TECHNICAL REPORT

TR-165

Vector of Profiles

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Summary

This Technical Report addresses the need for greater flexibility in setting DSL profiles by defining a vector of profiles. The DSL configuration parameters are divided into independent, but technically related, sets of parameters. Each parameter set defines a profile. The profiles are referenced from a vector of indices, each index identifying a unique profile. This allows a large number of profiles to be used without having to store huge quantities of profile data. The Vector of Profiles is a key enabler to DSL Quality Management. It is also expected to help Network Operators in the implementation of efficient and cost-effective Network Operation processes such as Network Creation, Service Delivery, Service Assurance and Troubleshooting.

1 Purpose and Scope

1.1 Purpose

The purpose of this Technical Report is to define a Vector of Profiles (VoP) based object model for DSL configuration that allows for great flexibility of configuration without an undue burden of data storage in DSL Element Managers or DSLAMs. This is particularly true for FTTx deployment scenarios with specific requirements depending on the PSD shaping on the remote DSLAM, noise margins, specific OLR features and INP configurations.

It is also expected to help Network Operators in the implementation of efficient and cost-effective Network Operation processes such as Network Creation, Service Delivery, Service Assurance and Troubleshooting.

The Vector of Profiles specified in this Technical Report obsoletes the object model for DSL line configuration defined in the Broadband Forum's TR-129. Legacy systems may still use that object model for configuration management. All other object models of TR-129 remain valid.

1.2 Scope

The Technical Report describes the Vector of Profiles approach and specifies the independent sets of parameters that form the profiles. The DSL configuration parameters are drawn from G.997.1 and the profiles are generic to DSL modems that conform to ITU-T Recommendations G.992.1, G.992.3, G.992.5 and G.993.2. Thus the approach can be used to configure multi-mode DSL modems.

This document only specifies the object model with respect to the structure of the managed objects. The detailed parameter definitions and their access mode (read-only vs. read-write) are specified in G.997.1.

The implementation of VoP is not specified in this Technical Report but two possible approaches to implementation in Network Elements are described and compared in Appendix A.

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 often capitalized. More information can be found be in RFC 2119 [1].

MUST	This word, or the terms "REQUIRED" or "SHALL", mean that the definition is an absolute requirement of the specification.
MUST NOT	This phrase, or the phrase "SHALL NOT", mean that the definition is an absolute prohibition of the specification.
SHOULD	This word, or the adjective "RECOMMENDED", means that there may exist valid reasons in particular circumstances to ignore this item, but the full implications must be understood and carefully weighed before choosing a different course.
SHOULD NOT	This phrase, or the phrase "NOT RECOMMENDED" means that there may exist valid reasons in particular circumstances when the particular behaviour is acceptable or even useful, but the full implications should be understood and the case carefully weighed before implementing any behaviour described with this label.
MAY	This word, or the adjective "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 www.broadband-forum.org

[1] RFC 2119	*Key words for use in RFCs to Indicate Requirement Levels*	IETF	1997
[2] G.997.1	*Physical layer management for Digital Subscriber Line (DSL) Transceivers*	ITU-T Recommendation	2006
[3] G.992.1	*Asymmetric digital subscriber line*	ITU-T	1999

	(ADSL) transceivers.	Recommendation	
[4] G.992.2	*Splitterless asymmetric digital subscriber line (ADSL) transceivers*	ITU-T Recommendation	1999
[5] G.992.3	*Asymmetric digital subscriber line transceivers 2 (ADSL2)*	ITU-T Recommendation	2002
[6] G.992.4	*Splitterless asymmetric digital subscriber line transceivers 2 (ADSL2)*	ITU-T Recommendation	2002
[7] G.992.5	*Asymmetric digital subscriber line (ADSL) transceivers – Extended bandwidth ADSL2 (ADSL2+))*	ITU-T Recommendation	2003
[8] G.993.2	*Very high speed digital subscriber line 2 (VDSL2)line transceivers 2 (ADSL2)*	ITU-T Recommendation	2006
[9] TR-129	*Protocol-Independent Management Model for Next Generation DSL Technologies)*	Broadband Forum Technical Report	2006
[10] G.997.1 Amendment 1	*Physical layer management for Digital Subscriber Line (DSL) Transceivers - Amendment 1*	ITU-T Recommendation	2006
[11] G.997.1 Amendment 2	*Physical layer management for Digital Subscriber Line (DSL) Transceivers - Amendment 2*	ITU-T Recommendation	2007

2.3 Definitions

The following terminology is used throughout this Technical Report.

