

DSL Technology Evolution

ADSL2/ADSL2plus/ADSL-RE/VDSL2



Today there are various DSL Technology Options

Family	ITU	Name	Ratified	Maximum Speed capabilities
ADSL	G.992.1	G.dmt	1999	7 Mbps down 800 kbps up
ADSL2	G.992.3	G.dmt.bis	2002	8 Mb/s down 1 Mbps up
ADSL2plus	G.992.5	ADSL2plus	2003	24 Mbps down 1 Mbps up
ADSL2-RE	G.992.3	Reach Extended	2003	8 Mbps down 1 Mbps up
SHDSL (updated 2003)	G.991.2	G.SHDSL	2003	5.6 Mbps up/down
VDSL	G.993.1	Very-high-data-rate DSL	2004	55 Mbps down 15 Mbps up
VDSL2 -12 MHz long reach	G.993.2	Very-high-data-rate DSL 2	2005	55 Mbps down 30 Mbps up
VDSL2 - 30 MHz Short reach	G.993.2	Very-high-data-rate DSL 2	2005	100 Mbps up/down

Market Status of DSL Technology

- ***DSL is the #1 Broadband Choice in the World with over 65% marketshare and more than 200 million users***
- ***DSL is available in every region of the world, and ADSL owns the majority of the market though VDSL and ADSL2plus are gaining ground***
- ***DSL is capable of providing up to 100 Mbp, and supports voice, video and data.***
- ***The new DSL network is IP-centric***
- ***There is broad equipment interoperability and there are currently established test specifications for ADSL, ADSL2plus, SHDSL, and soon VDSL2 will join the list***
- ***Finally, ADSL and home networking are a natural fit as DSL effectively supports multiple applications for multiple uses via each DSL connection.***

DSL Applications

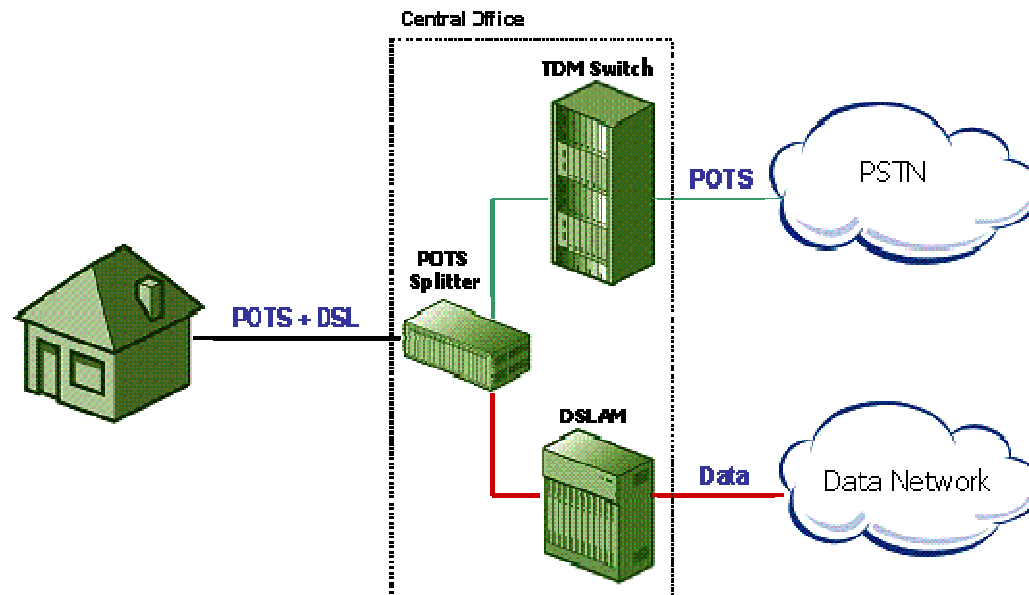
- Internet Access & File Sharing
- Video
 - Broadcast TV
 - Video On Demand
 - User generated video
- Telecommuting
- Online Education & Shopping
- Telemedicine
- Online Gaming



How Does DSL Work?

