TECHNICAL REPORT

TR-349
DSL Data Sharing

Issue: 1
Issue Date: July 2016

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Issue History

Issue Number	Approval Date	Publication Date	Issue Editor	Changes
1	18 July 2016	5 August 2016	Peter Silverman ASSIA Inc.	Original

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Executive Summary

This document describes and defines DSL data sharing. DSL data sharing applies in cases where more than one entity is involved with providing DSL service, typically with an infrastructure provider (InP) running the network, and multiple Virtual Network Operators (VNOs) operating and presenting retail service to consumers. DSL data sharing architectures are described, with centralized and distributed types presented here. High-level use cases are defined and requirements presented for these use cases. Two types of DSL data sharing interface are defined: profile-level and parameter level. The data and control parameters applicable to each use case are identified, and it is shown that most parameters are common to all use cases.

1 Purpose and Scope

1.1 Purpose

DSL data sharing provides an interface that allows diagnostics and status data to be disseminated from an infrastructure provider (InP, aka wholesaler) to a Virtual Network Operator (VNOs, aka retailer). DSL data sharing also allows a VNO to request changes in network configuration. DSL data sharing applies when an InP controls a physical DSL access network that supports virtual unbundling to VNOs and the InP and the VNOs perform management of broadband services. This Technical Report explores issues related to DSL data sharing and defines a standardized data model for DSL data sharing.

VNOs can access DSL data, which is shared by an InP to perform DSL Line Management (DLM) and Dynamic Spectrum Management (DSM). DLM and DSM technology has the potential to enable VNOs and InPs to enhance their services by lowering crosstalk, increasing speeds, and improving stability and diagnostics [2][9]. Sharing data on cable-plant and DSL configuration and performance allows multi-line DSM "level 2" optimizations to enhance the performance of all lines, and service may be offered on some lines that would not qualify otherwise. Multi-line optimizations can be coordinated across multiple operators. The ability of service providers to differentiate their service offerings can be enhanced by DSL data sharing.

DSL data sharing can be used with either physical or virtual unbundling. An InP can perform the roles of both wholesaler and retailer. There may also be two levels of InP: a Metallic Path Facility (MPF) provider at the lowest level, and an Access Node Operator (ANO) one level higher). There may be multiple VNOs and InPs and multiple regions or jurisdictions. And, a third party may be involved, for example a management system that coordinates services between wholesalers and retailers could be provided by third party that operates a cloud-based service. Also, the DSL data sharing interface could be used between different entities in a single company.

DSL data sharing can also help automate configuration, monitoring, and fault operations between wholesale and retail operators, saving OpEx by automating interactions and improving customer satisfaction. Fault correlation is enhanced, for example the root cause of a fault impacting multiple lines in a cable may be identified across multiple operators' lines, and then fixed with a single dispatch. DSL data sharing may facilitate trouble remediation for customer self-install by providing some access to line data and configuration by the customer.

Together, the improvements allowed by DSL data sharing can increase the overall broadband footprint and improve competitiveness with other broadband media (e.g., wireless).

The standardized data model in this Technical Report, specifying a defined set of parameters for DSL data sharing; can lower OpEx, eliminate uncertainty, and limit scope creep.

1.2 Scope

This Technical Report specifies data models that can serve as the basis of management interfaces for DSL-based broadband access data sharing, where DSL includes the ITU-T Recommendations for ADSL, ADSL2, ADSL2plus, VDSL2, and G.fast. The DSL data sharing interface occurs between management systems, which manage the network elements. Thus, the DSL data sharing interface need not be supported on the DSLAMs or their EMS. This document includes related use cases, and high-level architectural considerations. Security issues, such as access permissions to different datasets and data concurrency, are also addressed at a high level. Documents in the BBF DSL Quality Suite (DQS) provide context and framework for this specification, including the nomenclature in TR-197 [2], and the functional architecture in TR-198 [3].

DSL data sharing can be used with physical loop unbundling and with virtual unbundling. Also, DSL data sharing data may be used by a single retailer accessing data only on their own lines in cases where their internal management flows and processes include interacting but autonomous management entities, as well as by multiple retailers performing DSM across multiple lines.

High-level use cases are described here. The parameters defining the DSL data sharing interface are identified, for separate use cases, and separately for xDSL and G.fast. Most parameters are common to all use cases. Two levels of DSL data sharing interfaces are defined: profile-level and parameter-level. With profile-level DSL data sharing, the interface will need to abstract the management transactions, hiding certain details of the operations known to one of the parties from the others with higher level transactions. With parameter-level DSL data sharing significant details on the configuration and operational state of the DSL services may need to be shared between the entities that use the interface.

The DSL data sharing data model re-uses interfaces and data models already defined by the BBF [6] and related standards bodies to the largest extent that is practical. This document categorizes and identifies sections of these data models that apply to different use cases, enabling well-defined groups of parameters to be readily identified for applicable purposes. Wholesale models are defined in TR-178 [1] and previous documents at the Ethernet layer, whereas this document is concerned with the DSL or physical layer.

2 References and Terminology

2.1 Conventions

In this Technical Report, several words are used to signify the requirements of the specification. These words are always capitalized. More information can be found be in RFC 2119 [12].

MUST	This word, or the term "REQUIRED", means that the definition is an absolute requirement of the specification.
MUST NOT	This phrase means that the definition is an absolute prohibition of the specification.
SHOULD	This word, or the term "RECOMMENDED", means that there could exist valid reasons in particular circumstances to ignore this item, but the full implications need to be understood and carefully weighed before choosing a different course.
SHOULD NOT	This phrase, or the phrase "NOT RECOMMENDED" means that there could exist valid reasons in particular circumstances when the particular behavior is acceptable or even useful, but the full implications need to be understood and the case carefully weighed before implementing any behavior described with this label.
MAY	This word, or the term "OPTIONAL", means that this item is one of an allowed set of alternatives. An implementation that does not include this option MUST be prepared to inter-operate with another implementation that does include the option.

2.2 References

The following references are of relevance to this Technical Report. At the time of publication, the editions indicated were valid. All references are subject to revision; users of this Technical Report are therefore encouraged to investigate the possibility of applying the most recent edition of the references listed below.
A list of currently valid Broadband Forum Technical Reports is published at http://www.broadband-forum.org.

Document		Title	Source	Year
[1]	TR-178	*Multi-service Broadband Network Architecture and Nodal Requirements*	BBF	2014
[2]	TR-197	*DQS: DSL Quality Management Techniques and Nomenclature*	BBF	2012
[3]	TR-198i2	*DQS: DQM systems functional architecture and*	BBF	2012

		requirements		
[4]	TR-252i3	*xDSL Protocol-Independent Management Model*	BBF	2013
[5]	TR-298	*Management model for DSL line test*	BBF	2013
[6]	TR-371	*G.fast Vector of Profiles (VoP) Managed Object Structure*	BBF	2016
[7]	MR-257i2	*An Overview of G.993.5 Vectoring*	BBF	2014
[8]	TR-320	*Techniques to Mitigate Uncancelled Crosstalk on Vectored VDSL2 Lines*	BBF	2014
[9]	ATIS-0900007	*Dynamic Spectrum Management Technical Report, Issue 2*	ATIS	2012
[10]	ND1518	*Data Sharing for DSM*	NICC	2015
[11]	ND1513	*Report on Dynamic Spectrum Management (DSM) Methods in the UK Access Network*	NICC	2010
[12]	RFC2119	*Key words for use in RFCs to Indicate Requirement Levels*	IETF	1997
[13]	Brewer, Eric	"Towards Robust Distributed Systems," *Proc. 19th Ann. ACM Symp. Principles of Distributed Computing (PODC 00),* pp. 7-10.	ACM	2000,

2.3 Definitions

The following terminology is used throughout this Technical Report.

Access Node Operator (ANO)	The provider of the network access communications equipment including head-end equipment such as DSLAMs and MSANs. In a DSL access network, the ANO may also be called the "DSLAM Operator."
Control Parameters	Settings that effect changes to configurations, usually DSL line or DSLAM configurations. Control Parameters are typically grouped into Profiles to simplify management of services on a DSL Line A control parameter may be a low-level line setting (e.g., PSD mask), a profile that includes multiple line settings, or a general indication of preference (e.g., higher speed vs. stability).
Infrastructure provider	The Infrastructure Provider (InP) is an entity that is both the MPF provider and the ANO. The InP may also be known as a wholesaler or network operator.
Loop data	Data indicating loop make-up; cable, pair, gauge, length, bridged tap, etc. For multiple lines loop data should indicate which lines use the same cables or cable binders. Standardization of loop data is outside the scope of this Technical Report.
Metallic Path Facility (MPF)	Telephone cabling between customer premise NTP and the Main Distribution Frame or Sub-loop Distribution Frame.

MPF Provider The provider responsible for the provision and maintenance of the access cable and related cable infrastructure.

Profile A Profile, sometimes referred to a DSL Profile, is a predefined instance of a particular collection of control parameter settings. The same profile can be assigned to a number of DSLs, and different DSLs may be assigned different profiles.

Shared data Parameters that are reported in support of DSL data sharing. Shared data is read-only and may include the following: line test, diagnostics, status, and performance monitoring parameters, inventory data, line and channel configuration data, loop data and other data.

VNO Virtual Network Operator, also known as a retailer or Communications Provider (CP).

VULA Virtual Unbundled Local Access

2.4 Abbreviations

This Technical Report uses the following abbreviations:

AAA	Authentication, Authorization, Accounting
ALA	Active Line Access
AN	Access Node
ANO	Access Node Operator
CP	Communications Provider
CAP	Consistency, Availability, and Partitioning
DELT	Dual Ended Line Test
DLM	DSL Line Management
DQM	DSL Quality Management
DQS	DSL Quality Suite
DSM	Dynamic Spectrum Management
DSL	Digital Subscriber Line
FTTdp	Fiber to the Distribution Point
FTTH	Fiber to the Home
FTTN	Fiber to the Node
ID	Identification
IWF	Iterative Water-Filling
LLU	Local Loop Unbundling
InP	Infrastructure Provider
MELT	Metallic Line Test

MPF	Metallic Path Facility
MLWF	Multi-Level Water-Filling
OpEx	Operational Expenses
PSD	Power Spectral Density
QoS	Quality of Service
OAM	Operations, Administration, and Management
PSD	Power Spectral Density
RPC	Remote Procedure Call
SELT	Single-Ended Line Test
SMC	Spectrum Management Center
SLU	Sub Loop Unbundling
UPBO	Upstream Power Back Off
VNO	Virtual Network Operator
VULA	Virtual Unbundled Local Access

3 Technical Report Impact

3.1 Energy Efficiency

DSL data sharing can enable virtual unbundling which shares a single broadband network among multiple operators; this can be far more energy efficient than facilities-based unbundling. However, DSL data sharing can involve multiple instances of management systems, and multiple such systems may consume more energy than a single system.

