THE FUTURE OF COPPER

Jochen Maes, Broadband Innovation, Bell Labs Alcatel-Lucent
G.fast summit, Paris, May 2014

Alcatel·Lucent

FTTH
THE NEXT BIG THING SINCE DECADES

FIBER TO THE HOME: PRACTICALLY A REALITY

1988

John Bourne

BNR

INSTALLED FIRST COST ECONOMICS OF FIBER/BROADBAND ACCESS TO THE HOME

1988

K. LU, R. WOLFF AND F. GRATZER

BELL COMMUNICATIONS RESEARCH
445 SOUTH STREET, MORRISTOWN, NJ 07960

... It shows that fiber will be cost competitive for voice during the 1990's and predicts that Broadband access will become cost effective during the next 10 to 15 years ...

FIBER TO THE HOME : BIARRITZ (1984)... TWELVE CITIES (1988)

1988

Camille VEYRES (x) -- J. Jacques MAURO

Direction Générale des Télécommunications
FRANCE TELECOM - Service des Télécommunications
de l'Image - Paris - France

An Optimal Investment Strategy Model for Fiber to the Home

1988

Marvin A. Sirbu and David P. Reed

Carnegie Mellon University

Optical fibers reach into homes

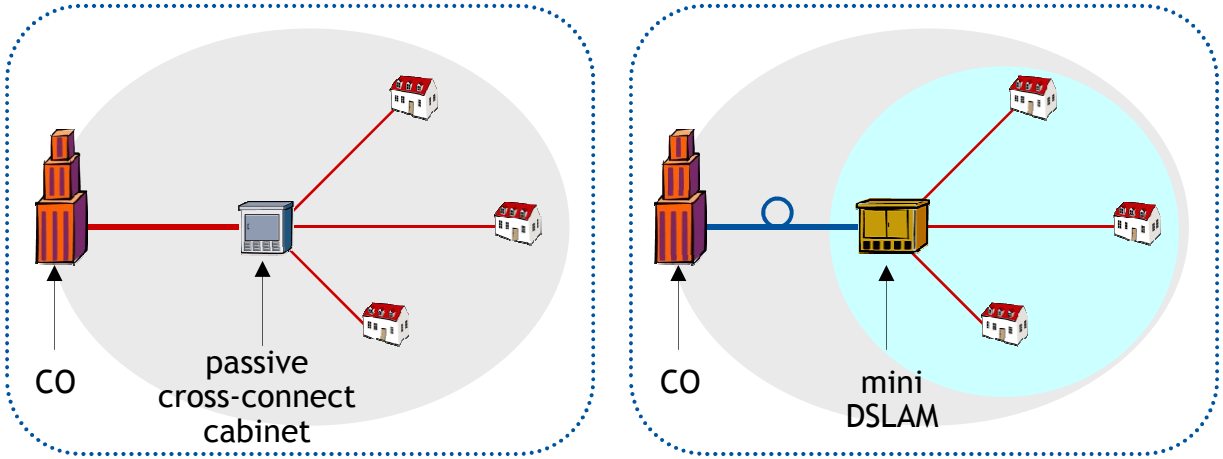
1989

Paul W. Shumate Jr. Bell Communications Research Inc.