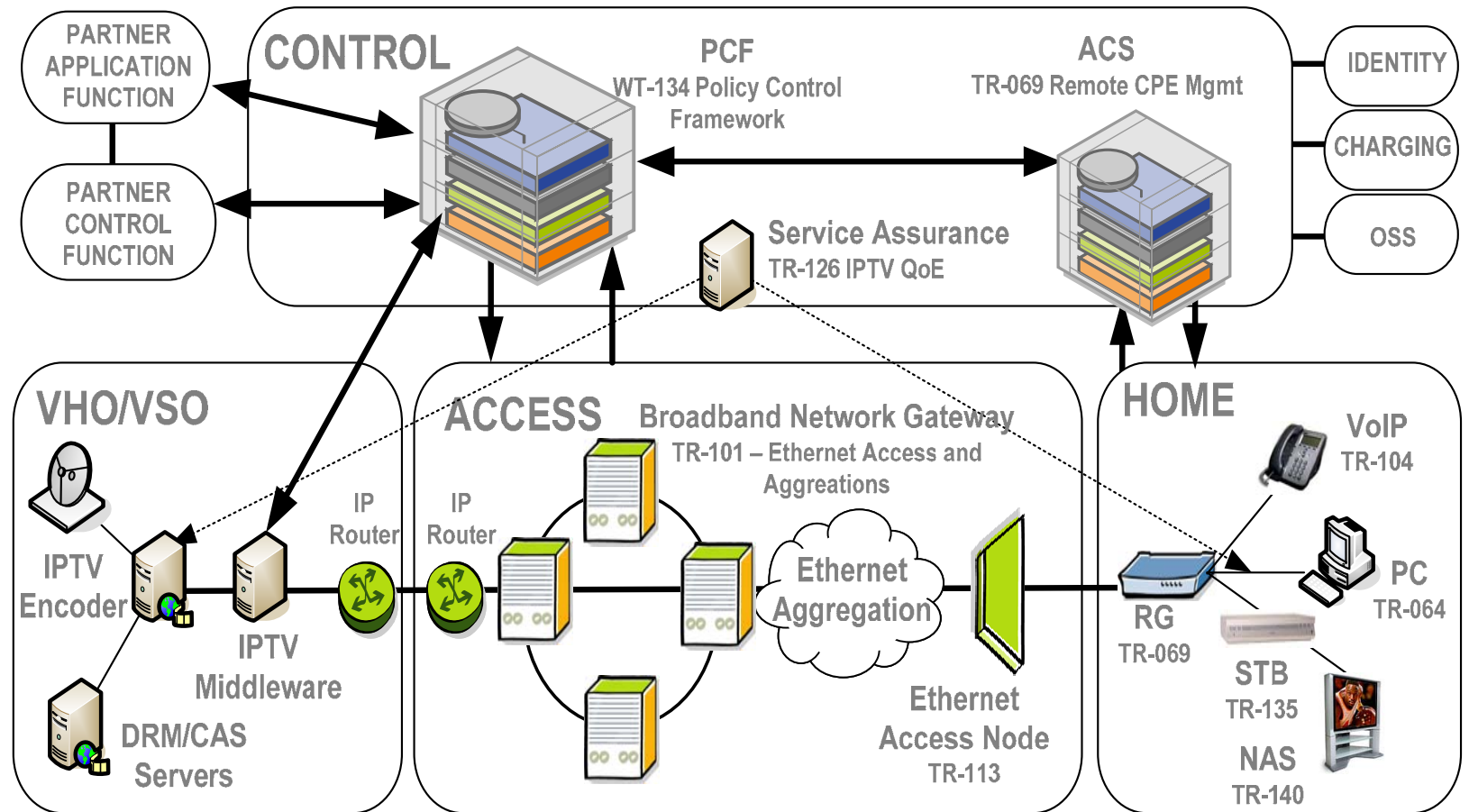
- Functional Elements
- Use of Bandwidth
- Channel Separation & POTS Splitter
- New IP-centric Architecture

