Business services in a DOCSIS network

Strategies for supporting Service Level Agreements (SLAs)

A Technical Paper prepared for SCTE/ISBE by

Ken Gold
Leader, Solutions Marketing
EXFO Inc.
250 Apollo Drive, Chelmsford, MA 01824
404-436-5756
ken.gold@EXFO.com

Jim Gayton
Marketing Manager, End-to-End Service Assurance and Analytics
EXFO Inc.
250 Apollo Drive, Chelmsford, MA 01824
978-3670-5622
jim.gayton@EXFO.com

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Introduction

The value enterprise customers place on their communications services is typically much greater than that of the residential customer. Unlike residential customers, their livelihood depends on their ability to stay connected, conduct commerce, and communicate with employees and business partners. Staying connected in the global, 24-hour economy requires more than just access to the internet. For many, this connectivity needs to meet increasingly stringent performance requirements—and best effort simply won't cut it.

Cable operators have been providing internet connectivity for many years now via the data over cable service interface specification (DOCSIS) protocol. Initially intended for residential internet connectivity, enhancements to the DOCSIS protocol have enabled operators to serve not only the increasingly demanding residential market but also the more lucrative enterprise market, with higher capacity (1Gbit/s or more) uplinks and downlinks that are more typically required by businesses, especially those who rely on internet connectivity for their livelihood.

However, the battle for business services is about more than just bandwidth. As businesses evolve, their connectivity needs are also evolving and raw bandwidth is now no longer the problem. Overall quality of experience (QoE) becomes a more meaningful consideration for these customers as reliability and end-user experience become more critical to their customers' overall satisfaction. A service level agreement (SLA) between an operator and a business customer is the traditional tool for defining and policing contractual obligations with regards to service performance. Businesses, for which connectivity is an essential part of their operations model, demand SLAs to ensure that operators deliver the best possible QoE, and when this does not occur, provide for financial remedies to compensate for lost revenue and damage to reputation.

This paper examines the role that active monitoring and analytics play in managing network and service performance—not only when SLAs are involved but also for tracking performance of all other services against published service level objectives (SLOs). Taking a continuous, proactive approach to managing services in their networks by utilizing active performance monitoring combined with deep analytics of the derived key performance indicators (KPI), operators can confidently provide SLA-based services knowing they have complete visibility into the performance of their DOCSIS networks.

Background

1. Delivering data services over coax

Cable operators, or multiple systems operators (MSOs), have been delivering data services over their coax access infrastructure for 20 years based on DOCSIS standards. Initially, DOCSIS was primarily used for best-effort residential internet access and was limited in bandwidth and Quality of Service (QoS) features. However, through continuous development and improvements, DOCSIS is now capable of access speeds of up to 10 Gbit/s and includes QoS capabilities to allow for prioritized traffic handling as well as constant bitrate (CBR) and variable bitrate (VBR) services. These improvements have opened the enterprise business services markets through initiatives, such as business services over DOCSIS (BSoD). Cable operators now compete actively against the traditional communications service providers (CSP) for small, medium and large enterprise customers.

DOCSIS is essentially a Layer 1/ Layer 2 solution that supports tunneling of customers' Layer 2 (Ethernet) and Layer 3 (IP) traffic transparently across the coax access infrastructure. From the perspective of business services, this is an important consideration. Today's business services are typically based on Metro Ethernet Forum (MEF) definitions of services as defined in the MEF Carrier Ethernet (CE) standards. Not only do these standards define the service creation (such as E-LINE, E-LAN and E-TREE) but they also include features for performance assurance monitoring, something essential to businesses that rely on internet access for their livelihood. DOCSIS does not currently support MEF service creation or performance assurance; however, since it is essentially transparent at Layer 2 and 3, it does not preclude or block CE payloads and features.

As cable operators continue to shift their DOCSIS networks towards higher bitrates and more sophisticated services for both the enterprise and residential customer, it is critical to know whether their networks can support these services as advertised; especially if growth is greater than expected. This is where features like active performance monitoring become an invaluable tool. Without this, operators are essentially blind to performance issues in their networks until customers call to complain, at which point it is too late.