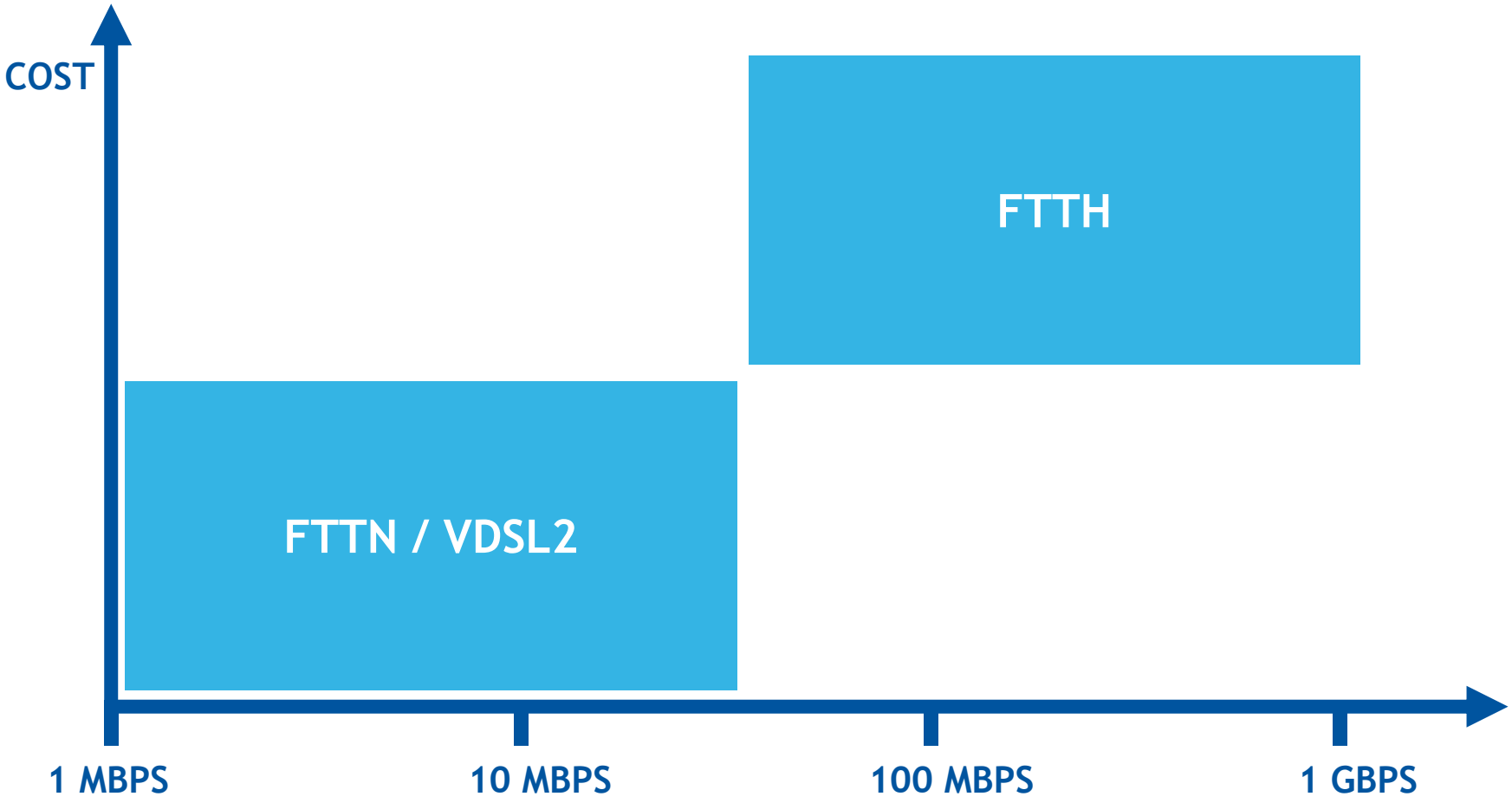
Alcatel·Lucent

THE REALITY
GRADUAL FIBER DEPLOYMENT

CO deployment → **FTTCab**

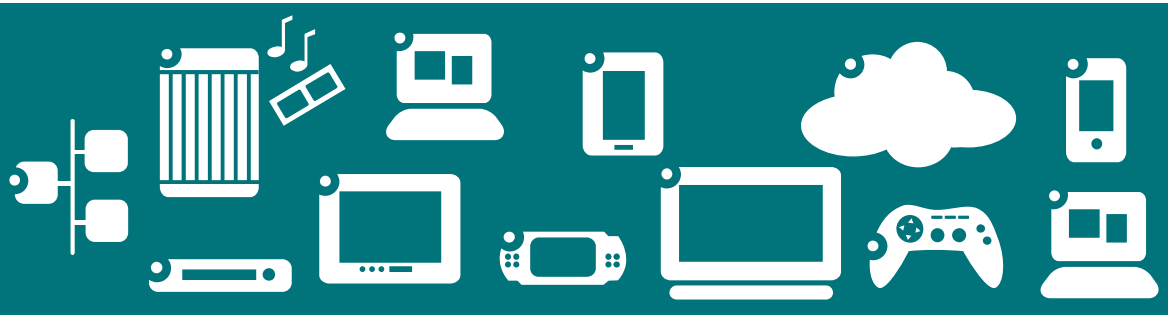


WE'VE SOLVED THE BANDWIDTH EQUATION

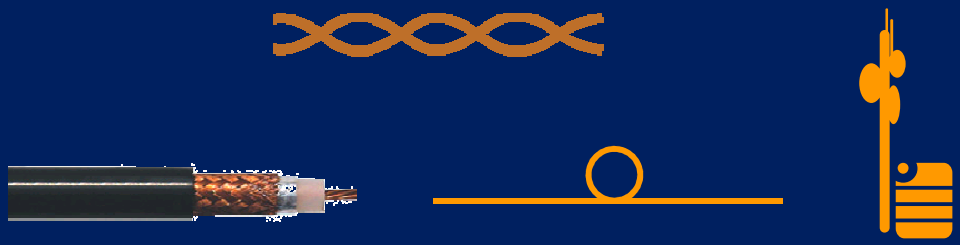


DRIVERS FOR BANDWIDTH

Applications



Competition



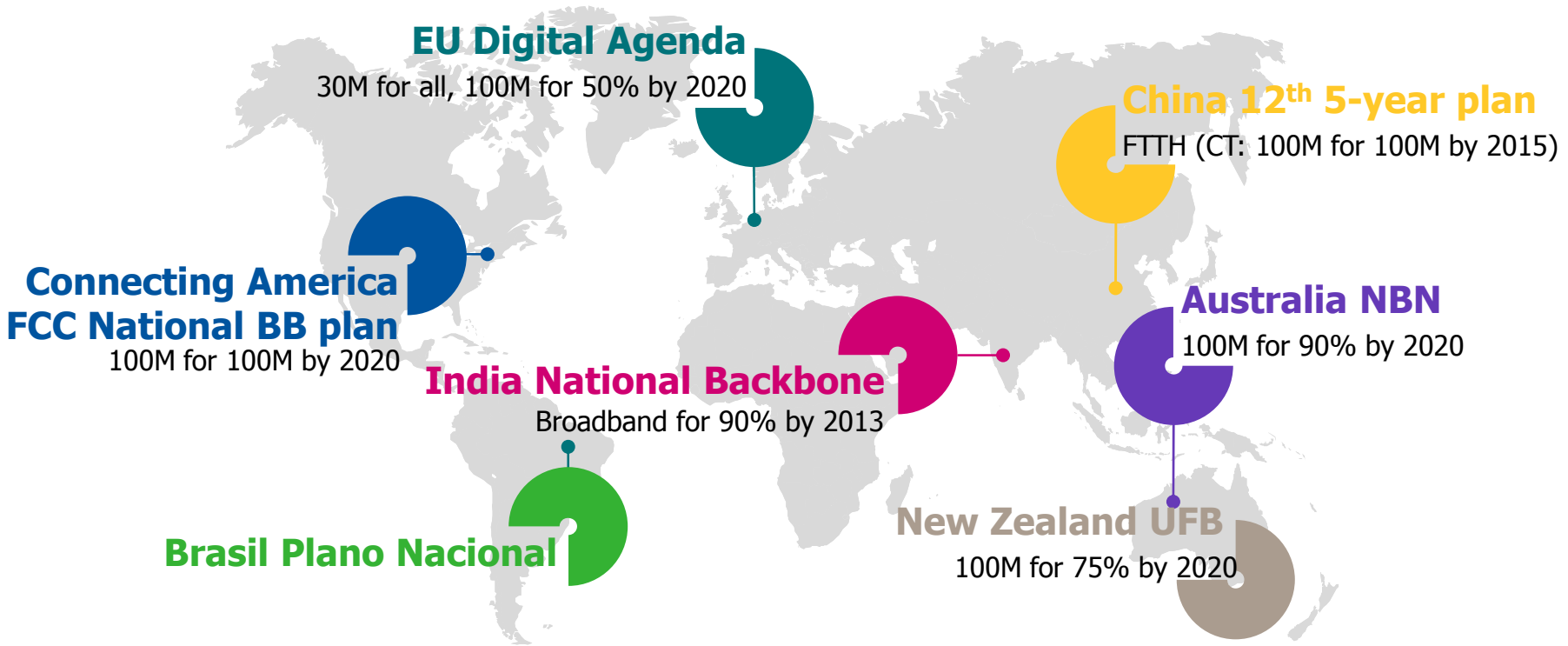
Regional incentives