Simple overview of ADSL in the phone network



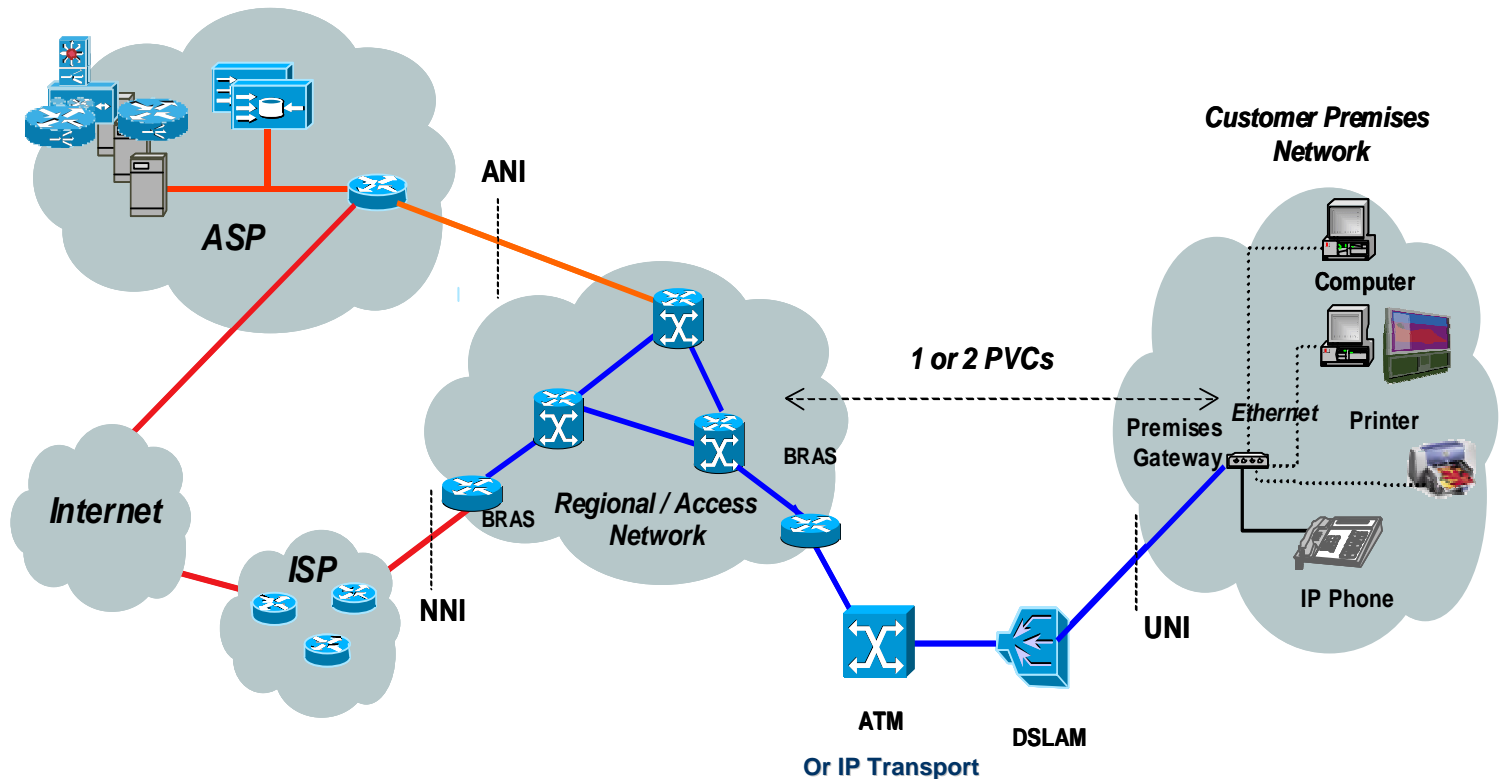
POTS- Plain Old Telephone Service

All the elements



IP Routing – Improves the Architecture

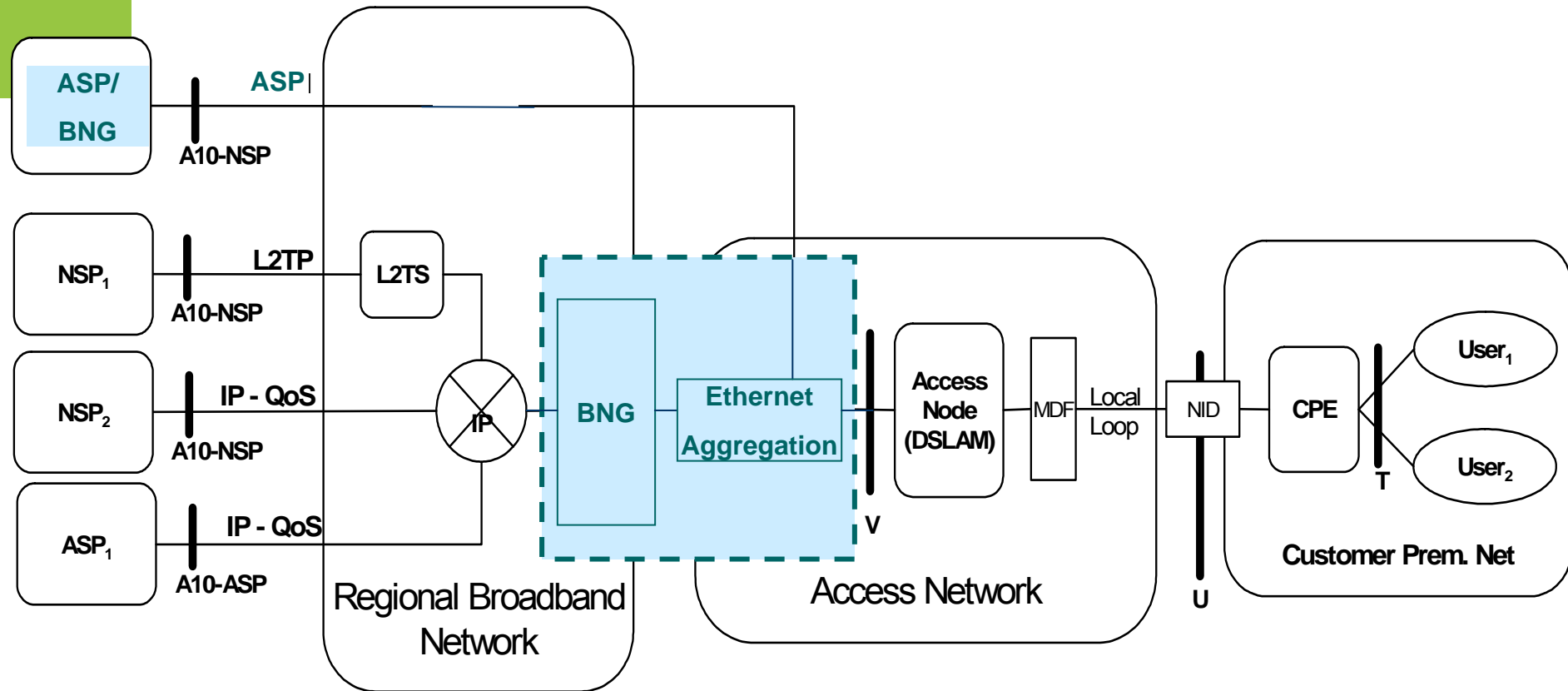
QoS Breakthrough!



TR-059 specifies IP Routed Network Architecture to support a mix of IP based services including IP Video from an Application Service Provider, by employing DiffServ.

