



# Deploying Mobile Backhaul

Ethernet Microwave Technology Choices for  
Lower OPEX

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This paper focuses on methods for reducing operation expenditure (OPEX) enabled by the shift to advanced Ethernet microwave backhaul solutions. Additional information about microwave technology, Adaptive Coding and Modulation and backhaul networks architecture can be found in Appendix 1 to this paper as well as on Ceragon's web site [www.ceragon.com](http://www.ceragon.com).

### Deliver more bits per leased spectrum

Microwave is the preferred backhaul technology by most of the world's mobile operators. Outside of the U.S.A., nearly 70% of all backhaul traffic travels over microwave links. Microwave is instant, reliable and relatively low-cost. Operators can lease spectrum and deliver several E1/T1s or even STM-1/OC-3s services over the air. But now that data services become more popular, clogging up the backhaul network, service providers turn to look for higher capacities that also offer lower cost per bit.

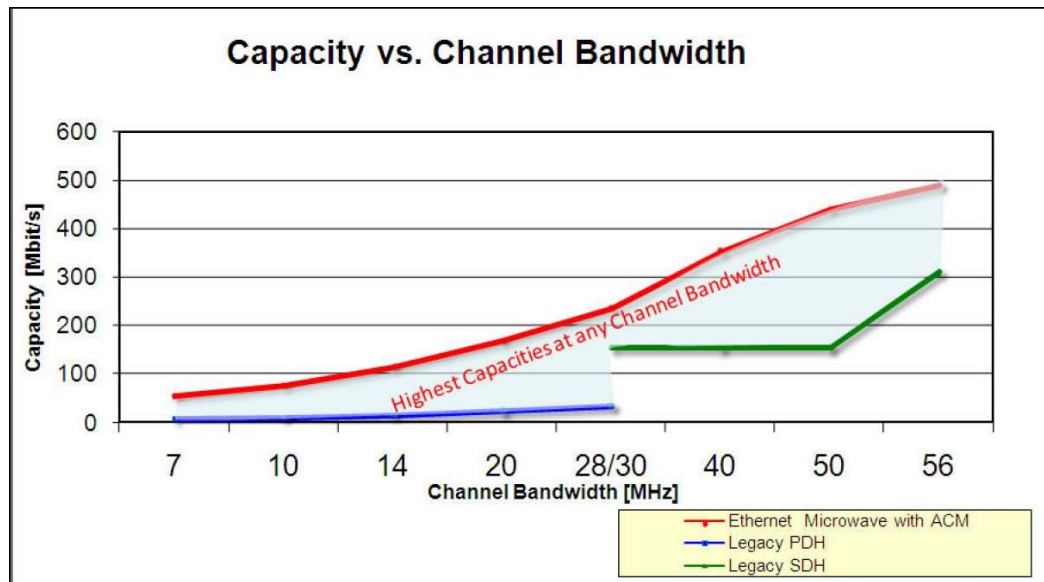


Figure 1: Deliver more bits per leased spectrum

Unlike 2G networks, in which voice was the premium service and almost only service, 3G networks today have to deal with increasing amounts of data. Data services consume much more bandwidth than voice, but generate far less revenue-per-bit. To compensate for that, and to maintain and increase profitability, service providers, need to be able to transport more bits over their given spectrum. In other words, they want much higher network and spectral utilization.

New Ethernet Microwave delivers the promise of higher capacity at a lower cost. By applying a set of techniques from compression to Adaptive Coding & Modulation, and by mapping Ethernet directly over the radio with no overheads, extremely high utilization can be achieved.

The following two examples show how network resources can be better utilized with Ethernet radio. Using a 7MHz channel bandwidth of leased spectrum, a service provider can carry up to 4xE1s / 6xT1s – or 10Mbps. With Ethernet Microwave, an operator can deliver as much as 50Mbps –more than four-times the capacity over the same licensed spectrum. At a 28/30MHz channel bandwidth, up to 236Mbps can be achieved –about 1.5 times the capacity of traditional SONET/SDH that deliver 155Mbps.