EUROPEAN COMMISSION

FEDERAL COMMUNICATIONS COMMISSION · USA

NBNCo Limited

ACCESS NETWORKS AROUND THE GLOBE CONTINUOUSLY NEED TO TRANSFORM TO KEEP UP WITH BANDWIDTH DEMANDS



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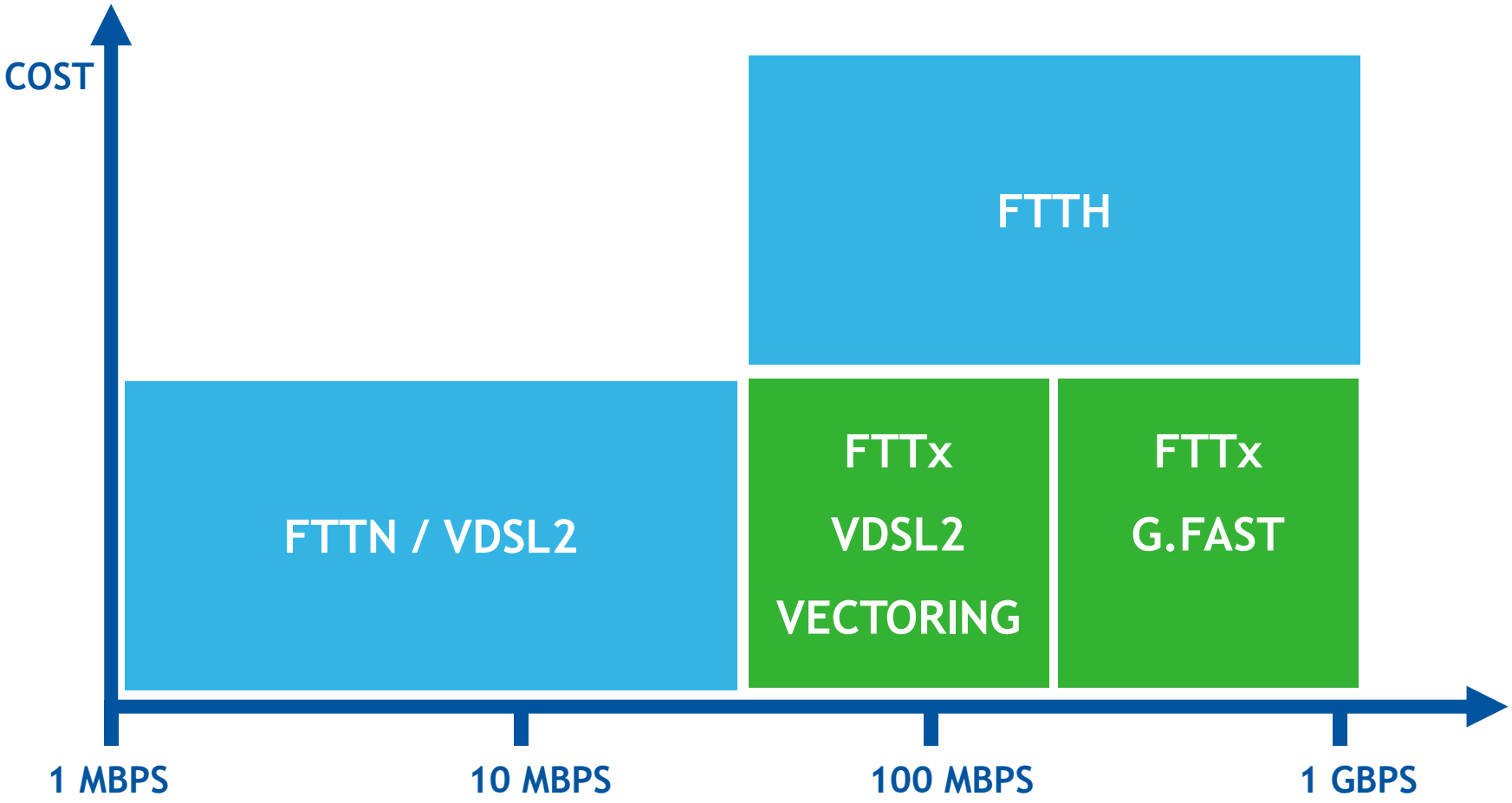
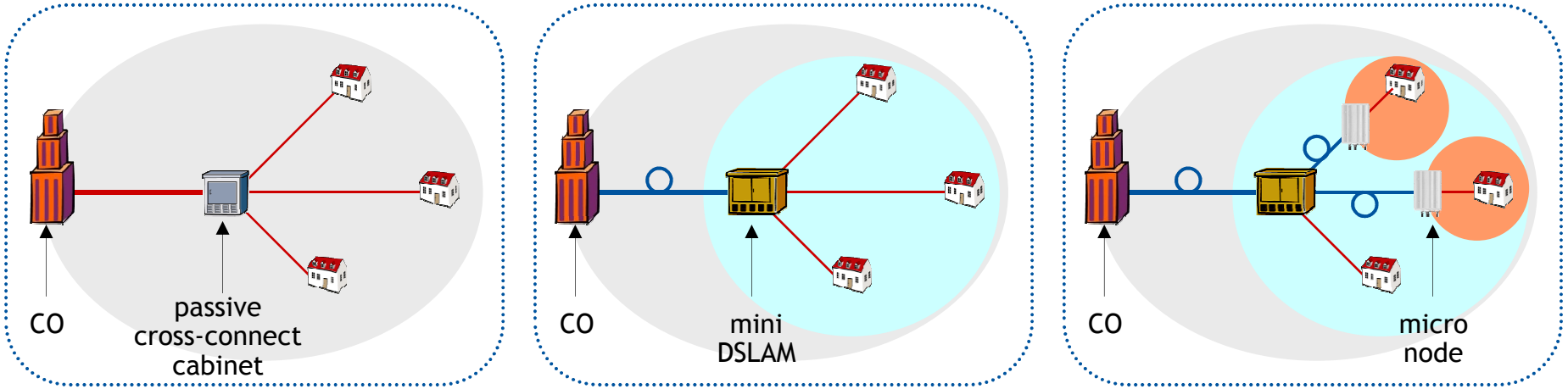
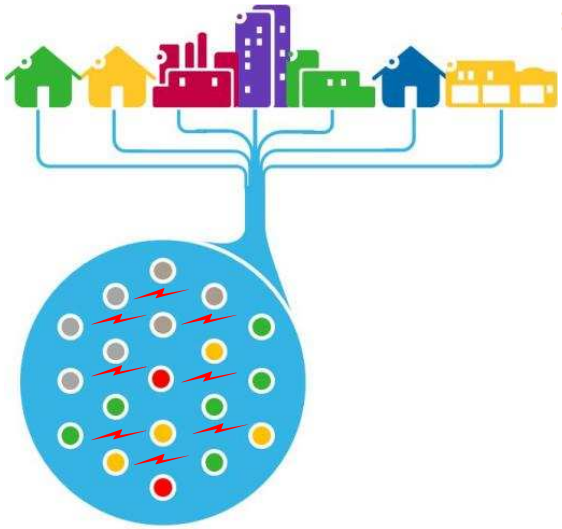