FTTx.	Summarises FTTB, FTTC and FTTK
Vector of Profiles	A set of N independent profiles, each profile containing a unique set of DSL modem configuration parameters and the value of each vector index referencing specific values of the parameters.
xDSL	Summarizes the DSL types ADSL (G.992.1/G.992.2), ADSL2 (G.992.3/G.992.4), ADSL2plus (G.992.5) and VDSL2 (G.993.2).

2.4 Abbreviations

This Technical Report uses the following abbreviations:

DS	Downstream

DPBO	Downstream Power Back-Off
DSLAM	Digital Subscriber Line Access Multiplexer
EMS	Element Management System
FTTB	Fibre To The Building
FTTC	Fibre To The Cabinet
FTTK	Fibre To The Kerb
FTTx	Fibre To The x.
INP	Impulse Noise Protection
NE	Network Element
PSD	Power Spectral Density
RFI	Radio Frequency Interference
SNR	Signal to Noise Ratio
US	Upstream
UPBO	Upstream Power Back-Off
VoP	Vector of Profiles

3 Technical Report Impact

3.1 Energy Efficiency

TR-165 has no impact on Energy Efficiency.

3.2 IPv6

TR-165 has no impact on IPv6.

3.3 Security

TR-165 has no impact on Security.

4 Introduction

DSLAMs support a limited number of different line configurations in order to avoid storing the very large amount of information that would be required if they were to be able to set the configuration for each modem arbitrarily. The individual line settings are chosen by a scalar quantity, selecting from a limited range of profiles. This is not sufficiently flexible for operators to be able to choose efficient configurations to cope with the large number of combinations of line parameters required to optimise performance for the service requirements and noise environment.

This approach is called the Vector of Profiles (VoP). The Broadband Forum's Technical Report TR-129 [9] specifies an object model that contains separate Line Spectrum Profiles and Line Service Profiles, which are pointed to from a template. This is similar to the principle of VoP but its line configuration parameters division into sets/profiles is not optimal. In the VoP approach the configuration parameters are divided into independent sets. Each set is used to define a profile and each index in the vector points to a specific profile.

5 Goals and requirements

The goal of vector of profiles is to maximize the choice of profiles whilst minimizing the storage requirements in the network element for the profiles.

In defining a Vector of Profiles two criteria that are used in specifying the sets of the G.997.1 [2] parameters that make up the elements (different sets of parameters) in a Vector of Profiles:

1. The parameters in different elements of a Vector of Profiles should be independent of each other.
2. In order to save memory, parameters that a network operator is likely to assign many values to (maximum sync rate could be an example) should be in different elements of the vector than those that are likely to have relatively few values.

The most useful ways of producing profiles that meet the criteria are:

- Line type
- Direction of transmission
- Channel
- Spectrum

Line type
This includes parameters that define the type of DSL and certain states that the DSL can be in.

Direction of transmission
Many parameters are defined for both the upstream and downstream directions and so independent profiles for each direction can be specified.

Channel
A DSL system can support multiple channels and so several profiles can be specified for supported channels.

Transmit Spectrum
Parameters that define the transmit spectrum characteristics can be grouped in a profile. A further sub-division can be applied for those parameters that are dependent on the type, or mode, of DSL.

The selection of the profiles based on the above is entirely logical and a good starting point. However, in practice there are some parameters for which a large choice of values is desirable and others that few different values are required. It is desirable to adjust the parameter sets taking this into account so that the parameters that remain fairly static are not repeated unnecessarily.