TR-101 Reference Model

Access Aggregation Moves from ATM to IP Ethernet



NSP – Network Service Provider
ASP – Application Service Provider

Latest Developments

What each DSL flavor
offers



SHDSL Option

- Not widely used in the industry
- G.shdsl (G.991.2)
 - ITU Recommendation
 - 1st Global Standard for DSL after ADSL
 - Harmonized w/ ETSI SDSL & ANSI HDSL2
 - Two-wire Operation
 - Symmetrical and Rate Adaptive
 - 192kbps to 2.312Mbps
 - Options to the Standard
 - 4-wire operation
 - Repeaters
 - Fixed rate operation at 784 kb/s and 1.544 kb/s



Latest options gaining ground

- ADSL2

- Approved by ITU-T as G.992.3 July 2002
- Features
 - Improved rate – up to 12Mbps by 1Mbps
 - Improved reach – around 600ft / 180m
 - Power cutback capability
 - Reduced framing overhead
 - Better modulation efficiency
 - Channelisation capability
 - Bonding of lines

Strong deployment ongoing

- ADSL2plus
 - Approved by ITU-T as G.992.5 January 2003
 - Features
 - Much increased rates – up to 20Mbps by 1Mbps
 - Doubled downstream frequency band to 2.2Mhz
 - Reduced cross talk
 - Allows provision of advanced services
 - Builds on all ADSL2 features
 - Legacy interoperable

Service Migration

- ADSL2plus
 - Backward interoperable
 - Services now available
 - Being installed as the “standard” modem chip set
 - Interoperability problems effectively overcome
- VDSL2
 - ADSL, ADSL2 and ADSL2plus interoperable
 - Services now available

Better support of new applications

- Triple / Quad play is becoming a reality!
 - ADSL2plus and VDSL2 both offer wide area 20+Mbps multi-channel speeds
 - Allows FTTC and direct from exchange service
 - Full service residential 50Mbps by 10Mbps – max
 - Wide area business Ethernet
 - Feeder transport to remote nodes – using bonding
 - 3 x HDTV (VDSL2), Internet, voice, gaming etc

Network Scalability

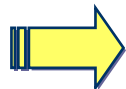
- ADSL2plus and VDSL2
 - With VDSL2 now approved:
 - Backward compatible with ADSL2plus etc
 - Offers highly scalable networks
 - Creates new flexibility for service providers
 - Steadily take fibre closer to the subscriber
 - Migrate ADSL → ADSL2plus → VDSL2
 - Easily implemented service expansion and upgrade

Standards evolution empower Video delivery at higher speeds

Next Generation ADSL: **ADSL2** (G.992.3)

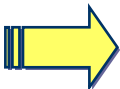
- > performance improvement (+100 kb/s on average)
- > improved interop, loop diagnostics, robustness
- > improved initialization & fast start-up
- > power management

ADSL



ADSL2plus (G.992.5)

- > downstream bandwidth boost up to 24.5 Mb/s



Reach Extended ADSL: **RE-ADSL2** (G.992.3 annex L)

- > loop reach increase of 600 to 900 m at low rates (192 kb/s DS + 96 kb/s US)

Double upstream (G.992.3/5 annex M)