THE REALITY
GRADUAL FIBER DEPLOYMENT CONTINUES

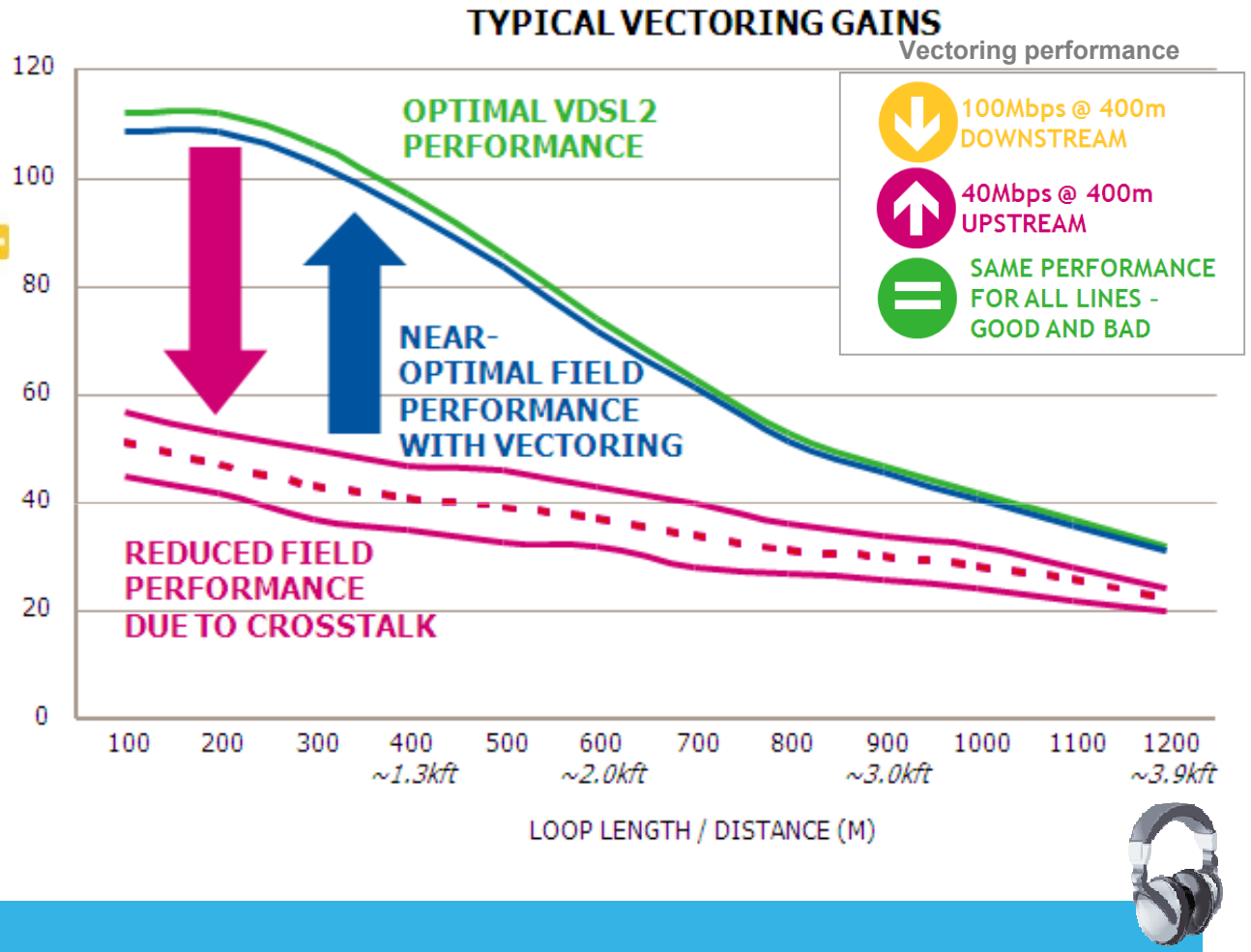
CO deployment → **FTTCab** → **FTTdp**



VDSL2 VECTORING CONCEPT

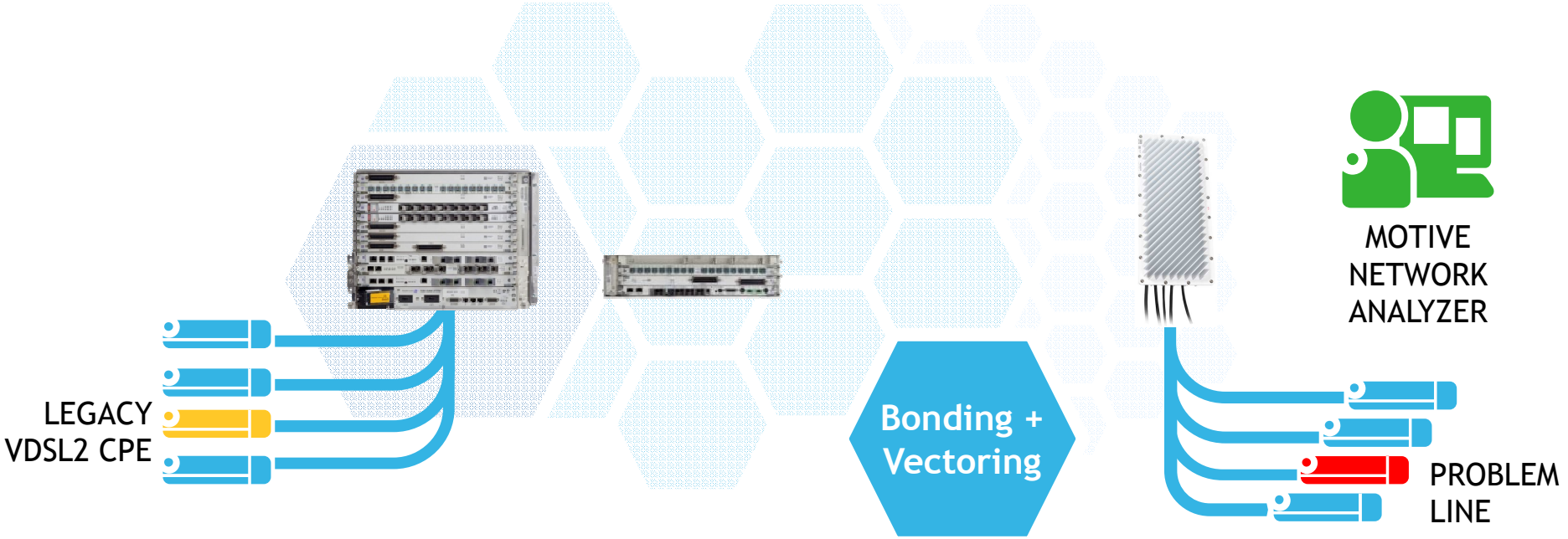


COPPER PAIRS INTERFERE WITH EACH OTHER, REDUCING BITRATES



VECTORING = NOISE CANCELLATION HEADPHONES FOR YOUR COPPER PLANT

MAKING VECTORING EASY TO DEPLOY



EASY MIGRATION

- Zero-touch Vectoring: no need to firmware-upgrade legacy VDS2 CPE
- Unique Alcatel-Lucent solution
- Re-use existing nodes

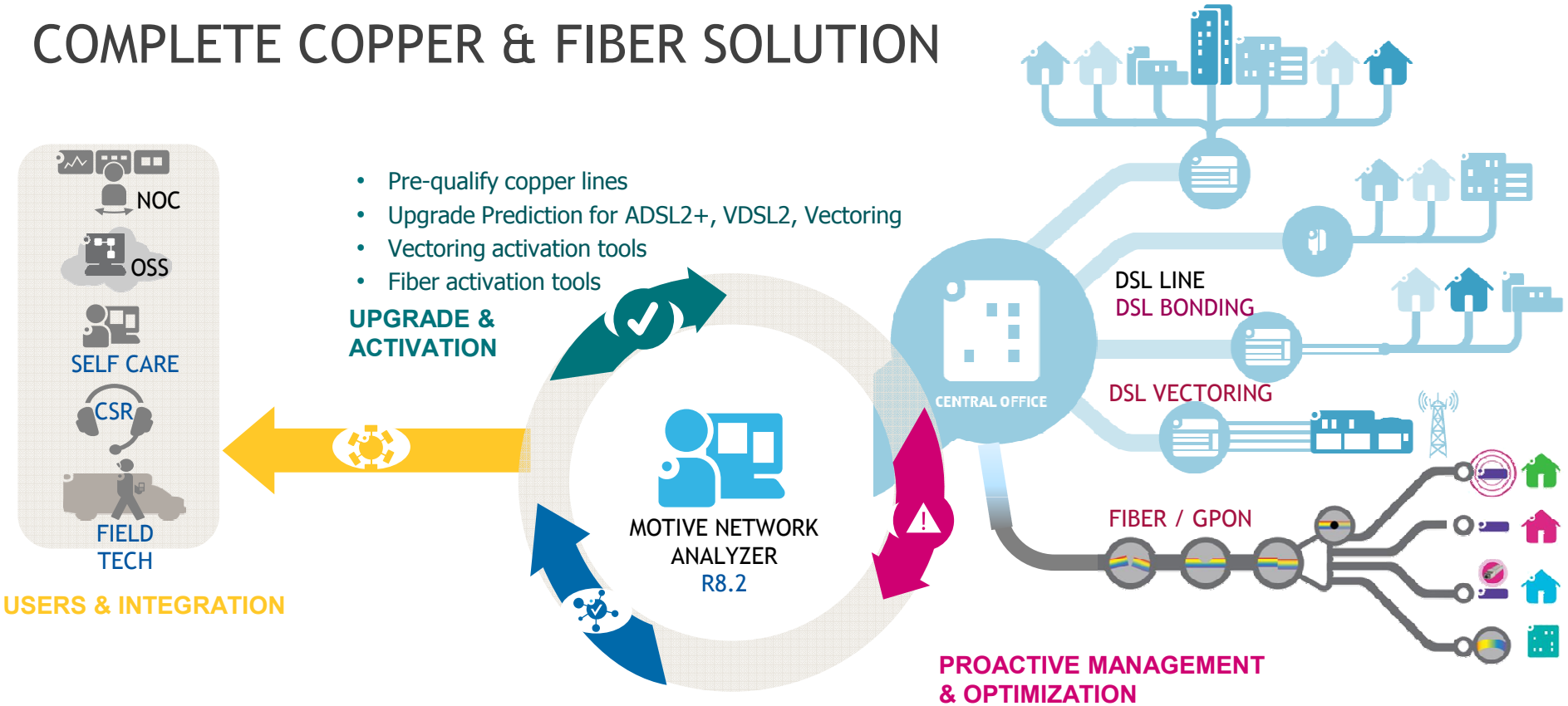
HIGH SCALABILITY

- System-Level Vectoring versus SEMs
- Bonding+Vectoring for increased reach/rate

EFFICIENT OPERATIONS

- Vectoring support in Motive Network Analyzer
- Cross-talk mapping
- SELT / DELT / MELT for Vectoring

5530 NETWORK ANALYZER
COMPLETE COPPER & FIBER SOLUTION



TROUBLESHOOTING

- Copper Line Diagnosis (using DELT / SELT / DSL stats / NBLT)
- DSL Binder/Bonding/Vectoring group diagnosis
- Fiber / GPON fault diagnosis (detect and localize)

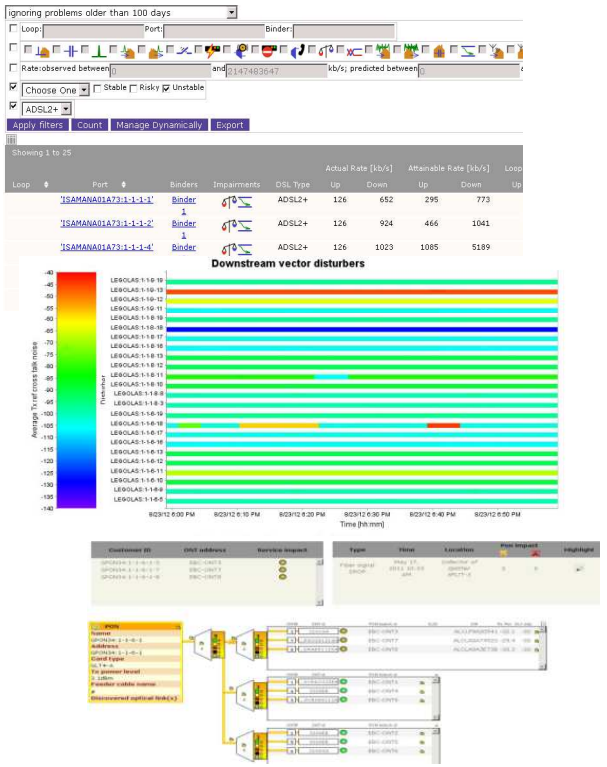
PROACTIVE MANAGEMENT & OPTIMIZATION

- Continuous DSL monitoring and QoS classification
- Dynamic Line Management (DLM)
- Proactive DSL fault diagnosis
- Continuous GPON monitoring and QoS classification
- Proactive Fiber / GPON fault diagnosis