Based on the experience of Service Providers, the categorisation and aggregation of G.997.1 parameters in the Vector of Profiles defined in Section 6 is based on the following:

Common

1. The Vector of Profiles distributes line configuration parameters in a way that allows decoupling and efficient management of the typical Network Operation phases: Service Planning, Network Creation and Service Delivery and Service Assurance/Troubleshooting

2. The Vector of Profiles decouples channel related parameters from spectrum related ones

3. Each profile in the Vector contains an additional attribute to serve as a description string.

Spectrum related parameters

4. The Vector of Profiles decouples those parameters which define the basic spectrum (e.g. the operation mode, the basic PSD profile, etc.) from those related to FTTC/K/B infrastructural spectrum shaping (i.e. DPBO and UPBO)

5. The Vector of Profiles decouples infrastructural spectrum shaping DPBO and UPBO parameters from each other

Service related parameters

6. The Vector of Profiles decouples those parameters which are part of the contractual offer (typically the bit rates) and those which involve the Service Assurance phase of Network Operation by acting on line robustness (e.g. the Noise Margin, INP and Delay)

7. The Vector of Profiles keeps channel-specific bit rate parameters together

8. The Vector of Profiles keeps channel-specific robustness parameters (INP and Delay) together

9. The Vector of Profiles decouples noise margin parameters from INP-Delay ones

Downstream vs Upstream parameters

10. The Vector of Profiles keeps the DS and US parameters together with the exception of DPBO vs UPBO parameters and channel data rate parameters.

6 Profile Definitions

TR-129 already divides the parameters in G.997.1 up into some individual profiles. Taking these as a starting point and applying the principles for sub-division above the following profiles are specified. Figure 1 shows the individual profiles which contain the parameters listed below. The parameter names are taken from G.997.1 and its amendments which give the parameter definitions.

