Creating faster, more efficient and more reliable microwave links

With the Nokia 9500 Microwave Packet Radio (MPR) and Multichannel

Application Note

Contents

Introduction

The exponential growth of mobile subscriber traffic and the move to Long Term Evolution (LTE) are putting tremendous stress on mobile backhaul networks, especially on microwave links that comprise more than 50 percent of the backhaul connections globally (Infonetics Research). Increasingly, microwave links have to utilize several scarce radio frequency (RF) microwave channels bonded together to scale microwave link capacity to required levels. Hence, it is critical that approaches used to bond microwave channels together do so with the utmost efficiency to maximize RF, and create faster, higher throughput, and more reliable microwave links.

The Nokia "multichannel" approach to bonding microwave channels together creates faster, more efficient microwave links with higher throughput to address the needs of LTE and beyond. This paper provides an overview of the Nokia 9500 Microwave Packet Radio (MPR) multichannel feature, and the advantages it provides to both maximize microwave link capacity and availability.

Evolution in scaling microwave links

The growth of mobile broadband data services and the transport of IP applications are forcing operators to progressively shift from time division multiplexing (TDM) and Ethernet hybrid microwave systems to packet microwave systems. Packet microwave systems carry all services in a packet format, including traditional services such as TDM and Asynchronous Transfer Mode (ATM), which are adapted to packet for transport across packet microwave links and networks. This approach sets the foundation for new ways to reliably scale microwave link capacity when compared to the scaling mechanisms of the past.

Traditional microwave channel scaling mechanisms

Over the past 20 years the primary mechanism to reliably scale microwave capacity over point-to-point links has been based on traditional Synchronous Digital Hierarchy/Synchronous Optical Network (SDH/SONET) 1:N protection mechanisms. Even today, this approach is still the basis for microwave N+1 protection mechanisms that are widely used by hybrid microwave systems to scale capacity, especially over ETSI microwave long haul links.

Microwave N+1 protection mechanisms have a rigid association between the SDH/SONET container (for example, STM1/OC3) and the related radio channel. Historically, this has lead to channel spacing regulations that accommodate STM1/OC3 capacities. The resulting traditional N+1 protection mechanisms have N channels used to transport NxSTM1/OC3 flows, and a spare protection channel that, when idle, can be used to carry low priority SDH/SONET traffic.

With the introduction of LTE, mobile backhaul networks have rapidly shifted from TDM-based networks to scalable Ethernet and IP packet networks that can satisfy bandwidth-hungry applications and services at a lower cost per bit. This shift is putting scaling pressures on the traditional hybrid microwave point-to-point links and networks. It is getting more difficult and inefficient to reliably scale microwave links with traditional hybrid microwave N+1 approaches. Packet microwave solutions can leverage more efficient microwave link scaling and protection mechanisms based on proven Ethernet link aggregation algorithms to reliably scale capacity.

Ethernet link aggregation group

The IEEE 802.3ad Ethernet standard introduced the concept of a Link Aggregation Group (LAG) — a standardized approach for bonding Ethernet connections together into a larger virtual Ethernet connection and spreading the traffic load between them. LAG also provides for Ethernet connection reliability — if an Ethernet connection fails, traffic is distributed to the remaining working connections in the LAG.

LAG has been proven to be very effective in scaling wireline Ethernet connections, and is widely deployed in this environment. However, to be effective in microwave networks, LAG has to be improved:

- By definition the connections that are part of the LAG virtual connection have to be the same capacity. LAG associates a traffic flow to a physical connection, which can be an issue with smaller capacity microwave channels, especially when they are using adaptive modulation to maximize channel capacity when environmental conditions worsen (for example, a severe storm).
- LAG relies on packet headers for flow identification and the subsequent distribution of flows across the physical Ethernet connections in the LAG. There are some backhaul environments where there is not enough packet header variation to efficiently distribute flows between the connections in a LAG (for example, traffic flows inside IPSec tunnels). The consequence is that all traffic is placed on the same connection in a LAG, congesting one connection, while the other connections in the LAG have available capacity.
- LAG protection is not hitless. When traffic is redirected from a failed connection to an active connection, traffic is impacted.