ACCESS NETWORK SOLUTIONS
USER EXAMPLES

NA-C / NA-F GUI

NETWORK OPERATIONS

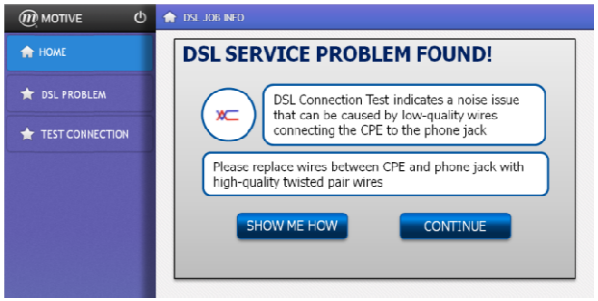


CUSTOMER SERVICE CONSOLE

AGENT-ASSISTED CARE

SELF SERVICE CONSOLE

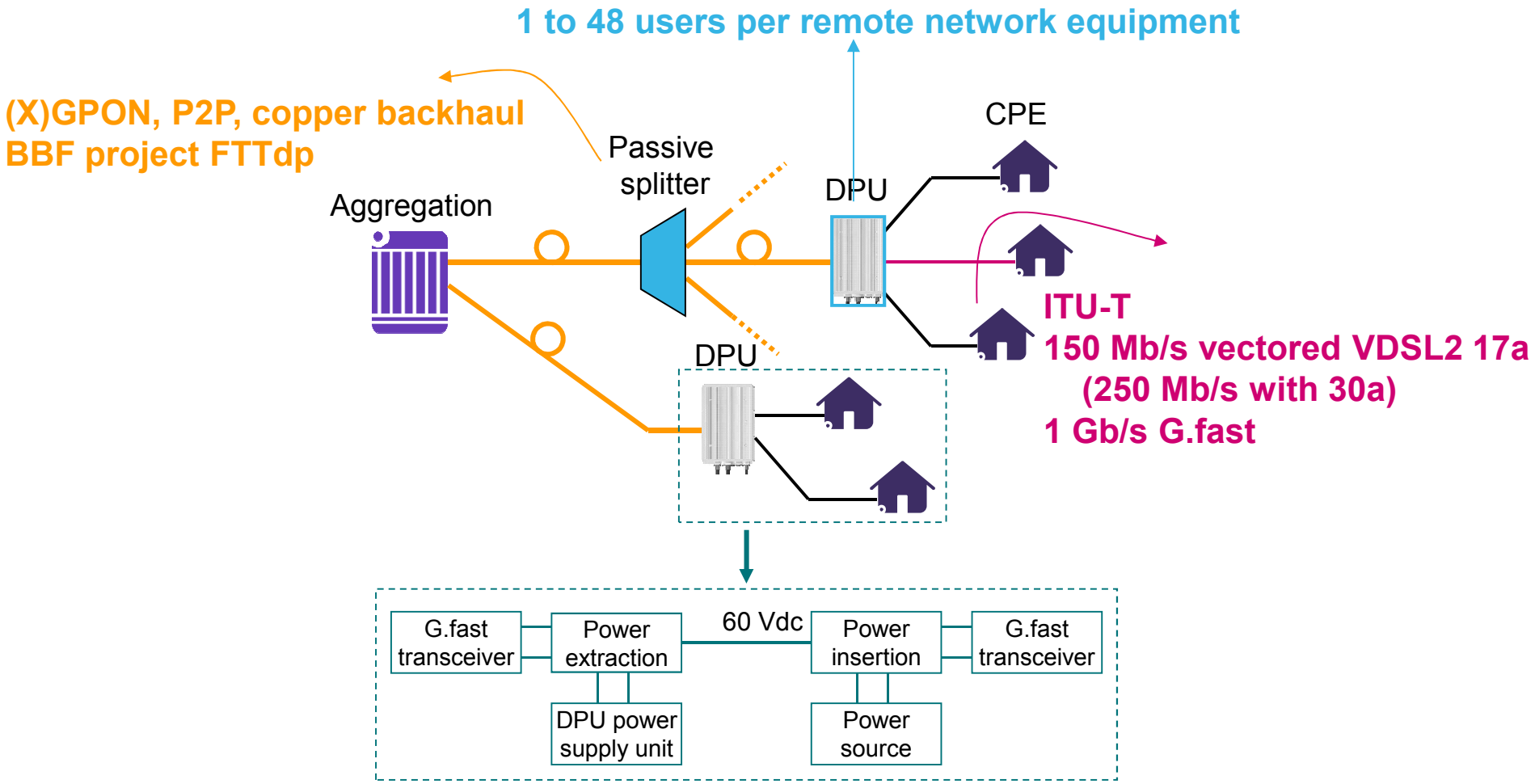
SELF CARE



FIELD TECH CONSOLE

FIELD TECH

FTTDP ARCHITECTURE

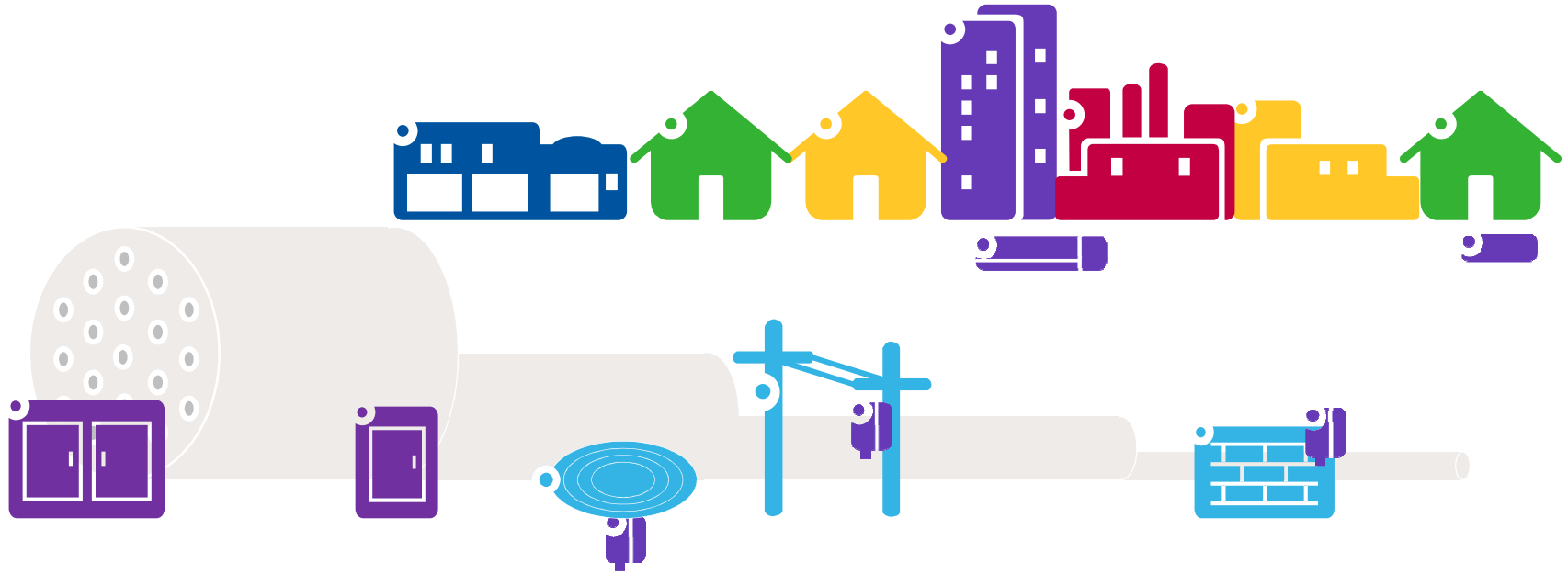


DPU can be powered from the customer premises
ETSI TM6 101548 CPE powered network equipment

FTTDP EQUIPMENT

Small
Energy efficient
Water tight

TYPICAL APPLICATIONS FOR G.FAST & G.FAST VECTORING



FTT… NODE CURB MANHOLE POLE BUILDING WALL FRONTDOOR

>200 METER
>100 SUBS
VDSL2 VECTORING

<200 METER
10s OF SUBS
VDSL2 VECTORING
EVOLUTION TO G.FAST VECTORING

a.k.a. “FTTdp”
(Distribution Point)