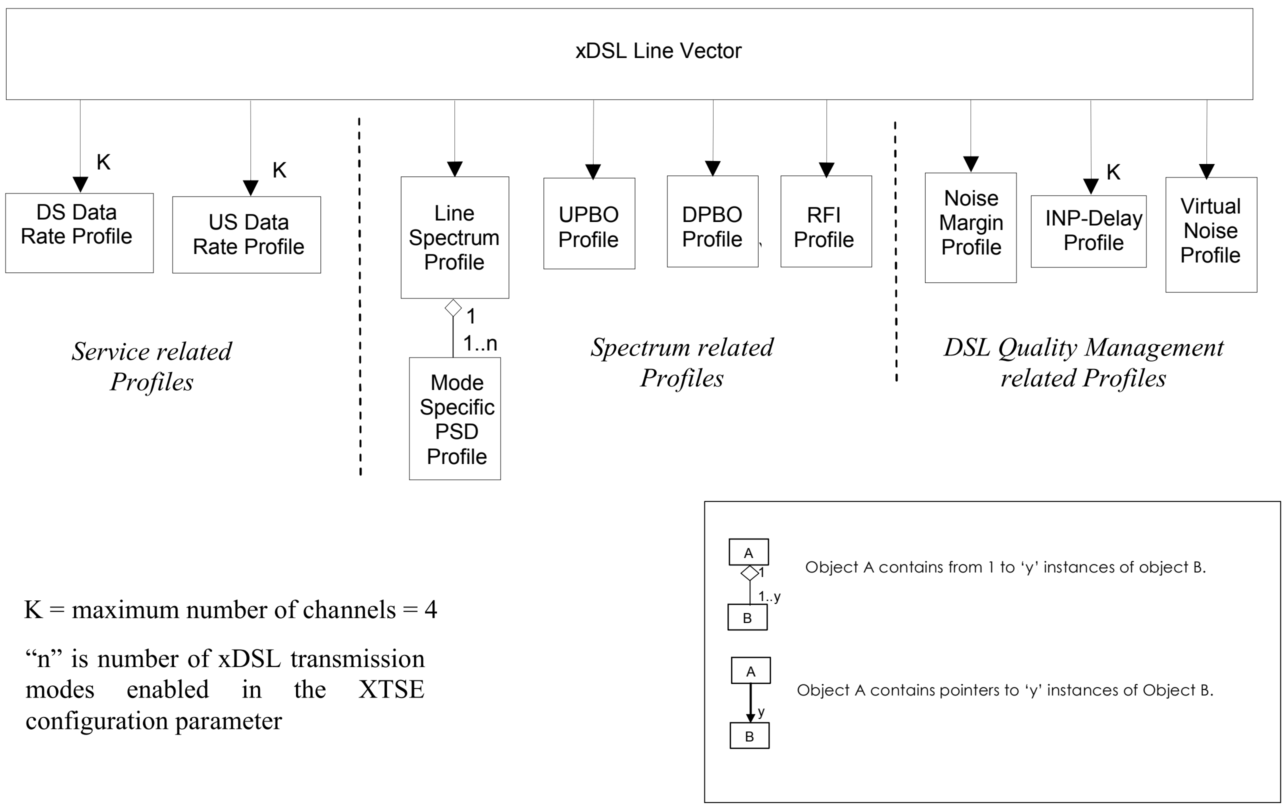

Figure 1 - Vector of Profiles

6.1 Service related profiles

The service related profiles contain the parameters for configuration of data rates for individual channels. There will be a separate data rate profile for each of the upstream and downstream channels. The number of possible channels varies with the type of DSL. For ADSL and VDSL2 there can be up to two in each direction and for ADSL2 and ADSL2plus there can be up to four in each direction. Thus to cover all possibilities there will be 8 indices in the vector for data rate profiles. If less than the maximum number of channels is to be used then the scalars corresponding to non-required channels MUST be set to a null value (0).

DS Data Rate Profile

The downstream data rate profile MUST contain the following parameters:

- Minimum Data Rate downstream
- Minimum Reserved Data Rate downstream
- Maximum Data Rate downstream
- Rate Adaptation Ratio downstream
- Minimum Data Rate in low power state downstream
- Maximum Bit Error Ratio downstream
- Data Rate Threshold Upshift downstream
- Data Rate Threshold Downshift downstream

US Data Rate Profile

The upstream data rate profile MUST contain the following parameters:

- Minimum Data Rate upstream
- Minimum Reserved Data Rate upstream
- Maximum Data Rate upstream
- Rate Adaptation Ratio upstream
- Minimum Data Rate in low power state upstream
- Maximum Bit Error Ratio upstream
- Data Rate Threshold Upshift upstream
- Data Rate Threshold Downshift upstream

6.2 Spectrum related profiles

Line Spectrum Profile

The Line Spectrum Profile contains the parameters that are mainly set during the service delivery phase, independently for upstream and downstream. They are combined into one profile as the number of different combinations is expected to be rather low. The Line Spectrum profile MUST contain the following parameters:

- xTU Transmission System Enabling (XTSE)
- Power Management State Enabling (PMMode)
- L0-TIME
- L2-TIME
- L2-ATPR
- L2-ATPRT
- CARMASK downstream
- CARMASK upstream
- VDSL2-CARMASK
- Minimum Overhead Rate Upstream (MSGMIN upstream)
- Minimum Overhead Rate Downstream (MSGMIN downstream)
- VDSL2 Profiles Enabling (PROFILES)
- VDSL2 US0 PSD Masks Enabling (US0MASK)
- Optional Cyclic Extension Flag (CEFLAG)

The Line Spectrum Profile includes configuration parameters that are independent of the specific transmission mode(s) enabled in the XTSE configuration parameter. However, there are configuration parameters where their setup depends on a transmission mode. Therefore, each Line Spectrum Profile is also associated with one or more Mode Specific PSD Profiles. When the vector of profiles refers to a Line Spectrum Profile it also implicitly refers to all Mode Specific PSD Profiles associated with it.

Mode Specific PSD Profile

The Line Spectrum Profile includes a configuration parameter (XTSE) that enables one or more transmission modes in the same profile. While all other parameters in the Line Spectrum Profile are independent of the enabled transmission mode(s) there are other configuration parameters where their setup depends on a transmission mode. Those parameters are covered by the Mode Specific PSD Profile. Practically, each Mode Specific PSD Profile is associated with a specific Line Spectrum Profile. When the vector of profiles refers to a Line Spectrum Profile it also implicitly refers to all Mode Specific PSD Profiles associated with it. Each transmission mode enabled in a Line Spectrum Profile is covered by one and only one of the Mode Specific PSD Profiles contained in that Line Spectrum Profile.

