

Actelis
Networks

XLR8



Mobile Backhaul

A White Paper





Mobile Backhaul in Ethernet over Copper Networks

A White Paper by Actelis Networks® Inc.



“Actelis is riding the Ethernet wave, earning the #1 market share by selling EFM bonded-copper products to service providers around the world for use in applications such as business connection, DSLAM backhaul, cell site backhaul, and city traffic control.”

*Michael Howard, Principal Analyst and Co-founder
Infonetics Research*

Learn more @ Actelis.com

Executive Summary

Mobile operators face unprecedented growth in demand for backhaul bandwidth generated through rapid deployment of the HSPA (High Speed Packet Access) data services required for emerging 3G and 4G applications. Backhaul traffic growth rates as high as 10% per month will become the norm rather than the exception, with a typical profile shown in Figure 1 below illustrating the traffic volume growth actually measured in one major European mobile operator's network.



Figure 1: Traffic Volume Growth

As the absence of fiber often presents a challenge because of the huge cost of trenching between RNC and base stations, the traditional solution has been to recruit additional T1/E1 circuits. But this has proved completely inadequate, since the incremental bandwidth of just 768 Kbps per copper pair, in the case of T1, or 1 Mbps for E1, is dwarfed by the ever increasing mobile data rates being provided. Most importantly, it does not make economic sense, since the cost of deploying sufficient numbers of these low speed T1/E1 circuits actually outpaces revenue growth, especially when many of these emerging data

services are charged on a flat rate monthly basis. Therefore, facing expanding consumer demands and competitive pressures to provide this bandwidth, mobile providers are seeking ways of reducing the associated OPEX, which means finding alternatives to T1/E1s. Network transport based entirely on Ethernet/IP has emerged as almost the sole alternative, operating over the same copper-based infrastructure but exploiting more efficient encoding and spectral management to increase the bit rate per pair substantially, and at the same time, lower the cost per bit by a similarly large factor.

“With deployments typically taking less than two weeks and ROI reached within one to two months, Actelis Networks' RAN backhaul solution is a highly attractive option for the operators.”

It is widely accepted by the mobile provider community that 30-50% of these total OPEX costs are incurred in the RAN (Radio Access Network). This makes the RAN the most effective place to start deploying Ethernet/IP technologies to achieve OPEX savings. This will help avoid the situation illustrated in Figure 2, where a dangerous divide is created by the increasing divergence between revenue and OPEX.

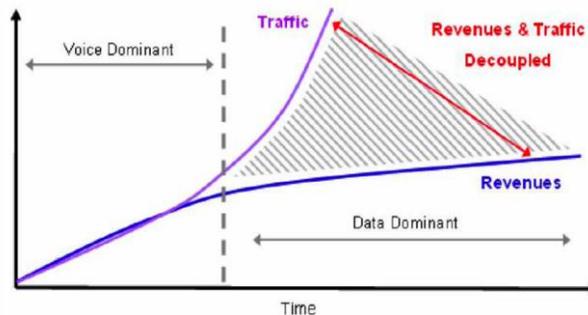


Figure 2: Decoupling revenue from OPEX

Actelis Networks' RAN backhaul solution bridges this divide most effectively by significantly reducing operational expenditures in the access network. By leveraging its patented, award-winning EFMplus™ technology, the Actelis solution shatters previous copper performance barriers by delivering more bandwidth than ever before—in excess of 10 Mbps over each pair! Furthermore, this solution will continue to support existing T1/E1 services, including voice. The Actelis RAN backhaul solution enables migration to a converged packet network, cost-effectively providing a combination of T1/E1 and Ethernet ports for 2, 3 and 4G base stations, with up to 100 Mbps Ethernet in the First Mile (EFM) transport connectivity from a single platform. Using an innovative and field-proven implementation for clock synchronization, Actelis allows operators to seamlessly and incrementally upgrade their access networks without sacrificing service quality or jeopardizing their core voice revenues. With deployments typically taking less than two weeks and ROI reached within one to two months, Actelis Networks' RAN backhaul solution is a highly attractive option for the operators.