3.2 IPv6

TR-349 has no impact on IPv6.

3.3 Security

TR-349 will have an impact on security as the defined DSL data sharing interface may cross boundaries between operating entities and the data transported may raise privacy considerations that need to be protected. See Section 7 for more information on security.

If the ultimate purpose of DSL data sharing is to allow different operators to control/manage the same piece of network equipment, then there are additional security issues that need to be taken into account. Control must be limited to the allowed subset of functions and ports that the 3rd party operators have right of access to, and there needs to be an InP 'security mediation function' to avoid any adverse impacts or conflicts that might arise.

3.4 Privacy

The DSL data sharing interface defined in TR-349 may transport data that is confidential to the operating entities or to the subscribers to the service. See Section 7 for more information on privacy.

4 Introduction

The DSL data sharing interface defined in this document is meant to enable providers in unbundled environments to jointly configure, manage, and operate a broadband access network where the various components of the access are owned and operated by different entities. As is illustrated in Figure 1, in such an environment multiple entities may directly or indirectly operate the network systems including the Access Node (AN), provide retail services to the end-customer, and be responsible for maintaining the outside plant of copper and fiber. A Virtual Network Operator (VNO) is also known as a Communications Provider (CP), or simply a “retailer.” An Infrastructure Provider (InP) is sometimes known as a “wholesaler.” Additionally, there may be two levels of InP: Access Node Operator (ANO) and Metallic Path Facility (MPF) provider, however the model proposed in this Technical Report does not define interfaces to MPF providers. Data sharing for DSL was pioneered in the UK NICC [10], which has created an informational document discussing the sharing of DSL data for the purposes of DQM/DSM. However this does not cover any of the commercial or business aspects.

For business and regulatory reasons these entities may have a hands-off relationship with each other where their interactions to manage the broadband service must occur through formally defined and limited interfaces, either human or automated. Each entity will have its own business goals and constraints, its own marketing strategy, and may operate under differing regulatory requirements. The fact that there may be multiple entities (VNOs in figure 1) offering the broadband service to users, sharing the resources of one or more network operators (the InPs in that figure) will likely involve this hands-off interaction. Resources stewarded by the InPs are shared between VNOs who are competitors in many regulatory environments.

This architecture of shared broadband resources where an InP provides services to multiple VNOs is often known as a Virtual Unbundled Loop Access (VULA). The goal of the DSL data sharing interface is to enable a level of flexibility to the various providers in VULA that is similar to that which would occur were there only a single integrated provider operating their own physical plant. There are some parameters that need to remain under the control of a single entity as their modification could have detrimental impact on any operators lines served from a node, e.g. Vector Group configuration. The DSL data sharing interface can preserve business separation while enabling operational flexibility. DSL data sharing, in the limit, can provide the VNOs with a virtualized access service that enables them to perform operations the same as they would with physical infrastructure.

The DSL data sharing interface can be multi-lateral among the multiple parties involved. The DSL data sharing interface can apply regardless of the specific multi-operator scenario: Layer 3 unbundling, VULA, Local Loop Unbundling (LLU), and Sub Loop Unbundling (SLU).

For DSL data sharing to succeed, the parties involved need to come to both commercial and technical agreements to share the data involved. Historically there has been some reluctance to share such data, not least because of its commercial sensitivity, and this may well be impacted by the local regulatory regime. Similarly this needs to be win-win; the potential benefits to the VNOs are fairly clear, however the InP will have to invest in additional network/management capability to implement the sharing, which needs to be commercially viable.

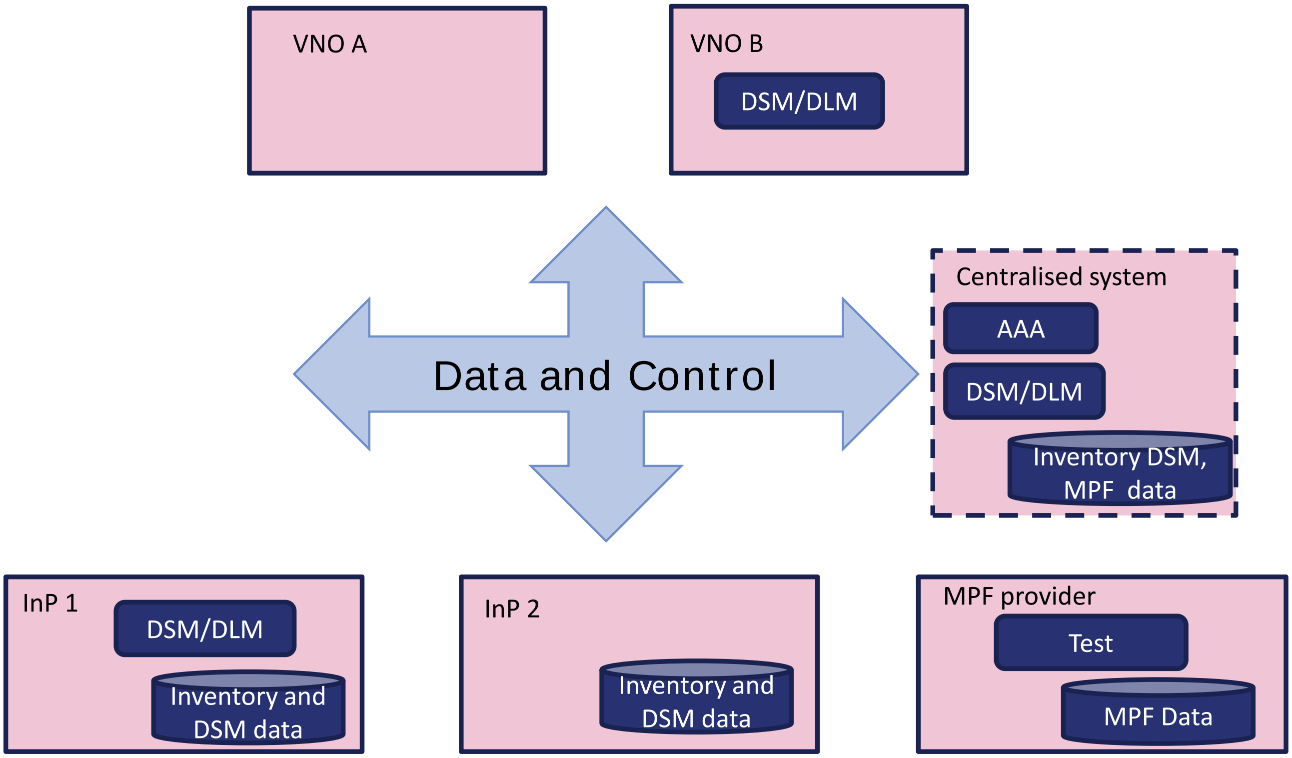

Figure 1 – High-Level Diagram of a DSL Data Sharing Environment

In the high-level architecture diagram (Figure 1), Infrastructure Providers (InPs) operate the Broadband network equipment including the Access Nodes (ANs). The Metallic Path Facility (MPF) provider is responsible for the maintenance and operation of the passive outside plant. It is the Virtual Network Operators (VNOs) who have the retail relationship with their end-customers. There is likely to be only one InP at a given nodal location. The InP and MPF provider may well be a single business entity. DSL data sharing may support an optional centralized system to provide coordination between VNOs. This centralized system could be operated by an InP, by an independent third party, or possibly one of the VNOs themselves. A centralized system could manage multiple groups of InPs and VNOs in different geographic regions or jurisdictions. A single VNO would only be responsible for DSM/DLM on the specific services they are responsible for. With a centralized system coordination of certain functions across multiple VNOs and InPs becomes possible e.g. AAA and DSM/DLM.

[R-1] The DSL data sharing architecture MUST support a single InP and multiple VNOs.
[R-2] The DSL data sharing architecture SHOULD support physical loop unbundling.

In unbundled environments with deep fiber deployments such as FTTdp, FTTN, and FTTH, economics make it likely that a single InP will operate ANs that serve multiple VNOs. The issue is that capital and operational resource requirements may make support for multiple ANs at a single location cost prohibitive. The DSL data sharing interface can thus become the tool that enables a VNO to support operations that provide differentiated services to its retail customers while using the common resources of the shared AN provided to the VNO by the InP. The functions that a VNO requires from the InP (and possibly the MPF provider) over a DSL data sharing interface to provide this differentiation include:

- Ability to request diagnostic tests, such as MELT and SELT, on the lines provided by the InP.
- Ability to gather DELT test diagnostics and status parameter data, performance data such as counters, and state information on the line from the InP, both real-time and historical.
- Ability to request optimization of the line using DSM, DLM, or similar technologies.
- Ability to assign profiles to a specific end-customer's service based on the VNOs' own definitions of its offered services.

The DSL data sharing architecture and interfaces must be able to provide this differentiation while meeting the following requirements.

[R-3] All systems involved in DSL data sharing MUST preserve the confidentiality and integrity of data of all entities.

[R-4] DSL data sharing SHOULD enable VNOs to perform DLM, which is also known as DSM level 1 [2][9][11].

[R-5] DSL data sharing SHOULD enable the use of multi-line optimization techniques such as DSM level 2 [9], and DSM level 3 which is the optimization of vectored DSL [2][9].

[R-6] DSL data sharing MUST support providing of performance information as specified in Table 4 for DSL services and Table 5 for G.fast services.

[R-7] DSL data sharing MUST support providing information to VNO's as specified in Table 4 and Table 5 from AN's supporting services from multiple VNO.

It may be desirable to provide a DSL data sharing interface that abstracts the details of AN management from the VNO to separate specific deployment details from the services provided by the InP to the VNO. This is especially true where a centralized DSL data sharing architecture coordinates multiple VNOs and possibly multiple InPs, as defined in section 5.1.1. Such an abstracted interface is generally associated with "profile-level" DSL data sharing as presented in Section 9.1 .

[R-8] DSL data sharing SHOULD support an abstracted view of AN management.

Contrasting with the above requirement, in certain models the VNO may require detailed information about the state of the DSL connection and abstraction may be less appropriate, this is likely to be the case in a distributed DSL data sharing architecture, as defined in section 5.1.2. Such a detailed interface is generally associated with "parameter-level" DSL data sharing as presented in Section 9.2 .

[R-9] DSL data sharing SHOULD provide detailed information as specified in Table 4 for DSL services and Table 5 for G.fast services about the state of the connection.

5 Functional Architecture

There are two fundamental architectures for DSL data sharing, centralized and distributed. These affect requirements on the DSL data sharing interface. A high level view of these is shown in Figure 2. Each has significant differences in the nature of the data and transactions required to be sent over the DSL data sharing interface. The goal of the interface defined in this document, however, is single interface that can be used to support both centralized and distributed DSL data sharing.