The Mode Specific PSD Profile MUST contain the parameters that define the downstream and upstream PSDs for a specific xDSL mode.

- xDSL mode (possible values from the list in G.997.1/paragraph 7.3.1.1.1)
- Downstream Maximum Nominal Power Spectral Density (MAXNOMPSD
- downstream)
- Upstream Maximum Nominal Power Spectral Density (MAXNOMPSD
- upstream)
- Downstream Maximum Nominal Aggregate Transmit Power (MAXNOMATP
- downstream)
- Upstream Maximum Nominal Aggregate Transmit Power (MAXNOMATP
- upstream)
- Upstream Maximum Aggregate Receive Power (MAXRXPWR upstream)
- Downstream PSD Mask (PSDMASK downstream)
- Upstream PSD mask selection
- Upstream PSD Mask (PSDMASK upstream)
- VDSL2 Limit PSD Masks and bandplans enabling (LIMITMASK)
- VDSL2 US0 Disabling (US0DISABLE)
- VDSL2 PSD Mask Class Selection (CLASSMASK)

UPBO Profile

The UPBO Profile MUST contain all the parameters related to upstream power back-off.

- 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)
- Reference electrical length per band (Band number, UPBOKLREF-pb)

DPBO Profile

The electrical length of the cable from the CO to the cabinet at the FTTx site is applied, on a site, card or port basis during the network creation phase; it needs to be enforced on each DSL line of the site to guarantee spectral compatibility. To avoid a huge amount of profile combinations it should to be separated from all other spectrum related parameters. The DPBO profile MUST contain the following parameter:

- Downstream Power Back-Off E-side Electrical Length (DPBOESEL)
- Downstream Power Back-Off assumed Exchange PSD mask (DPBOEPSD)
- Downstream Power Back-Off E-side Cable Model (DPBOESCMA,
- DPBOESCMB and DPBOESCMC)
- Downstream Power Back-Off Minimum Usable Signal (DPBOMUS)
- Downstream Power Back-Off span Minimum Frequency (DPBOFMIN)
- Downstream Power Back-Off span maximum frequency (DPBOFMAX)

RFI Profile

RFI notches are necessary only when radio services may be disturbed during operation, therefore this parameter should be separated from all other profiles. The RFI profile MUST contain the following parameter:

- RFIBANDS

6.3 DSL Quality Management related profiles

SNR Margin Profile

Noise margins are important for line robustness and need to be configured independently from other spectrum related parameters to reduce the amount of combinations. These parameters may be adjusted because of the changed disturber's impact while data rates aren't changed. The SNR Margin profile MUST contain the following parameters:

- Downstream Minimum Noise Margin (MINSNRMds)
- Upstream Minimum Noise Margin (MINSNRMus)
- Downstream Target Noise Margin (TARSNRMds)
- Upstream Target Noise Margin (TARSNRMus)
- Downstream Maximum Noise Margin (MAXSNRMds)
- Upstream Maximum Noise Margin (MAXSNRMus)
- Downstream Signal-to-Noise Ratio Mode (SNRMODEds)
- Upstream Signal-to-Noise Ratio Mode (SNRMODEus)
- Downstream Rate Adaptation Mode (RA-MODEds)
- Upstream Rate Adaptation Mode (RA-MODEus)
- Downstream Upshift Noise Margin (RA-USNRMds)
- Upstream Upshift Noise Margin (RA-USNRMus)
- Downstream Downshift Noise Margin (RA-DSNRMds)

- Upstream Downshift Noise Margin (RA-DSNRMus)
- Downstream Minimum Time Interval for Upshift Rate Adaptation (RA-UTIMEds)
- Upstream Minimum Time Interval for Upshift Rate Adaptation (RA-UTIMEus)
- Downstream Minimum Time Interval for Downshift Rate Adaptation (RA-DTIMEds)
- Upstream Minimum Time Interval for Downshift Rate Adaptation (RA-DTIMEus)

INP-Delay Profile

The INP-Delay parameters for each pair of upstream and downstream channels will be in an INP-Delay Profile. To cover all possibilities there will be 4 indices in the vector for INP-Delay Profiles. If less than the maximum number of channels is to be used then the scalars corresponding to non-required channels MUST be set to a null value (0).

