

Reinventing DSL with Copper Pair Bonding

Wednesday, October 26

1:30 – 3:00 p.m.

Venetian Ballroom I



Technology Forum at TELECOM '05



Alliance for Telecommunications
Industry Solutions

Reinventing DSL with Copper Bonding

ATIS Technology Conference

Telecom 05

October 26, 2005

Reinventing DSL: Higher Speeds

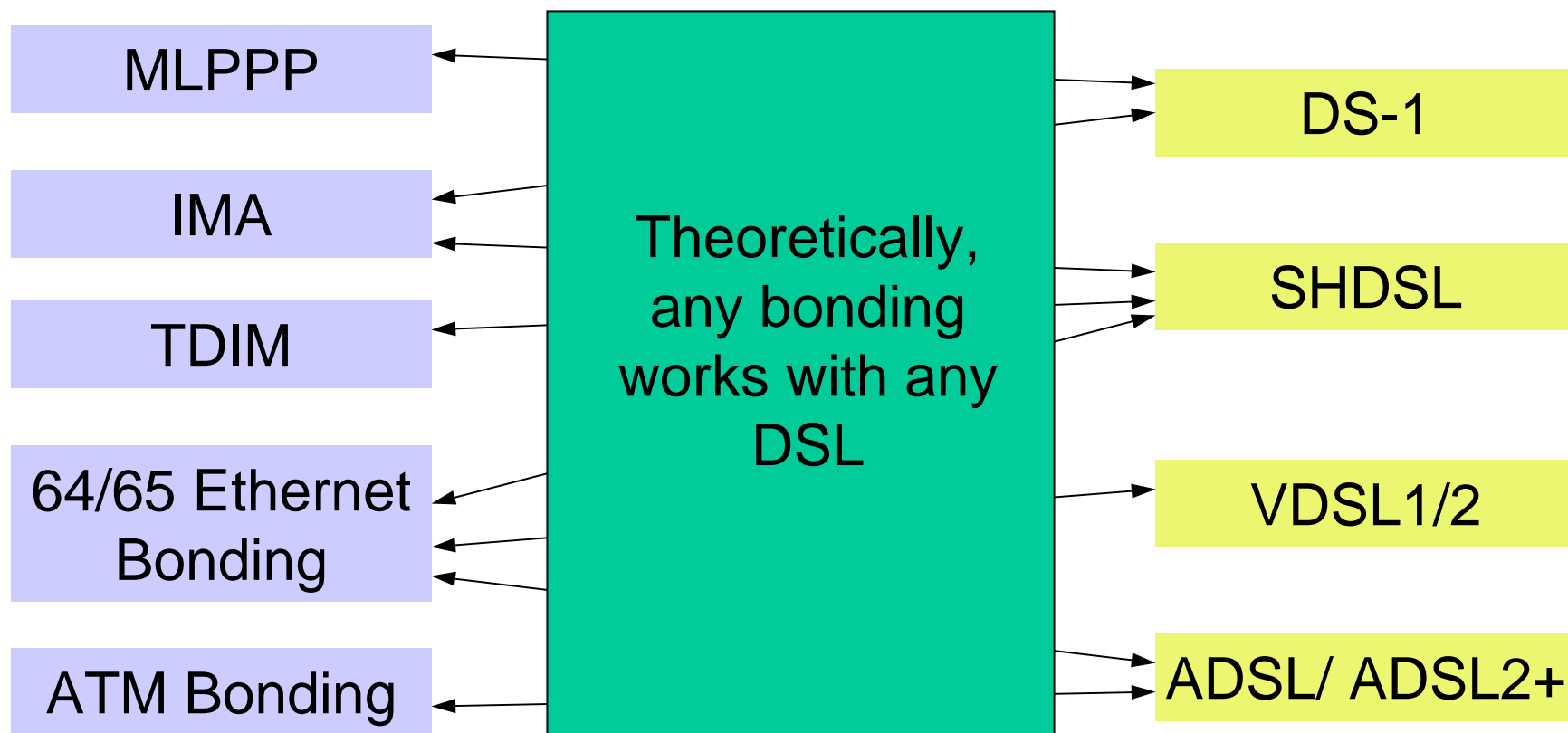
- **Competition**
 - Cable
 - 3G Wireless
- **Migration**
 - From 1.5 Mbps to 15 Mbps or more
- **Standards**
 - Need cost-effective, standard solutions