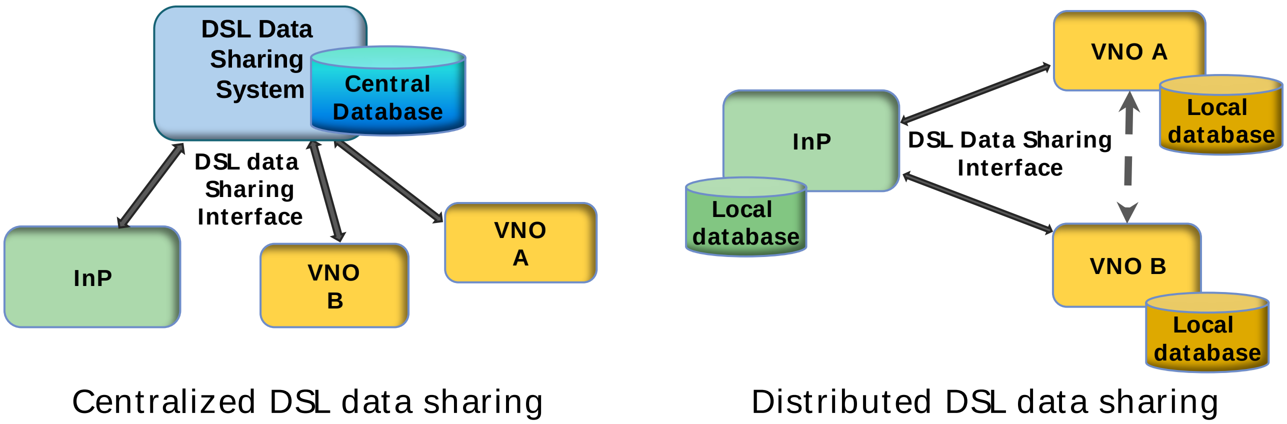

Figure 2 – Centralized and Distributed DSL data sharing architectures

5.1 Centralized DSL Data Sharing Architecture

An example of such a centralized system for DSL services is DSM administered through a centralized Spectrum Management Center (SMC), as defined in TR-198 [3] and the ATIS DSM Technical Report [9]. In this case, the SMC runs centralized DSM algorithms [9] to apply calculated profiles or PSD masks to each line, and oversee the resulting performance impacts among the multiple lines.

Centralized DSL data sharing presumes the ability of the centralized system to collect data from the access nodes, and apply controls by the centralized system. Both of these operations may be amenable to summarization. The transaction set over the DSL data sharing interface may abstract both the data delivered to the VNOs into simpler summaries, including use of DSL profiles.

In the case of diagnostics in a centralized environment the centralized system may perform diagnostic analysis for all lines in the access nodes that it oversees providing the VNO with results of the tests over the DSL data sharing interface.

The centralized system may be operated by the Metallic Path Facility (MPF) provider, InP, by a third party, or a particular VNO; however in a centralized architecture a single system manages all the lines served from any access node.

The centralized system may be hosted on a virtualized platform. This can allow separation of VNOs such that they access their own virtualized AN.

There may be a local data collection function (DCF) or functions [3] near the ANs and probably within the InP domain; this can allow low-delay messaging and scalability. In this case the data analysis functionality is centralized while data collection is distributed among the local data collectors. A separate DCF would need a secure interface between itself and a centralized system; this interface could be part of the DSL data sharing interface.

[R-10] Use of local data collection (DCF) with a secure interface SHOULD be supported by a centralized system performing data collection.

5.1.1 Centralized DSM

For performing DSM, DSL data sharing can be controlled from a centralized system, which has a view of all DSLs on access nodes that share the same physical cable. This architecture may apply in a single operator scenario or in multi-operator scenarios. DSM levels 2 and 3, which perform multi-line optimizations, can use multi-line data and perform optimization algorithms across multiple VNOs' lines while maintaining privacy of data between VNOs.

With DSM in a multi-operator environment, DSL data sharing can be used by providers to indicate general preferences to the SMC; e.g., to indicate that certain service levels are desired on certain lines. The SMC then uses these preferences to guide the configuration of DSM and run a DSM algorithm to determine desired line settings. The SMC then either directly configures the access nodes with these line settings, or requests the operator of the access node to implement preferred line settings. Then the SMC can use DSL data sharing to inform the VNOs about the settings and performance that were actually enabled by the central SMC on the access notes.

In the centralized architecture in a multi-provider environment, the SMC is responsible for the implementation of the DSM algorithms. Therefore, the VNOs do not necessarily require detailed line status information (including historical data) required to implement the DSM algorithms, but they would still want summaries of the data. Similarly, the transactions between the VNO and the SMC can be at a high level e.g. to indicate whether optimization is required, or to indicate the optimization criteria, based on the VNO's requirements for a particular customer.

5.2 Distributed DSL Data Sharing Architecture

In multi-operator scenarios the management functions may be distributed, that is each VNO is provided the data to perform its own analysis for either diagnostic or control purposes. Then, DSL data sharing is distributed. While distributed algorithms can operate with no shared data, increasing levels of DSL data sharing generally allow increasingly effective management.

The requirements on the data model for distributed DSL data sharing may be significantly different from those for centralized DSL data sharing, as each VNO wants detailed information as required by their management systems for their own lines and also for the other lines on the same access node as needed for multi-line optimizations. The control transactions provided over the DSL data sharing interface can be significantly more complex and may involve setting profiles and controlling individual parameters. This is contrasted with the centralized scenario where the centralized management center receives requests from VNO to optimize and controls certain parameters of the optimization but the detailed selection of parameters is performed by the centralized system and can be hidden from any of the VNOs. Distributed DSL data sharing may use a parameter-level DSL data sharing interface.

5.2.1 Distributed DSM

In the case of DSL services provided on a common AN, DSM level 2 may be implemented in a distributed fashion. Given sufficient knowledge about the DSL environment and operating point, individual VNOs can perform their own DSM level 2 algorithms on their own SMC. Examples of distributed DSM level 2 algorithms are distributed Multi-Level Water-Filling (MLWF) and Iterative Water-Filling (IWF) [9]. With distributed DSM, as operators can access more data about other lines they can better adjust their lines' power and spectra to lower crosstalk and increase performance.

Distributed DSM level 2 can be significantly enhanced with DSL data sharing [10]. However in order to implement DSM Level 2 in such an environment each operator will require data on both their own lines and on other lines in the access node/binder group. With appropriate data on the performance of other lines a distributed SMC can identify performance targets on the lines under its control, and request transmit power or PSD adjustments that take into account the effect from, and the effect on, other lines controlled by other providers on the access node. Appropriate information provided over with DSL data sharing can tell an operator if their line is creating crosstalk that adversely impacts other lines, and then the operator can decrease their line's transmit power or spectra to ameliorate this problem.

[R-11] A distributed DSL data sharing architecture that supports DSM level 2 MUST provide each VNO with information on all lines to which DSM level 2 is applied to enable distributed DSM level 2.

Note: Distributed Algorithms should be chosen carefully to avoid problems with instability.

5.3 Centralized vs. Distributed

The CAP theorem [13] states that any networked shared-data system can have only two of three desirable properties: Consistency, Availability, and Partitioning, but in practice various trade-offs can be made between all three criteria. Centralized DSL data sharing can have good consistency and availability, with no partitioning. Distributed DSL data sharing has partitioning, but may sacrifice consistency or availability because the data and algorithms are distributed on management systems at the various VNOs and InPs. However, there is no inherent conflict resolution mechanism obvious in the distributed system. In order to successfully support both distributed and centralized architectures the DSL data sharing interface must strive for consistency (e.g., data concurrency), and availability (e.g., lower transaction latency). In order to support these two goals:

[R-12] Shared data MUST be time-stamped.

Also, distributed DSL data sharing may not allow a VNO to make just a general indication of control preference (e.g., speed vs. stability) across the DSL data sharing interface, but may require a VNO to specify a specific profile or parameter settings. However, even in the distributed case, an InP could offer a service to the VNOs to enable management using such general indications.

5.4 Relation to Broadband Forum DQM and DSM Models

TR-197 [2] and TR-198 [3] provide definitions of the architecture for the Broadband Forum's DSL Quality Management (DQM) management framework. The DSL data sharing interface enables use of the techniques outlined in TR-197 in the DSL data sharing environment described in this document. TR-198 presents the DQM systems functional architecture and requirements for a single-operator scenario. The DSL data sharing interface defined here extends TR-198 to apply to multiple operator scenarios. The DSL data sharing interface supports communications related to the DQM Analysis, DQM Control, and Constraints listed in the reference model of Figure 1 of [3]. This TR provides description of certain DQM functions related to standardization of the other interfaces listed in section 5.2, Other Interfaces, of TR-198 Issue 2; with special attention to the C, C', C'', X, F, and W interfaces. The DSL data sharing interface enables shared control of the DSM functionality using DQM techniques as defined in Appendix A of TR-198 Issue 2.

6 Interfaces and transactions

The following interfaces and transactions are presented since these may support both centralized and distributed DSL data sharing architectures.

6.1 Transactions

The following transactions typically need to be supported on a DSL data sharing interface:

1. Control transactions
    a. Set a profile on a line
    b. Request optimization
    c. Perform tests
    d. Gather data on a given line on demand
    e. Request diagnostic analysis
    f. Define a new profile
2. Data transactions
    a. Results of optimization
    b. Performance information
    c. Historical information
    d. Information on other lines on the AN
    e. Loop data
    f. Test data

6.2 Interfaces

There are four interfaces that may be involved:

1. The DSL data sharing interface
2. An interface for requesting plant test and retrieving data (e.g. MELT).
3. An ordering and business relationship interface that allows a VNO to order service, control the service offered to the customer.
4. An interface for plant inventory notification / change, such as for providing loop data.

Interfaces 3 and 4 are not in the scope of this Technical Report and are for further study.

[R-13] The protocol independent data model for Interface 2 SHOULD be as defined in TR-298, Management model for DSL line test [5].

Additionally there are operations related to management of a shared AN, that may be outside the scope of a DSL data sharing interface per-se and are therefore outside the scope of this Technical Report. These include internal operations such as customer relationship management.

6.2.1 Latency and performance considerations for the DSL data sharing interface

The communications channel used for DSL data sharing should have sufficiently high speed and low delay to handle to the expected volume of transactions/threads. It is not desirable for VNOs to generate excess traffic or traffic with high peaks.

7 Security, Privacy, and Data Integrity

The transparency of the DSL data sharing interface may vary, from straight pass-through of commands and data to and from the equipment, to a filtered or simplified interface being presented to the VNOs, that abstracts the particular qualities of the AN and its services from the VNO.

A possible way of hiding details of the equipment from the VNOs is to have an abstraction layer between the equipment and the DSL data sharing interface. The abstraction layer translates DSL data sharing transactions to and from the VNOs into specific commands, and the InP provides data and services to VNOs that are independent of details of the actual AN deployed. The service provided by the InP thus is able to be versatile and support differentiation while being independent of the particular ANs utilized. This abstraction layer can perform privacy and security functions.