The reason for separating the INP-Delay Profile from the Data Rates Profile is to provide different robustness and delay behaviour for services like online gaming, voice and video. These parameters may be adjusted because of changed disturber's impact while data rates aren't changed, as they are set at the service delivery phase. The INP-Delay profile MUST contain the following parameters:

- Force framer setting for impulse noise protection (FORCEINP) downstream
- Minimum Impulse Noise Protection (INPMIN) downstream
- Minimum Impulse Noise Protection 8kHz (INPMIN8) downstream
- Maximum Interleaving Delay downstream
- Force framer setting for impulse noise protection (FORCEINP) upstream
- Minimum Impulse Noise Protection (INPMIN) upstream
- Minimum Impulse Noise Protection 8kHz (INPMIN8) upstream
- Maximum Interleaving Delay upstream
- Maximum Delay Variation (DVMAX)
- Channel Initialization Policy Selection (CIPOLICY)

Virtual Noise Profile

The Virtual Noise Profile MUST contain the virtual noise PSDs:

- Downstream Transmitter Referred Virtual Noise (TXREFVNds)
- Upstream Transmitter Referred Virtual Noise (TXREFVNus)

A Virtual Noise PSD is not used if the corresponding SNRMODE parameter is set to 0. The SNRMODE parameters for upstream and downstream are in the SNR Margin Profile

Appendix I. Possible Implementation Approaches

I.1 Introduction

This document defines a Vector of Profiles (VoP) for DSL line configuration that allows better flexibility of the configuration components and more efficient use of data storage in the DSL Element Management System (EMS) and Network Element (NE), compared to the architecture specified by TR-129.

This informative appendix describes two alternatives for implementing the VoP and associating it with DSL lines, a ***direct attachment*** of a VoP to each DSL line and an ***indirect attachment*** of a VoP to each DSL line.

In either case, the assumption is that the DSLAM is required to allocate memory for storing all instances of the profiles that the management system (i.e., EMS and/or NMS) defines as well as the information regarding to the configuration of each DSL line.

I.2 Method of Profiles Attachment to DSL Line in TR-129

TR-165 revises and improves the management model defined in TR-129 [9]. The management model in TR-129 is based on three main configuration profiles: Line Spectrum profile, Line Service profile and Channel Configuration profile (which, according to TR-129, is embedded in the Line Service profile). In addition there is an upper layer profile-of-profiles, called a **template,** which can be considered as a simplified VoP.

Each DSL line is associated, according TR-129, with an identifier of the configuration template that is appropriate for it.

The following Figure 2 illustrates the method defined in TR-129, where there are two pools of profiles and one pool of profile templates and each one of the *L* DSL lines points to one of the templates.

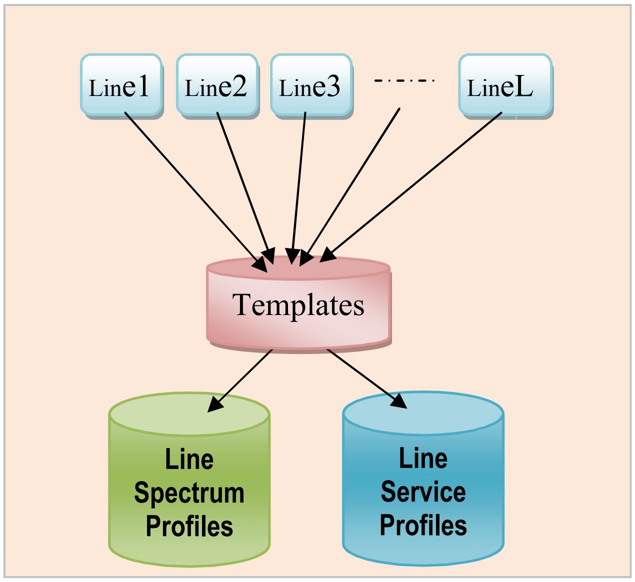

Figure 2 - Profiles attachment to DSL Lines in TR-129

The memory consumption for storing configuration information in the TR-129 based management model is:

P_T x T + L where:

- P_T is the number of different templates stored in memory,
- T is the number profile indices in each template, and
- L is the number of DSL lines in the DSLAM; each is assigned one template index

In addition, $\sum_{p=1}^{p=T}(N_p \times P_p)$ memory addresses are needed for the profiles storage where:

- N_P is the number of parameters in profile p and P_P is the number of different p profiles.

