

SAToP Protocol is the On/Off Ramp to Next-Generation Networks

Because of Ethernet's cost and efficiency advantages, service providers around the world are migrating their communications infrastructures from TDM/ATM technology to Ethernet and IP/MPLS. However, with significant investments in legacy networks, providers continue to derive substantial revenue streams from those assets — for example, high-margin T1/E1 services. Consequently, they face a complex problem: how to evolve their networks smoothly to Ethernet/IP/MPLS while at the same time capping their investments in TDM/ATM technology in order to maximize the return on those investments and help enable their customers to protect their investments in TDM-based access equipment.

Basically, service providers are seeking a solution that will allow them to use less bandwidth to continue offering high-tariff services transparently over a lower cost transport infrastructure. Structure Agnostic TDM over Packet (SAToP) is an industry standard protocol designed specifically to tackle these issues. Functioning as a Circuit Emulation Service (CES), SAToP helps enable service providers to deliver reliable, high-quality T1/E1 circuits over an Ethernet infrastructure, thereby reducing or eliminating the need for a parallel TDM network.

Used to transport TDM bit streams as pseudowires over packet-switched networks, the SAToP protocol treats traffic as an arbitrary bit stream, disregarding any structure that may exist in the TDM bit stream. Network equipment that supports SAToP executes the following steps:

- Segments the synchronous bit stream
- May adapt — but does not compress — TDM or SONET/SDH frames
- Adds a control word to each segment
- Attaches outer and inner labels
- Transports packets through pseudowires over the MPLS network to the destination
- Strips out the MPLS labels
- Checks, uses and then strips out the control word
- Extracts the TDM frames for delivery

SAToP Applications in Wide Area Networks and Access

With the ongoing migration from TDM to Ethernet networks, service providers can leverage SAToP in two regions of their networks — Wide Area Network (WAN) trunks and Ethernet access circuits. By combining SAToP with their investment in an IP/MPLS core, service providers can seamlessly transition TDM circuits and long-haul trunks from legacy ATM and SONET/SDH networks to the core MPLS infrastructure.

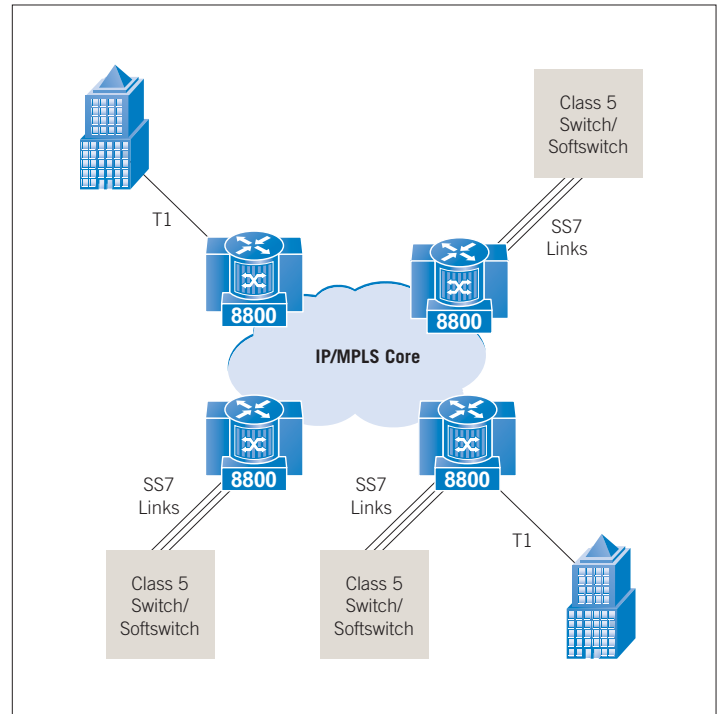


Figure 1. Typical SS7 infrastructure

In the case of Ethernet access circuits, SAToP easily combines with Ethernet to give TDM traffic a “free ride” on Ethernet links. That free ride readily translates into additional revenue streams and reduced costs for service providers themselves, and investment protection of TDM-based premises equipment for providers' enterprise customers.

Alternative to Reselling Leased Lines

For those providers with nationwide IP/MPLS backbones, SAToP enables quick turn-up of long-haul T1/E1 or T3/E3 services, eliminating the need to resell leased line services from national SONET/SDH providers. Providers can also use SAToP to satisfy high-bandwidth applications more cost-effectively, especially those with a short service life.