Note that certain parameters if changed incorrectly could adversely effect all lines on an AN, It should be possible for the ANO to retain control of certain key parameters. This could be done by use of this abstraction layer to maintain or withhold control of specific parameters, e.g., power levels or vector group settings.

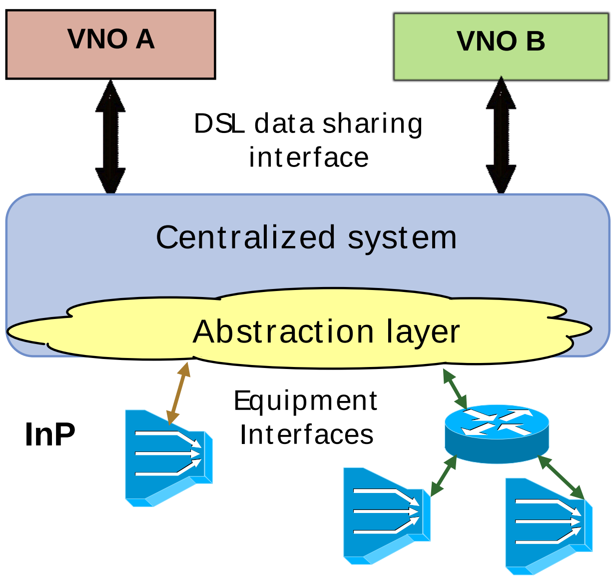

Figure 3 – Abstraction layer concept.

VNO A is generally not allowed to access to data about VNO B's lines and cannot control VNO B's lines. However, with centralized DSL data sharing, centralized functions including an analysis and diagnosis function and profile selection, may access data and perform some control actions on all the VNOs' lines.

If a profile is applied by an InP or VNO that disrupts service then a remediation is needed; and this should be coordinated between the VNO and InP. Data concurrency can be an issue if more than one entity can control profiles; this and other security issues should be handled.

[R-14] A centralized system MUST be able to perform the AAA functions associated with DSL Data Sharing.

[R-15] In distributed architectures the individual participants SHOULD be able to perform the AAA functions associated with DSL Data Sharing.

[R-16] Control actions of one VNO MUST NOT adversely impact other VNOs' lines.

[R-17] The control systems MUST support mechanisms to prevent any line being configured inappropriately and/or such that it would fail to comply with local regulations.

There are constraints and limits in the frequency, granularity and amount of collected data. VNOs may be allowed to select pre-existing profiles, define their own profiles, set some parameters within a limited range, etc.

[R-18] The DSL data sharing interface SHOULD allow for different levels of abstraction and aggregation for each of the following transactions

- configuration capabilities,
- line test data,
- diagnostics
- line status.

8 Use Cases

Some high level use cases are outlined below and then the data and control parameters associated to each use case are outlined in Table 1. Further, if the DSL data sharing interface is only to support particular use cases, then the DSL data sharing interface may support the common parameters in Table 2, plus only the parameters applicable to the supported use cases in Table 3. Note, however, that most parameters are common to all use cases.

1. DSM level 1 / DLM

DSM level 1 monitors, controls, and optimizes transceiver and line settings independently on each DSL. DSM level 1 is synonymous with Dynamic Line Management (DLM) [2]. Each VNO can run DLM / DSM level 1 on their lines if they can access line data and perform re-profiling.

2. DSM level 2

DSM level 2 involves joint multi-line optimization of signals and crosstalk, including balancing the transmit power of multiple lines and performing spectral optimization. DSM level 2 can be centralized (see section 5.1.1), or DSM level 2 can be distributed (see Section 5.2.1).

3. Vectoring, including vector/non-vector compatibility and UPBO for vectoring.

Vectoring "drains the swamp" of background crosstalk, increasing the need for DSM level 1 / DLM. Data sharing may assist vectoring control and optimization. Vectoring can also involve compatibility of a vectored group, and a second group of lines that are either a vectored group or a group of non-vectored lines [7][8]. Vectoring lowers the need for Upstream Power Backoff (UPBO), thereby changing the optimal UPBO settings.

4. Line diagnostics and monitoring

Each VNO can have automated real-time access to DSL monitoring and fault data via the DSL data sharing apparatus and arrangements. This is useful for VNOs network monitoring as well as repair and troubleshooting operations. Real-time data on performance metrics and service attributes enables classic network monitoring as well as service level monitoring.

5. Fault Correlation

Shared data can be used to correlate multiple faults across multiple lines and multiple service providers; and this can further be used to help coordinate dispatches. Consider a fault that is common to multiple lines in a given section of cable, for example a wet or damaged cable. Pooled data across multiple VNOs and/or InPs can be used to identify that the fault occurs in a single shared cable section. A single dispatch to fix that cable section is much better than dispatching to each troubled line separately.

6. Services differentiation

DSL data sharing and control can help the development of new service offerings. For example, VNOs can offer services with different Quality of Service (QoS) levels, for example to provide business class service. Data sharing can help ensure that the DSL physical layer can support the necessary QoS attributes.

7. Network planning

With shared data, VNOs can improve their network planning capabilities and use their own qualification rules. Network planning can be enhanced by knowing the speeds attainable on other DSLs in the same geographic area or neighborhood. Note; some of this information could be commercially sensitive and so may not be shared.

8.1 Per-Use Case DSL Data Sharing Interface

The parameters exchanged in DSL data sharing can be stratified separately for each different use case. Then, VNOs or InPs that only use DSL data sharing for particular use cases could have a DSL data sharing interface that only supports those particular use cases. Table 1 presents a high-level description of the parameters that are particularly applicable to each use case.

Table 1 High-level parameter set descriptions, per use case.

Use Case	Range	Data parameters	Control parameters
Use Case 1. DSM level 1 / DLM	Per line	Fault monitoring, performance monitoring, test, diagnostic, status parameters and counters, and SELT and MELT data.	Profile selection, Creation of new profiles.
Use Case 2. DSM level 2	Multiple Lines	DSM level 1 data on multiple lines, Spectral data (per sub-carrier), and Loop data indicating interacting lines.	Profile selection; transmit power, PSD, and margin settings, etc.
Use Case 3. Vectoring	Multiple Lines	Loop information indicating vectored/non-vectored lines, Vector group ID, XLIN, DSM level 2 data.	Vectoring controls, DSM level 2 controls.
Use Case 4. Line diagnostics and monitoring	Per line	DSM level 1 data, packet counters, Ethernet OAM.	Counter intervals, Unsolicited error performance report (alarm) thresholds.
Use Case 5. Fault correlation	Multiple Lines	Multi-line DSM level 1 data, fault monitoring, performance monitoring, test, diagnostic, and status parameters and counters; Loop data; Packet counters; and Ethernet OAM data.	Counter intervals, Unsolicited error performance report (alarm) thresholds.
Use Case 6. Services differentiation	Per line	N/A	Single-line profile selection, Creation of new profiles, Data rate, margin, INP settings.
Use Case 7. Network planning	Multiple Lines	Attainable net data rate, Neighborhood data, Loop data.	N/A

- If the DSL data sharing interface is stratified separately for different use cases, the range of data (per line or for multiple lines) MUST be as defined in Table 1.

If only certain use cases are of interest, then the DSL data sharing interface need only support the profiles or parameters applicable to those use cases. Table 2 presents the data and control parameters that are common to all use cases, and Table 3 presents the data and control parameters that apply separately to each use case of DSL data sharing. Many parameters are common to all use cases. The individual parameters for the DSL data sharing interface of each section listed in Table 2 and Table 3 are defined in Section 9.

- If the DSL data sharing interface is stratified separately for different use cases, the common data parameters in Table 2, and the data parameters associated to each use case in Table 3, MUST be supported across the DSL data sharing interface.
- If the DSL data sharing interface is stratified separately for different use cases, the common control parameters in Table 2, and the control parameters associated to each use case in Table 3, MUST be supported across the DSL data sharing interface.

Table 2 Data and control common to all use cases.

Data common to all use cases	
Specification	Sections
TR-252i3	5.3 xDSL Termination Unit (xTU) 6 Object Model for xDSL Status Monitoring 7 Object Model for xDSL Performance Management 9.1 xTU Sub-Carrier Status
TR-371	A.2.3 FAST Termination Unit (FTU) A.3 Object model for FAST Status Monitoring A.4 Object model for FAST Performance Management A.6 Object model for FAST Testing / Diagnostics
Control common to all use cases	
Specification	Sections
TR-252i3	Profile pointers: 5.1 xDSL Line 5.4 xDSL Line Configuration Vector Profile creation: 5.5 Service Related Profiles, 5.6 Spectrum Related Profiles, 5.7 DSL Quality Management Related Profiles
TR-371	A.2.1 FAST Line A.2.4 Line Configuration Vector A.2.5 Service related profiles A.2.6 Spectrum related profiles A.2.7 DSL Quality Management related profiles

Table 3 Data and control specific to separate use cases.

Spec.	Use Case 1. DSM level 1 / DLM	Use Case 2. DSM level 2	Use Case 3. Vectoring	Use Case 4. Line diagnostics and monitoring	Use Case 5. Fault correlation	Use Case 6. Services differentiation	Use Case 7. Network planning
Data							
TR-252i3			9.1.2 xTU G.993.5 (Vectoring) Sub-Carrier Status, VCE_ID, VCE_port_index	9.2 xTU Data Gathering Report	9.2 xTU Data Gathering Report, Loop data, Ethernet OAM data	N/A	Loop data
TR-371						N/A	
TR-298	SELT and MELT			SELT and MELT		N/A	
Other		Loop data	Loop data	Ethernet OAM data	Loop data, Ethernet OAM data	N/A	
Control							
TR-252i3				8 Object Model for xDSL Performance Threshold Management	8 Object Model for xDSL Performance Threshold Management		N/A
TR-371			3.2.7.5 Vectoring Profile	A.5 Object model for FAST Performance Threshold Management	A.5 Object model for FAST Performance Threshold Management		N/A
TR-298	SELT and MELT profiles			SELT and MELT profiles			N/A

9 Profile-Level and Parameter-Level DSL Data Sharing Interfaces

Two levels of DSL data sharing interface are defined: profile-level and parameter-level. Profile-level is at a higher layer of abstraction than parameter-level. Profile-level may only provide broad sets of control, e.g., selection from a limited set of profiles which typically under the control of the ANO. Profile-level and parameter-level DSL data sharing could be blended, such as by adding some data parameters into the profile-level elements. However, here only the end cases are defined: fully profile-level and fully parameter-level.

9.1 Profile-Level DSL Data Sharing Interface

Profile-level DSL data sharing is applicable where, as is shown in Figure 3, an abstraction layer can be considered to hide certain details of the configuration and operational status of the services and the network elements supporting them between the InP and the VNOs. The VNO may only be able to configure their lines by selecting from a set of profiles offered by the InP. Similarly, data reported to VNOs may only be within pre-defined datasets.