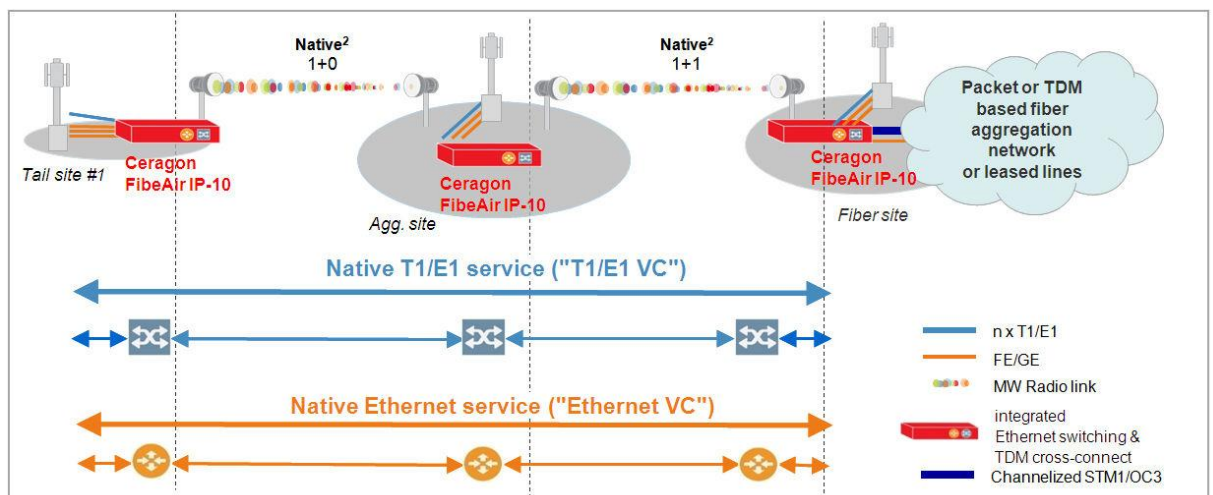
## Manage a single physical network to enable two logical networks

While Ethernet brings the promise of higher capacities at a lower cost, there's still the issue of migrating today's TDM networks to Ethernet. One of the major challenges in any network migration plan is capping investments while reducing operational overheads during the process. This paper suggests such a cost-efficient migration path.

Common deployments of mobile Access backhaul consist of multiple hops in a tree shaped topology. Multiple E1/T1s are then aggregated into an STM-1/OC-3 channel at fiber sites deeper in the network. This type of deployment requires management and provisioning of E1/T1s all the way from one end of the network cloud to the other. But now, the migration to Ethernet requires operators to handle two networks at the same time. So how does that contribute to OPEX reduction?

The total cost of migration can be significantly reduced by utilizing a platform that supports both native TDM and native Ethernet. Such a "Native2" platform eliminates the need to maintain and manage two separate physical networks.

Figure 2 shows a risk free, integrated microwave solution in which a single network device can operate in TDM mode, Ethernet mode, or both. By integrating Ethernet switching capabilities and TDM Cross-Connect functionality both services are managed, concurrently or separately, over the microwave cloud. In other words, two logical networks can coexist over a single physical network at the cost of a single network element. No additional penalties and no incremental costs.