Business services over Ethernet

2. Types of business services

Ethernet services for businesses can be broadly categorized into three class: basic internet (best effort), business Ethernet (with a defined SLO) and enhanced business Ethernet (with a contractual SLA). Furthermore, within each class, there can be many variations depending on the performance commitments for such things as available bandwidth, service availability, latency, jitter and packet loss. The cost of the service is directly proportional to the level of performance required by the business and the type of guarantee associated with the service.

2.1. What is a SLA?

So, what exactly is a service level agreement? Essentially, it is a contract between the operator and their customer that provides performance commitments with regards to the service itself and, quite often, with regards to how the operator will behave when the performance commitments are not being met. Typical SLA requirements include such things as:

- Maximum latency
- Maximum delay variation (jitter) and/ or maximum inter-packet delay variation
- Maximum packet loss
- Service availability
- Help desk availability
- Help desk responsiveness
- Timeframe for equipment replacement for failure
- Penalties for not meeting commitments

The last point is primarily how a SLA differs from an SLO. For an SLO, operators publish objectives for the performance of the service and for their responsiveness during outage or degradation events; however, there is no financial penalty associated with a failure to meet the objective.

2.2. How are SLAs managed in a MEF Carrier Ethernet network?

The market for business Ethernet services is a robust and highly competitive market which, in the past, has tended to favor the traditional telecom CSPs over cable operators. The reasons for this are mostly historical and include breadth of coverage, incumbency based on traditional telecom voice services and the ability to offer SLAs on critical, high revenue and margin services.

CSP business services are typically based on Carrier Ethernet standards from the Metro Ethernet Forum (MEF). These standards, along with complimentary standards from the IEEE, IETF and ITU-T, provide facilities within Carrier Ethernet to support performance monitoring at various layers of the protocol stack, including ITU-T Y.1731 for Layer 2 and IETF RFC 6349 Two-Way Active Measurement Protocol (TWAMP) for Layer 3. Both protocols are considered 'active' performance monitoring methods since they require coordinated support from both ends of the measurement path to derive their relevant KPIs, such as delay (or latency), delay variation (or jitter) and packet loss.

To provide highly precise measurements, especially one-way latency and jitter between any two points across the entire network and correlate these measurements with other measurements in the network, requires each measurement point to provide a timestamp referenced to a common clock source. The accuracy and resolution of this timestamp is highly dependent on both the method used for distributing timing synchronization and the processing speed of the device.

Timing distribution in today's Ethernet networks is typically done through either a standardized packet timing protocol (PTP), such as IEEE 1588v2, or a global navigation satellite system (GNSS), such as the U.S. global positioning system (GPS) or the European version, GALILEO. Of greater importance, however, is the speed at which the endpoint can process packets and timestamps in the active measurement protocol. Traditionally, MEF-based service endpoints that supported highly accurate performance monitoring would implement the timestamping functionality in hardware as close to the PHY level as possible to avoid any additional latency or jitter caused by software processing delays. By the same token, in virtualized networks, based on network function virtualization (NFV), the implementation of the active protocol—TWAMP for example—as well as timestamp management would be located in the service chain as close to the MAC layer processing as possible to avoid any additional latency and jitter.

Managing the SLA for a Carrier Ethernet service typically involves two domains. First, the CSP would actively track the relevant KPIs and establish threshold crossing alerts to notify their network or service operations center anytime a service was trending towards or had violated a SLA condition. Additionally, the customers themselves would either receive a monthly report of the performance of their services or have access to an online portal where they could track performance of their services in real-time or near real-time.

2.3. Options for implementing SLAs in DOCSIS networks

The question is: can today's DOCSIS networks support SLA-based Ethernet business services? As described above, to support a SLA, three things are required:

1. Support for an active protocol for end-to-end performance measurements
2. The ability to implement the protocol without adding significant additional latency or jitter
3. A synchronized and precise timestamp

Let's look at each of these requirements.

The standardized, active protocols used for performance monitoring operate at either Layer 2, in the case of ITU-T Y.1731, or Layer 3 for IETF TWAMP. Since we have already shown that DOCSIS can transparently carry Layer 2 and Layer 3 protocols, we can safely assume these protocols can be supported.