Actelis Meets the Traditional and Emerging Challenges of RAN Backhaul

Introduction

The explosive growth in bandwidth consumption by new multimedia 3G and 4G applications is making a move to Ethernet-based transport in the RAN access networks both compelling and necessary for mobile operators. This brings a number of traditional and fresh challenges relating to reliability, timing and Quality of Service (QoS), but all of these are fully addressed by the Actelis RAN backhaul solution based on our ML650 Ethernet Access Device (EAD) product family.

The introduction of new differentiated services like music downloads, instant messaging, streaming media, video conferencing, and VoIP, has made QoS a vital ingredient of a backhaul network. QoS support enables the mobile provider to give priority to those services that need real-time performance and/or that generate the most revenue.

“Actelis has implemented a clocking solution with timing accuracy that exceeds that provided by traditional T1 and E1 circuits.”

Indeed, support for QoS enables mobile operators to offer differentiated Service Level Agreements (SLAs). The objective is to establish a tiered revenue base, offering higher service levels to customers paying the most. This enables the operator to match service profiles to a user base comprising a mixture of pre-paid, contract, and business customers sharing the same RAN backhaul network.

In the rest of this section, we will discuss how Actelis meets these challenges under four key categories: Synchronization, BER (Bit Error Rate)/Availability, Latency, and Emerging Challenges.

- Synchronization is needed to simulate legacy T1/E1 services over IP/Ethernet backhaul circuits, recreating the timing that used to be provided automatically by SDH/SONET and PDH networks.
- BER/Availability deals with interference, attenuation and physical issues such as wire cuts that all threaten to disrupt service, with the aim being to reach or exceed the hallowed “five nines” level of availability (equating to at most five minutes downtime per year) delivered by traditional fixed line carrier networks.
- Latency needs to be minimized to ensure that round trip delays are kept within the limits required by two way services, in particular voice. The emerging challenges relate to supporting specific levels of QoS and matching these to the varying requirements of different services and users.

Synchronization

Synchronization has only become an issue with the advent of Ethernet transport and, in particular, the pseudo wires used to simulate legacy T1/E1 services. Until about five years ago, synchronization was an inherent feature of legacy SDH/SONET and PDH networks. It was generally supported at a level that enabled the air interfaces of BTS's and Node-B's to be synchronized with a Primary Reference Clock (PRC), traceable to within ± 50 ppb (parts per billion). This prevented cross-talk arising through timing differences between neighboring cell towers, enabling smooth handovers between cell towers while allowing the handsets to decode the radio signals.

Pseudo wires, however, lack an inherent mechanism for synchronization and must therefore rely on external mechanisms to come anywhere close to the demanding ± 50 ppb synchronization. A range of solutions have been tried to fix this shortcoming, the most common method being Adaptive Clock Recovery (ACR). But, ACR relies on an underlying asynchronous transport network that can exhibit both varying transit times, as well as periods of congestion. As a result, ACR does not guarantee reliable clock delivery and, therefore, cannot be trusted to provide synchronization.

Actelis has been aware from an early stage of the need to guarantee synchronization over the pseudo wires supported by our ML658 Integrated Cell Site gateway, the first product in our ML650 EAD family (Note: Visit www.actelis.com to learn more about our ML650 product family). We have achieved this by implementing a clocking solution with timing accuracy that actually exceeds that provided by traditional T1 and E1 circuits. Our clock implementation eliminates all concerns relating to clock recovery over pseudo wires. This unique architecture ensures that Actelis' mobile backhaul products provide our customers with the best guaranteed clock accuracy and reliability of any copper-based backhaul solution, meeting and indeed exceeding the requirements of ITU-T G.823/G.824.

“By utilizing the unique EFMplus technology, Actelis' RAN backhaul solution ensures that the 3 R's of EFM: Rate, Reach and Reliability are maximized.”

