Electricity and transportation organisations should consider fgOTN as a replacement for SDH

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Electricity and transportation organisations (including road and rail network operators) often still use low-speed legacy connection technologies to support long-since-deployed, mission-critical security and control applications. Indeed, older control and security devices can be connected using a variety of legacy interfaces and access links; the associated data traffic is often aggregated and transported over synchronous digital hierarchy (SDH) networks.

SDH networks provide the dedicated, secure, consistent, low-latency connectivity that is a critical requirement for the applications being supported. SDH-capable, multi-service access equipment is also often able to serve older control system devices that use legacy interfaces and access connections. However, SDH technology is no longer evolving and cannot effectively support new smart control services and applications that require higher bandwidth.

Players in the electricity and transportation sectors, as well as the operators serving them, should consider replacing SDH with multi-service equipment that supports fine-grain optical transport networking (fgOTN).

Legacy services remain essential for providers of critical infrastructure in the electricity and transportation sectors

Electricity, road and rail infrastructure providers collectively operate millions of installed control systems and security devices. Many of these are connected to SDH transport networks using legacy interfaces or low-speed leased lines (analogue, T1/E1 or T3/E3), either directly or via access devices or multi-service access and aggregation devices.

These control systems support sector-specific critical applications such as tele-protection, security and stability control (SSC) systems in electricity networks; SCADA, GSM-R and train control systems (including signalling) in the rail sector; and emergency road communications. They also support more-general applications such as passenger information systems and dispatch control systems. All of these applications are essential for ongoing operation and safety, and as such, have stringent security and performance requirements (often imposed by regulation).

SDH networks have widely been used to aggregate the (generally low-bit-rate) traffic from older control and security devices and have been able to deliver dedicated capacity, reliability, service isolation (and hence security) and low latency. SDH transport networks have also been able to efficiently support a range of legacy access connection types including lower-speed plesiochronous digital hierarchy (PDH), pulse-code modulation (PCM) digital telephony, E1/T1 and E3/T3 lines.

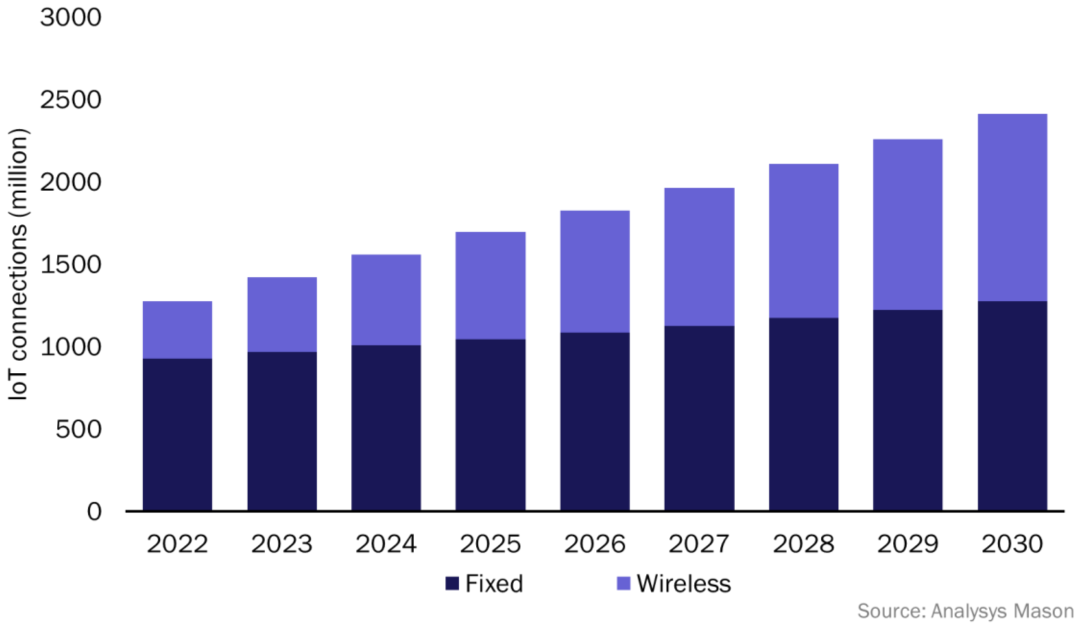
Supporting new services with SDH technology is increasingly challenging and inefficient

SDH has offered many advantages, but the technology requirements of electricity, road and rail infrastructure providers are changing as they seek to digitalise and automate their operations and SDH technology is not evolving to meet these requirements. There is no longer a technology development roadmap for SDH because the major standards bodies have changed their focus to look at newer, alternative technologies. Indeed, the last update of the SDH standard was finalised in 2007 and vendors are no longer investing in developing new SDH equipment.

SDH technology cannot meet the expected bandwidth requirements of new technologies and applications. Individual SDH containers have a maximum size of 155Mbit/s, and there is a limit of 10Gbit/s in any single fibre in SDH networks. Additional fibres are therefore required where capacity demands exceed 10Gbit/s. Maximum transmission distances can also be limiting in larger networks.

The performance parameters of SDH networks were sufficient to support thousands of low-speed connections, but they are not designed to cope with modern, sensor-rich, highly connected, automated infrastructure. Electricity, road and rail networks are being upgraded with the installation of millions of additional connected meters, sensors, cameras, actuators and automation control points, as Figure 1 shows.

Figure 1: IoT connections in the electricity, road and rail sectors, worldwide, 2022–2030



These additional devices often require far higher bandwidths, and the volumes of video and HD video traffic generated by control systems are growing rapidly. The future deployment of real-time digital twin solutions for system design, evaluation, testing and operation, as well as the use of unmanned systems for inspection and operation, will increase both the number of end points and the requirements for device/service capacity even further.