The Nokia 9500 MPR addresses these limitations with a modified LAG implementation called multichannel, a capability that is contributing to the success of Nokia packet microwave systems globally, and especially in North America where microwave has had to rapidly scale to meet the backhaul needs of LTE early adopters.

Multichannel – a key tool in scaling microwave capacity

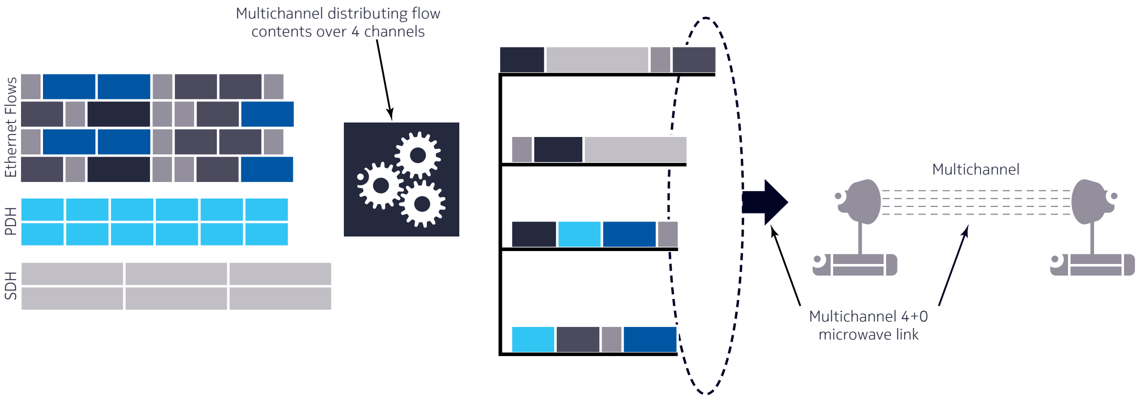
Similar to LAG, the Nokia multichannel is based on the distribution of a set of traffic flows over a bundle of radio channels. Channels operate in parallel; however, they may have different frequency bands, polarizations, and/or channel spacing. Multichannel can bundle together as many channels as a microwave link design requires. The number of channels in a multichannel group is referred to as N+0, where "N" is the number of channels and "+0" means that multichannel, which is unlike traditional microwave protection mechanisms, requires no dedicated protection channel. Rather than having a dedicated protection channel, multichannel links are designed with enough total throughput to handle individual channel failures or reductions in capacity (for example, weather impairments) of underlying bonded channels.

Spare capacity in underlying multichannels is pooled and assigned to traffic flows that need to be redirected from one channel to another because of a failure or weather impairments. This more efficient utilization of the bundle of parallel N+0 channels reduces microwave link and network total cost of ownership (TCO) when compared to traditional N+1 mechanisms which leave one channel effectively empty, and incur the cost of one extra radio per microwave site. The extra radio channel dedicated to protection can also be difficult to obtain in frequency-congested areas.

The multichannel advantage

Multichannel distributes traffic flow contents across the channel group, rebuilding the flows after they are carried across the microwave link. This is done while preserving the correct sequence of the flow contents, and minimizing delay, so as to not impact service level agreements (SLAs). A single high-capacity flow can be distributed across several channels that individually may have a lower capacity with respect to the original traffic flow. For example, a single packetized TDM SDH service no longer requires a complementary sized channel; a bundle of channels with the sum of the required capacity is all that is required. This foundational multichannel trait can be used to create 10 Gb/s, and higher, microwave links.

Figure 1. Multichannel operation – reliably distributing flow contents across a group of channels without breaking SLAs



Because the Nokia 9500 MPR transports all services in a packet format (that is, traditional TDM and ATM services are packetized) it can take full advantage of an adaptive modulation aware multichannel capability:

- **Any service can be carried over a multichannel group**

  Traditional TDM and ATM services can be mixed with Ethernet and IP traffic over the same multichannel link. There is no need to partition and/or constantly adjust portions of microwave channels to support TDM traditional services versus IP and Ethernet services, as is the case with hybrid microwave systems. With multichannel there is no longer a direct correspondence between a channel and a flow — flow contents are distributed over the channels in the multichannel group. Hence, high-capacity flows can be carried over a group of channels that individually have less capacity then a flow requires; a key feature to address cases where microwave channels have to temporarily reduce their modulation level to address environmental conditions that impact microwave channel performance.