Note that P_T is $<= \prod_{p=1}^{p=T} P_p$ as in practice the management system does not use every potential combination of the p profiles.

I.3 Direct Attachment of VoP to DSL Line

With this approach there are two layers in implementing the VoP. One layer includes the tables for all profiles that are part of the VoP. The management system creates instances of those profiles as needed and removes instances of profiles when no longer required. The other layer is the VoPs and, according to this approach, each DSL line directly points to all profile instances that construct the configuration VoP it uses. This is realized by implementing, for each DSL line, a number of managed objects that are profile indices. In case the management system wishes to set a configuration for the DSL line or modify the configuration of a DSL line, it directly accesses and modifies the relevant indices in the set of managed objects belonging to that DSL line.

The following Figure 3 illustrates the method of direct attachment of profiles to DSL lines, where each one of the L lines directly points to instances from V profile pools.

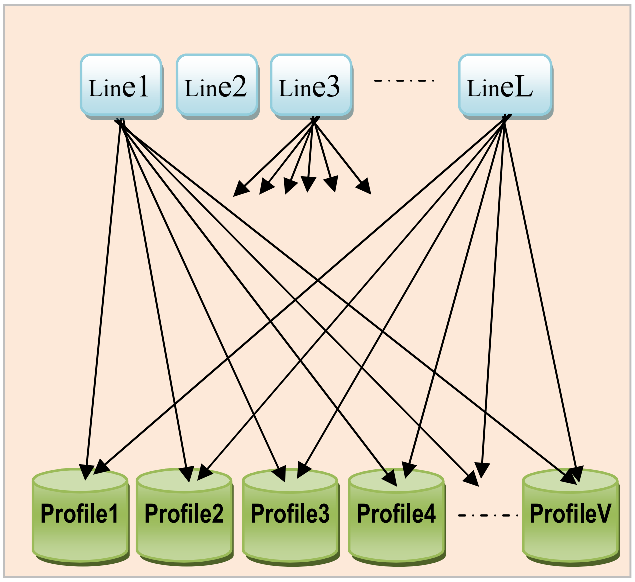

Figure 3 - Direct attachment of VoP to DSL Lines

The memory consumption for storing configuration information in the direct attachment model is:

L x V where:

- V is the number profile indices in the VoP, and
- L is the number of DSL lines in the DSLAM; each is assigned a set of profile indices

In addition, $\sum_{p=1}^{p=V}(N_p \times P_p)$ memory locations are needed for the profile storage where:

- N_P is the number of parameters in profile p and P_P is the number of different p profiles.

Note that (L x V) is <= $\prod_{p=1}^{p=V} P_p$ as in practice the management system does not use every potential combination of the p profiles.

I.4 Indirect Attachment of VoP to DSL Line

With this approach there are three layers in implementing the VoP. One layer includes the tables for all profiles that are part of the VoP. This layer is identical to the one implemented according to the direct attachment approach. The second layer is a VoP table with a profile index per each profile in the VoP. The management system creates instances of VoPs when needed (i.e., for configuring one or more DSL lines) and removes instances of VoPs when no longer required. The third layer is the association of each DSL line with a VoP. This is realized by a single managed object, a VoP index, implemented for each DSL line. When the management system wishes to configure a specific DSL line or modify the configuration of a specific DSL line, it creates a new VoP and writes its identifier in the VoP index of that specific DSL line. If the required VoP already exist in memory, then the management system only need to write its identifier in the VoP index of the specific DSL line.

The following Figure 4 illustrates the method of indirect attachment of profiles to DSL lines, where there are V profile pools and one VoPs pool and each one of the L lines directly points to an instance of VoP.