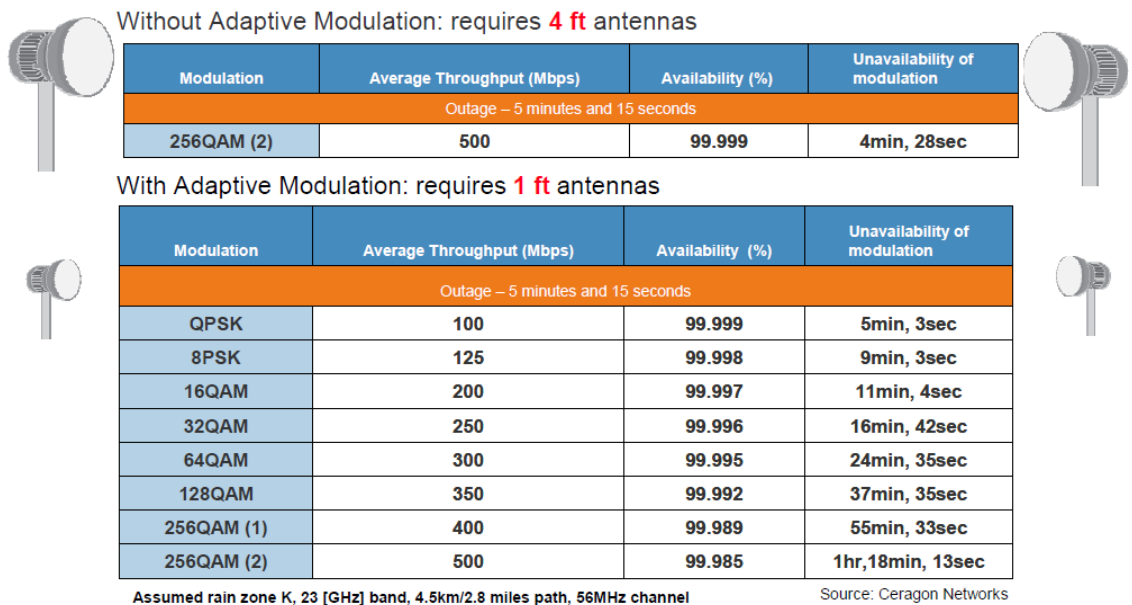
**Figure 2: Manage a single physical network to enable two logical networks**

## Smaller footprint, reduced spectrum licensing fees and lower equipment count

At the end of the day, mobile operators measure the performance of their microwave solutions by the amount of capacity they can deliver and the availability of the service. In the old TDM days, achieving higher capacities and better availability was always coupled with increased expenses. Costs were driven up since capacity increase usually required licensing additional frequency, increasing channel bandwidths, enhancing the modulation, installing bigger antennas, increasing transmission power or employing diversity schemes and different link configurations.

Today, new Ethernet microwave systems that employ Adaptive Coding and Modulation (ACM) help to decouple cost and capacity. Looking at Figure 3 (below), we can see an example of how ACM helps to cut down on OPEX. Smaller antennas cost less to purchase and to operate. Rent fees, for placing antennas on rooftops and cellular towers, can also be significantly reduced (Roof and tower space lease in the US for example is \$100 per foot per month, on average. A simple calculation shows that an operator would have to pay \$4,800 a year for a 4 ft antenna, compared with only \$1,200 for a 1 ft antenna. That's \$3,600 saved every year per antenna, or \$7,200 per link).

With Ethernet microwave the trade-off between antenna and availability (shown in figure 3) becomes almost irrelevant. Ethernet systems allow vendors to differentiate between high priority and low priority services. Since not all services are created equal, there is usually no need to provision the entire network with 99.999% availability. In the example below, 100Mbps is guaranteed for real-time voice and video services, with an additional 400Mbps at 99.99% or 99.985% availability for non-real-time data applications.



**Figure 3: Lower space and lower spectrum lease fees**

## Ethernet Microwave improves the bottom line – Operator X test case

Let us now discuss the issue of availability. To meet availability requirements, radio network planners select and match from given tables of licensed channel bandwidths and modulations (see Tables 1-3 below). Each channel bandwidth carries a price tag –an annual frequency licensing fee operators pay to state regulators. Hence selecting the availability option is not just a matter of quality, it’s also a question of price.

The tables below demonstrate a test case of Operator X who is planning to provide a 50Mbps service. In this particular test case, by using Ethernet Microwave, Operator X has a choice of three different channel bandwidths, 7MHz, 14MHz and 28MHz. Each option requires a different modulation scheme in order to reach the 50Mbps capacity, and results in different licensing fees. Needless to say –the variety of choices is made possible by employing ACM. Without ACM, our operator would have been forced to use the 28MHz channel in which 50Mbps is guaranteed in QPSK.

As already mentioned above, there is no longer a need to provision 99.999% availability across the entire network. Hence, Operator X is no longer forced to choose the maximum availability, but rather the most cost efficient one. Once it decides on the minimum guaranteed bandwidth required for voice and time-critical services, Operator X can enjoy much higher flexibility in its planning process. This would also result in huge savings potential, as demonstrated in the tables below.