- **Hitless redirection of traffic from one channel to the other**

  Radio impairments can affect the propagation of a microwave channel, degrading performance. Multichannel quickly detects degradations in performance, and rapidly takes steps to rebalance traffic so that high-priority traffic SLAs are not impacted.

- **No need to dedicate protection capacity that has to support the bandwidth requirements of the most demanding service**

  Multichannel introduces new link design concepts when compared to traditional N+1 network engineering. Multichannel enables the removal of the traditional N+1 protection channel; instead multichannel introduces the concept of “spare capacity”, capacity that can be dynamically distributed over multiple channels according to individual channel available throughput. Committed capacity for premium services can be met with the dynamic distribution of flow contents over engineered worst case channel capacities (for example, when channels leverage adaptive modulation to move to the lowest order modulation level to address worst case environmental conditions).

These multichannel advantages offer higher performing microwave links when compared to hybrid microwave systems that use traditional N+1 protection mechanisms, even when TDM traffic is the only service that is being transported over a microwave link.

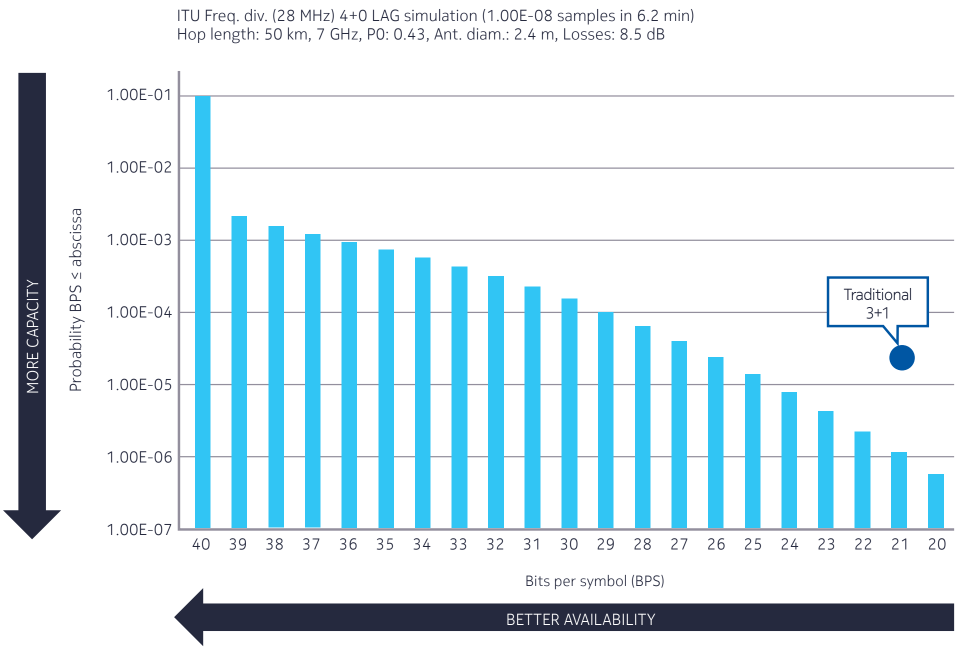
As multichannel was designed to be aware of the changes in throughput introduced by adaptive modulation, maximum channel capacities can be achieved when environmental conditions are favorable to the use of higher order modulation levels. This provides extra capacity above the worst case engineered capacities, and can be used to create faster, higher throughput, and more efficient microwave links and networks.