10s OF METERS
1 SUB
VDSL2
EVOLUTION TO G.FAST

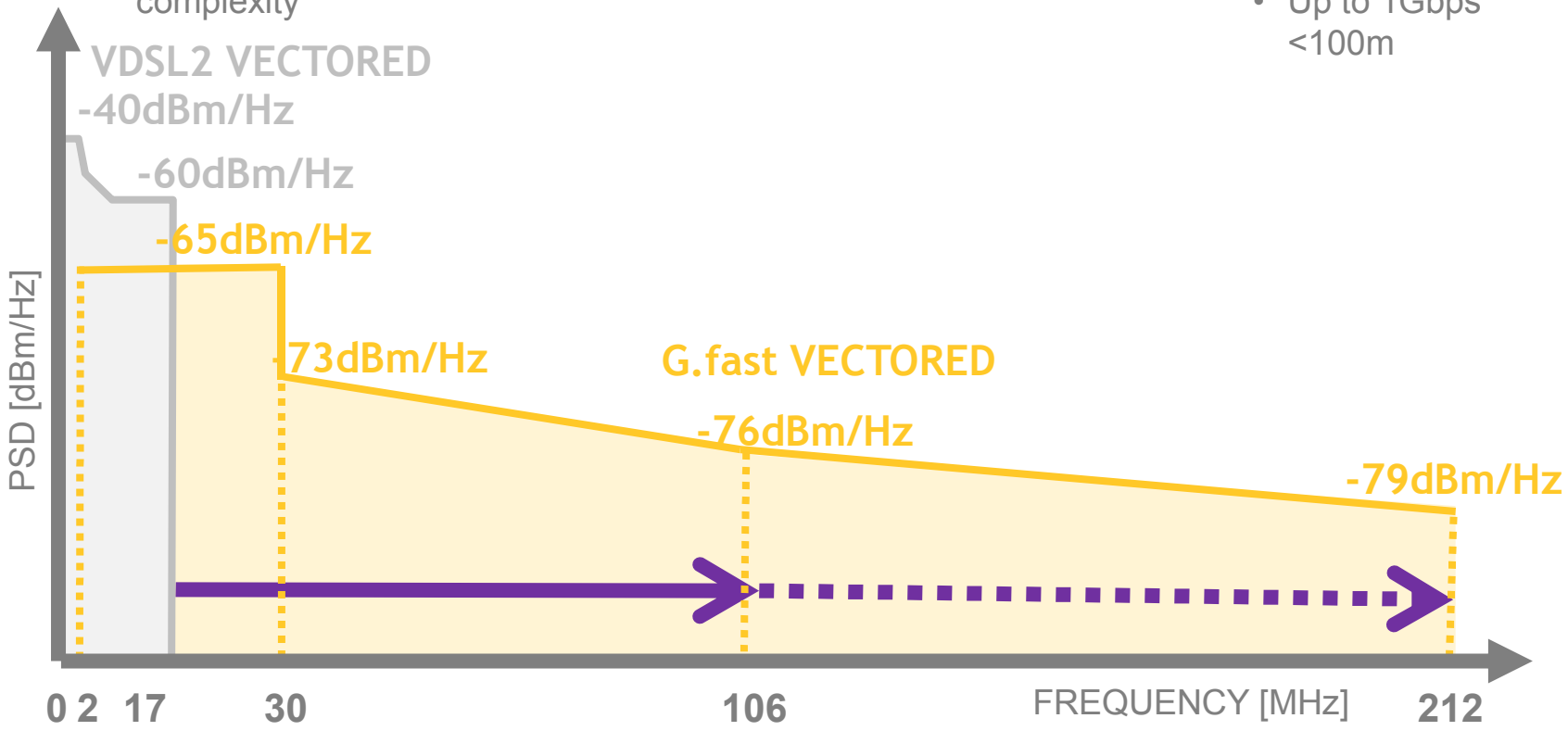
GIGABIT SPEEDS WITH G.FAST

$$C = \eta W \log_2\left(1 + \frac{|H|^2 P_t}{\Gamma(\sigma_0^2 + I)}\right)$$

1 MORE BANDWIDTH
- G.fast: up to 106 MHz (212 MHz in future)
- Limitation on bits/s/Hz to manage design complexity

2 SHORT DISTANCE
- To reduce attenuation at high frequencies

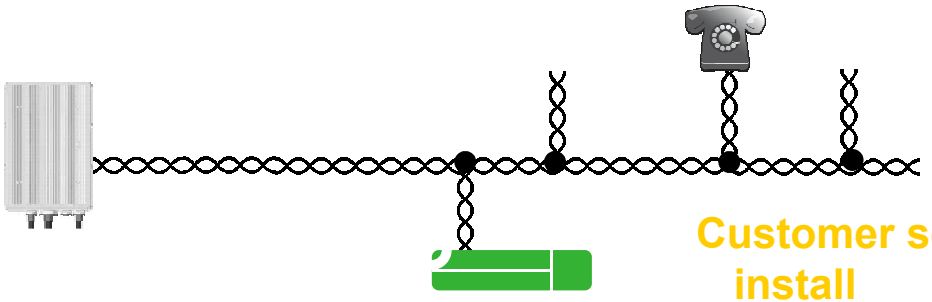
3 HIGH BITRATES
- Standard targets:
  - 150Mbps @ 250m
  - 200Mbps @ 200m
  - 500Mbps @ 100m
  - Up to 1Gbps <100m



EASE OF INSTALLATION

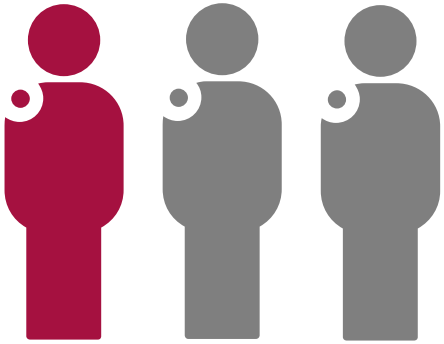
Easy deployment

- DPU install-and-forget
- Remotely managed
- Managed when unpowered

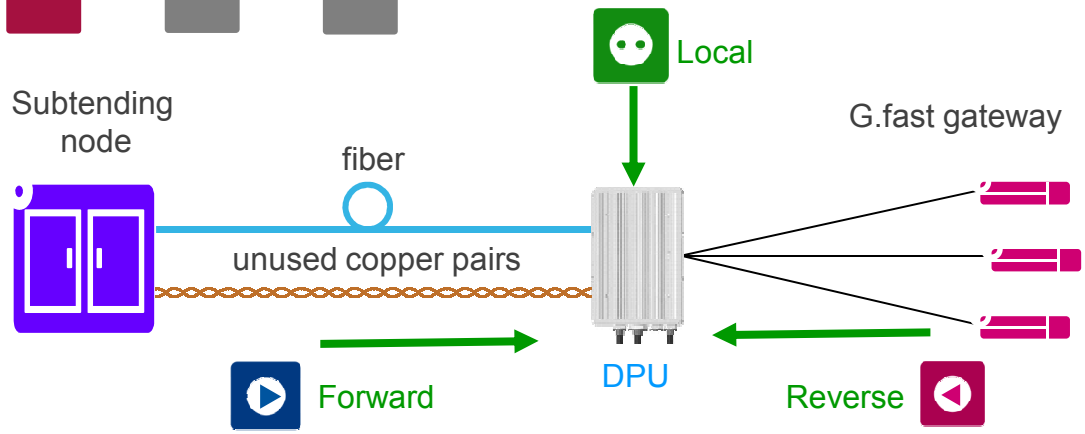


Customer self-install

- Robust performance on existing in-home wiring (bridged taps)
- Reduced rate compared to technician install



30% of FTTH subscribers change their mind when the engineer asks where he can drill holes in the wall for the fiber