Implementing the protocol will require additional functionality at the customer premise (cable modem) and possibly the headend in the case of hosted services. Supporting one of the standardized performance monitoring protocols in the headend is likely not an issue as most routers and switches support them today. Support at the cable modem will be more of a challenge as most, if not all, cable modems do not support these protocols today.

Like the active protocol, support for timestamp synchronization will be the same, with the headend likely supporting both a GNSS or PTP solution—but not the cable modem. Cable modems may support the network timing protocol (NTP), but this protocol does not provide sufficient timestamp precision for today's SLA based services.

2.3.1. Options for enhancing DOCSIS networks for SLA support

There are four options for enhancing DOCSIS networks to support SLA-based services using either ITU-T Y.1731 or IETF TWAMP active performance monitoring protocols.

- **Option 1: Add additional inline equipment**
  This is easiest and quickest way to add support for both Carrier Ethernet-based service creation and performance monitoring for SLAs. Simply connecting a traditional CSP-style network interface device (NID) to the customer Ethernet port of the cable modem will allow the generation and termination of both the MEF service itself (policing, shaping, etc.) and the performance monitoring protocols required by the SLA. The downside of this solution is it involves additional space, power and cost at the customer premise as well as an additional management burden for operations. The NID would also introduce an additional point of failure.
- **Option 2: Software only solutions**
  It may be possible to upgrade some of the existing cable modems to support the active performance monitoring protocols and packet timing protocol; however, such a solution would likely suffer from unacceptable latency and jitter issues since the cable modem would probably not support real-time timestamp functionality, or be optimized for the required processing speed.
- **Option 3: Upgraded DOCSIS equipment**
  This method would involve developing a new DOCSIS cable modem with active performance monitoring protocols and timestamp synchronization support. Such a solution would eliminate most of the negative issues associated with Option 1. However, the solution would still likely be cost-prohibitive from a network retrofit and operations integration perspective as well as the MSOs traditional modem upgrade cycle.
- **Option 4: Network Function Virtualization** (NFV)
  This option holds the best promise for cost-effective implementation. By leveraging the software defined networking (SDN) and NFV transformation already being considered by many cable operators, the development of a cable modem that supports virtualized network functions (VNFs) would allow for the instantiation of a protocol, such as Y.1731, directly into the service chain at the customer premise. Such a cable modem could also support the required timestamp

functionality, through an additional VNF, positioned in the service chain to ensure minimal impact on latency and jitter measurements.

3. What will be the impact of network virtualization?

Network virtualization represents a fundamental change in the way communications networks are built and operated. By leveraging lower costs, high-performance server platforms, along with 'white box' edge devices based on industry-standard X86 processors, entire networks can be built using SDN and NFV. What this means to operators is a lower-cost network, based on open platforms, implemented in software, which can be readily scaled to meet demand and leverage the latest techniques for rapidly developing new services. Since the network and its' services are built in software, new services, enhanced network functionality and upgrades are essentially handled as software upgrades. With regards to managing SLA-based services, new or existing services can be upgraded simply by adding a standards-based performance monitoring VNF wherever it is required.

Many cable operators are already considering how they can leverage this industry transformation to benefit their bottom line. Some of the key benefits of virtualized networking include:

- The ability to leverage economies of scale when purchasing networking hardware – i.e., servers, storage, white box edge devices
- The ability to define new services as software functions only, enabling an agile or dev-ops approach that save both time and money and does not require new hardware
- Existing services can be upgraded simply by adding an additional VNF into the service chain
- Many of the functions traditionally found on the customer premise, such as firewalls, traffic policing/shaping or other QoS management functions, can be aggregated back into the core of the network where they can be managed more consistently and securely
- SDN and NFV networks leverage automation and orchestration heavily, greatly reducing the need for manual intervention in most operations processes

3.1. SLA support comes for free

One of the features of a virtualized network is that the service layer is abstracted fully from the physical layer. The benefit of this separation is that the network and service topologies can be continually optimized to address changes in the network, such as traffic congestion or hardware failure. However, this also means it is no longer possible to infer service quality from network QoS metrics since the service can be moved at any time due to optimization. For this reason, the only way to manage end-to-end service quality is to implement performance monitoring at the service endpoints. By doing this, performance monitoring becomes part of the service itself and stays with the service—regardless of how the network is optimized. Consequently, every service is equipped to support a SLA, if required.

