improve the network. Thus service provider can offer more cost efficient, higher capacity Ethernet backhaul alternatives to the mobile operators.

References

[1] Cisco Visual Networking Index: Global Mobile Data Traffic Forecast Update, 2011–2016
[2] ITU-T Recommendation G.8261/Y.1361 "Timing and Synchronization Aspects in Packet Networks"
[3] Peter Briggs, Ericsson UK, Rajesh Chundury, Ericsson USA, Jonathan Olsson, Ericsson Sweden, "Carrier Ethernet for Mobile Backhaul", *IEEE Communications Magazine, October 2010, pp. 94-100*
[4] Ran Soffer, "Microwave wireless backhaul for LTE networks", Provigent, January 2010
[5] Pramila A, Sasindra M Prabhu, "Migrating to Carrier Ethernet in Mobile backhaul", Tech Mahindra Limited, 2009
[6] Adva Optical Networking, "Mobile backhaul Evolution", Adva October 2009
[7] Zere Ghebretensaé, Janos Harmatos, Kåre Gustafsson, Ericsson, "Mobile Broadband Backhaul Network Migration from TDM to Carrier Ethernet", *IEEE Communications Magazine, October 2010, pp. 102-109*