7MHz				14MHz				28MHz			
ACM Point	Modulation	# of E1s	Ethernet Capacity (Mbps)	ACM Point	Modulation	# of E1s	Ethernet Capacity (Mbps)	ACM Point	Modulation	# of E1s	Ethernet Capacity (Mbps)
1	QPSK	4	12	1	QPSK	8	26	1	QPSK	16	51
2	8 PSK	6	18	2	8 PSK	12	36	2	8 PSK	22	67
3	16 QAM	8	25	3	16 QAM	18	54	3	16 QAM	32	97
4	32 QAM	10	30	4	32 QAM	21	64	4	32 QAM	42	130
5	64 QAM	12	36	5	64 QAM	24	74	5	64 QAM	53	162
6	128 QAM	13	42	6	128 QAM	29	89	6	128 QAM	64	195
7	256 QAM	16	49	7	256 QAM	34	104	7	256 QAM	70	212
8	256 QAM	18	55	8	256 QAM	38	115	8	256 QAM	75	236

**Tables 1-3: Modulation- capacity performance per channel bandwidth**

Table 4 and 5 below show Operator X’s OPEX savings with ACM. The annual licensing fee per channel bandwidth is represented in US\$ in Table 4. The table also depicts the percentage of links Operator X can shift to a narrower band while still maintaining a 50Mbps service (“Applicability of high modulation”). From the calculation below we learn that Operator X can shift as many as 80% of its links to narrower frequency bands. The savings achieved are calculated in Table 5.

Channel Bandwidth	7MHz	14MHz	28MHz
Band 23 GHz Annual License Fee	\$ 1,294	\$ 2,582	\$ 5,158
Applicability of high modulation	25%	55%	20%

**Table 4: Licensing fee per channel bandwidth**

# of Base station	2,000
Microwave Backhaul (%)	60%
# of Microwave links	1,200
Before ACM annual spectrum OPEX	\$6,189,600
After ACM	\$3,330,240
<b>Annual OPEX saving</b>	<b>\$2,859,360</b>
<b>Annual OPEX Saving in %</b>	<b>46%</b>

**Table 5: Annual OPEX saving for Operator X**

Using this simple calculation – made under relatively conservative assumptions, it is plain to see that a significant portion of the annual licensing fee budget can be routed to the bottom line. Total yearly savings for this relatively small mobile network, amount to \$2.8 million in licensing fees alone.

## Conclusion

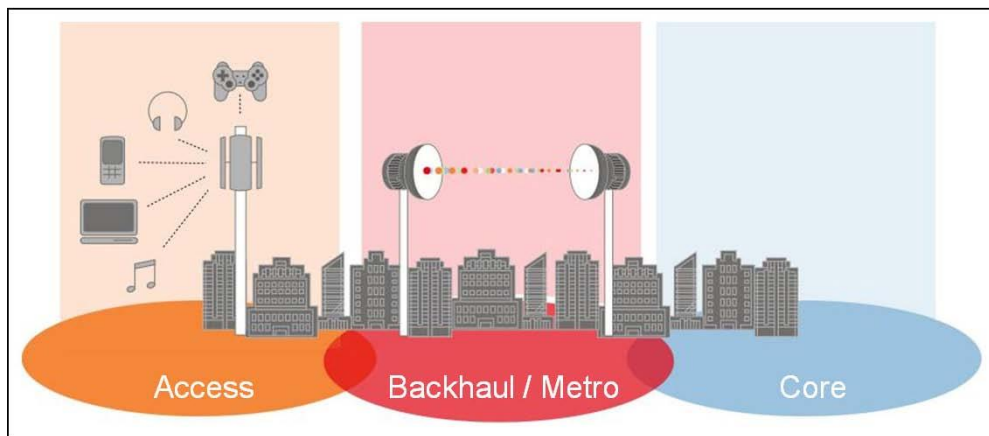
In a cost-sensitive market, any dollar saved on operational expenditure equals one more dollar to the bottom line. Ethernet microwave backhaul solutions that employ ACM power mobile operators with a variety of tools with which to reduce OPEX.