We also recognized that the clocking requirements apply to the end-to-end transport network, not just the backhaul. Indeed, the Actelis ML658, as the EFM solution operating at the access level, provides only a small part of this overall transport network. Therefore, Actelis made it an explicit design goal to surpass the ITU-T G.823/G.824 specifications in order to ensure that there is headroom in the rest of the network to meet the overall end-to-end ± 50 ppb timing specification. The outcome is a product that only consumes a fraction of the ± 50 ppb budget. Consequently, mobile providers deploying the Actelis Networks ML658 solution can take advantage of pseudo wires while making synchronization an irrelevant issue once more, just as it was in the pure SDH/SONET era.

An additional advantage of the Actelis Networks solution is its integrated holdover capability. If the synchronization at the CO side of an Actelis EFM link becomes unavailable or connectivity to the BSC/RNC is lost, the ML658 will provide clock holdover and synchronization to the base station. This holdover capability enables the base station to get back on air within seconds of re-establishing connectivity to the BSC/RNC, rather than having to wait the additional 15 to 45 minutes it typically takes to re-acquire synchronization and PRC tractability at the base station.

Availability and BER

These might seem slightly unrelated problems, but both availability and BER are concerned with delivery of services that conform with guaranteed SLAs. Loss sensitive services such as voice and video are driving the requirement for low BERs, with a BER of $< 9/10$ the accepted level for a tail T1/E1 access circuit. In the case of availability, the objective is to exceed the “five nines” level, which imposes considerable demands on the quality, durability, and resilience of the associated equipment used to provide such circuits. Additionally, a number of factors have to be considered in dealing with the special issues arising in copper networks, such as varying noise levels and cross talk.

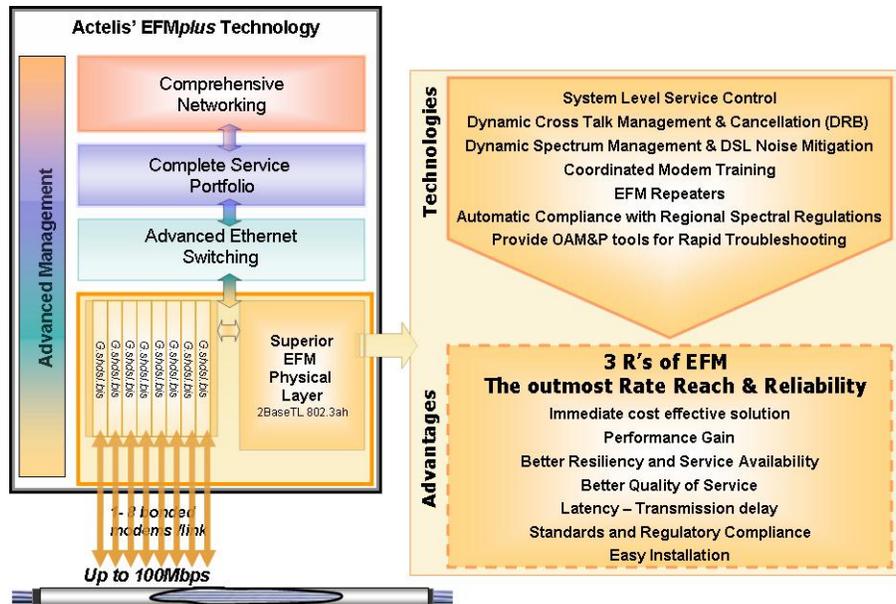


Figure 3: Actelis Networks' patented, award-winning EFMplus™ technology

Actelis has a long history of providing high-service availability and low BER, and has developed the EFMplus suite of technologies that together ensure the highest possible levels of both. By utilizing the unique EFMplus technology, Actelis' RAN backhaul solution ensures that the 3 R's of EFM: *Rate, Reach and Reliability* are maximized. Specifically, the following mechanisms are provided by our EFMplus technology, resulting in a highly reliable link and minimizing interference between circuits and different services within the access network:

- Cross-Talk Management (CTM), which coordinates the modem line rate training process across multiple pairs in the EFM bundle, results in increased total link data rate, balanced SNR margins across pairs, and bringing BER down below the required 9/10 level.
- Automatic compliance with regional spectral regulations using sophisticated estimates of loop attenuation and loop length to eliminate the need for complicated inputs from the user.
- Cut-line protection to ensure that the service delivery of both T1/E1 and Ethernet will continue unaffected even in the event of a copper pair being disconnected. This, combined with advanced QoS in the RT, ensures that high priority T1/E1 traffic is unaffected by adverse conditions in the copper plant.

Actelis' EFMplus technology additionally guarantees the best reach of any EFM-based product. The extended reach, up to 40,000 feet (12 km) from the CO, is achieved by Actelis' unique XR239 EFM Repeater products. This maximizes the available bandwidth that can be delivered to more remote base stations, while maintaining maximum availability and low BER.

As an added precaution to ensure maximum availability, Actelis Networks' ML658 is environmentally hardened to the most stringent standard for temperature and moisture tolerances: NEMA-TS2 -40°C to +74°C.

Latency

Both 2G and 3G voice services are highly sensitive to delay, with one-way handset to BSC/RNC latency budgets of less than 30 ms. As with synchronization, conforming with this stringent latency budget was not an issue in traditional SDH/SONET and PDH networks, where one-way delays of under 10 ms were normal. With the introduction of pseudo wires, the potential for delay became greater with more variation so that special measures had to be taken.

When EFM is used to backhaul pseudo wires, latency becomes a function of the CES packetization delay combined with the EFM Ethernet frame transit time. Actelis Networks' ML658 keeps the CES packetization delay to an absolute minimum, typically less than 5 ms. This, combined with the typical delay of 2 ms for the EFM Ethernet frame transit time, keeps the total delay well below the 10 ms last mile delay budget recommended for RAN backhaul.

Emerging Challenges of RAN Backhaul

The new generation of 3G and 4G multimedia services has made QoS an important factor in RAN backhaul, while the business need to match service levels to the revenue obtained from different classes of customer requires the ability to support differentiated SLAs. Mobile operators typically now have a customer base comprising people who pay different amounts in a variety of models, including pre-pay, various fixed rates, with options for additional value added services paid for at the time they are consumed. There are also business customers paying more for higher levels of service. All these customers share the same backhaul infrastructure.

Actelis Networks' ML658 enables service to be differentiated across a multiple dimensions. Firstly, T1/E1 ports can be individually prioritized, giving the mobile provider the ability to differentiate between voice and data delivered over these circuits. Additionally, the ML658 permits MEF10 based QoS differentiation between various types of data services. Using service profiles, the mobile provider can give precedence to business contract data services over pre-paid data services, precedence to real-time video conferencing versus instant messaging and so forth. Implementing Hybrid Strict Priority (SP) and Weighted Fair Queue (WFQ) scheduling with 8 hardware queues, sophisticated frame classification and filtering, along with MEF10 3-color metering for service ingress rate limiting with up to 8 user defined services, the ML658 allows the mobile provider to guarantee that the revenue stream from HSPA services is fully optimized and maximized.

Enabling Evolution of RAN Backhaul

By vigorously addressing the four fundamental quality aspects of RAN backhaul, including the comprehensive service QoS capabilities, Actelis Networks has created a solution that enables mobile providers to begin seamless migration from TDM to Ethernet safe in the knowledge that their core voice revenue will not be compromised. A number of migration paths are available to the individual mobile provider, depending on the existing mix of technologies in the RAN backhaul network. The following diagrams depict some of the most common scenarios or starting points encountered in mobile networks.

Figure 4 illustrates a situation where a T1/E1 over HDSL is replaced with the Actelis solution providing 4xT1/E1. This is a simple replacement that quadruples the available bandwidth to the base station.

