Use of Microwave Technologies in Carrier Ethernet Services

Abhishek Pawar
ME Student, EXTC dept.
SLRTCE, Mira Road
abhishek.pawar@vit.edu.in

Prof.Aboli Moharil
Asst. Professor, EXTC Dept.
SLRTCE, Mira Road
deshaboli@gmail.com

Abstract: The main goal of this paper is to provide telecommunication networking professionals,developersand researchers an overview ofhow modern Microwave Technology (Terrestrial Microwave) has become an efficient alternative to Fiber optics and Copper when deploying Carrier Ethernet Services in access networks.

***Index Terms* -**Microwave,Carrier,Ethernet,Access Networks

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I. INTRODUCTION

Customers increasingly want more bandwidth and better service quality to meet their application needs. Carrier Ethernet services are frequently the best selection to meet these requirements. This paper provides an overviewof how modern Microwave technology provides an efficient alternative to copper and fiber in the access network.Some of the characteristics of Carrier Ethernet that make it attractive are:

- Easy to install and use
- Cost effective to buy and operate
- Allows for service flexibility

Carrier Ethernet services are provided over the widely available and wellunderstood IEEE defined Ethernet interface. This interface is inexpensive,standardized and enables subscribers to add bandwidth incrementally, ifneeded. Ethernet services offer a flexible method for enterprises andindividuals to connect remote offices, suppliers and business partners with theQoS and reliability their applications require.

Microwave technology is increasingly used to provide Carrier Ethernet. The main advantages of Microwave based Ethernet solutions are:

- Rapid deployment time
- Cost effective when compared to other approaches
- Offers throughput that rivals fiber for many applications
- Mature carrier-grade solution

Because it uses radio spectrum instead of physical connective it eliminates “right of way” issues that complicate installation of fiber or copper media. In many environments, Microwave can provide the lowest cost per bit fortransporting Ethernet services. It is a competitive choice for capacities, up to 1 Gigabit per second and with ongoing developments in Microwave technology we expect to see capacity expand to several Gigabits in the near future.

However, many misconceptions exist regarding Microwave technology as an access media for Ethernet services. These misconceptions include: insufficient capacity, weather influenced performance degradation, and concerns about spectrumavailability. Recent developments in Microwave technology and Ethernet services are making these concerns moot and highlighting other benefits of Microwave technology in access networks.

II. THE EVOLUTION OF MICROWAVE

There are significant benefits to using Microwave in the access network. Gigabit capacity is achievable today. This capacity is sufficient for most Carrier Ethernet applications. Two growing applications, cellular backhaul and business services can both be served with Gigabit capacity. Microwave performs over the distance ranges required for most accessnetworks. From a few hundred feet to many miles, microwave is capable of delivering Gigabit Ethernet services in the distances that service providers require to reach subscribers.A common assumption is that Microwave requires a clear line-of-site to performadequately. This is still the case for predictable Microwave operation in licensed frequency bands. However recent technical developments enable Microwave to function in many non-line-of-sight applications in lower unlicensed frequency bands.Today the primary application for Microwave technology is the backbone of cellular traffic from mobile base stations. More than 60% of the worlds existing Mobile base stations are connected via Microwave. Historically PDH and SDHhave been the protocols used to backhaul voice services for GSM and WCDMA systems.

Typically, copper or fiber is used for connectivity in access networks. However, there are instances where these physical media are problematic. Right-of-way was mentioned previously. This refers to instances where it is difficult, costly, or impossible, to pull wire into a subscriber location. Reasons for this may include: lack of legal jurisdiction to cross private property, physical impediments to wire such as water, roads or topology or concerns with security of the media due to interference from human or environmental factors. In these cases Microwave provides a compelling option for connecting subscribers in the access network to facilities and services available in Central Offices and different locations.

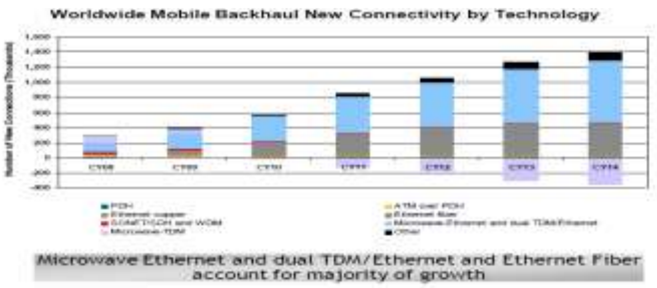

Figure 1. How Ethernet-based Microwave backhaul connections will increasingly take the place of legacy-based Microwave backhaul connections (i.e. PDH E1/T1).