- > double upstream bandwidth

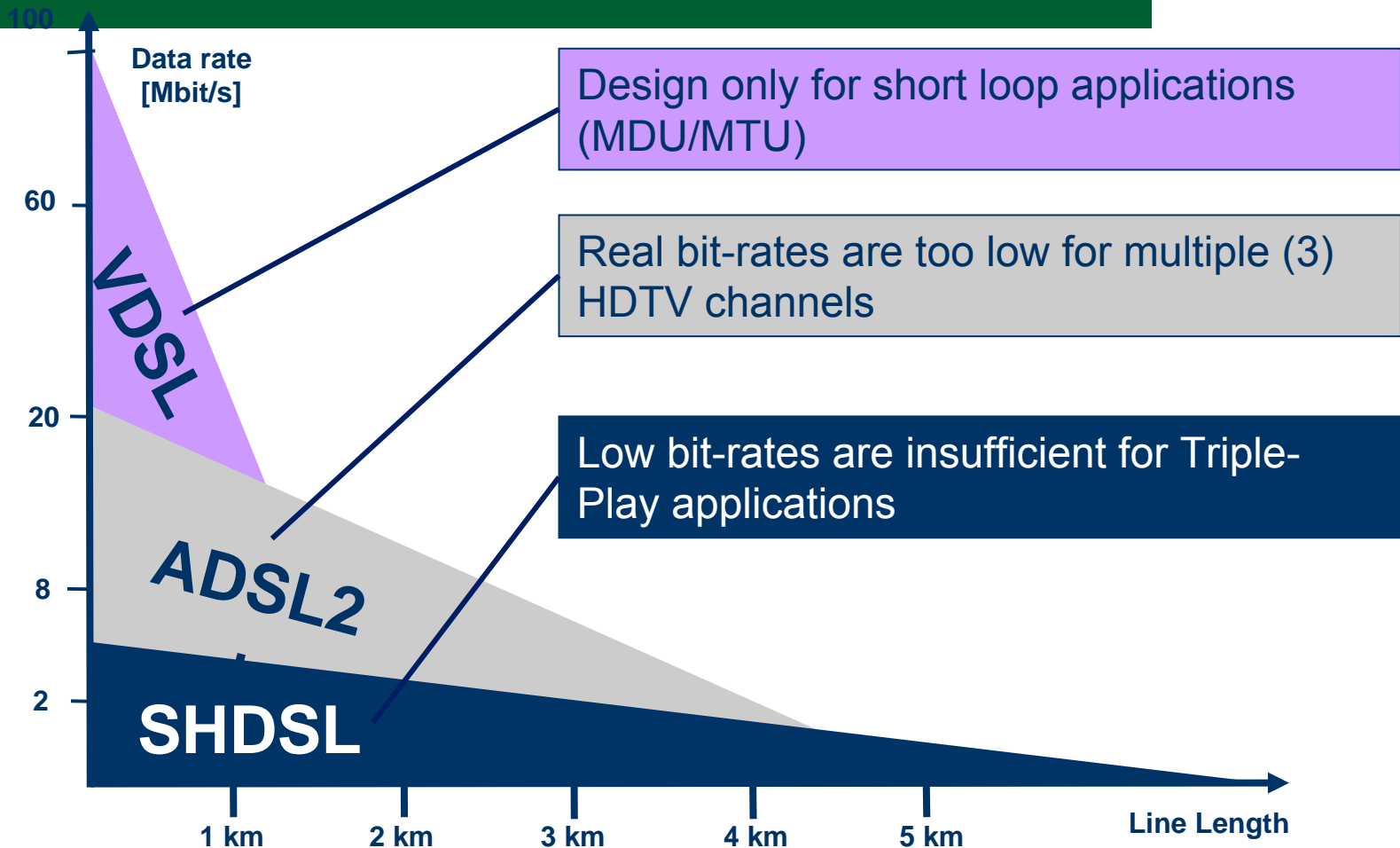
VDSL2

Very high speed DSL

- > bandwidths up to 100 Mb/s on short loops
- > different band plans
 - Plan 997: compromise band plan for symmetric and asymmetric traffic
 - Plan 998: optimized for asymmetry
 - Plan Fx: flexible band plan

**Most service providers update with a triple pack:
ADSL2, ADSL2plus and RE-ADSL at the same time
Or go straight to VDSL2**

Existing High Speed Technologies Did Not Solve the Problem of Bottlenecks



VDSL2 = VDSL Speeds with ADSL/2+ Reach and Flexibility

VDSL2 Standardization







- VDSL2 standardization started in January 2004
- Main technology development in ITU-T
- North American system requirements in ANSI/NIPNAI
- European system requirements in ETSI
- Reached consent in May 2005 (Geneva Meeting)

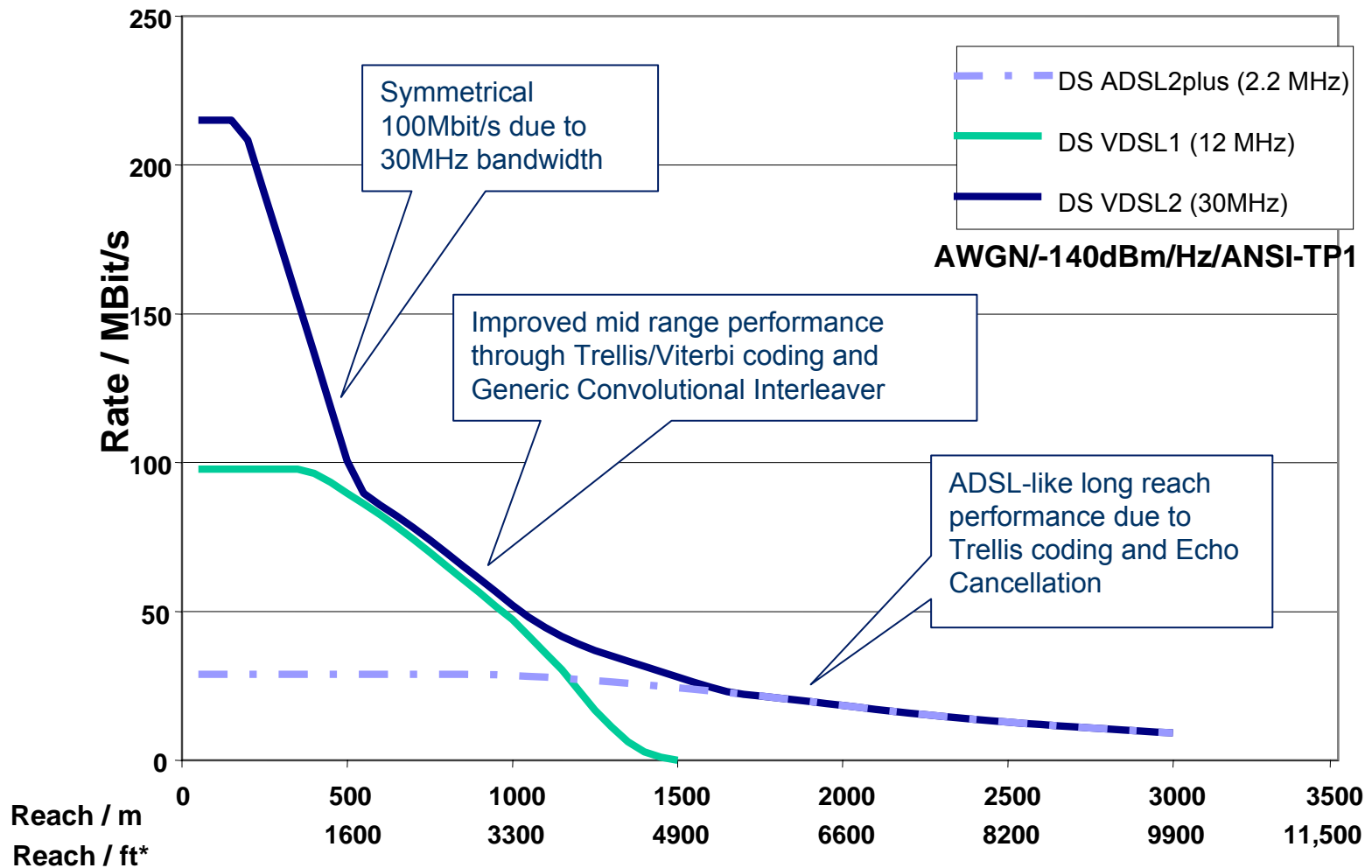
VDSL2 Key Features

- DMT modulation
 - Same as ADSL
 - Bandwidth increased from 12 MHz to 30 MHz
 - Up to 4096 tones (8x ADSL2plus!)
- Worldwide Versatile Standard
 - 8 profiles defined for different services
 - Different bandplans for the regions
 - Variety of PSDs to optimize spectral compatibility
- Support for a variety of services
 - Integrated Quality of Service features
 - ATM as well as Ethernet payload
 - Channel bonding for extended reach or rate