Replacing SDH networks has been challenging, despite the growing limitations of the technology. SDH technology is valued for its security, service isolation and latency. It forms a critical component of infrastructure deployments that are often heavily regulated. In addition, organisations may not be willing to migrate to alternative aggregation and backbone technologies if that means retrofitting or replacing installed security and control systems.

Electricity and transportation infrastructure providers should consider deploying multi-service technology that supports fgOTN

Optical transport networking (OTN) has already been widely used within aggregation and backbone networks for the purposes of efficiently grooming and transporting multiple services over optical links. However, until now, low-speed legacy services have been mapped into containers with a minimum bandwidth of 1.25Gbit/s (ODU0), thereby potentially resulting in significant bandwidth wastage when multiple low-speed applications are multiplexed into multiple ODU0 containers on a one-to-one basis. In addition, OTN is an agnostic transport technology, so does not provide port protection for specific services.

Recent OTN standards developments (specifically the development of fgOTN; Figure 2) mean that OTN is now a more-suitable choice when it comes to replacing SDH technology, especially when the aggregation and transportation of traffic for legacy security and control systems is required.

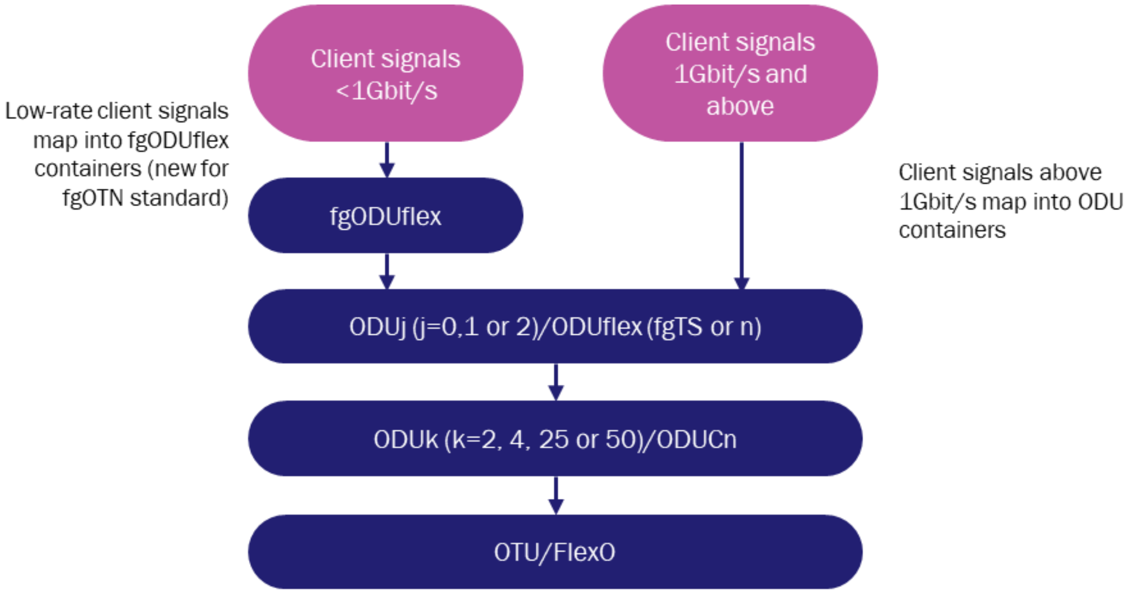
Figure 2: Recent and in-progress fgOTN (ITU-T) standards

Feature	ITU-T standard	Progress
Overview	G.708.20	Released at the end of 2023
Architecture	G.872	Released at the end of 2023
Interfaces	G.709	Released at the end of 2023
Hitless bandwidth adjustment	G.709	Released at the end of 2023
Protection	G.808.4	Expected in 3Q 2024
Device features	G.798	Expected in 3Q 2024
Clock	G.8251	Expected in 3Q 2024
Management	G.874 and G.875	Expected in 3Q 2024

Source: Analysys Mason

The new fgOTN standards optimise OTN to deliver improved support for lower-speed legacy services by introducing much smaller containers with a minimum size of 10Mbit/s (Figure 3).

Figure 3: Mapping of signals in a fgOTN network



Acronyms/definitions
ODU = optical data unit
ODUflex = data containers with flexible sizes
ODUCn = non-switchable container defined for transport >100Gbit/s
OTU = optical channel transport unit
fgTS = fine grain tributary slot (approx. 10Mbit/s)
Flexible OTN (FlexO) = service enabling handoff >100Gbit/s and use of 100GE optical modules

Source: Analysys Mason

Other key features of the initial fgOTN standards include:

- fixed timeslots that enable service isolation
- microsecond-level latency and very low latency jitter
- guaranteed bandwidth as well as sub-100ms hitless bandwidth adjustment (that is, bandwidth adjustment that does not affect services)
- hop-by-hop clock transmission to support constant bit rate (CBR) services
- improved operations, administration and maintenance (OAM) including fast protection switching (sub-50ms) and monitoring and protection for sub-paths.

Multi-service access and aggregation equipment that is equipped with legacy interfaces and that supports fgOTN is becoming commercially available, and the product range is expected to expand in the coming months. Electricity, road and rail players, as well as the operators serving them, should consider deploying such multi-service equipment as a replacement for SDH-based predecessors.

Doing so can help to protect legacy investments and transform the support of legacy services in the aggregation and backbone networks by improving efficiency, security, reliability and scalability of organisations' mission-critical infrastructure. It can also provide a migration path for the deployment of next-generation digitalised and highly automated infrastructure.