III. TODAY'S MICROWAVE TRANSPORT APPLICATIONS

There are two types of Microwave equipment being deployed today, Packet and Hybrid Microwave. They are used in both fully packet oriented networks as well as networks that transport both TDM voice and packet data traffic.

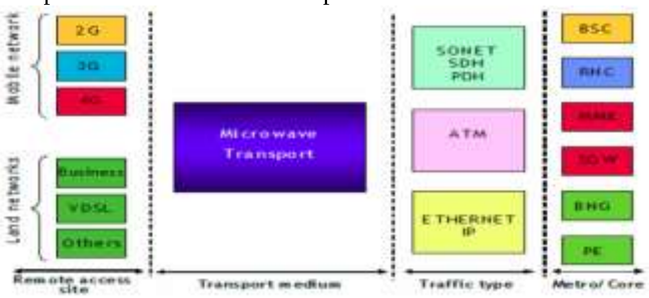

Figure 2.Types of Technologies connected to a Microwave infrastructure

One of the primary uses of Microwave transport applications is connecting customers to core nodes. Figure 2 above illustrates the types of technologies that are often connected to a Microwave infrastructure. The left side of the figure illustrates the type of customers typically connected to a microwave transport infrastructure.

- Mobile access, belonging to the different generations of mobile services
- Fixed devices (corporate customer-edge or remote VDSL units) to connect
- users to fixed broadband access)
- Customer premises equipment (CPE)

The right side of the figure illustrates connections in the core nodes:

- BSC, RNC and MME/SGW for mobile services (2G, 3G, 4G respectively)
- BNG for fixed broadband access
- PE router for business applications

Similarly Microwave transport applications enable connections to and from remote sites as part of an aggregation and/or distribution network for other traffic types. A partial list of these applications includes:

- Broadband networks to support the conversion to digital television
- Broadband networks to support DSL access in rural areas, overcoming the
- distance limitations of the DSLAM and broadband backbone
- Back up routes to Fiber for network protection
- Extend network reach to remote locations or as an alternative to Fiberbackbone networks

These applications are becoming more important as service providers supportrich media applications like: video, video surveillance, video conferencing, E-Learning,VoIP and disaster recovery. The growth of these applications andcellular backhaul is contributing to a growth in Microwave deployments.

IV. TECHNICAL DEVELOPMENTS THAT IMPROVE MICROWAVE TRANSMISSION

Carrier Ethernet is defined by the ability to insure quality of service, reliability and manageability. Progress in Microwave technology ensures that Carrier Ethernet attributes are maintained end to end.

4.1 Microwave Aware Transmission

Microwave Aware Transmission (MAT) combines the following 4 features which are available in today's Packet and Hybrid Microwave solutions supporting Ethernet Services. These features are:

- Optimized radio transmission
- Adaptive modulation
- Packet QoS
- Service aware traffic management

4.1.1 Optimized Radio Transmission

Microwaveradio is a flexible and cost-effective alternative for transmission of voice, data, and video services in all parts of a fixed or wireless mobile network, including applications for the backhaul or direct access services. With the scale and flexibility of today's new radio technology, implementing a microwave network is more economical and easier then ever. A typical microwave link can be installed in just a few days.
Optimized Radio Transmission (ORT) refers to the ability to intelligently compress packet transmissions according to the categorization of incoming traffic by type (i.e. CESoE (MEF8), SAToP/CESoPSN, ATM PWE3, Ethernet, etc.)and service (TDM voice, VoIP, real-time service, or best effort data).

4.1.2 Adaptive Modulation

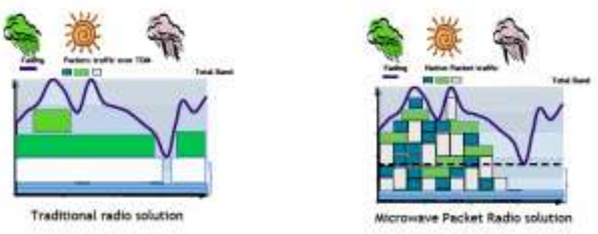

Figure 3.Radio Solution over traditional and microwave packet traffic

Adaptive Modulation is an important new technology for Microwave networks. This technique is used to increase radio throughput by adjusting the modulation profile aspropagation conditions change**.** Figure 3 illustrates how adaptive code modulation technology can automatically adjust modulation modes and dynamically enable service transport according to the performance of air interface channels that might be affected by bad weather conditions.