VDSL2 - All The Benefits of ADSL2/2plus, Higher Speeds Than VDSL1

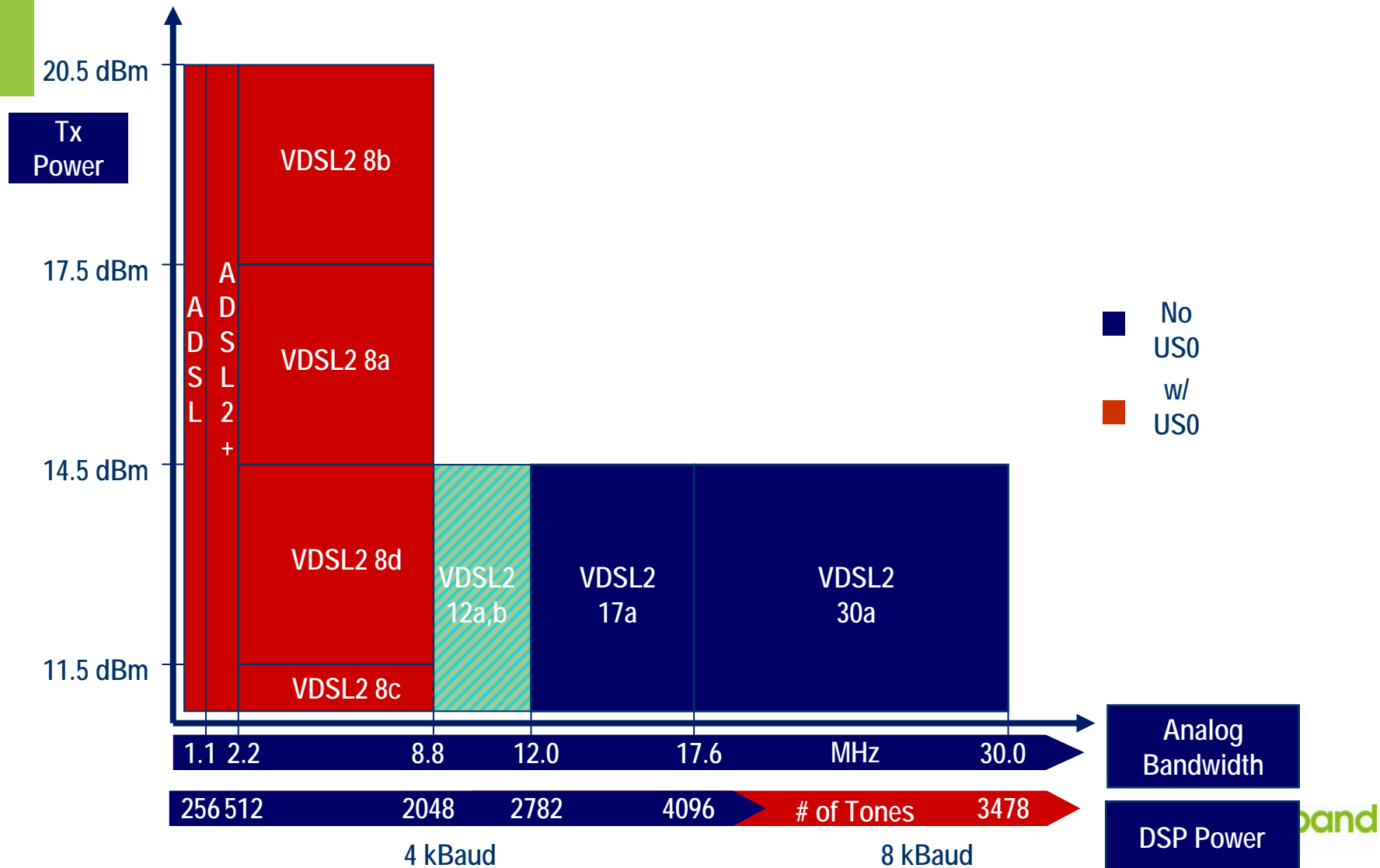
Criteria	VDSL2 Benefits	
Bandwidth	<div> VDSL1  12MHz </div> <hr/> <div> VDSL2  30MHz </div>	Much higher performance for short loops
Trellis, SRA, GCI	<div> VDSL1 None </div> <hr/> <div> VDSL2 Mandatory </div>	Improved performance
Long Reach	<div> VDSL1  1km </div> <hr/> <div> VDSL2  3km ... </div>	90% customer reach + single technology
ADSL Compatibility	<div> VDSL1 None </div> <hr/> <div> ADSL, ADSL2, ADSL2plus </div>	Reuse existing ADSL infrastructure
Quality Of Service (QoS)	<div> VDSL1 None </div> <hr/> <div> VDSL2 Dual Latency, Dual Bearer, Pre-Emption </div>	Enable Triple – Play applications