SS7 Links over an IP Network

Service providers with significant Class 5 voice networks and nationwide IP/MPLS backbones can use those backbones to migrate their Signaling System 7 (SS7) infrastructure to SAToP — and significantly reduce networking costs in the process. As shown in Figure 1, the SS7 infrastructure typically comprises Class 5 end offices/softswitches, often connected in a full mesh of T1s/E1s, many of which are less than half-filled. SAToP transported over the IP/MPLS infrastructure enables service providers to bypass a third-party SONET/SDH infrastructure.

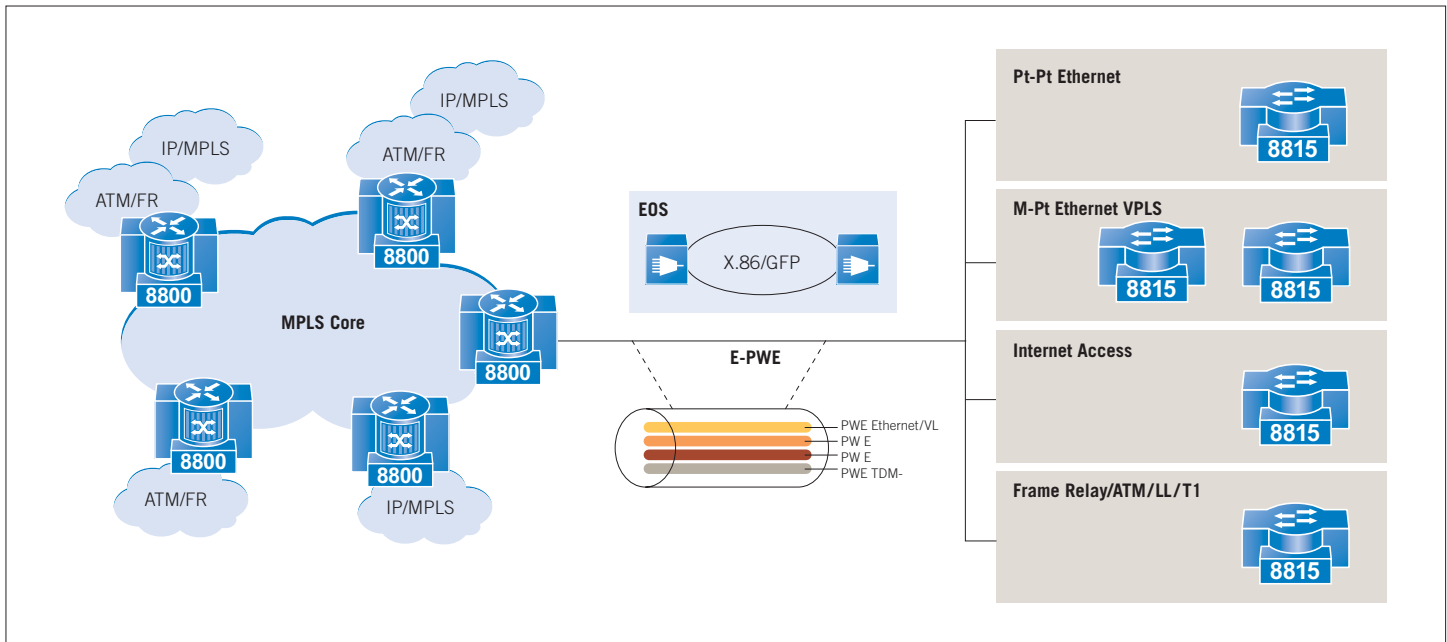


Figure 2. SAToP supports TDM services over Ethernet

PBX Connectivity over Ethernet Access

In an effort to offer faster access speeds and attract new business customers, service providers continue to deploy fiber directly into enterprise office parks and Multi-Tenant Units (MTU). Business organizations, in turn, want to use Ethernet transport for traffic across the Metro and WAN. Although they seek the benefit of Ethernet's higher bandwidth at lower cost, they also want to re-use existing customer premises equipment as much as possible in order to maximize cost control and extend the life of those investments. SAToP helps service providers satisfy these requirements.

With its support for TDM services over Ethernet (Figure 2), SAToP delivers the Primary Rate Interface (PRI) connections required by enterprise PBX and key systems to signal and route calls, and it delivers the stringent QoS and reliability that enterprise customers demand.