Bonding Defined

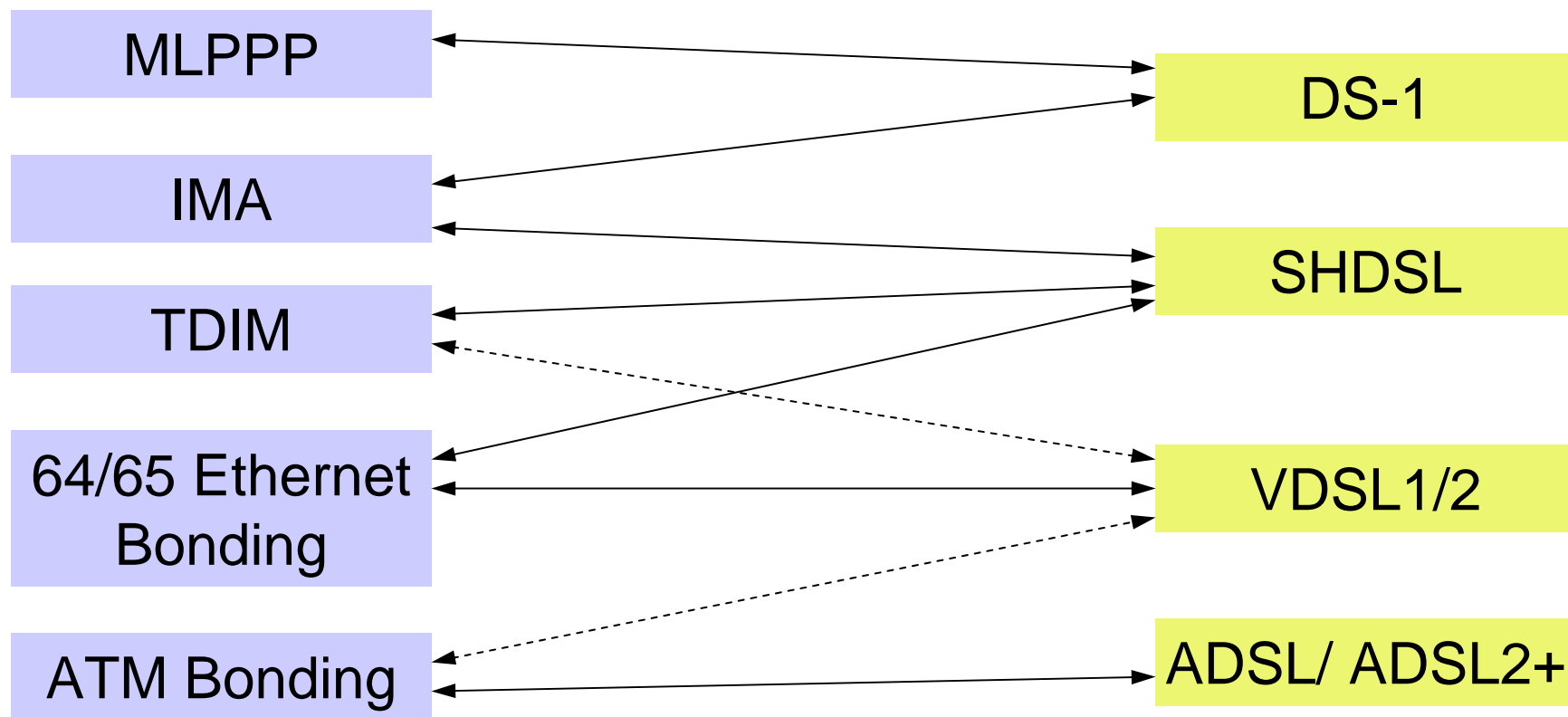
■ Inverse Multiplexing

- Payload Bonding
- Combining the payloads of 2 or more DSL links into a single “fat pipe”
- Many Standards available
 - MLPPP (RFC 1990) – relies on underlying HDLC
 - IMA – Inverse Multiplexing for ATM
 - T1.427, G.998
 - .01/.1: ATM Cell Bonding
 - .02/.2: Ethernet Transport (64/65 TC)
 - .03/.3: Time Division Inverse Multiplexing (TDIM)
 - IEEE 802.3ah – Ethernet bonding with SHDSL/VDSL

What Bonding with What DSL?



What Bonding with What DSL?



In practice, these mappings are the most common

Beyond Standards

- Multiple Input Multiple Output (MIMO)
 - Can be applied mostly independent of payload bonding method
 - Rates can be boosted through
 - In-Domain Crosstalk Cancellation
 - Out-of-Domain Crosstalk Compensation
 - Pair-diverse Coding
 - Out of domain gains can vary widely
 - Most gain requires large (8-12 pairs) group size
 - Depends on # and type of other system and noise

Panelists

- Jürgen Lison, Alcatel
 - Bonding and ADSL2+
- Rouben Toumani, Ikanos
 - Bonding and VDSL2
- Gary Tennyson, BellSouth
 - Bonding Deployment Considerations



Reinventing DSL with Bonding

Jürgen Lison, Alcatel

- Why bond?
 - Capture new customers with extended reach
 - Address business needs with symmetrical services
 - Offer triple play services
- Shannon's Law and market realities
 - Bonded ADSL2+ fills the gaps
- Bonding challenges and solutions
- Summary

How some people bond lines

Key features:

- Poor scalability
- High fixed investment costs
- Safety concerns
- And not very flexible



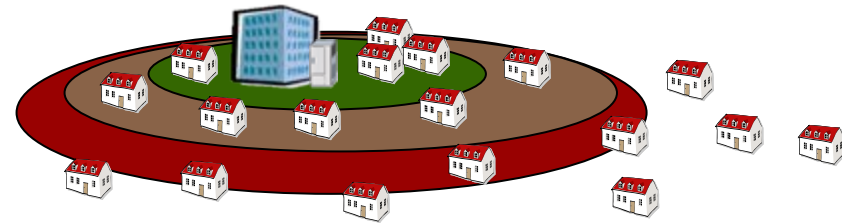
Why Bond ADSL2+?

- At any **REACH** – Double **RATE** (DS, US)
- Generally Available and shipping **TODAY**
- Stable, standard technology
- Chip synergies with legacy ADSL
- Greater range of marketable bandwidths than single pair VDSL/VDSL2

Expanding the customer (and revenue) base for DSL

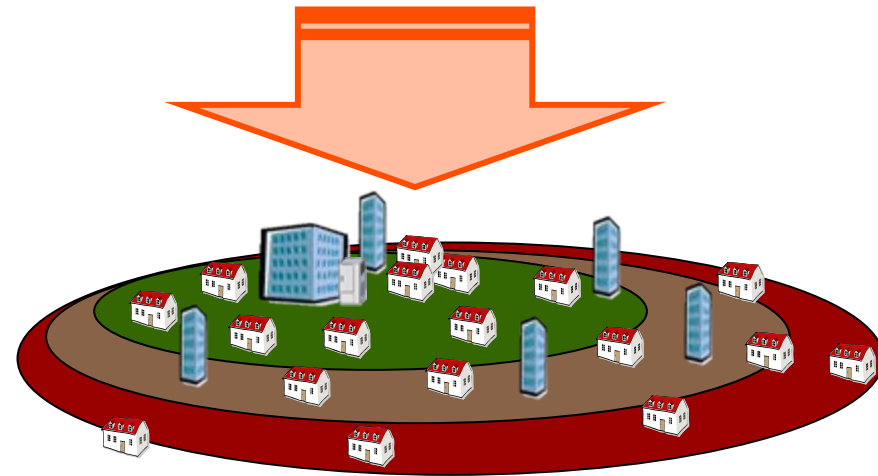
Extending Reach

- Bonded ADSL2+ doubles data rates at any given reach
- Customers previously unable to qualify for DSL – now qualify



Symmetrical Services

- Double upstream bandwidth
- T1 replacement opportunity
- Target SMB customers
- Competitive positioning over cable



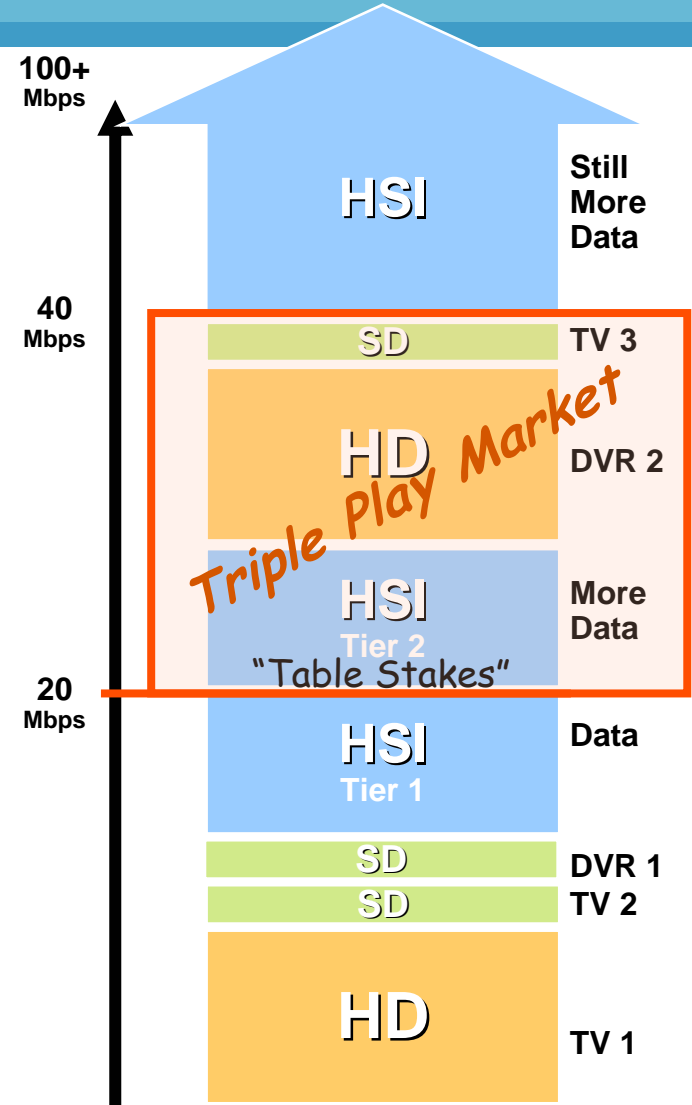


Delivering the Triple Play

How much bandwidth is needed at the home?