VDSL2 Performance



* Numbers are rounded

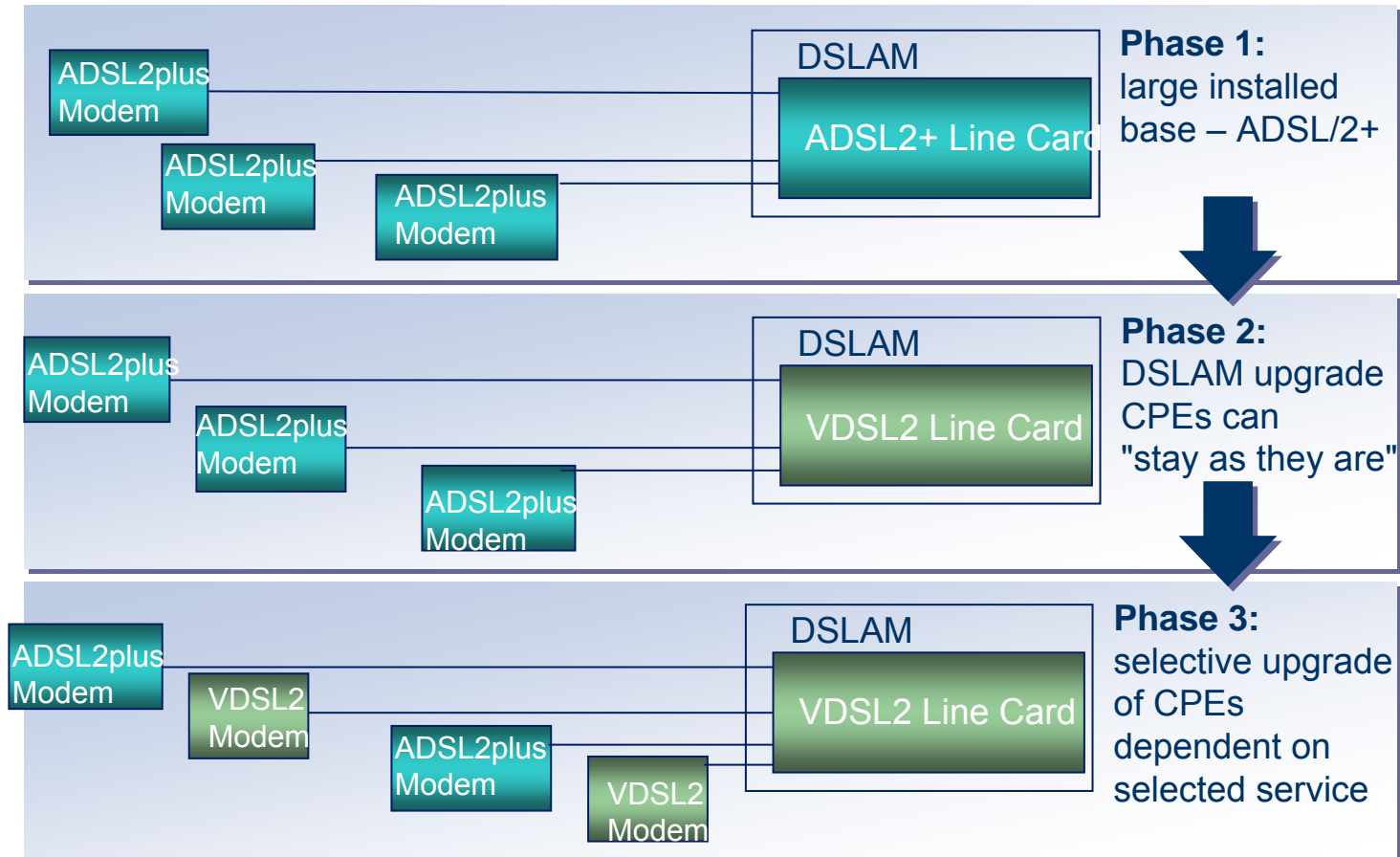
VDSL2 Standard – Profiles



Bandplans, Annexes, PSDs



ADSL2plus Backwards Compatibility



ADSL2plus backwards compatibility will make VDSL2 deployment scenario much more attractive for the Carriers and will speed up the technology adoption.

Market Trends – Deployment By Region

Europe

- Triple-Play with at least 3 DTV channels + 5Mbps surfing + VoIP
- 30Mbps downstream, 3Mbps upstream
- **VDSL2 compliant**
- **ADSL backwards compatible**
- **20.5dBm transmit power**
- **Fits into existing ATM infrastructure**
- ADSL-like long reach performance

Mainland China

- Triple-Play with at least 3 DTV channels + 5Mbps surfing + VoIP
- 30Mbps downstream, 3Mbps upstream
- **VDSL2 compliant**
- **ADSL backwards compatible**
- **20.5dBm transmit power**
- **Fits into existing ATM infrastructure**
- ADSL-like long reach performance

USA, Canada

- Triple-Play with at least 3 HDTV channels + 5Mbps surfing + VoIP
- 30Mbps downstream, 3Mbps upstream
- **VDSL2 compliant**
- **ADSL backwards compatible**
- **17.5dBm transmit power**
- ADSL-like long reach performance