A service ID, typically defined by the InP and made available to the VNOs, may be used to identify the different DSL services offered to subscribers. The service ID is arbitrary (e.g. Gold, Silver, Bronze). A VNO could assign each line a service ID.

- For profile-level DSL data sharing, the following information about line performance MUST be provided:
  - Line Identification
  - Actual data rate
  - Maximum attainable data rate (ATTNDR)
  - Stability. This is defined by the InP but could be a simple descriptive term (e.g. ‘Unstable,’ ‘Stable,’ ‘Very Stable) The meaning of such a term needs be understood by all users of the DSL data sharing interface.
  - DSL profile ID. A mutually understood ID that identifies the actual DSL profile in use for a given user and service. The DSL profile ID is predefined and understood by both InP and VNO.
- Additional abstracted line performance information SHOULD be made available over a profile-level DSL data sharing interface.

The profile-level DSL data sharing interface may also support access to detailed performance, test, diagnostics, and status parameters.

- For profile-level control, the DSL data sharing interface MUST support the following two cases:
  - VNOs MUST be able to select the offered service, within the set of services that can be offered on that line.
  - VNOs MUST be able to configure their lines via profile selection, within the set of selectable profiles provided by the InP.

The set of offered services and selectable profiles is outside the scope of this Technical Report.

The profile-level DSL data sharing interface may also support detailed control of the configuration parameters.

9.2 Parameter-Level DSL Data Sharing Interface

DSL data sharing at the parameter level exchanges individual parameter and control signals. In practice, setting individual control parameters may be implemented by the VNO and InP jointly agreeing a new customized profile. While parameters may be stratified per use case as in Section 8.1 , this section specifies DSL data sharing parameters for all use cases. An exception is counter (alarm) thresholds, which are not included here but would be included for purposes such as use case 4, line diagnostics and monitoring; and use case 5, fault correlation.

Table 4 and Table 5 categorize parameters as Category 1, Category 2, or un-categorized (blank table entry). Category 1 parameters are vital for the DSL data sharing interface to provide meaningful control and monitoring capabilities. Category 2 parameters significantly enhance the capabilities of the DSL data sharing interface. In addition, un-categorized parameters would further represent a full and complete set of all data and control parameters for DSL data sharing.

- For parameter-level DSL data sharing for xDSL, the DSL data sharing interface MUST support the "Category 1" data and control parameters in Table 4.
- For parameter-level DSL data sharing for G.fast, the DSL data sharing interface MUST support the "Category 1" data and control parameters in Table 5.
- For parameter-level DSL data sharing for xDSL, the DSL data sharing interface SHOULD support the "Category 2" data and control parameters in Table 4.
- For parameter-level DSL data sharing for G.fast, the DSL data sharing interface SHOULD support the "Category 2" data and control parameters in Table 5.

For parameter-level DSL data sharing for xDSL and for G.fast, the DSL data sharing interface may also support the un-categorized data and control parameters in Table 4 and Table 5 respectively.

Table 4 Categorized DSL data sharing data and control parameters for xDSL.
Note 1 - this represents profile-level control.

TR-252i3, xDSL Protocol-Independent Management Model [4]					
Sec. #	**Section Name**	**Parameter**	**Applicability**	**Data Category**	**Control Category**
5	Object Model for xDSL Configuration Management				
5.1	xDSL Line				
		xDSL Line Identifier		1	
		Pointer to xDSL Line Configuration Vector		1	Note 1
		Pointer to xDSL Line Threshold Template			Note 1
		Power Management State Forced (PMSF)			
		Loop Diagnostics Mode Forced			
		Automode Cold Start Forced			
		xDSL Transmission System		1	
		Power Management State		1	
		Initialization Success/Failure Cause		2	
		Update request flag for near-end test parameters (UPDATE-TEST-NE)			
		Update request flag for far-end test parameters (UPDATE-TEST-FE)			
5.2	xDSL Channel				

		Channel Number			
5.3	xDSL Termination Unit (xTU)				
		xTU Identifier (xTU-C or xTU-R)		1	
		xTU G.994.1 Vendor ID		1	
		xTU System Vendor ID		1	
		xTU Version Number		1	
		xTU Serial Number		1	
		xTU Self-Test Result		2	
		xTU xDSL Transmission System Capabilities		2	
		Current 15-minute Interval Elapsed Time (0 to 900 sec)			
		Number of previous 15-minute Intervals (0 to N)			
		Number of previous invalid 15-minute Intervals (0 to N)			
		Current 1-day Interval Elapsed Time (0 to 86400 sec)			
		Number of previous 1-day Intervals (0 to M)			
		Number of previous invalid 1-day intervals (0 to M)			
5.4	xDSL Line Configuration Vector				
		xDSL Line Configuration Vector Identifier		1	Note 1
		Pointer to Data Rate Profile for Channel Number 1…4	ds & us	1	Note 1
		Pointer to Line Spectrum Profile		1	Note 1
		Pointer to Noise Margin Profile		1	Note 1
		Pointer to Virtual Noise Profile		1	Note 1
		Pointer to UPBO Profile		1	Note 1
		Pointer to DPBO Profile		1	Note 1
		Pointer to RFI Profile		1	Note 1
		Pointer to SOS Profile		1	Note 1
		Pointer to INM Profile		1	Note 1
		Pointer to the Re-initialization Policy Profile		1	Note 1
		Pointer to Vectoring Profile		1	Note 1
5.5	Service Related Profiles				
		Minimum Data Rate	ds & us		1
		Minimum Reserved Data Rate	ds & us		
		Maximum Data Rate	ds & us		1
		Rate Adaptation Ratio	ds & us		
		Minimum Data Rate in low power state	ds & us		
		Maximum Bit Error Ratio	ds & us		
		Data Rate Threshold Upshift	ds & us		
		Data Rate Threshold Downshift	ds & us		
		Minimum SOS Data Rate (MIN-SOS-DR)	ds & us		
		Minimum Expected Throughput for retransmission (MINETR_RTX)	ds & us		2
		Maximum Expected Throughput for retransmission (MAXETR_RTX)	ds & us		2
		Maximum Net Data Rate for retransmission (MAXNDR_RTX)	ds & us		
		Target net data rate (TARGET_NDR)	ds & us		2

		Target Expected Throughput for retransmission (TARGET_ETR)	ds & us		2
5.6	Spectrum Related Profiles				
	Line Spectrum Profile				
		xTU Transmission System Enabling (XTSE)			1
		Power Management State Enabling (PMMode)			
		L0-TIME			
		L2-TIME			
		L2-ATPR			
		L2-ATPRT			
		CARMASK	ds & us		1
		VDSL2-CARMASK			1
		Minimum Overhead Rate Upstream (MSGMIN)	ds & us		
		VDSL2 Profiles Enabling (PROFILES)			2
		VDSL2 US0 PSD Masks Enabling (US0MASK)			
		Optional Cyclic Extension Flag (CEFLAG)			
		Retransmission MODE (RTX_MODE)	ds & us		2
	Mode Specific PSD Profile				
		xDSL mode (possible values from the list in paragraph 7.3.1.1.1/G.997.1)			2
		Maximum Nominal Power Spectral Density (MAXNOMPSD)	ds & us		1
		Maximum Nominal Aggregate Transmit Power (MAXNOMATP)	ds & us		1
		Upstream Maximum Aggregate Receive Power (MAXRXPWR upstream)			
		PSD Mask (PSDMASK)	ds & us		1
		Upstream PSD mask selection			
		VDSL2 Limit PSD Masks and bandplans enabling (LIMITMASK)			2
		VDSL2 US0 Disabling (US0DISABLE)			1
		VDSL2 PSD Mask Class Selection (CLASSMASK)			1
	UPBO Profile				
		Upstream Power Back-Off electrical loop length (UPBOKL)			
		Force CO-MIB electrical loop length (UPBOKLF)			
		Upstream Power Back-Off reference PSD per band (Band number, UPBOPSD-pb parameters a and b)			1
		Reference electrical length per band (Band number, UPBOKLREF-pb)			
		Alternative Electrical Length Estimation Mode (AELE-MODE)			
		UPBO Electrical Length Threshold Percentile (UPBOELMT)			
	DPBO Profile				
		Downstream Power Back-Off E-side Electrical Length (DPBOESEL)			1

		Downstream Power Back-Off assumed Exchange PSD mask (DPBOEPSD)			
		Downstream Power Back-Off E-side Cable Model (DPBOESCMA, DPBOESCMB and DPBOESCMC)			1
		Downstream Power Back-Off Minimum Usable Signal (DPBOMUS)			1
		Downstream Power Back-Off span Minimum Frequency (DPBOFMIN)			1
		Downstream Power Back-Off span maximum frequency (DPBOFMAX)			1
	RFI Profile				
		RFIBANDS			1
5.7	DSL Quality Management Related Profiles				
	SNR Margin Profile				
		Minimum Noise Margin (MINSNRM)	ds & us		2
		Target Noise Margin (TARSNRM)	ds & us		1
		Maximum Noise Margin (MAXSNRM)	ds & us		1
		Signal-to-Noise Ratio Mode (SNRMODE)	ds & us		2
		Rate Adaptation Mode (RA-MODE)	ds & us		2
		Upshift Noise Margin (RA-USNRM)	ds & us		2
		Downshift Noise Margin (RA-DSNRM)	ds & us		2
		Minimum Time Interval for Upshift Rate Adaptation (RA-UTIME)	ds & us		2
		Minimum Time Interval for Downshift Rate Adaptation (RA-DTIME)	ds & us		2
	INP-Delay Profile				
		Force framer setting for impulse noise protection (FORCEINP)	ds & us		
		Minimum Impulse Noise Protection (INPMIN)	ds & us		1
		Minimum Impulse Noise Protection 8 kHz (INPMIN8)	ds & us		2
		Maximum Interleaving Delay	ds & us		2
		Maximum delay for retransmission (DELAYMAX_RTX)	ds & us		1
		Minimum delay for retransmission (DELAYMIN_RTX)	ds & us		2
		Minimum impulse noise protection against SHINE for retransmission (INPMIN_SHINE_RTX)	ds & us		2
		Minimum impulse noise protection against SHINE for retransmission 8khz (INPMIN8_SHINE_RTX)	ds & us		
		SHINERATIO_RTX	ds & us		2
		Minimum impulse noise protection against REIN for Retransmission (INPMIN_REIN_RTX)	ds & us		2
		Minimum impulse noise protection against REIN for Retransmission 8 kHz (INPMIN8_REIN_RTX)	ds & us		
		REIN Inter-arrival Time for Retransmission (IAT_REIN_RTX)	ds & us		2
		Maximum Delay Variation (DVMAX)			
		Channel Initialization Policy Selection (CIPOLICY)			2