Depends on the services offered

- Video
 - High bandwidth and high QOS
 - HD and SD
 - Multiple STBs, DVRs, and PIPs
- Voice
 - Low bandwidth but high QOS
- Data
 - High bandwidth but bursty
 - Some QoS
 - Supply-side product:
"If you build it, they will come."



IPTV and interactivity

IPTV drives interactive services

- Multiple Picture-in-picture streams
- Online gaming
- Video on Demand

Services drive more bandwidth

- Multiple HD streams
- Quick response video games

Competition drives more bandwidth

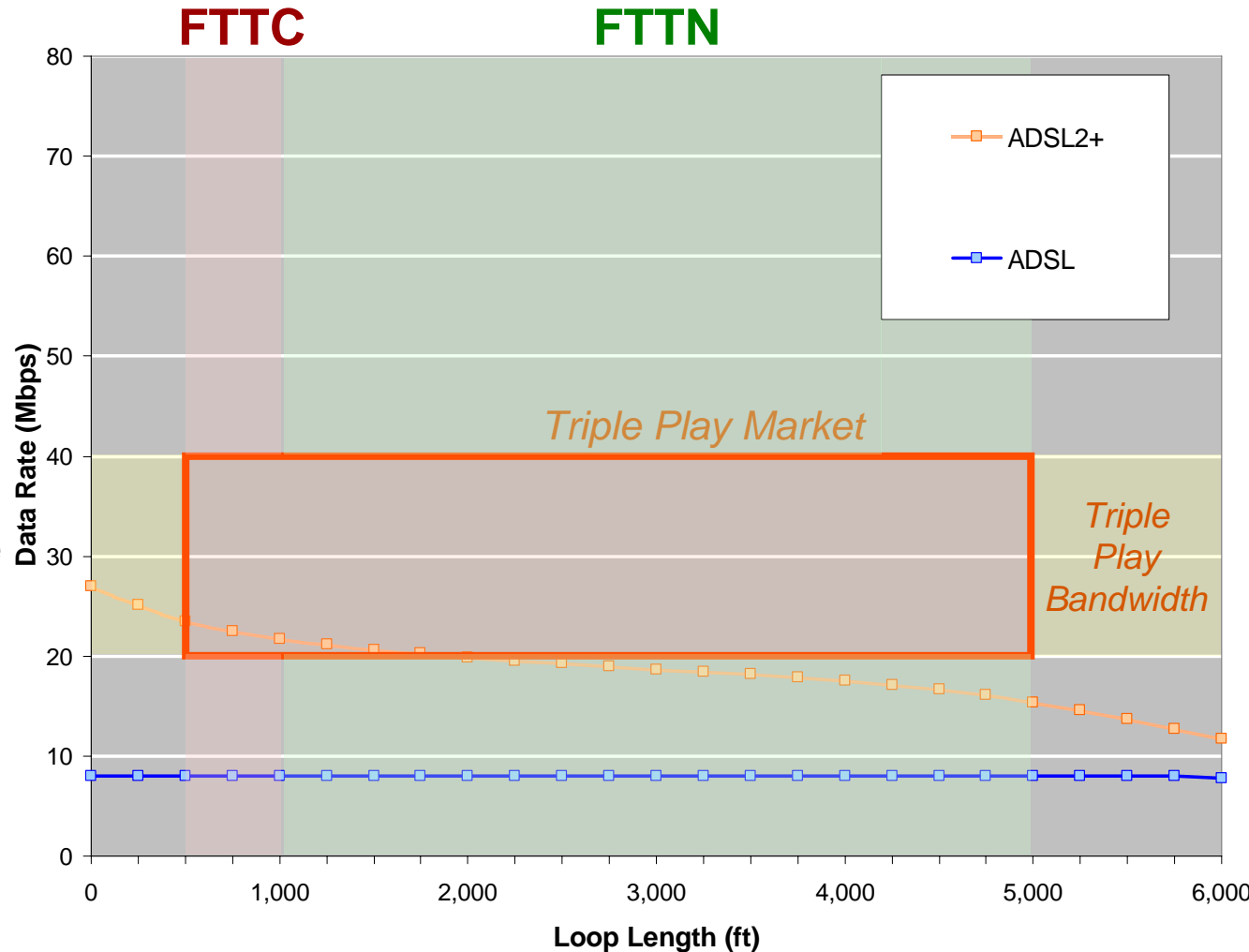
- Cable is and will continue to differentiate on “perceived” data bandwidth



The market requires an access network transformation

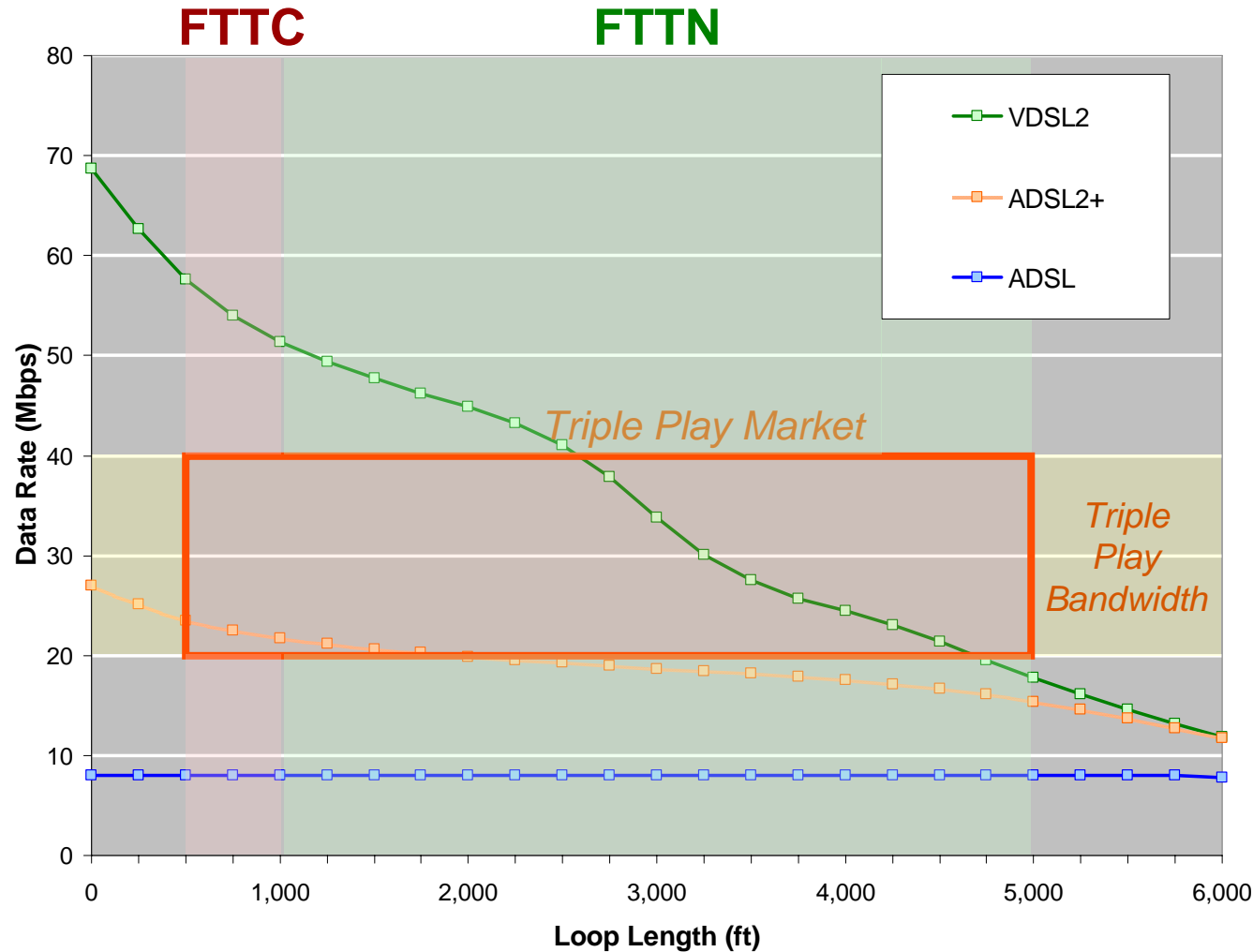
Single Pair ADSL or ADSL2+ won't deliver the Triple Play