4.1.3 Packet QoS

TheQoS methods have a somewhat lesser role to play when there is no congestion or physical faults in the network, although they can improve bandwidth utilization and throughput at any level of traffic. But it is at the points of congestion where bandwidth guarantees and priority to certain packets over others become critical.

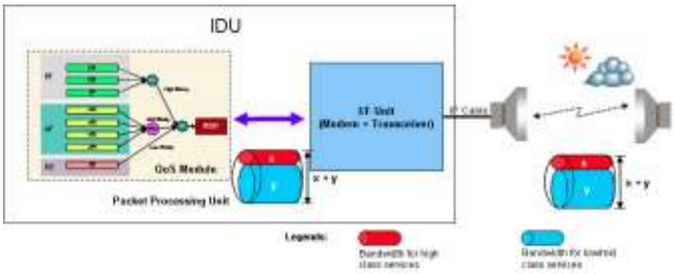

Figure 4.QoS Interface

QoS in Microwave systems can be achieved by combining adaptive modulation technology and QoS mechanisms that adjust traffic management policy in real-time based on the performance of the air interface as shown in Figure 4.Microwave systems have the ability to adapt traffic throughput to the availablebandwidth by discarding packets according to standards based QoS markings performed at PWE3/MPLS level or at Ethernet level. When the full bandwidth is restored on the air interface the equipment will automatically resume forwarding all packets.

4.1.4 Service Aware Traffic Management

Service aware traffic management refers to the ability to differentiate packets by its type. The transmitted data stream may be composed of T1/E1s, ATM, IP, or Ethernet. These packets may come from multiple sources and may have different quality requirements. For example, ATM traffic from a 3G base station may carry voice (a high priority, real time service) and data (a lower priority and possibly non-real-time service). Service awareness gives theMicrowave network the ability to differentiate, classify, and transmit packets according to class of service markings. Service aware traffic management is used in the transmission process, for example by applying different compression algorithms to specific packet types.

4.2 Increase Data rates

There are a number of approaches to increasing throughput over a microwave link. First, capacity is boosted by higher order modulation. Second, adding more spectrum increases capacity. A third approach combines anumber of microwave carriers into a single Microwave transmission link.
Increasingmodulation makes the radio more sensitive to propagation anomalies such as rain and multi-path fading. To avoid shorter Microwave links the increased sensitivity can be compensated for by: 1) higher output power, 2)larger antennas and 3) more advanced receiver functions such as error correction algorithms. Alternatively Adaptive Modulation can be used for packet based Microwave systems to maximize throughput during all propagation conditions preserving a cost efficient solution.

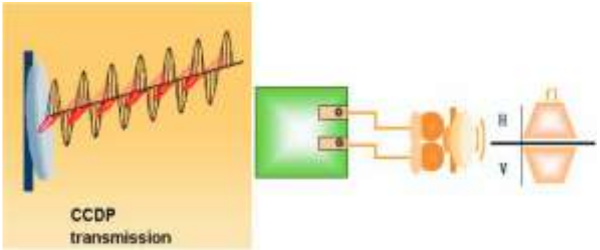

Figure 5.Cross Polarized Channel Configuration

The flexible data rates of packet technology allow microwaves to increase the data rate as much as possible in each channel. Figure 5, illustrates the cross polarizedchannel configuration, enabled by cross polarization interference cancellation (XPIC) technology, to double the data rate without increasing channel bandwidth. Another mechanism used in microwave networks is the ability to transmit indiverse frequencies simultaneously. This mechanism doubles the capacity over the air by using two different transmission channels at two quite different carrier frequencies. The big advantage with respect to using two contiguous carrier frequencies is resilience in case of fading due to bad weather conditions. The usage of very different frequencies implies that bad weather conditions will not impact the two carriers at the same time. So, in case of fading at least one of the two channels is always available.

4.4 Timing/Synchronization Distribution

Figure 6.Packet-BasedTransportation

Figure 6 shows some of the mechanisms used for transporting and distributing time/synchronization across a microwave based network. These include:

- GPS (external mechanism)
- Synchronous Ethernet
- Packet-based clock recovery (i.e. ACR, IEEE 1588v2)

Besides traditional GPS based timing synchronization method, SynchronousEthernet and IEEE 1588v2 can be seen as complementary methods for the transport of timing over a packet network; both are used in practical scenariosfor timing distribution. Adaptive clock recovery may be use to synchronizeT1/E1 circuit emulation.