		MAXDELAYOCTET split parameter (MDOSPLIT)			2
		ATTNDR Method (ATTNDR_METHOD)			
		ATTNDR MAXDELAYOCTET-split parameter (ATTNDR_MDOSPLIT)			
	Virtual Noise Profile				
		Virtual Noise (VN)	ds & us		
		Far End Crosstalk Transmitter Referred Virtual Noise (FEXT TXREFVNds)			
		Near End Crosstalk Transmitter Referred Virtual Noise (NEXT TXREFVNds)			
		Virtual Noise Scaling Factor (TXREFVNSF)	ds & us		
	SOS Profile				
		SOS time Window (SOS-TIME)	ds & us		
		Minimum Percentage of Degraded Tones (SOS-NTONES)	ds & us		
		Minimum Number of normalized CRC anomalies (SOS-CRC)	ds & us		
		Maximum Number of SOS (MAX-SOS)	ds & us		
		SNR Margin Offset of ROC (SNRMOFFSET-ROC)	ds & us		
		Minimum INP of ROC (INPMIN-ROC)	ds & us		
	INM Profile				
		INM Inter Arrival Time Offset (INMIATO)	ds & us		
		INM Inter Arrival Time Step (INMIATS)	ds & us		
		INM Cluster Continuation value (INMCC)	ds & us		
		INM Equivalent INP Mode (INM_INPEQ_MODE)	ds & us		
	Re-initialization Policy Profile				
		Re-Initialization Policy Selection (RIPOLICY)	ds & us		2
		REINIT_TIME_THRESHOLD	ds & us		2
	Vectoring Profile				
		Vectoring frequency-band control (VECTOR_BAND_CONTROL)	ds & us		1
		FEXT Cancellation Line Priorities (FEXT_CANCEL_PRIORITY)	ds & us		2
		FEXT cancellation enabling/disabling (FEXT_CANCEL_ENABLE)	ds & us		1
		requested XLIN subcarrier group size (XLINGREQ)	ds & us		
		Vectoring Mode Enable (VECTORMODE_ENABLE)			2
	Data Gathering Profile				
		Logging depth event percentage per event (LOGGING_DEPTH_EVENT_PERCENTAGE_i)	VTU-O and VTU-R		
		Logging depth for VTU-O reporting (LOGGING_DEPTH_REPORTING)	VTU-O and VTU-R		
		Logging data report newer events first – VTU-R (LOGGING_REPORT_NEWER_FIRST)			
6	Object Mode for xDSL Status Monitoring				
6.1	xTU Line Status				

		xTU Current Status	Near-End Failures for xTU-C / Far-End Failures for xTU-R		
		Last State Transmitted	ds & us	2	
		Signal-to-Noise Ratio Margin (SNRM)	ds & us	1	
		Actual Signal-To-Noise Ratio mode (ACTSNRMODE)	ds & us	2	
		Maximum Attainable Data Rate (ATTNDR)	ds & us	1	
		Actual Power Spectrum Density (ACTPSD)	ds & us	1	
		Actual Aggregate Transmit Power (ACTATP)	ds & us	1	
		VDSL2 Profile		1	
		VDSL2 Limit PSD Mask and Bandplan		2	
		VDSL2 US0 PSD Mask			
		VTU-O Estimated Upstream Power Back-Off Electrical Loop Length (UPBOKLE)		2	
		VTU-R Estimated Upstream Power Back-Off Electrical length (UPBOKLE-R)		2	
		Trellis Use (TRELLIS)	ds & us		
		Actual Cyclic Extension (ACTUALCE)			
		Actual Rate Adaptation Mode (ACT-RA-MODE)	ds & us		
		UPBO receiver signal level threshold (RXTHRSH)	ds & us		
		Actual impulse noise protection of ROC (ACTINP-ROC)	ds & us		
		Actual SNR Margin of ROC (SNRM-ROC)	ds & us		
		Date/time-stamping of near-end test parameters (STAMP-TEST-NE)			
		Date/time-stamping of far-end test parameters (STAMP-TEST-FE)			
		Date/time-stamping of last successful OLR operation (STAMP-OLR)	ds & us		
		VCE ID (VCE_ID)		1	
		VCE port index (VCE_port_index)		1	
		Actual RIPOLICY (ACTRIPOLICY)	ds & us	2	
		XLIN subcarrier group size (XLING)	ds & us		
		Retransmission used (RTX_USED)	ds & us	2	
		ATTNDR actual method (ATTNDR_ACT_METHOD)			
		ATTNDR actual impulse noise protection (ATTNDR_ACTINP)	ds & us		
		ATTNDR actual impulse noise protection against REIN (ATTNDR_ACTINP_REIN)	ds & us		
		ATTNDR actual delay (ATTNDR_ACTDELAY)	ds & us		
		Near-end aggregate achievable net data rate (AGGACHNDR_NE)			
		Far-end aggregate achievable net data rate (AGGACHNDR_FE)			
		Actual Alternative Electrical Length Estimation Mode (ACT-AELE-MODE)			
		Actual Vectoring Mode (ACTVECTORMODE)		2	
6.1.1	xTU Band Status				
		Band number (1, N)			
		Line Attenuation per band (LATN)	ds & us	1	
		Signal Attenuation per band (SATN)	ds & us	2	

		Signal-to-Noise Ratio Margin per band (SNRMpb)	ds & us	2	
		Estimated Upstream Power Back-Off Electrical length per band (UPBOKLE-pb)	VTU-O & VTU-R	2	
6.1.2	xTU Channel Status				
		Actual Data Rate	ds & us	1	
		Previous Data Rate	ds & us		
		Actual Delay		2	
		Actual Impulse Noise Protection (ACTINP)		1	
		Impulse Noise Protection Report (INPREPORT)			
		Actual size of Reed-Solomon codeword (NFEC)			
		Actual number of Reed-Solomon redundancy bytes (RFEC)			
		Actual number of bits per symbol (LSYMB)			
		Actual interleaving depth (INTLVDEPTH)		1	
		Actual interleaving block length (INTLVBLOCK)		1	
		Actual Latency Path (LPATH)			
		Actual net data rate downstream (ACTNDR)	ds & us		
		Actual impulse noise protection against REIN downstream (ACTINP_REIN)	ds & us		
6.1.3	xTU Annex C G.992.3,5 Status				
7	Object Model for xDSL Performance Management				
7.1	xTU Line Performance				
		Interval Number (0 for current; 1..N/M for previous/history intervals)	Current & History; 15-min & 1-day		
		Interval Status	Current & History; 15-min & 1-day		
		Forward Error Correction Seconds - Line (FECS)	Current & History; 15-min & 1-day; L & LFE	2	
		Errored Seconds – Line (ES)	Current & History; 15-min & 1-day; L & LFE	1	
		Severely Errored Seconds – Line (SES)	Current & History; 15-min & 1-day; L & LFE	1	
		Loss of Signal Seconds – Line (LOSS)	Current & History; 15-min & 1-day; L & LFE	1	
		Unavailable Seconds – Line (UAS)	Current & History; 15-min & 1-day; L & LFE	1	
		Full Initializations	Current & History; 15-min & 1-day, xTU-C	1	
		Failed Full Initializations	Current & History; 15-min & 1-day, xTU-C	1	

		Short Initializations	Current & History; 15-min & 1-day, xTU-C	2	
		Failed Short Initializations	Current & History; 15-min & 1-day, xTU-C	2	
		Loss-of-power interruption count (LPR_INTRPT)	Current & History; 15-min & 1-day, xTU-C		
		Host-Reinit interruption count (HRI_INTRPT)	Current & History; 15-min & 1-day, xTU-C		
		Spontaneous interruption count (SPONT_INTRPT)	Current & History; 15-min & 1-day, xTU-C		
		Near-end (xTU-C) Impulse Noise Performance Monitoring Counters	Current & History; 15-min & 1-day, xTU-C	2	
		Far-end (xTU-R) Impulse Noise Performance Monitoring Counters	Current & History; 15-min & 1-day, xTU-R	2	
		Near-end Successful SOS count (SOS SUCCESS NE)	Current & History; 15-min & 1-day	2	
		Far-end Successful SOS count (SOS SUCCESS FE)	Current & History; 15-min & 1-day	2	
		Near-end ''leftr'' defects seconds	Current & History; 15-min & 1-day	1	
		Far-end ''leftr'' defects seconds	Current & History; 15-min & 1-day	1	
		Near-end Error-free bits	Current & History; 15-min & 1-day	1	
		Far-end Error-free bits	Current & History; 15-min & 1-day	1	
		Near-end Minimum error-free throughput (MINEFTR NE)	Current & History; 15-min & 1-day	1	
7.2	xTU Channel Performance				
		Interval Number (0 for current; 1..N/M for previous/history intervals)	Current & History; 15-min & 1-day		
		Interval Status	Current & History; 15-min & 1-day		
		Code Violations – Channel (CV)	Current & History; 15-min & 1-day, C & CFE	1	
		Forward Error Corrections – Channel (FEC)	Current & History; 15-min & 1-day, C & CFE	1	
8	Object Model for xDSL Performance Threshold Management				
8.1	xDSL Line Threshold Template				
		Template Name			Note 1
		Pointer to the Line Threshold Profile	xTU-C & xTU-R, 15-min & 1-day		Note 1

		Pointer to the Channel Threshold Profile	xTU-C & xTU-R, 15-min & 1-day		Note 1
8.2	xTU Line Threshold Profile				
		Profile Name			Note 1
		Forward Error Correction Seconds - Line Threshold (FECS-L/LFE)	L & LFE		
		Errored Seconds – Line Threshold (ES-L/LFE)	L & LFE		
		Severely Errored Seconds – Line Threshold (SES-L/LFE)	L & LFE		
		Loss of Signal Seconds – Line Threshold (LOSS-L/LFE)	L & LFE		
		Unavailable Seconds – Line Threshold (UAS-L/LFE)	L & LFE		
		Full Initializations Threshold	xTU-C		
		Failed Full Initializations Threshold	xTU-C		
		Short Initializations Threshold	xTU-C		
		Failed Short Initializations Threshold	xTU-C		
		Spontaneous Interruption Count (SPONT_INTRPT) Thresholds (24-hour interval)	xTU-C		
		"leftr" defect threshold (LEFTR_THRESH)			2
8.3	xTU Channel Threshold Profile				
		Profile Name			Note 1
8.4	xTU Channel Thresholds				
		Channel Number			
		Code Violations – Channel Threshold (CV-C/CFE)	C & CFE		
		Forward Error Corrections – Channel Threshold (FEC-C/CFE)	C & CFE		
9	Object model for xDSL Testing / Diagnostics				
9.1	xTU Sub-carrier Status				
		Sub-Carrier Group Number (1..J)			
		Channel Characteristics Function Linear Representation Scale (HLINSC)	ds & us		
		H(f) linear subcarrier group size (HLING)	ds & us		
		Channel Characteristics Function Linear Representation (HLINps)	ds & us		
		Channel Characteristics Function Logarithmic Measurement Time (HLOGMT)	ds & us	2	
		H(f) logarithmic subcarrier group size (HLOGG)	ds & us		
		Channel Characteristics Function Logarithmic Representation (HLOGps)	ds & us	1	
		Quiet Line Noise PSD Measurement Time (QLNMT)	ds & us	2	
		QLN(f) subcarrier group size (QLNG)	ds & us		
		Quiet Line Noise PSD (QLNps)	ds & us	1	
		Signal-to-Noise Ratio Measurement Time (SNRMT)	ds & us		
		SNR(f) subcarrier group size (SNRG)	ds & us	2	
		Signal-to-Noise Ratio (SNRps)	ds & us	1	