- Better data rates are possible
- Basic video can be delivered, but HDTV and any cable competition hurts marketability
- DLC loop lengths are not IPTV-enabled with ADSL2+



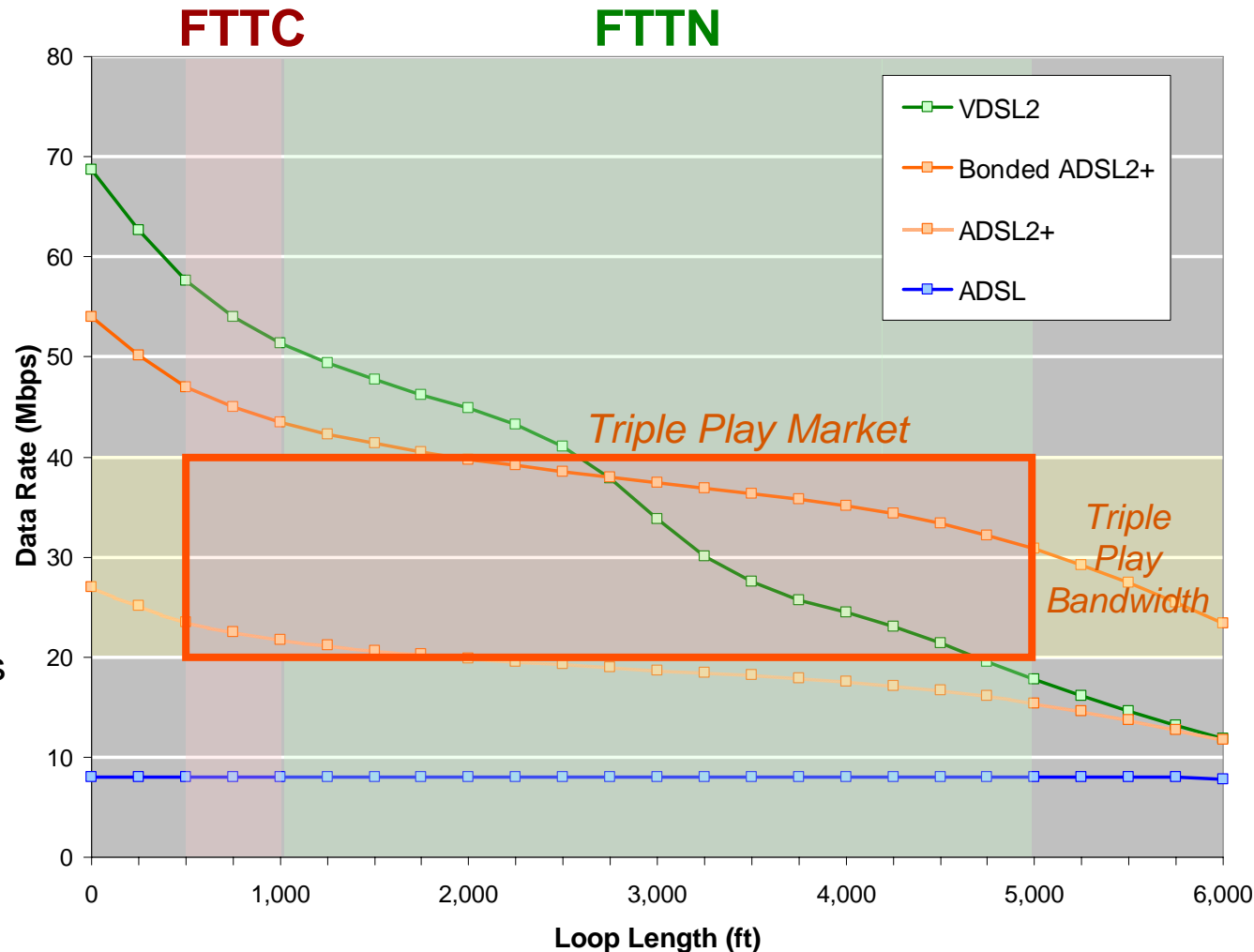
VDSL2 is one solution

- Enables complete triple play over copper
- Simple approach:
 - One pair
 - Easy management
- New technology
 - Economics of scale
 - Higher impact from interference



Bonded ADSL2+ transforms the copper access plant

- Provides the widest range of options for Triple Play
- Synergies with existing ADSL
 - Chipsets
 - Power profile
- Complexities
 - Multiple pairs not available everywhere
 - Managing data across two pairs
 - B/OSS issues to be resolved



Execution presents challenges...that have solutions!