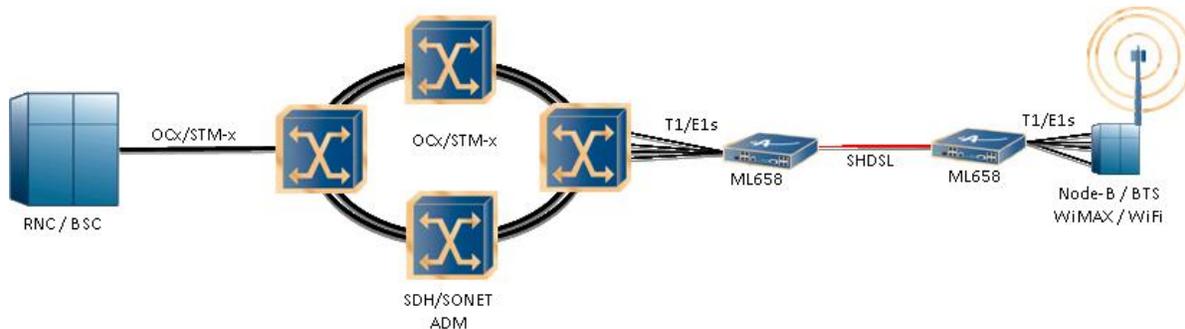


Figure 4: Actelis ML658 – 4xT1/E1 over 2 Copper Pairs

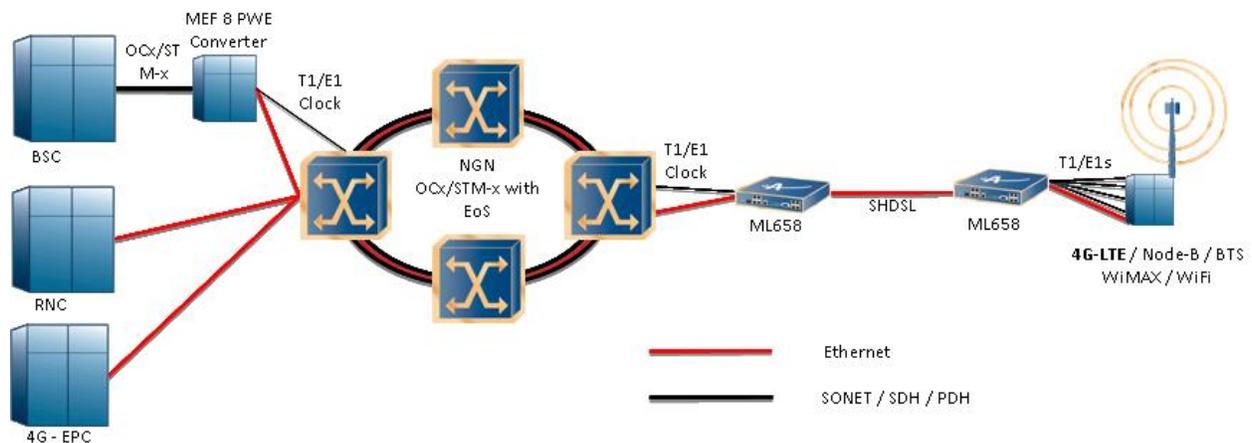


Figure 5: Actelis ML658 – 4xT1/E1 + 100 Mbps Ethernet

“With a comprehensive solution to the synchronization problem that has been haunting the industry for years, Actelis has finally enabled mobile providers to utilize pseudo-wires in the RAN backhaul and transport networks to complement and ultimately replace traditional T1/E1 circuits.”

Providing TDM and Ethernet, together while maintaining synchronization, can be accomplished by upgrading the core transport network to NGN EoS SDH/SONET. Figure 5 illustrates a base station being provided with 4xT1/E1 and 100 Mbps of Ethernet bandwidth. A centralized pseudo-wire gateway converts the Ethernet MEF-8 PWE's to traditional TDM T1/E1's and hands over via an STM-1 to the BSC/RNC. This represents a substantial increase in capacity that enables migration all the way through 3G and 4G / LTE.