		Bits Allocation (BITSps)	ds & us	1	
		Gains Allocation (GAINSps)	ds & us	2	
		Transmit Spectrum Shaping (TSSps)	ds & us		
		MEDLEY Reference PSD (MREFPSD)	ds & us	1	
9.1.1	xTU Annex C G.992.3/5 Sub-Carrier Status				
9.1.2	xTU G.993.5 (Vectoring) Sub-Carrier Status				
		Sub-Carrier Group Number (1..J)			
		XLIN scale (XLINSC)	ds & us		
		XLIN subcarrier group size (XLING)	ds & us		
		XLIN bandedges (XLINBANDS)	ds & us		
		FEXT coupling (XLINps)	ds & us	1	
9.2	xTU Data Gathering Report				
		Logging depth – VTU (LOGGING_DEPTH)	VTU-O & VTU-R		
		Actual logging depth for reporting – VTU (ACT_LOGGING_DEPTH_REPORTING)	VTU-O & VTU-R		
		Event trace buffer – VTU (EVENT_TRACE_BUFFER)	VTU-O & VTU-R		

Table 5 Categorized DSL data sharing data and control parameters for G.fast.

Note 1 - this represents profile-level control.

TR-371 Section 3; FAST Managed Object Model					
Sec. #	**Section Name**	**Parameter**	**Applicability**	**Data Category**	**Control Category**
3.2.1	FAST Line				
		pointer-to-threshold-template			Note 1
		line-configuration-vector		1	Note 1
		pointer-to-line-configuration-vector-profile		1	Note 1
		rtx-tc-test-mode (RTX_TESTMODE)	ds & us		
		tps-tc-test-mode (TPS_TESTMODE)	ds & us		
		dra-test-mode (DRA_TESTMODEds)	ds & us		
		update-ne-test (UPDATE-NE-TEST)			
		update-fe-test (UPDATE-FE-TEST)			
		xlog-disturber-vce-port-index			
3.2.3	FAST Termination Unit (FTU)				
		g.994.1-vendor-id (FTUx_GHS_VENDOR)	FTU-O and FTU-R	1	
		version-number (FTUx_VERSION)	FTU-O and FTU-R	1	
		self-test-result (FTUx-SELFTEST)	FTU-O and FTU-R	2	
		dpu-system-vendor-id (DPU_SYSTEM_VENDOR)	FTU-O and FTU-R	1	
		dpu-serial-number (DPU_SYSTEM_SERIALNR)	FTU-O and FTU-R	1	
		vce-id	FTU-O	2	
		vce-port-index	FTU-O	2	
		profiles-supported	FTU-O and FTU-	1	

			R		
3.2.4	Line Configuration Vector				
		pointer-to-tdd-profile		1	Note 1
		pointer-to-downstream-data-rate-profile		1	Note 1
		pointer-to-upstream-data-rate-profile		1	Note 1
		pointer-to-line-spectrum-profile		1	Note 1
		pointer-to-upbo-profile		1	Note 1
		pointer-to-rfi-profile		1	Note 1
		pointer-to-noise-margin-profile		1	Note 1
		pointer-to-fra-profile		1	Note 1
		pointer-to-retransmission-profile		1	Note 1
		pointer-to-fast-retrain-policy-profile		1	Note 1
		pointer-to-vectoring-profile		1	Note 1
3.2.5	Service related profiles				
3.2.5.1	Time Division Duplexing Profile				
		total-symbol-periods (MF)		1	
		downstream-symbol-periods (Mds)		1	
		cyclic-extension (CE)			
3.2.5.2	Downstream Data Rate Profile				
		maximum-net-data-rate (MAXNDRds)		1	
		minimum-expected-throughput (MINETRds)		1	
		maximum-gamma-data-rate (MAXGDRds)			
		minimum-gamma-data-rate (MINGDRds)			
3.2.5.3	Upstream Data Rate Profile				
		maximum-net-data-rate (MAXNDRus)		1	
		minimum-expected-throughput (MINETRus)		1	
		maximum-gamma-data-rate (MAXGDRus)			
		minimum-gamma-data-rate (MINGDRus)			
3.2.5.4	Low Power Data Rate Profile				
		maximum-net-data-rate-in-L2.1 (L2.1-MAXNDR)			
		maximum-net-data-rate-in-L2.2 (L2.2-MAXNDR)			
		minimum-expected-throughput-in-L2.1 (L2.1-MINETR)			
		minimum-expected-throughput-in-L2.2 (L2.2-MINETR)			
		minimum-expected-throughput-after-exit-from-L2.1 (L2.1-MINETR-EXIT)			
3.2.6	Spectrum related profile				
3.2.6.1	Line Spectrum Profile				
		PROFILES		1	
		maximum-psd-reduction-l2.1 (L2.1-MAXPSDR)			
		Maximum Aggregate Transmit Power (MAXATP)	ds & us	1	
		sub-carrier maskin (CARMASK)	ds & us	1	
		PSD mask (MIBPSDMASK)	ds & us	1	
3.2.6.2	UPBO Profile				
		upbopsd-a (UPBOPSDA)		1	
		upbopsd-b (UPBOPSDB)		1	
		upbo-upstream-electrical-length (UPBOKL)			

		upbo-force-electrical-length (UPBOKLF)			
		upbo-reference-electrical-length (UPBOKLREF)			
3.2.6.3	RFI Profile				
		RFI bands (RFIBANDS)		1	
		International Amateur Radio bands (IARBANDS)		2	
3.2.7	DSL Quality Management related profiles				
3.2.7.1	Noise Margin Profile				
		target-noise-margin (TARSNRM)	ds & us		1
		target-noise-margin-in-l2 (L2-TARSNRMds)			
		maximum-noise-margin-in-l2 (L2-MAXSNRMds)			
		maximum-noise-margin (MAXSNRM)	ds & us		1
		minimum-noise-margin (MINSNRM)	ds & us		2
		upshift-noise-margin (SRA-USNRM)	ds & us		2
		upshift-noise-margin-in-l2.1 (L2.1-SRA-USNRMds)			
		minimum-upshift-time-interval (SRA-UTIME)	ds & us		2
		downshift-noise-margin (SRA-DSNRM)	ds & us		2
		downshift-noise-margin-in-l2.1 (L2.1-SRA-DSNRMds)			
		minimum-downshift-time-interval (SRA-DTIME)	ds & us		2
		RMC target-noise-margin (TARSNRM-RMC)	ds & us		2
		RMC minimum-noise-margin (MINSNRM-RMC)	ds & us		2
		RMC maximum-bit-loading (MAXBL-RMC)	ds & us		
3.2.7.2	Fast Rate Adaptation Profile				
		time-window (FRA-TIME)	ds & us		2
		minimum-degraded-tones (FRA-NTONES)	ds & us		2
		uncorrectable-dtu (FRA-RTXUC)	ds & us		2
		vendor-discretionary-fra-triggering-criteria (FRA-VENDISC)	ds & us		2
3.2.7.3	Retransmission Profile				
		maximum-delay (DELAYMAX)	ds & us		1
		minimum-inp-against-shine (INPMIN_SHINE)	ds & us		2
		shine-ratio (SHINERATIO)	ds & us		2
		minimum-inp-against-rein (INPMIN_REIN)	ds & us		2
		rein-inter-arrival-time (IAT_REIN)	ds & us		2
		minimum-rfec-nfec-ratio (RNRATIO)	ds & us		2
3.2.7.4	Fast Retrain Policy Profile				
		los-defect-persistency (LOS-PERSISTENCY)	ds & us		
		lom-defect-persistency (LOM-PERSISTENCY)	ds & us		2
		lor-defect-persistency (LOR-PERSISTENCY)	ds & us		
		re-initialization--time-threshold (REINIT_TIME_THRESHOLD)	ds & us		2
		low-etr-threshold (LOW_ETR_THRESHOLD)	ds & us		2
3.2.7.5	Vectoring Profile				
		fext-cancel-enabled (FEXT_CANCEL_ENABLE)	ds & us		1
		xlog-group-size-req (XLOGGREQds)			
3.3	Object model for FAST Status Monitoring				
3.3.1	FAST Line Status				
		G.9701 profile (PROFILE)		2	

		link-state (LINK_STATE)		1	
		init-success-failure-cause (INITSFCAUSE)		2	
		actual-cyclic-extension (ACTUALCE)			
		time-stamp-at-g1-update (STAMP-TEST-NE-G1)	FTU-O		
		time-stamp-at-g2-update (STAMP-TEST-NE-G2)			
		link-state-at-g1-update (LINK-STATE-TEST-NE-G1)			
		initialization-failure (LINIT)	FTU-O		
		loss-of-signal (LOS)	FTU-O		
		loss-of-rmc (LOR)	FTU-O		
		loss-of-margin (LOM)	FTU-O		
		loss-of-power (LPR)	FTU-O		
		test-time-stamp (STAMP-TEST-FE)time-stamp-at-g1-update (STAMP-TEST-FE-G1)	FTU-R		
		time-stamp-at-g2-update (STAMP-TEST-FE-G2)			
		link-state-at-g1-update (LINK-STATE-TEST-FE-G1)			
		loss-of-signal (LOS-FE)	FTU-R		
		loss-of-rmc (LOR-FE)	FTU-R		
		loss-of-margin (LOM-FE)	FTU-R		
		loss-of-power (LPR-FE)	FTU-R		
		Initialization-last-transmitted-signal (INITLASTSSIGNAL)	ds & us		
		snr-margin (SNRM)	ds & us	1	
		snr-margin-in-l2.1 (L2.1-SNRM)	ds & us		
		snr-margin-in-l2.2 (L2.2-SNRM)	ds & us		
		upbo-electrical-length (UPBOKLE)	ds	2	
		upbo-electrical-length (UPBOKLE-R)	us	2	
		actual-agg-tx-power (ACTATP)	ds & us	1	
		robust-management-channel:snr-margin (SNRMRMC)	ds & us	2	
		robust-management-channel:snr-margin-in-l2 (L2-SNRM-RMC)	ds & us		
		signal-attenuation (SATN)	ds & us	1	
		last-successful-bitswap-time-stamp (STAMP-BSW)	ds & us		
		last-successful-autonomous-sra-time-stamp (STAMP-SRA)	ds & us		
		last-successful-fra-time-stamp (STAMP-FRA)	ds & us		
		last-successful-rpa-time-stamp (STAMP-RPA)	ds & us		
		last-successful-tiga-time-stamp (STAMP-TIGA)	ds		
3.3.2	FAST Channel Status				
		net-data-rate (NDR)	ds & us	2	
		net-data-rate-in-l2.1 (L2.1-NDR)	ds & us		
		net-data-rate-in-l2.2 (L2.2-NDR)	ds & us		
		expected-throughput (ETR)	ds & us	2	
		expected-throughput-in-l2.1 (L2.1-ETR)	ds & us		
		expected-throughput-in-l2.2 (L2.2-ETRds)	ds & us		
		gamma-data-rate (GDR)	ds & us		
		attainable-net-data-rate (ATTNDR)	ds & us	1	
		attainable-expected-throughput (ATTETR)	ds & us	2	
		attainable-gamma-data-rate (ATTGDR)	ds & us		
		actual-inp-against-shine (ACTINP)	ds & us		
		actual-inp-against-rein (ACT_REIN)	ds & us		
		dtu-fec-codeword-length (DTU–NFEC)	ds & us	2	
		dtu-fec-redundancy (DTU–RFEC)	ds & us	2	
		fec-codewords-per-dtu (DTU–Q)	ds & us		
3.4	Object model for				