Challenges

- Finding additional copper pair between subscriber and DSLAM



- New “Bonding-ready” CPE required



- OSS systems not currently supporting bonding



Solutions

- Most homes have two pair for legacy POTS requirements

- System level bonding eliminates DSLAM rewiring: use the next pair, regardless of position

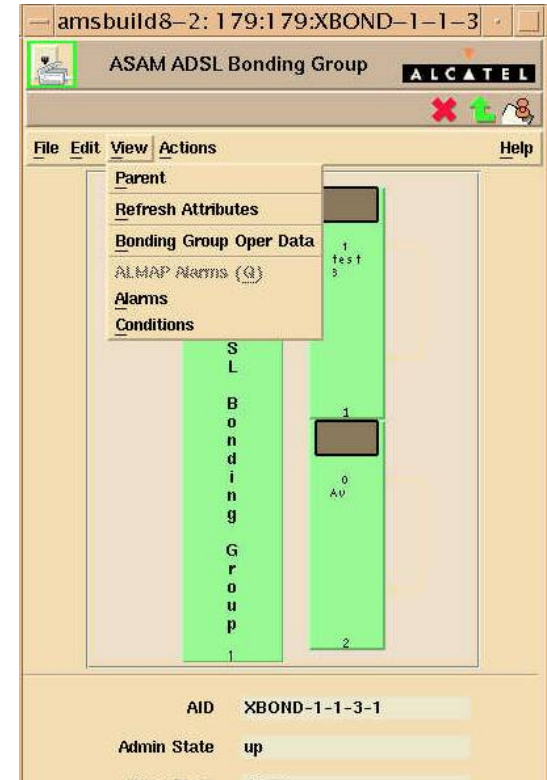
- IPTV: New CPE will be required regardless
ERDSL: New customers need CPE

- OSS is already designed to support two lines per customers

- Element management tools enable efficient bonding management within current operations practices and systems

Integrated bonding with service provider's NMS/OSS systems

- Operations procedures are the SAME as currently employed
 - TL1 upstream interface for flow through provisioning, performance monitoring, and alarm surveillance
 - Tools to examine equipment inventory and customer status
 - Easy to use GUI for troubleshooting, and maintenance purposes
- Simplicity of system-level bonding
 - OSS does not have to worry about “which two lines to pair”
 - “Any line” to “any line” capability
 - Integration into existing element management



Summary

Bonding Copper Pairs

- Enables triple play services over copper and node/curb distances
- Provides means to expand residential DSL customer base
- Allows competitive SMB service offerings

Operational challenges have clear solutions

All of this is available – TODAY

B R O A D E N Y O U R L I F E

www.alcatel.com



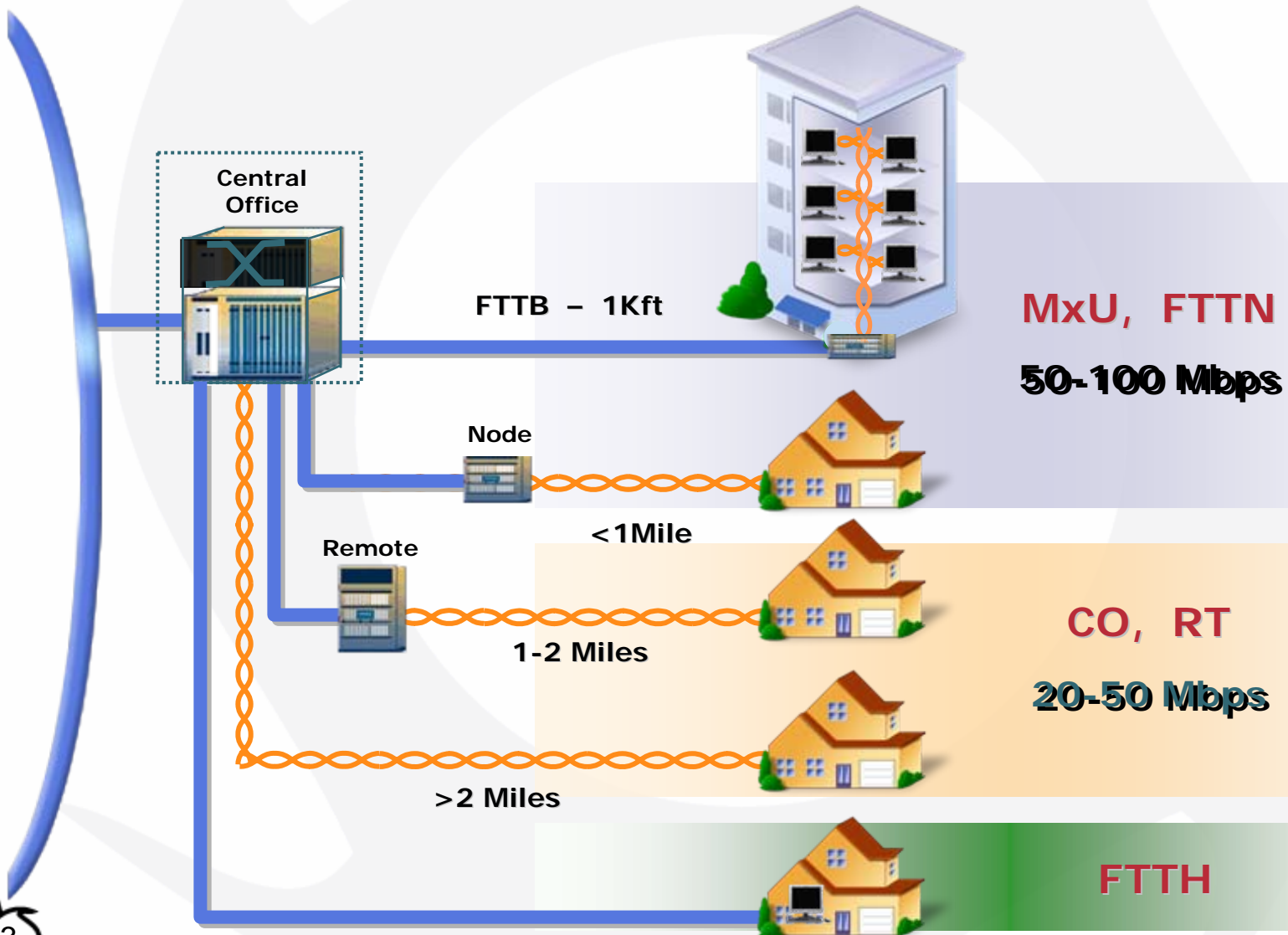
Reinventing DSL: Delivering 25Mbps & Beyond Over Existing Copper Pairs