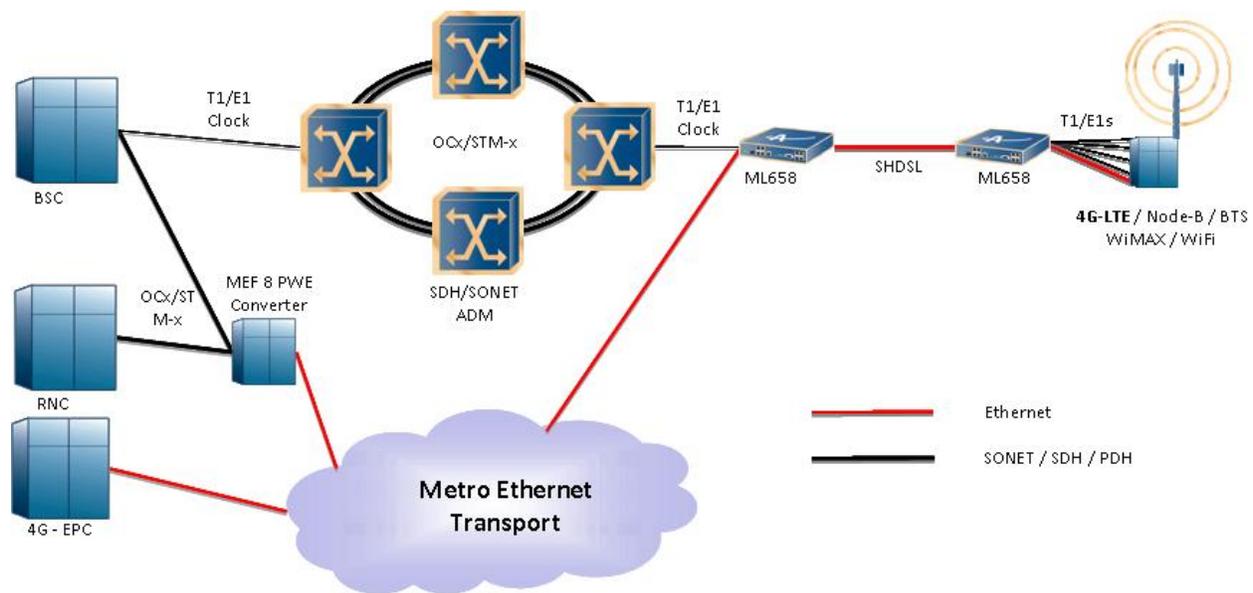


Figure 6: Actelis ML658 – 4xT1/E1 + 100 Mbps Ethernet

An alternative route is to implement the solution illustrated in Figure 6. Here the SDH/SONET network provides synchronization whereas all traffic to and from the base station is transported over a Metro Ethernet Network. As in Figure 5, the conversion from pseudo wires to TDM is performed centrally.

Finally, a full migration to an all Ethernet transport network can be accomplished by deploying a Metro Ethernet transport network that supports Synchronous Ethernet and IEEE 1588v2. The Actelis ML658 is the first platform that supports a viable and cost effective migration strategy for mobile backhaul. With a comprehensive solution to the synchronization problem that has been haunting the industry for years, Actelis has finally enabled mobile providers to utilize pseudo wires in the RAN backhaul and transport networks to complement and ultimately replace traditional T1/E1 circuits.

Operational Efficiencies and EMS Integration

One of the most important advantages of Actelis' Carrier Ethernet over Copper™ solutions is their ease of installation and deployment. Actelis is continuously investing in algorithms and software tools that reduce the installation and deployment burden on the customer, and that provide advanced diagnostic capabilities to reduce troubleshooting time and costs when problems arise.

Actelis' products automate the process of optimizing bitrate allocation among different copper pairs while guaranteeing compliance with regional spectral regulations. Other EFM vendors place the burden of this compliance on the customer, who has to specify parameters like loop length and spectral masks. In contrast, Actelis systems select all of these parameters automatically in a process that is completely transparent to the user.