	FAST Performance Management				
3.4.1	FTU Line Performance				
		invalid-data-flag (PREV_NE/FE_15/24_L_INVALID)	History; FTU-O & FTU-R; 15-min & 24-hour		
		time-stamp (PREV_NE/FE_15/24_L_STAMP)	History; FTU-O & FTU-R; 15-min & 24-hour		
		successful-tiga (CURR/PREV_15/24_TIGA)	Current & History; FTU-O; 15-min & 24-hour		
		full-initializations(CURR/PREV_15/24_FULL_INITS)	Current & History; FTU-O; 15-min & 24-hour	1	
		failed-full-initializations (CURR/PREV_15/24_FAILEDFULL_INITS)	Current & History; FTU-O; 15-min & 24-hour	1	
		fast-initializations (CURR/PREV_15/24_FAST_INITS)	Current & History; FTU-O; 15-min & 24-hour	2	
		failed-fast-initializations (CURR/PREV_15/24_FAILEDFAST_INITS)	Current & History; FTU-O; 15-min & 24-hour		
		link-state-l2.1n-seconds (CURR/PREV_15/24_L21N)	Current & History; FTU-O; 15-min & 24-hour		
		link-state-l2.1b-seconds (CURR/PREV_15/24_L21B)	Current & History; FTU-O; 15-min & 24-hour		
		link-state-l2.2-seconds (CURR/PREV_15/24_L22)	Current & History; FTU-O; 15-min & 24-hour		
		loss-of-power-interruptions (CURR/PREV_15/24_LPR_INTRPT)	Current & History; FTU-O; 15-min & 24-hour		
		host-reinit-interruptions (CURR/PREV_15/24_HRI_INTRPT)	Current & History; FTU-O; 15-min & 24-hour		
		spontaneous-interruptions (CURR/PREV_15/24_SPONT_INTRPT)	Current & History; FTU-O; 15-min & 24-hour		
		measured-time (CURR/PREV_NE/FE_15/24_L_TIME)	Current & History; FTU-O & FTU-R; 15-min & 24-hour		

		loss-of-signal (CURR/PREV_NE/FE_15/24_LOS)	Current & History; FTU-O & FTU-R; 15-min & 24-hour	2	
		loss-of-margin (CURR/PREV_NE/FE_15/24_LOM)	Current & History; FTU-O & FTU-R; 15-min & 24-hour	2	
		loss-of-rmc (CURR/PREV_NE/FE_15/24_LOR)	Current & History; FTU-O & FTU-R; 15-min & 24-hour		
		loss-of-power (CURR/PREV_NE/FE_15/24_LPR)	Current & History; FTU-O & FTU-R; 15-min & 24-hour		
		errored-seconds (CURR/PREV_NE/FE_15/24_ES)	Current & History; FTU-O & FTU-R; 15-min & 24-hour	1	
		severely-errored-seconds (CURR/PREV_NE/FE_15/24_SES)	Current & History; FTU-O & FTU-R; 15-min & 24-hour	1	
		loss-of-signal-seconds (CURR/PREV_NE/FE_15/24_LOSS)	Current & History; FTU-O & FTU-R; 15-min & 24-hour	2	
		loss-of-rmc-seconds (CURR/PREV_NE/FE_15/24_LORS)	Current & History; FTU-O & FTU-R; 15-min & 24-hour		
		unavailable-seconds (CURR/PREV_NE/FE_15/24_UAS)	Current & History; FTU-O & FTU-R; 15-min & 24-hour	2	
		successful-bit-swaps (CURR/PREV_NE/FE_15/24_BSW)	Current & History; FTU-O & FTU-R; 15-min & 24-hour		
		successful-autonomous-sra(CURR/PREV_NE/FE_15/24_SRA)	Current & History; FTU-O & FTU-R; 15-min & 24-hour		
		successful-fra (CURR/PREV_NE/FE_15/24_FRA)	Current & History; FTU-O & FTU-R; 15-min & 24-hour		
		successful-rpa (CURR/PREV_NE/FE_15/24_RPA)	Current & History; FTU-O & FTU-R; 15-min & 24-hour		
3.4.2	FTU Channel Performance				
		invalid-data-flag (PREV_NE/FE_15/24_C_INVALID)	History; FTU-O & FTU-R; 15-min & 24-hour		
		time-stamp (PREV_NE/FE_15/24_C_STAMP)	History; FTU-O		

			& FTU-R; 15-min & 24-hour		
		measured-time (CURR/PREV_NE/FE_15/24_C_TIME)	Current & History; FTU-O & FTU-R; 15-min & 24-hour		
		error-free-bits (EFB–C/P15M/24H/us/ds)	Current & History; FTU-O & FTU-R; 15-min & 24-hour	1	
		minimum-error-free-throughput (MINEFTR–C/P15M/24H/us/ds)	Current & History; FTU-O & FTU-R; 15-min & 24-hour	1	
		code-violations (CURR/PREV_NE/FE_15/24_CV)	Current & History; FTU-O & FTU-R; 15-min & 24-hour	1	
		uncorrected-dtus (CURR/PREV_NE/FE_15/24_RTXUC)	Current & History; FTU-O & FTU-R; 15-min & 24-hour		
		retransmitted-dtus (CURR/PREV_NE/FE_15/24_RTXTX)	Current & History; FTU-O & FTU-R; 15-min & 24-hour	2	
3.5	Object model for FAST Performance Threshold Management				
3.5.1	FAST Threshold Template				
		pointer-to-line-thresholds-profile-for-ne-15m	Line		Note 1
		pointer-to-line-thresholds-profile-for-ne-24h	Line		Note 1
		pointer-to-line-thresholds-profile-for- fe-15m	Line		Note 1
		pointer-to-line-thresholds-profile-for-fe-24h	Line		Note 1
		pointer-to-channel-thresholds-profile-for-ne-15m	Channel		Note 1
		pointer-to-channel-thresholds-profile-for-ne-24h	Channel		Note 1
		pointer-to-channel-thresholds-profile-for- fe-15m	Channel		Note 1
		pointer-to-channel-thresholds-profile-for-fe-24h	Channel		Note 1
3.5.2	FAST Line Threshold Profile				
		errored-seconds-threshold (THRESHOLD_NE/FE_15/24_ES)	FTU-O & FTU-R; 15-min & 24-hour		Note 1
		severely-errored-seconds-threshold (THRESHOLD_NE/FE_15/24_SES)	FTU-O & FTU-R; 15-min & 24-hour		Note 1
		unavailable-seconds-threshold (THRESHOLD_NE/FE_15/24_UAS)	FTU-O & FTU-R; 15-min & 24-hour		Note 1
		full-initializations-threshold (THRESHOLD_NE_15/24_FULL_INITS)	FTU-O & FTU-R; 15-min & 24-hour		Note 1
		failed-initializations-threshold (THRESHOLD_NE_15/24_FAILEDFULL_INITS)	FTU-O & FTU-R; 15-min & 24-hour		Note 1

		fast-initializations-threshold (THRESHOLD_NE_15/24_FAST_INITS)	FTU-O & FTU-R; 15-min & 24-hour		Note 1
		loss-of-signal-seconds-threshold (THRESHOLD_NE/FE_15/24_LOSS)	FTU-O & FTU-R; 15-min & 24-hour		Note 1
		loss-of-rmc-seconds-threshold (THRESHOLD_NE/FE_15/24_LORS)	FTU-O & FTU-R; 15-min & 24-hour		Note 1
		failed-fast-initializations-threshold (THRESHOLD_NE_15/24_FAILEDFAST_INITS)	FTU-O & FTU-R; 15-min & 24-hour		Note 1
		spontaneous-interruptions-threshold (THRESHOLD_NE_24_SPONT_INTRPT)	FTU-O & FTU-R; 24-hour		Note 1
3.5.3	FAST Channel Threshold Profile				
		code-violations-threshold (THRESHOLD_NE/FE_15/24_CV)	FTU-O & FTU-R; 15-min & 24-hour		Note 1
		uncorrectable-dtus-threshold (THRESHOLD_NE/FE_15/24_RTXUC)	FTU-O & FTU-R; 15-min & 24-hour		Note 1
		retransmitted-dtus-threshold (THRESHOLD_NE/FE_15/24_RTXTX)	FTU-O & FTU-R; 15-min & 24-hour		Note 1
3.6	Object model for FAST Testing / Diagnostic				
3.6.1	FAST Sub-Carrier Status				
		actual-tx-psd (ACTPSDps)	ds & us	1	
		snr-measurement-time (SNRMT)	ds & us	2	
		snr-sub-carrier-group-size (SNRG)	ds & us		
		snr[n] (SNRps)	ds & us	1	
		bits-allocation (BITSps)	ds & us	1	
		RMC sub-carrier-bits-allocation[n] (BITSRMCps)	ds & us	2	
		hlog-measurement-time (HLOGMT)	ds & us	2	
		hlog-sub-carrier-group-size (HLOGG)	ds & us		
		hlog (HLOGps)	ds & us	1	
		qln-measurement-time (QLNMT)	ds & us	2	
		qln-sub-carrier-group-size (QLNG)	ds & us		
		qln (QLNps)	ds & us	1	
		aln-measurement-time (ALNMT)			
		aln-sub-carrier-group-size (ALNG)			
		aln (ALNps)		2	

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