Rouben Toumani, PhD.
Ikanos Communications

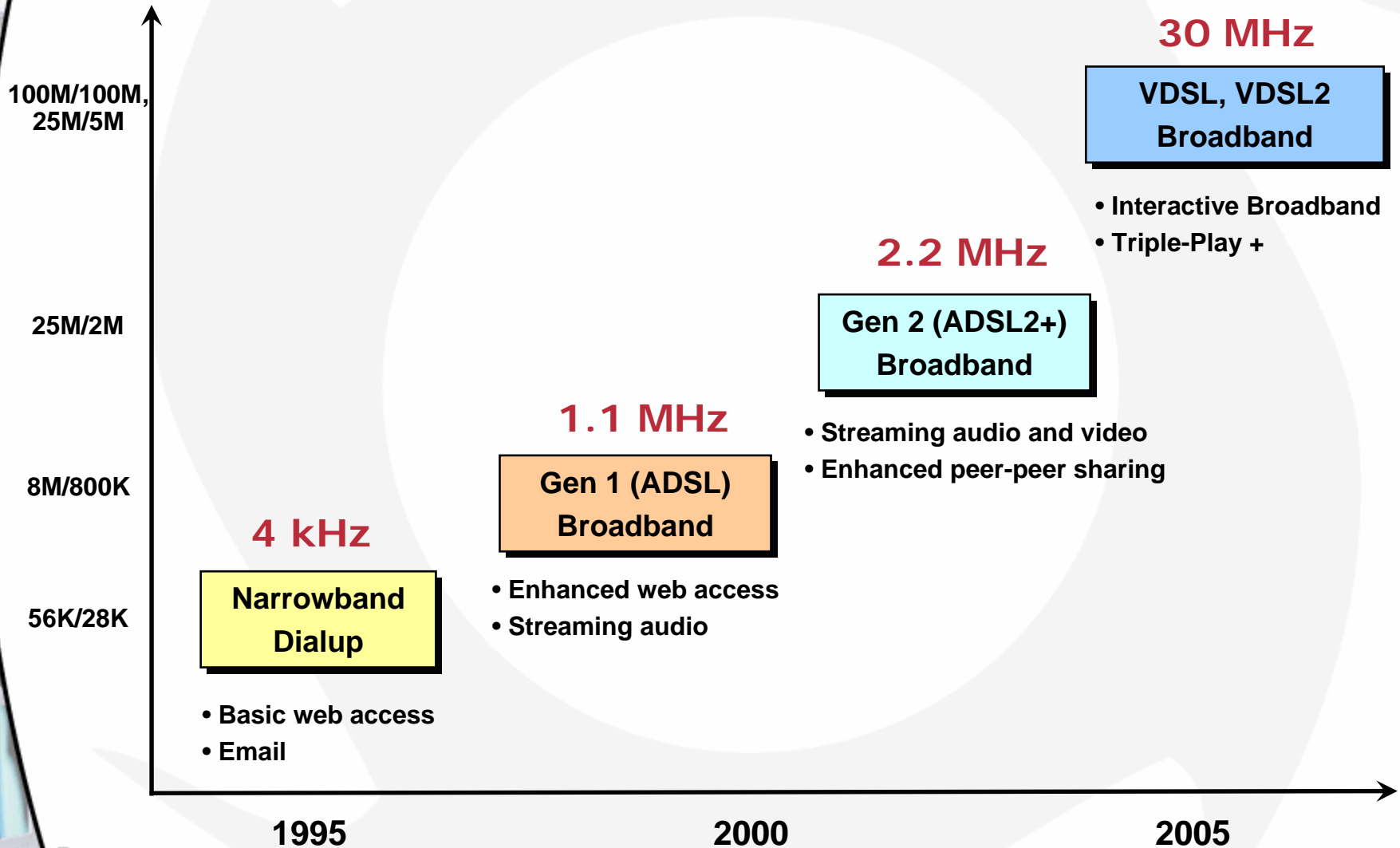
Overview

- » The copper access network is evolving driven by new applications and services
- » DSL technologies have evolved to meet the need
 - ADSL -> ADSL2+ -> VDSL -> VDSL2
 - VDSL2 has emerged as a universal DSL technology to serve multiple deployment options in the access network
 - From Dial-up to Fiber-Fast Broadband Performance
 - From FTTP to Exchange-Based distances
- » Promising new technologies on the horizon
 - Bonding of two or more pairs of copper
 - Great performance enhancement with existing technologies
 - Applies to multiple physical layers (ADSL to VDSL2)
 - Dynamic Spectrum Management (DSM)
 - Noise cancellation techniques (MIMO)
 - Dynamic Noise Management