When a channel is unable to support the highest capacity service/flow in a traditional hybrid microwave system, it is necessary to move all of that traffic to another available channel. In the case of multichannel, the traffic on the channel to be protected (either at its full or residual capacity due to adaptive modulation) can be distributed across other channels, provided that the sum of their spare capacity is at least equal to the capacity required. The probability of delivering the committed traffic throughput is the sum of the probabilities of all of the remaining channel combinations that can provide equal or more traffic than is required to protect the compromised channel (that is, the degradation of one channel can be compensated by the excess capacity available on other channels within the bundle). This approach leads to:

- Faster, higher throughput, more efficient microwave links that can meet, or exceed, the same availability requirements that traditional N+1 deployments provide
- Higher availability for higher capacity traffic flows

With respect to availability, it is instructive to compare the performance of 4 channels in a multichannel 4+0 configuration with the performance of a traditional 3+1 system. In the following figure, multichannel (indicated by blue bars) availability is not a single fixed point, as is the case for the traditional N+1 approach, but can be represented as a series of values corresponding to different capacity levels. Given the same capacity, the availability of a multichannel system is increased when compared to a standard N+1 system. The end result is that given the same number of channels, and the same link availability value, the capacity of a multichannel link is about 20 percent higher than the capacity supported by an N+1 approach. In many cases this advantage translates into requiring one less RF channel, or using a smaller diameter antenna. Regardless of how the savings are achieved, this represents a significant contribution to microwave network TCO savings.

Figure 2. Multichannel versus traditional N+1 scaling and protection



Ultimately, multichannel offers a new, more efficient approach to how microwave link availably is calculated. To facilitate multichannel introduction Nokia has adapted its design tools to support multichannel availability calculations and demonstrate the benefits of multichannel over traditional N+1 approaches.

Even more capacity and reliability

The 9500 MPR capacity tool kit is a set of tools, both at the RF and the packet level, which helps operators solve microwave network scaling challenges. The capacity tool kit includes radio techniques such as Cross-Polarization Interference Cancelation (XPIC) to create two channels using one frequency, hierarchical quadrature amplitude modulation (HQAM), high-system gain radios, advanced packet compression that can be used to increase microwave link throughput by as much as 300, and multichannel.

Multichannel is designed to operate in conjunction with any of the other technologies available in the tool kit, and can be used for both linear and ring network topologies. For example, packet booster and multichannel can be deployed independently or together as part of a broader capacity expansion. However, it is when they are used together that the advantages over hybrid microwave links are even more compelling, and provide the foundation for faster, higher throughput, more efficient links for all services. In configurations which use ring microwave network topologies, multichannel can be deployed in conjunction with the 9500 MPR ITU-T G.8032v2 protocol implementation, an implementation that allows for 50 ms network protection and full exploitation of ring capacity by any mix of services (for example, TDM, ATM, Ethernet, and IP).

NOKIA

Summary

Service providers all over the world have upgraded major portions of their networks to IP and Ethernet packet-based infrastructure. However, many networks still require a microwave upgrade to support IP and Ethernet-based services more efficiently. Nokia is the world leader in packet microwave, and also has more than 60 years of experience and innovation in microwave technology. The Nokia 9500 Microwave Packet Radio solution provides the features required to seamlessly evolve from traditional microwave networks to all-IP microwave networks. This includes support for an efficient, scalable, and reliable multichannel implementation that not only increases link capacity by up to 20 percent, but also increases link availability by up to 1.5 times when compared to traditional microwave channel scaling approaches. Multichannel is part of a wider 9500 MPR network capacity enhancing tool kit that delivers faster, higher throughput, and more efficient microwave networks with reduced network TCO.

Acronyms

ATM	Asynchronous Transfer Mode
BPS	Bits Per Symbol
ETSI	European Telecommunications Standards Institute
HQAM	Hierarchical Quadrature Amplitude Modulation
IEEE	Institute of Electrical and Electronics Engineers
IP	Internet Protocol
IPSec	Internet Protocol Security
ITU	International Telecommunication Union
ITU-T	ITU Telecommunication Standardization Sector
LAG	Link Aggregation Group
LTE	Long Term Evolution
MPR	Microwave Packet Radio
PDH	Plesiochronous Digital Hierarchy
RF	Radio Frequency
SDH	Synchronous Digital Hierarchy
SLA	Service Level Agreement
SONET	Synchronous Optical Network
TCO	Total Cost of Ownership
TDM	Time Division Multiplexing
XPIC	Cross-Polarization Interference Cancelation

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