T1/E1 Wireless Backhaul Services over Fiber/Ethernet

From the inception of the mobile industry in the early 1980s, wireless carriers have leased T1/E1 lines from local exchange carriers to backhaul cell site traffic. Given the explosive growth of the wireless industry, operators are trying to strengthen their profit margins by controlling the equally explosive rise in backhaul costs. According to a study by Atlanta-based telecom database marketing and consulting firm GeoResults, in 2005 each wireless operator required an average of three T1s/E1s per cell site to manage backhaul, but by 2011 will need at least nine T1s/E1s per cell site — a 200 percent increase.

On average, transport costs equal nearly one-quarter of wireless operators' revenue, and 60–75 percent of those transport fees are allocated to backhaul costs. Those numbers translate into a U.S. backhaul market that will total more than \$40 billion by 2011, according to GeoResults. Globally, GeoResults estimates that wireless operators will spend more than \$30 billion on backhaul expense between 2007 and 2011. In the face of these financial pressures, wireless operators are understandably looking for alternatives to leased T1/E1 backhaul lines, either in the form of more affordable T1s/E1s or native Ethernet service.

Most wireless operators plan to upgrade their base stations to Ethernet over time, depending on bandwidth demands and economics. However, to maximize revenues they need a migration strategy based on a cost-effective, scalable infrastructure that can support 2G and 3G services. The chosen infrastructure must also be able to protect operators' existing network investments by offering more capacity at lower cost.

SAToP helps pave a strategic migration path. Wireless operators, most of whom do not have their own SONET infrastructure nearby, can install a small-scale, SAToP-compliant router at each cell site. That router communicates with a larger, SAToP-compliant router at an aggregation point, such as a Central Office (CO). By enabling the transport of T1s/E1s over an Ethernet/MPLS pseudowire, SAToP allows wireless operators to retain their T1/E1 circuits and continue to add more.

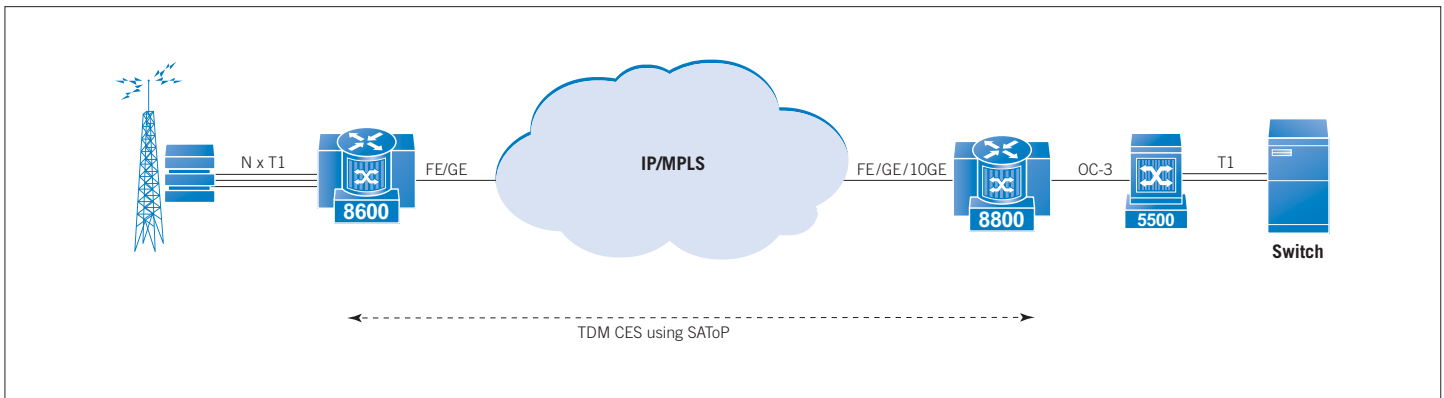


Figure 3. An IP/Ethernet/TDM edge device, such as the Tellabs® 8600 Managed Edge System, aggregates cell site traffic onto the IP/Ethernet backbone

Further, by enabling telcos and alternative carriers to leverage their own packet networks for backhaul connectivity, SAToP saves a great deal of money — they no longer need to build out a full SONET network to add the T1/E1 circuits that wireless operators require.

The wireless backhaul market presents a significant opportunity for Multiple System Operators (MSO) as well, coinciding with one of the industry's major strategic objectives. Many MSOs have made significant investments in fiber or Hybrid Fiber-Coax (HFC) infrastructures over the past several years in order to provide broadband and voice services to residential customers. With carrier-grade Ethernet networks and, in many cases, SONET/SDH-based fiber rings in their Metro markets, MSOs are looking for ways to leverage those investments.

With fiber facilities in place near many of the nation's cell sites, MSOs only need to build short spurs to those towers and deploy low-cost Ethernet access interfaces to create a unified data network in order to provide scalable backhaul service to wireless operators.