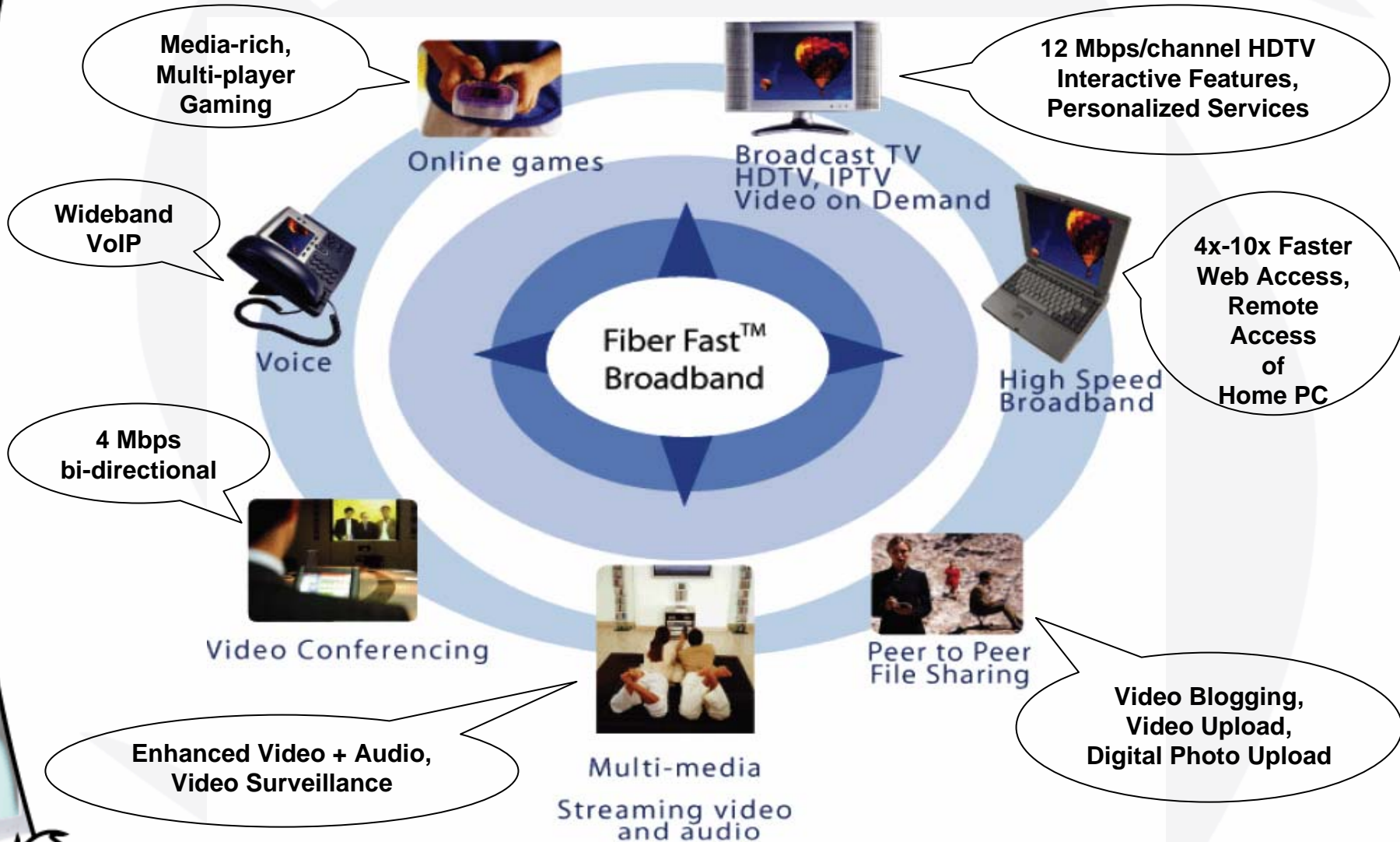
Fiber/Copper Deployment Scenarios



Telco Access Evolution



Interactive Broadband: The Next Wave



VDSL2: The Universal DSL Technology

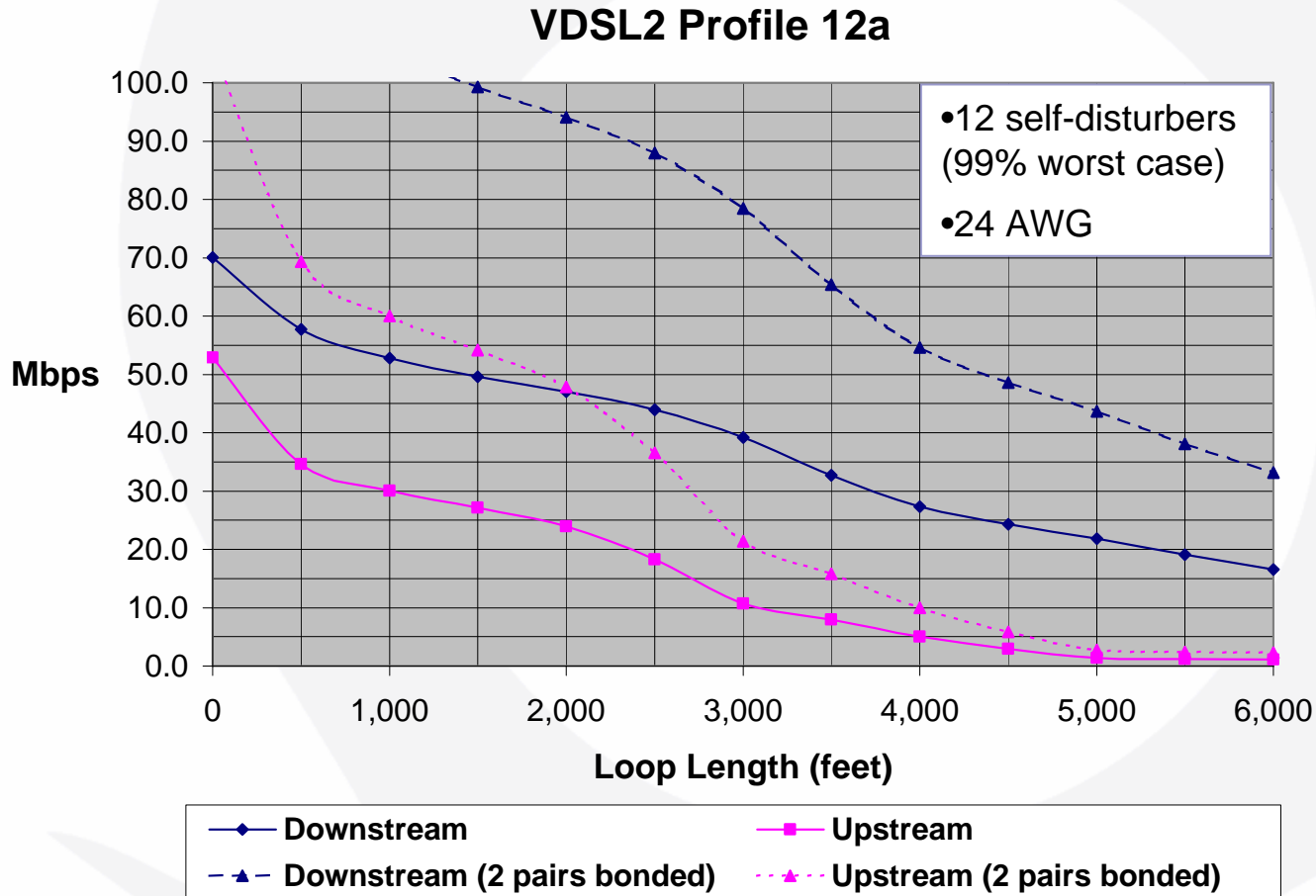
- » Cost-effective fiber bandwidth over copper
 - Capability to deliver 100 Mbps symmetric services
 - Supports triple-play
 - Supports interactive services (enhanced upstream)
 - Designed for integration with IP packet based networks
- » Built on solid, proven DMT technology
 - 100 Million lines and counting!
 - Seamless multi-mode (ADSL/ADSL2/ADSL2+/VDSL/VDSL2)
- » Key technology enhancements
 - Wider spectrum utilization up to 30 MHz
 - Trellis Coded Modulation (TCM)
 - Deployment-optimized implementations: Profiles
 - PSD shaping for co-existence with the deployed services
 - Optional U0 band expanded to 276 kHz for long reach

Technology Enhancements

Bonded VDSL2

- » VDSL2 Copper Pair Bonding
 - Standards (ITU-T G.998 / ATIS T1.427 series) compliant
 - Packet (Ethernet): Seamless integration into IP based networks
 - Also ATM for legacy networks and TDIM for DS3 transport
 - Data aggregation protocol above the Physical Layer
 - Offers greatest flexibility / optimized implementations
- » Market Drivers for Bonded VDSL2
 - Ensure ubiquitous service offering / geographic footprint
 - Commercial MTU's, Residential MDU's
 - Business: High reliability, guaranteed symmetric rates
 - Avoids copper ownership / building access issues
 - Single Family Residential
 - Consumer: Offer the highest broadband rates available
 - Perfect for deep fiber / PON network architectures

Bonding 2 pairs of VDSL2



Technology Enhancements: DSM (Dynamic Spectrum Management)

» Four Levels of DSM

- Level 0: Nothing “hogs” the available wire line spectrum
 - In use today: Spectrum Management Rules (T1.417)
 - Systems shall not cause each other “significant degradation”
- Level 1: Politeness = Near transmitter “speaks softly”
 - Transmits only the power needed for service offering
 - Especially useful for “near-far” problem
- Level 2: Spectrum Balancing
 - Adaptively determines PSDMASK
 - Shorter loop uses higher frequencies with less penalty
- Level 3: Vectoring = Intelligent Service Provider Network
 - Active management of both CO and CPE modems
 - Serious number crunching gains serious performance

Technology Enhancements: MIMO (Multiple Input Multiple Output)

- » Technology used in wireless networks
- » Now being introduced for copper bonded systems
 - Intra-network transport (Cell site backhaul, T1/T3 gap)
 - 12+ pairs bonded in end-to-end system, vector managed
- » The ultimate Level 3 DSM
 - Vectoring = true mitigation of NEXT and FEXT crosstalk
 - MIMO NEXT mitigation: US is easier
 - Co-located receivers seeking common enemy – exploits the alien crosstalk correlation across lines
 - Useful to create greater rate symmetry (better US)
 - DS more complex:
 - Must use transmitter pre-compensation
 - Pre-comp is based on data of varying accuracy

Summary

- » Drivers of copper access network evolution include:
 - Triple Play / HDTV delivery
 - Peer-to-peer applications requiring greater upstream
- » DSL technologies have evolved to meet the need
 - Bonding provides additional coverage
 - DSM & MIMO: active noise mitigation is the next step
- » VDSL2:
 - VDSL2 has arrived as the universal DSL technology
 - Ready to implement future technology enhancements

Reinventing DSL with Copper Pair Bonding



October 26, 2005

Gary Tennyson
BellSouth Telecommunications



>> Building a Competitive Broadband Network

- New distribution areas – Fiber To The Curb (FTTC)
- Base of existing distribution areas – Fiber To The Node (FTTN)
- Both drive fiber deeper into the loop network

>> Fiber To The Curb

- Telephony and DSL service is supported, not an overlay
- Fiber placed throughout a serving area as it is developed
- Optical Network Units (ONU) provide for conversion from an optical to an electrical interface
 - Maximum Distance from ONU to a subscriber's residence/business is 500 feet
 - Short drop allows us to take advantage of the very high data rates offered by VDSL

>> Fiber To The Node

- New platforms will support the existing base of DSL lines
 - Large existing base of remote DSLAM's could create a complex spectrum management problem in an overlay network
 - Multi-mode ports to support existing DSL
- Initial focus on ADSL2plus
- Planning to use VDSL2 as we move forward
- Bonding

>> What is Bonding ?