Different powering options

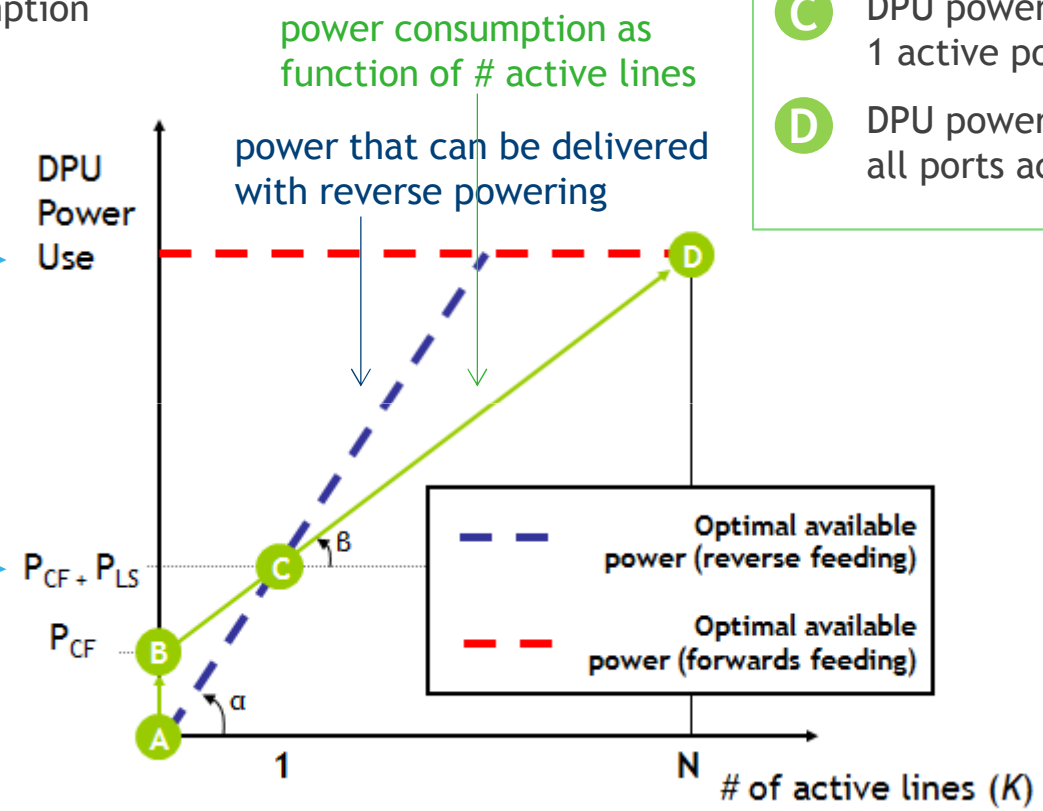
REVERSE POWERING CHALLENGES

P_{CF} = power consumption common functionality
P_{LS} = line specific power consumption

- A: DPU not powered
- B: DPU powered, but all lines disabled
- C: DPU powered, 1 active port
- D: DPU powered, all ports active

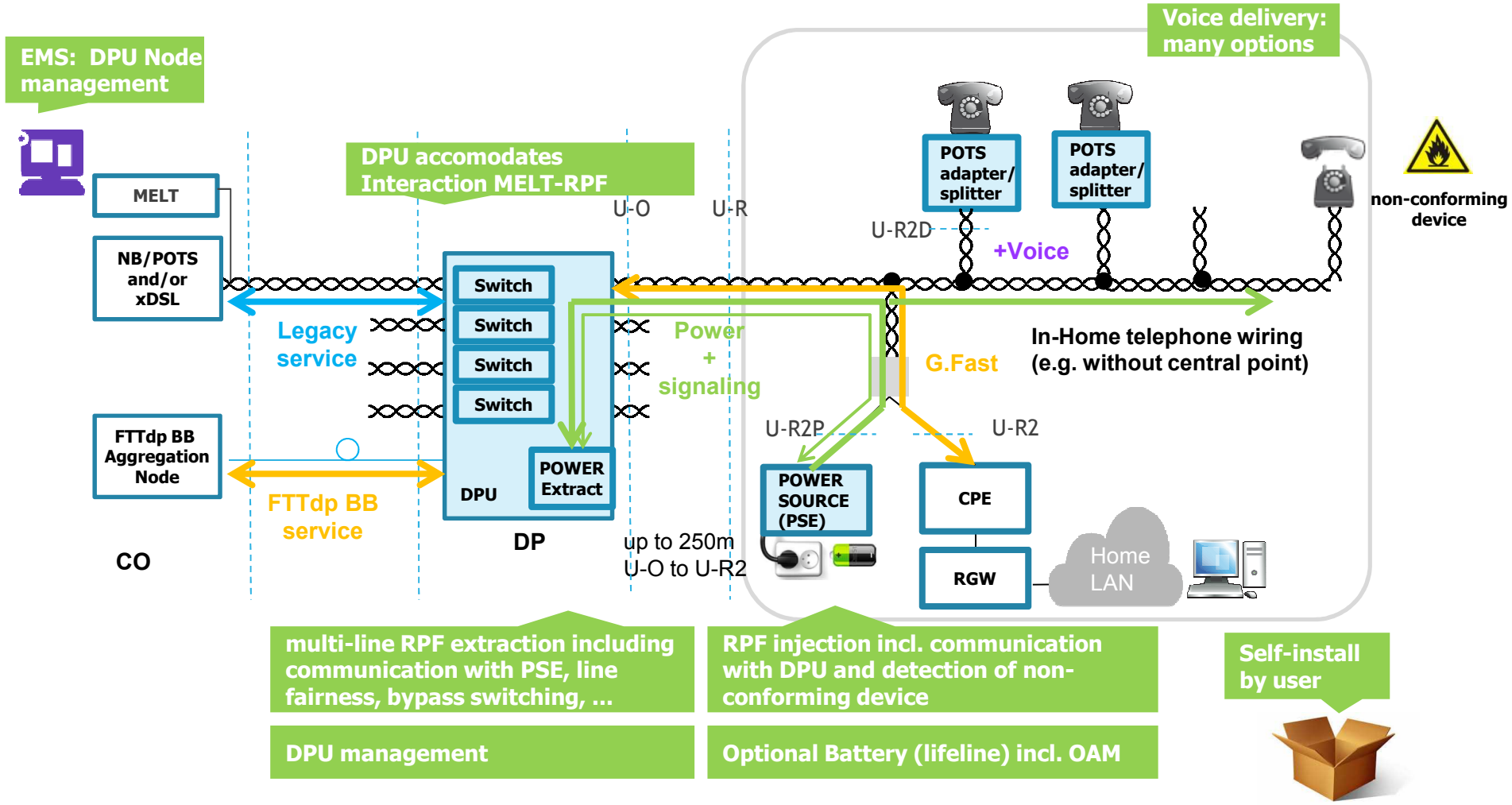
High end:
power consumption with all lines active is limited by thermal dissipation constraints

Low end:
single line should be able to power common part + 1 line specific part



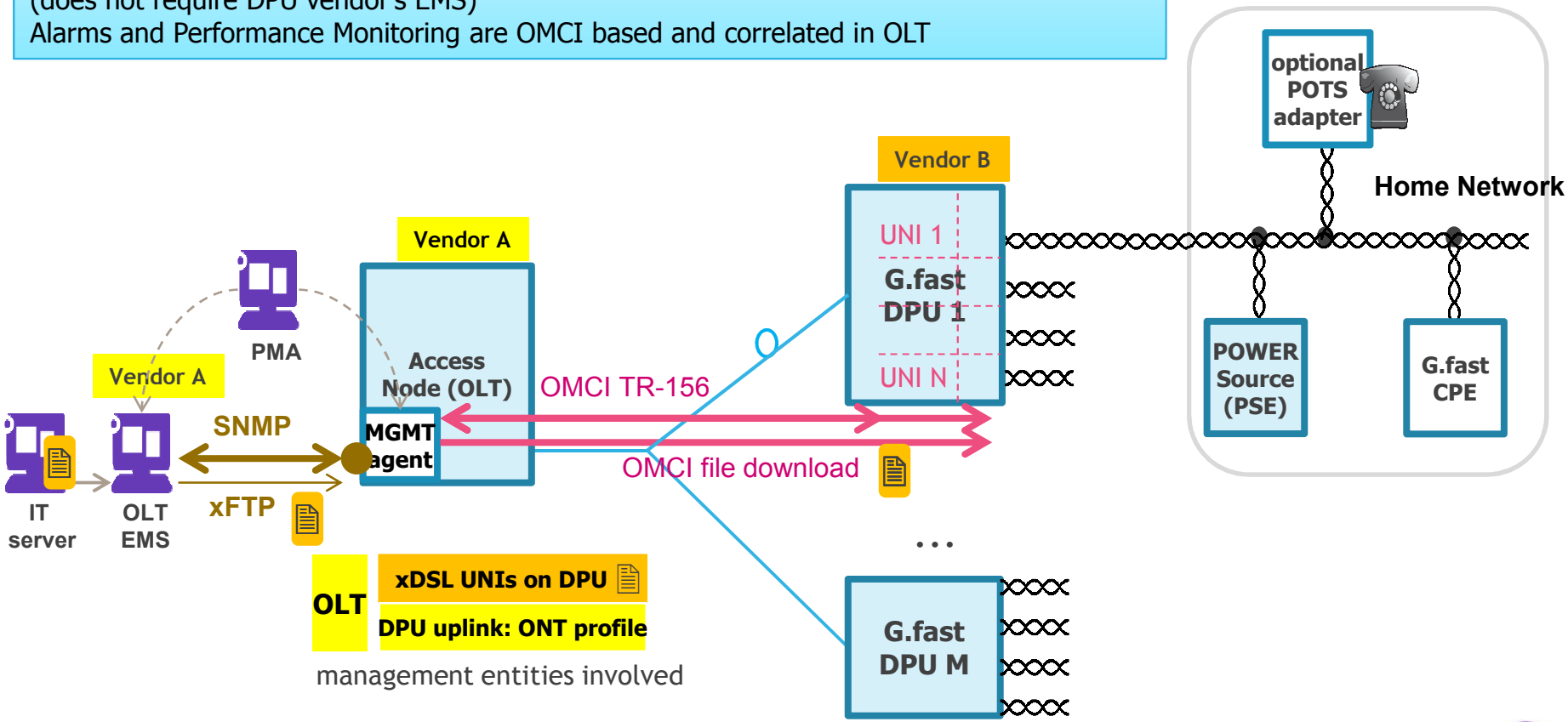
For reverse powering most challenging situation is first user powering DPU