“By deploying Actelis Networks’ mobile backhaul solution, new bandwidth intensive applications can be supported within weeks of initiating the deployment and at a fraction of the cost of any other solution.”

Actelis supports a wide range of fault detection and troubleshooting techniques and standards. Of these, the ability to do both facility and service loopbacks at the T1/E1 level ensures easy integration into existing and time-tested SDH/SONET/PDH workflow and troubleshooting procedures.



Actelis Networks ML658 Ethernet Access Device

The Actelis systems can be managed in-band and out-of-band by the Actelis’ MetaASSIST™ View graphical craft application and via the multiplatform element management system, MetaASSIST EMS. The management protocols include standard TL1 command line interface and SNMP, using standard MIBs (Management Information Bases) for seamless integration with third party Network Management Systems (NMS). The Actelis MetaASSIST EMS solution offers standard “northbound” interfaces that integrate the lower level device and physical level management easily into customers’ existing operational support systems.

The Economics of Actelis’ Mobile Backhaul Solution

When it comes to the economics of base station backhaul and, in particular, last mile tail circuits, the potential savings that can be realized by using copper as a medium are immense. In most cases, copper is already deployed to the base station, thereby obviating the cost and the provisioning time associated with digging to lay fiber. By deploying Actelis Networks’ mobile backhaul solution, new bandwidth intensive applications can be supported within weeks of initiating the deployment and at a fraction of the cost of any other solution. CAPEX savings in excess of 80% are commonplace, and ROI will often be reached within the first month of deployment. By deploying Actelis Networks’ RAN backhaul solution, mobile provider can close the gap between the revenue generated by the new 3G and 4G applications

and the vast bandwidth requirements of these applications, and thereby re-establish a healthy and sustainable relationship between revenue and OPEX.

Summary

The key point is that Actelis Networks has addressed all the emerging QoS and SLA requirements that mobile operators face deploying multimedia 3G and 4G services delivered via a variety of business models, while not forgetting that legacy 2G services dominated by voice still provide most of the revenues. Most mobile operators want to keep these voice services running over T1/E1 for now, which means using pseudo wire technology to emulate the required circuits. By comprehensively addressing the fundamental quality aspects of RAN backhaul and offering a solution that guarantees the highest level of clock synchronization with minimal latency, Actelis has ensured that the requirements of legacy T1/E1 and 100 Mbps of Ethernet are both met across the backhaul network. In this way, Actelis Networks enables the mobile operator to take their service offerings to the next level of multi-megabit mobile services without endangering their exiting “cash cows” of legacy 2G services, while ensuring that revenues significantly exceeds OPEX. Actelis’ ML658, with its emphasis on the “3 R’s” of EFM: *Rate, Reach, and Reliability*”, provides a solution that mobile operators can count on.

“CAPEX savings in excess of 80% are commonplace, and ROI will often be reached within the first month of deployment.”

Actelis Networks Mobile Backhaul Solution

The Actelis ML650 Ethernet Access Device (EAD) product family is the best solution in the market for mobile operators seeking a cost-effective solution to transport both data and circuit traffic efficiently, while honoring the SLA and QoS requirements of RAN backhaul. The Actelis mobile backhaul solution enables integrated delivery of high-speed carrier Ethernet, PWE3 CESoETH (MEF-8), and synchronization services over the existing copper infrastructure at symmetric rates up to 100 Mbps.

The first product to be launched in the Actelis ML650 EAD product family, the ML658 Integrated Cell Site Gateway, provides 4x10/100Base-T copper Ethernet ports and 4xT1/E1 circuits over the copper infrastructure that is delivered from the 2G (BSC) or 3G (RNC) switching centers to the co-located 2G (BTS) or 3G (Node-B) base stations. The ML658 device also provides a strict timing reference, delivered either from a synchronized T1/E1 port, maintaining better than 50 ppb frequency stability and Stratum 3 holdover.