- Provides for summing the capacity of two or more DSL lines
 - Involves multiple physical-layer transceivers
 - One data stream 'seen' by the user
- Provides for greater data rates and/or operation on longer loops
- Needed with ADSL2plus for data rates greater than about 12 – 18 Mbps in a multi-pair environment
- Not unique to ADSL2plus

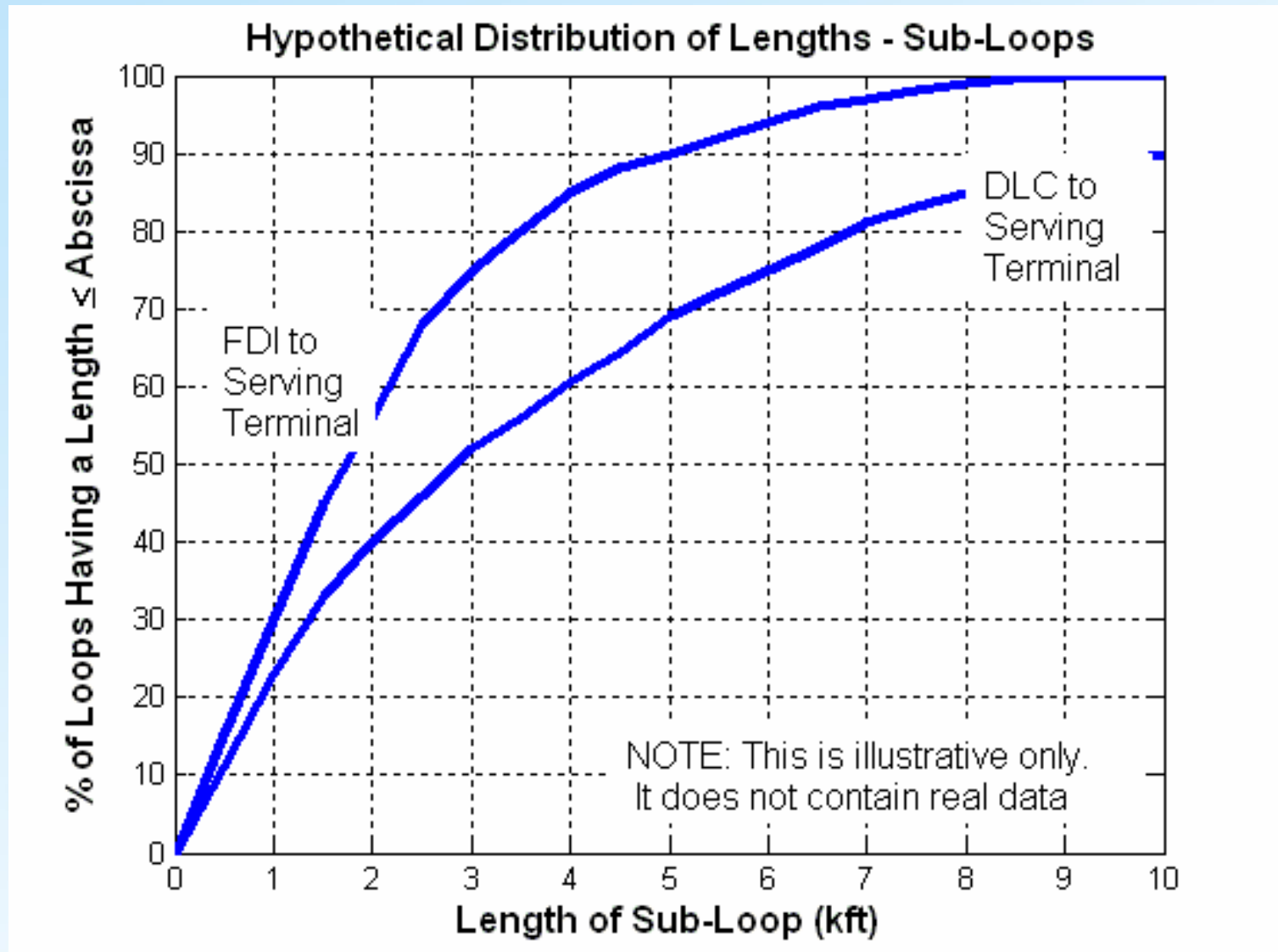
>> Why Choose Bonded DSL ?

- Decision requires insight into several areas:
 - DSL Rate/Reach
 - Distribution of loop lengths
 - Availability of vacant pairs
- What is the targeted maximum data rate ?
- What is the targeted coverage, i.e., what percent of loops should be capable of supporting the targeted data rate ?

>> DSL Reach Depends on the Targeted Data Rate

- Need to consider different disturber types
 - Repeatered T1, for example
 - Self-FEXT not typically seen as a limiting factor at lower data rate and frequencies; more impact at higher data rates and frequencies
 - Existing DSL transferred to new platform – common launch level
- Bridge Taps
- Gauge – coarse gauge may not provide the improvement that you would expect

>> Distribution of Loop Lengths



>> Loop Reach Impacts Costs

- Shorter loop reach => More nodes
 - Per site costs
 - Cabinets
 - Power
 - Interconnection
 - Easement costs
 - Are interconnection points available ?
 - Existing DLC RT's – power, pad, and interconnection are available
 - Existing FDI's – interconnection is available
 - Re-sectionalized plant
- Bonding provides tradeoff between pair availability and the number of nodes

>> Planning Considerations

- Unequal data rates
 - Two DSL's cannot simultaneously be experiencing the worst-case crosstalk
 - Bonding will support unequal data rates to take advantage of this
- Are vacant pairs available in the serving terminals ?
- Two lines are needed from the DSLAM to the CPE modem
 - New drop will often be needed (buried/aerial)
 - New Inside Wire may be needed
 - Truck roll

>> Operational Considerations

- System-wide bonding vs. card-level bonding
 - System-wide bonding allows bonding of a new line to an existing line without a transfer
 - Card-level bonding can require a transfer
- The second line may not have an underlying POTS line
 - Loop testing without a telephone number ?
 - Sealing Current ?
- Bonding-capable CPE is required