Japan, Korea, Taiwan

- Upgrade of existing 70Mbps services to 100Mbps symmetrical
- 100Mbps downstream, 100Mbps upstream
- **VDSL2 compliant**
- **ADSL backwards compatible**
- **14.5/20.5dBm transmit power**
- ADSL-like long reach performance

Broadband Forum's VDSL2 Work in Progress

- **Interoperability**
 - Finalizing performance/functional requirements (WT-114 and WT-115)
 - **Interoperability test plan for VDSL2 (PD-139)**
 - Enables efficient interoperability testing
 - First plugfest planned for January 2006
 - Ongoing test events with the interoperability test labs
- **Management**
 - **Protocol Independent Object Model For Managing VDSL2 (WT-129)**
 - Based on ITU G.997.1
 - Adopting new objects from G.vdsl2

Summary

- ADSL2plus and VDSL2 offer triple play at last
 - Reach allows wider serving areas
 - Rates allow triple play and enhanced services
 - Ethernet rapidly taking over from ATM
 - Offers LAN extension type services – no signal conversion
 - Network architecture evolving faster than ever before – Broadband Forum driven

Release Plan

Provides overview and
roadmap of key TRs



BroadbandSuite Release 1.0

Key Capabilities : Internet access via ADSL or SHDSL over a QoS-enabled ATM architecture.
Supports VoIP transport & VoDSL

ACCESS R1.0	HOME R1.0	CONTROL R1.0
TR-059 : Architecture Requirements for the Support of QoS-Enabled IP Services	TR-069 : CPE WAN Mgmt Protocol	TR-090 : Protocol Independent Object Model for Managing Next Generation ADSL Technologies
TR-067 : ADSL Interop Test Plan	TR-111 : Applying TR-069 to Remote Management of Home Networking Devices	TR-066 : ADSL Network Element Mgmt
TR-092 : Broadband Remote Access Server (BRAS) Requirements Document	TR-068v2 : Base Requirements for an ADSL Modem with Routing	TR-051 : DSL Specific Conventions for the ITU-T Q.822.1 Performance Mgmt Bulk Data File Structure
TR-060 : Interop Test Plan for SHDSL	TR-064 : LAN-Side DSL CPE Configuration Specification	TR-050 : CORBA v2 for ADSL EMS-NMS Interface
TR-043 : Protocols at the U Interface for Accessing Data Networks using ATM/DSL	TR-133 : TR-064 Extensions for Service Differentiation	TR-027 : SNMP-based ADSL LINE MIB
TR-042 : ATM Transport over ADSL Recommendation	TR-104 : Provisioning Parameters for VoIP CPE	TR-024 : DMT Line Code Specific MIB
TR-025 : Core Network Architecture for Access to Legacy Data Network over ADSL	TR-098 : Gateway Device Version 1.1 Data Model for TR-069	
TR-013 : Interface & Configurations for ADSL: Central Office	TR-062 : Auto-Config for the Connection Between the DSL Broadband Network Termination (B-NT) and the Network using ATM	
	TR-061 : Interfaces and System Configurations for ADSL: Customer Premises	

BroadbandSuite Release 2.0 (2006-2007)

Key Capabilities :

Triple-play access via ADSL2plus over a QoS-enabled Ethernet architecture.

Full support for multicast to enable IPTV streaming.

ACCESS R2.0	HOME R2.0	CONTROL R2.0
TR-101 : Ethernet-centric multicast-capable architecture	TR-124 : Functional Requirements for Broadband Residential Gateway Devices	TR-130 : xDSL EMS to NMS Interface Functional Requirements
TR-100 : ADSL2plus performance test plan	TR-069 Amendment 1 : CPE WAN Management Protocol	TR-129 : Protocol-Independent Management Model for Next Generation DSL Technologies
TR-067 Issue 2 : ADSL Interoperability Test Plan	TR-098 Amendment 1 : Internet Gateway Device Data Model for TR-069	TR-128 : Addendum to TR-090, Protocol Independent Object Model for Managing Next Generation ADSL Technologies
	TR-122 : Base Requirements for Consumer-Oriented Analog Terminal Adapter Functionality	
	TR-068 : Base Requirements for an ADSL Modem with Routing	

BroadbandSuite Release 3.0 (late 2008)

Key Capabilities : Triple-play access via GPON over a QoS-enabled Ethernet architecture.
Full support for multicast to enable IPTV. Integrated remote management of Set-Top Box

ACCESS R3.0	HOME R3.0	CONTROL R3.0
TR-101 : Ethernet-centric multicast-capable architecture	TR-135 : Residential Data Model for a TR-069 Enabled Set Top Box	TR-117 : Broadband Trouble Reporting
WT-156 : Extending TR-101 to GPON fibre access systems	TR-140 : Data Model for a TR-069 Enabled Storage Device	TR-141 : Protocol Independent Management Model for TR-101 Compliant Access Node
WT-138 : Validation of G.997.1 Parameters	TR-142 : Framework for use of TR-069 with PON Access	WT-147 : Layer 2 Control Mechanism
WT-127 : Dynamic Testing of DSL Transceivers with Splitters	TR-143 : CPE Throughput Performance Test Mechanism	WT-159 : Management Framework for xDSL Bonding
	WT-107 : Internet Gateway Device Data Model version 2 (includes bonded DSL)	WT-176 : ADSL2plus Profiles for IPTV
	PD-157 : TR-069 Common Managed Objects	

Work that is complete

**Thanks for taking the time to learn
about our DSL related work**

Check out our Release
Program to learn more
about related TRs