Microwave radio transmission over the air interface equipment is synchronous and can be used to distribute a timing signal over the air interface and across the network. Microwave nodes supporting synchronous Ethernet can be part of the clock synchronization chain just like other Ethernet nodes that support synchronous Ethernet. In addition, the service aware capabilities of today'smicrowave radios, assure optimal transfer of timing distribution.T1/E1 line clock, recovered from a PDH or SDH connection, as well as Synch-In/Synch-Out signals (e.g. sine wave at different frequencies), are also supported for frequency distribution in hybrid microwave scenarios (traditional PDH or SDH access or aggregation).Today's Microwave equipment can support multiple sources of synchronization. This means that the path through the network from the synchronization source(s) to each network element can be protected with multiple synchronization sources and multiple transport paths.

V. HYBRID MICROWAVE

Hybrid Microwave handles packets and TDM natively (without mapping onto another protocol), transporting multimedia traffic efficiently and allowing operators to launch data services cost-effectively without impacting traditional TDM services.Hybrid Microwave transport is an interesting new choice for operators thatrequire the coexistence of both TDM/ATM circuit services and Carrier Ethernet packet services. The Microwave interface can encapsulate TDM and packet services into a unified Microwave frame prior to transmission. HybridMicrowave supports three types of interface modes: TDM, hybrid (TDM + packet), and packet.

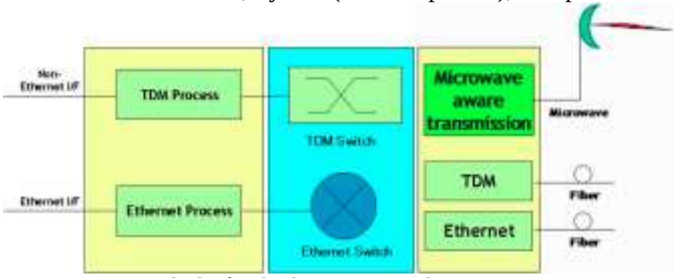

Figure 7.Function Block of Hybrid Microwave radio system

A separate TDM processing unit at the top of the illustration handles TDMcircuits and the Ethernet switch at the bottom of the illustration handles theCarrier Ethernet packets. Then the native TDM and Ethernet traffic streams receive independent allocations of the total available Microwave radio link capacity.A separate QoS handling capability of the Ethernet multiplexer ensuresdifferential treatment of IP/Ethernet packets according to their QoS markings.

Finally, both traffic streams are mixed at the Air Frame Multiplexer on the RF card before being transmitted via the dish antenna to the receiving remote station. This functionality ensures efficient handling of multiservice traffic and aflexible network migration strategy for mobile backhaul networks.

VI. PACKET MICROWAVE

Packet Microwave handles Carrier Ethernet packets natively, transporting multimedia traffic efficiently and allowing operators to launch data services cost-effectively without impacting traditional voice service. With Packet Microwave the operator maintains a single packet network that hosts both TDM and IP/Ethernet traffic.

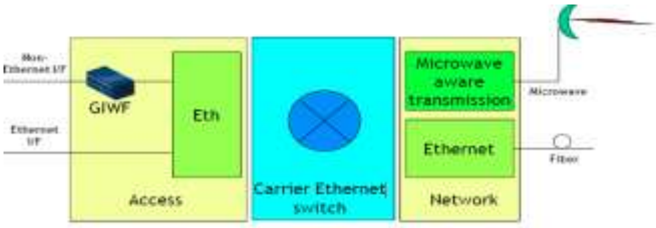

Figure 8.Function Block of Packet Microwave radio system

Packet Microwave converges the Ethernet and Non-Ethernet (e.g.TDM, ATM) traffic over a single packet transport layer called the multiservice aggregationlayer, using industry standard Pseudo-Wire and Circuit Emulation technologies(e.g. CESoE (MEF-8) SAToP/CESoPSN, ATM PWE3; HDLC PWE3 and others). T1/E1, ATM and IP/Eth are carried over a common layer and therefore over one single physical interface, sharing a common packet transmission infrastructure, regardless of the nature of carried traffic. Carrier Ethernet becomes the single convergence transport layer.

VII. CONCLUSION

Microwave technologies are evolving to meet the needs of service providers that seek to offer Carrier Ethernet services. As this evolution occurs, it is desirable to have seamless transport services across the entire network. A Microwave infrastructure that is capable of delivering differentiated CarrierEthernet services provides an important option to enhance overall network reach. Packet and Hybrid Microwave technologies enable efficient transmission of both TDM circuits and IP/Ethernet packets over the same radio link, enablingreliable transport network migration. These new Microwave radio technologies offer cost-effective and innovative wireless transmission solutions for CarrierEthernet services; giving operators a next-generation transport alternative for building voice and data networks.

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