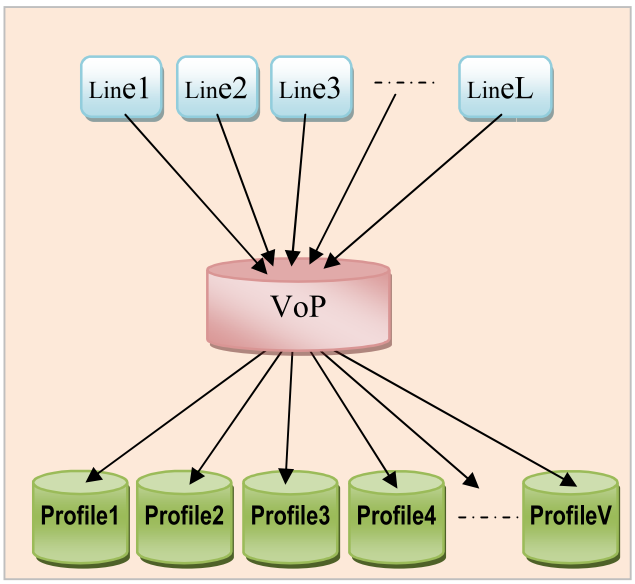

Figure 4 - Indirect attachment of VoP to DSL Lines

The memory consumption for storing configuration information in the indirect attachment model is:

P_V x V + L where:

- P_V is the number of different VoPs stored in memory,
- V is the number profile indices in each VoP, and
- L is the number of DSL lines in the DSLAM; each is assigned one VoP index

In addition, $\sum_{p=1}^{p=V} (N_p \times P_p)$ memory locations are needed for the profile storage where:

- N_P is the number of parameters in profile p and P_P is the number of different p profiles.

Note that P_V is $<= \prod_{p=1}^{p=V} P_p$ as in practice the management system does not use every potential combination of the p profiles.

I.5 Comparison of Direct and Indirect Attachment Approaches

I.5.1 Ease of Operation

I.5.1.1 First Setup

The ***direct attachment*** approach requires that each DSL line will be assigned its own set of V indices, and that requires V 'WRITE' operations (V is the number of profiles indices in the VoP) while configuring each DSL line.

With the ***indirect attachment*** approach if the management system already uses the same configuration for any other DSL line in the DSLAM, it simply associates the new DSL line with the same VoP index. That requires a single 'WRITE' operation. Only if the DSL line is the first to use the specific configuration planned for it then creating the VoP and associating the DSL line with the new VoP requires V+1 'WRITE' operations.

I.5.1.2 Configuration Changes

The ***direct attachment*** approach allows the management system to modify a specific component of any DSL line configuration at the DSLAM by simply changing the involved profile index in the VoP which is attached to the affected DSL line. This can be performed with a single 'WRITE' operation.

The ***indirect attachment*** always replaces a VoP index with another VoP index. So, if the management system does not already use the modified configuration for any other DSL line in the DSLAM, it should first create a new VoP and then associate the affected line with the new VoP index. If the VoP with the modified configuration already exist then the operation is simply changing the VoP index associated with the affected DSL line. So, the cost of configuration changes in this case is one or (V+1) 'WRITE' operations, depending on whether or not there is a need to create a new VoP.

I.5.1.3 VoP Maintenance

In the ***indirect attachment*** approach, the management system is required to determine from time to time what VoPs are being used by the DSLAM and remove unused VoPs from the DSLAM's memory. Such an operation is irrelevant in ***direct attachment*** approach.

I.5.2 Memory Consumption

From A.3 and A.4 above it is clear that the memory consumption for storing the configuration profiles is the same no matter what attachment approach is selected. The difference between the two approaches is on higher layers, where only profile indices are involved.

The memory required for storing the VoPs with the ***direct attachment*** approach is constant, i.e., number of indices in the VoP multiplied by the number of lines in the DSLAM. This makes the ***direct attachment*** optimized for the case where each DSL line in the DSLAM has a different configuration.

The ***indirect attachment***, however, stores each VoP only once. So, in case M lines share the same configuration VoP_X the only one copy of VoP_X is stored in the DSLAM's memory, instead of M copies in the other approach. This makes the ***indirect attachment*** optimized for the case in which a significant number of lines in the DSLAM have identical configuration.

End of Broadband Forum Technical Report TR-165