3.2. What about the impact of DAA?

While network virtualization may still be in the planning stages, most cable operators are investing in the Distributed Access Architecture (DAA) standards. This initiative will drive a great many changes in the access/coax part of the network. As a result, it presents an ideal opportunity to introduce X86-based cable modem devices, which could support DAA as well as standard-based performance monitoring—all with the longer-term goal of supporting virtualized networking once it is adopted.

Introducing performance monitoring capabilities on all services, not just SLA-based services, will allow cable operators to have complete visibility into the performance of their DOCSIS networks, allowing them to confidently offer SLA-based services knowing the network can fully support them.

Making your network smarter

4. Data-driven operations and marketing

An operators network is their greatest asset. Operators that can best leverage their networks will have a distinct advantage in a highly competitive market. By instrumenting most, if not all, of the services to generate KPIs on a continuous basis, operators can implement a big-data analytics environment to develop an extremely granular view of their networks—both from the operational standpoint and from the perspective of how their customers are using their services. Knowing if a SLA has been violated is certainly important; however, being able to predict the behavior of a service against a SLA gives operators the opportunity to remedy the problem before the customer notices. This saves not only the cost of a SLA violation, it also helps to maintain a positive public image and keep high-revenue customers happy. Understanding which services are in greatest demand as well as where they are located, and correlating this data against non-network information, such as economic growth indicators, can provide insight into future marketing campaigns, new service growth opportunities and network capacity planning.

4.1. The role of analytics in predictive SLA management

Analytics have become integral tools for managing SLAs. By being able to track KPIs at the network, service and customer level, and correlate them against issues found throughout the network or external to the network, such as extreme weather or natural disasters, operators can develop smarter insights that can alert them when a service is at risk of violating a SLA. Having this detail in advance of the violation, especially if automation plays a key role in orchestrating troubleshooting, allows operators to take a proactive stance in support of SLA management, rather than the more traditional approach.

4.2. Leveraging analytics for service innovation

This same big data analytics environment can also be leveraged to provide a very granular view of how each and every service in the network is being utilized. By analyzing such things as types of service, growth of these services, customer loyalty per service, price, cost or even external factors, such as new construction activity, economic growth, population demographics and more, operators can develop extremely granular and targeted marketing campaigns with a very high degree of confidence. And based on this information, investment programs can be developed, again with a very high degree of confidence of success.

Conclusion

Business services are an important part of cable operators' strategic growth initiatives. Being able to offer SLAs on these services and compete against CSP operators is critical to this growth. DOCSIS networks have come a long way in their ability to offer the bandwidth required by medium and large business; however, they still lack the facilities necessary for effective SLA management.

Several options exist for enhancing existing DOCSIS networks with standard-based active performance monitoring to generate the required KPIs for SLA management. Unfortunately, most of these options come with some serious drawbacks in terms of measurement accuracy or cost. However, the cable industry is currently going through significant architectural changes—both now and in the near future. This opens up the opportunity to enhance the DOCSIS network to support industry competitive SLAs.

Abbreviations

CSP	communications service provider
DAA	distributed access architecture
DOCSIS	data over cable service interface specification
GNSS	global navigation satellite system
GPS	global positioning system
IEEE	Institute of Electrical and Electronics Engineers
IETF	Internet Engineering Task Force
ITU-T	International Telecommunication Union - Telecommunication Standardization Sector
KPI	key performance indicator
LLC	logical link control (layer)
MAC	media access control (layer)
MEF	Metro Ethernet Forum
MSO	multiple systems operator
NFV	network function virtualization
NID	network interface device
NTP	network timing protocol
PHY	physical (layer)
PTP	packet timing protocol
QoE	quality of experience
QoS	quality of service
RFC	request for comments
SDN	software defined networking
SLA	service level agreement
SLO	service level objective
TWAMP	two-way active measurement protocol
VNF	virtualized network function