As noted earlier, most wireless operators are seeking more affordable T1s/E1s for their backhaul traffic as opposed to native Ethernet services. Although MSOs can position themselves to satisfy both requirements, offering T1s/E1s — with their higher tariff rates relative to Ethernet virtual circuits — clearly provides larger revenue streams.

An MSO targeting the wireless backhaul market can deploy an IP/Ethernet/TDM edge device, such as the Tellabs® 8600 Managed Edge System, to aggregate cell site traffic onto the IP/Ethernet backbone. By enabling the MSO to provide T1/E1-over-Ethernet services — or for that matter, Ethernet-over-SONET/SDH, TDM or HFC — the multiservice access node precludes the need for expensive network overlays (Figure 3).

Depending on its infrastructure, an individual MSO can immediately pursue the wireless backhaul market by using its SONET/SDH-based network, or it can leverage its embedded Ethernet investments with incremental upgrades to edge devices that support T1/E1-over-Ethernet service. Either way, MSOs have a significant opportunity to capture a share of the booming wireless backhaul market and generate significant new revenue streams by implementing solutions that support guaranteed Ethernet and/or MPLS. For additional information about Tellabs products that help build a comprehensive CES portfolio, please visit www.tellabs.com/solutions.

SAToP and Clock Synchronization

Implementing CES via SAToP encompasses three functional areas — network clock synchronization, adaptive clock recovery and network transport requirements.

Network Clock Synchronization

Network clock synchronization is required in any synchronous service to ensure the integrity of data delivery. Because TDM is a Constant Bit Rate (CBR) service, it requires stringent synchronization parameters. Two critical aspects of network clock synchronization are jitter and wander.

Noise or crosstalk on transmitted signals can cause the timing of digital pulses to vary — a variation measured in terms of “jitter.” Excessive jitter presents a problem, because fluctuations occur randomly and change very quickly in time. If the jitter rate is too high, it is likely to cause a correspondingly high Bit Error Rate (BER).

“Wander” is the measurement of synchronization problems, meaning the long-term variation of digital signals from their ideal position in time. Because wander signals are buffered, excessively high wander will result in either the loss of a whole frame (buffer overflow) or the repetition of a frame (buffer underflow). In either case, the internal data carried within these streams will be corrupted, causing degradation of service quality.

Adaptive Clocking Recovery

In CO applications, clocking can be derived from an external Building Integrated Timing Supply (BITS) source. In some applications, it is not cost-effective to supply a BITS for a remote location, such as a cell tower or enterprise site.

To support TDM circuits over Ethernet, T1/E1 bits are encapsulated into Ethernet frames and then sent at a rate determined by T1/E1 frequency. Adaptive clock recovery replicates the original T1/E1 frequency at the remote end after the Ethernet frames have been received.

Ethernet frames traversing the network can vary in arrival times. Adaptive clock recovery takes into account network delays caused by the path, network traffic and queuing. Congestion, packet loss and routing changes have a negative effect on the performance of adaptive clock recovery.

Tellabs Solutions Deliver Maximum Interoperability

To pave a cost-effective migration path to next-generation networks, Tellabs supports SAToP in an end-to-end, scalable product portfolio. By combining its high-capacity, carrier-class Tellabs® 8800 Multiservice Router (MSR) Series with cost-effective, modular CPE/CLE devices, Tellabs delivers a complete managed solution. For additional information, please visit www.tellabs.com.

References

Standards and Specifications

Circuit Emulation based on IETF SAToP (Structure Agnostic Transport over Packet) RFC4533. <http://www.ietf.org/rfc/rfc4553.txt>

IETF Drafts

<http://www.ietf.org/internet-drafts/draft-ietf-pwe3-cesopsn-07.txt>
<http://www.ietf.org/internet-drafts/draft>

Acronyms

ATM	Asynchronous Transfer Mode
BITS	Building Integrated Timing Supply
CES	Circuit Emulation Service
CLE	Customer Located Equipment
CPE	Customer Premise Equipment
FR	Frame Relay
HFC	Hybrid Fiber-Coax
IP	Internet Protocol
MPLS	Multiprotocol Label Switching
MSO	Multiple System Operator
PW	Pseudowire
PWE3	Pseudowire Emulation Edge-to-Edge
RFC	Request For Comment
SDH	Synchronous Digital Hierarchy
SONET	Synchronous Optical Network
SS7	Signaling System 7
TDM	Time Division Multiplexing
WAN	Wide Area Network

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