## Appendix A

### Point-to-Point Microwave Backhaul

Backhaul is generally defined as the network components which connect client/subscriber access sections of networks with their core switching and management topologies. It transports considerable traffic from a POP to the rest of the network, and essentially acts as the “glue” that pieces all of the network elements together. This enables the network to deliver seamless and transparent broadband communications to its customers effortlessly, and with high reliability and availability.

Ceragon Networks serves the mobile and fixed backhaul market using high capacity point-to-point microwave technology. More information about Ceragon and its leading FibeAir® solutions can be found at: [www.ceragon.com](http://www.ceragon.com).

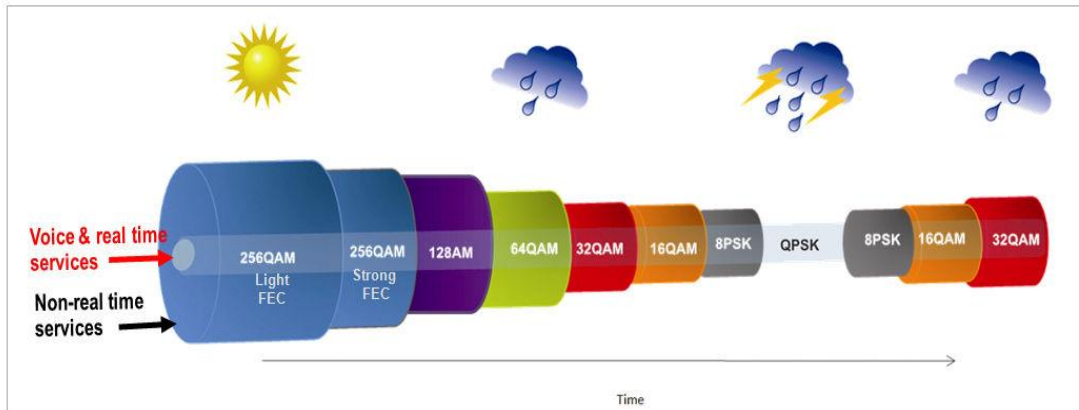


*Figure 4 – generic backhaul application*

### Adaptive Coding and Modulation

Adaptive Coding and Modulation (ACM) refers to the automatic adjustment that a wireless system can make in order to optimize over-the-air transmission and prevent weather-related fading from causing communication on the link to be disrupted. When extreme weather conditions, such as a storm, affect the transmission and receipt of data and voice over the wireless network, an ACM-enabled radio system automatically changes modulation and/or coding allowing real-time applications to continue to run uninterrupted. Varying the modulation and/or also varies the amount of bits that are transferred per signal, thereby enabling higher throughputs and better spectral efficiencies. For example, a 256 QAM modulation can deliver approximately four times the throughput of QPSK (4QAM).

More information about ACM can be found in a white paper titled: “Flex Your Backhaul Network with Adaptive Coding & Modulation” on Ceragon Networks’ website at: [Ceragon\\_Adaptive\\_Coding\\_Modulation\\_White\\_Paper.pdf](http://Ceragon_Adaptive_Coding_Modulation_White_Paper.pdf)



*Figure 5: Ceragon's unique 8- steps Adaptive Coding & Modulation*

## ABOUT CERAGON

Ceragon Networks Ltd. (NASDAQ: CRNT) is the premier wireless backhaul specialist.

Ceragon's high capacity wireless backhaul solutions enable cellular operators and other wireless service providers to deliver 2G/3G and LTE/4G voice and data services that enable smart-phone applications such as Internet browsing, music and video.

With unmatched technology and cost innovation, Ceragon's advanced point-to-point microwave systems allow wireless service providers to evolve their networks from circuit-switched and hybrid concepts to all IP networks.

Ceragon solutions are designed to support all wireless access technologies, delivering more capacity over longer distances under any given deployment scenario.

Ceragon's solutions are deployed by more than 230 service providers of all sizes, and hundreds of private networks in more than 130 countries.

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