REVERSE POWER FEED FRAMEWORK

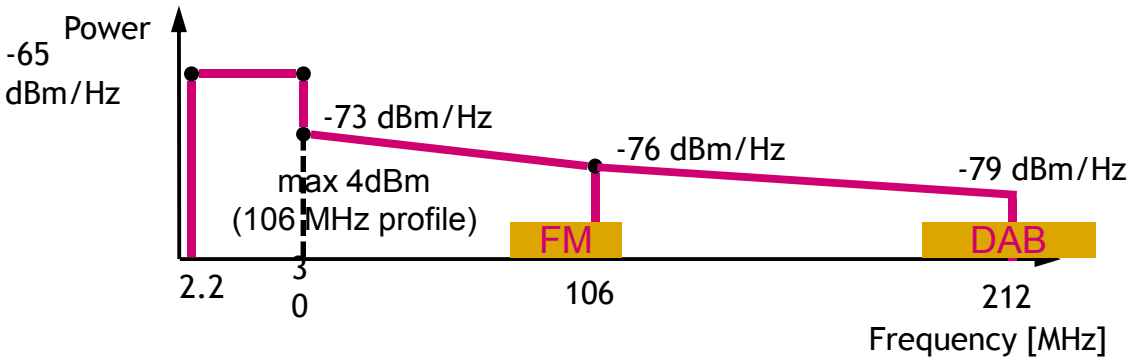


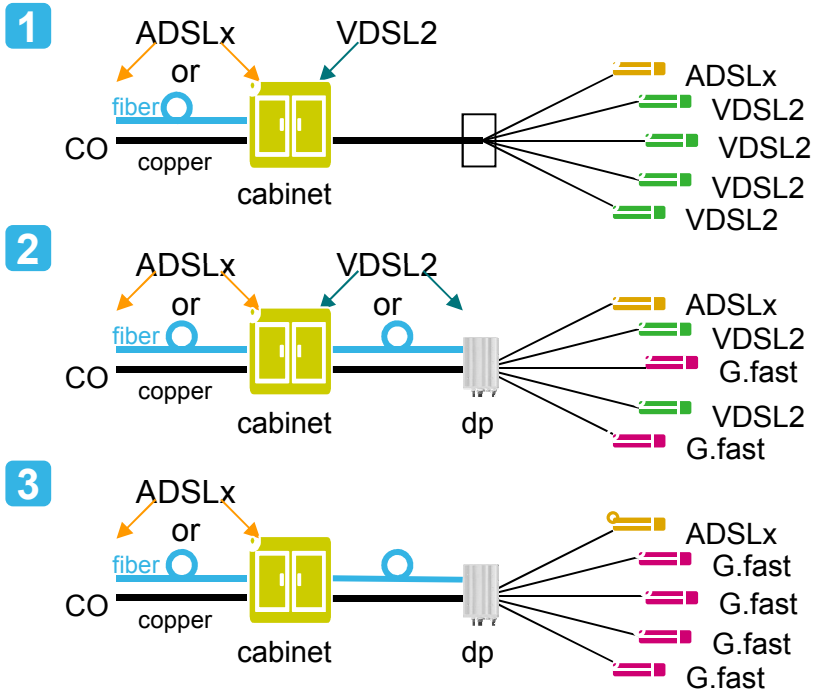
G.FAST DPU MANAGEMENT, PON UPLINK
TR-156 BASED INTEROPERABLE APPROACH

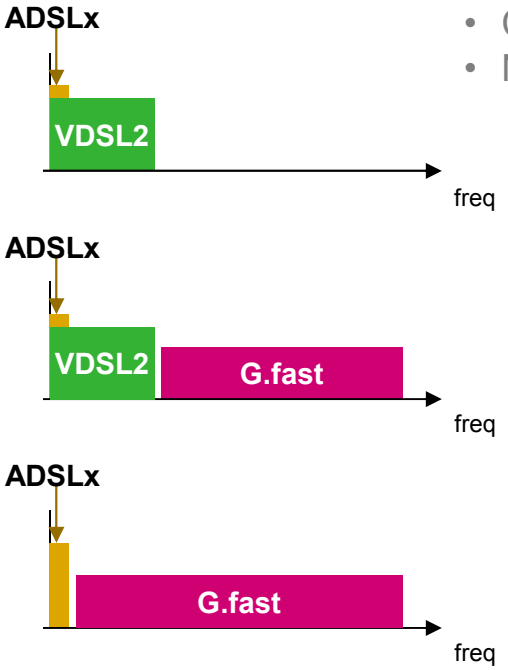
Simplification: no OMCI standardization of xDSL provisioning required
Requires OMCI standardization of Performance Monitoring and status portion of xDSL MIB
Ensures IP safety & scalability: Only 1 IP address needed per OLT (no IP in DPU)
Persistent Management Agent can be integrated in existing platform (OLT EMS or OLT)
DPU Config file generator can be integrated on some IT infrastructure
(does not require DPU vendor's EMS)
Alarms and Performance Monitoring are OMCI based and correlated in OLT



CO-EXISTENCE







Ingress/egress control

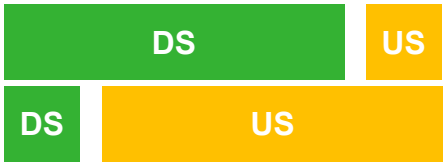
- Can notch any band
- No egress noticed so far

Upgrade scenario

- Start above VDSL2 for co-existence
- Use full 2.2-106 MHz spectrum once all VDSL2 users migrated

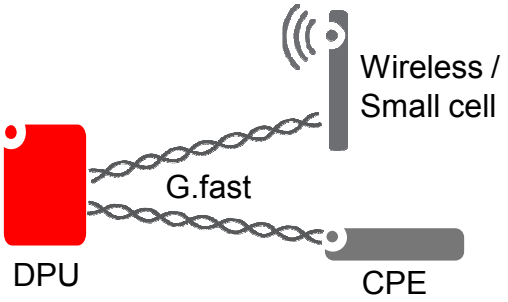
FLEXIBLE NOTCHING CAPABILITIES FOR COMPATIBILIY WITH LEGACY SERVICES

VERSATILE



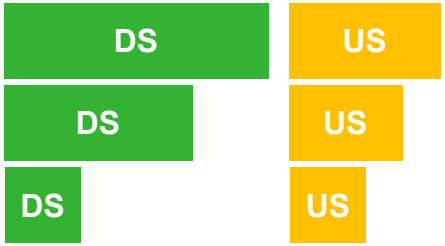
Flexible DS:US ratio

- Mandatory 30:70 to 90:10
- Optional 10:90 to 30:70



Mobile backhaul

- Low latency framing option
- Network Timing Reference and Time of Day



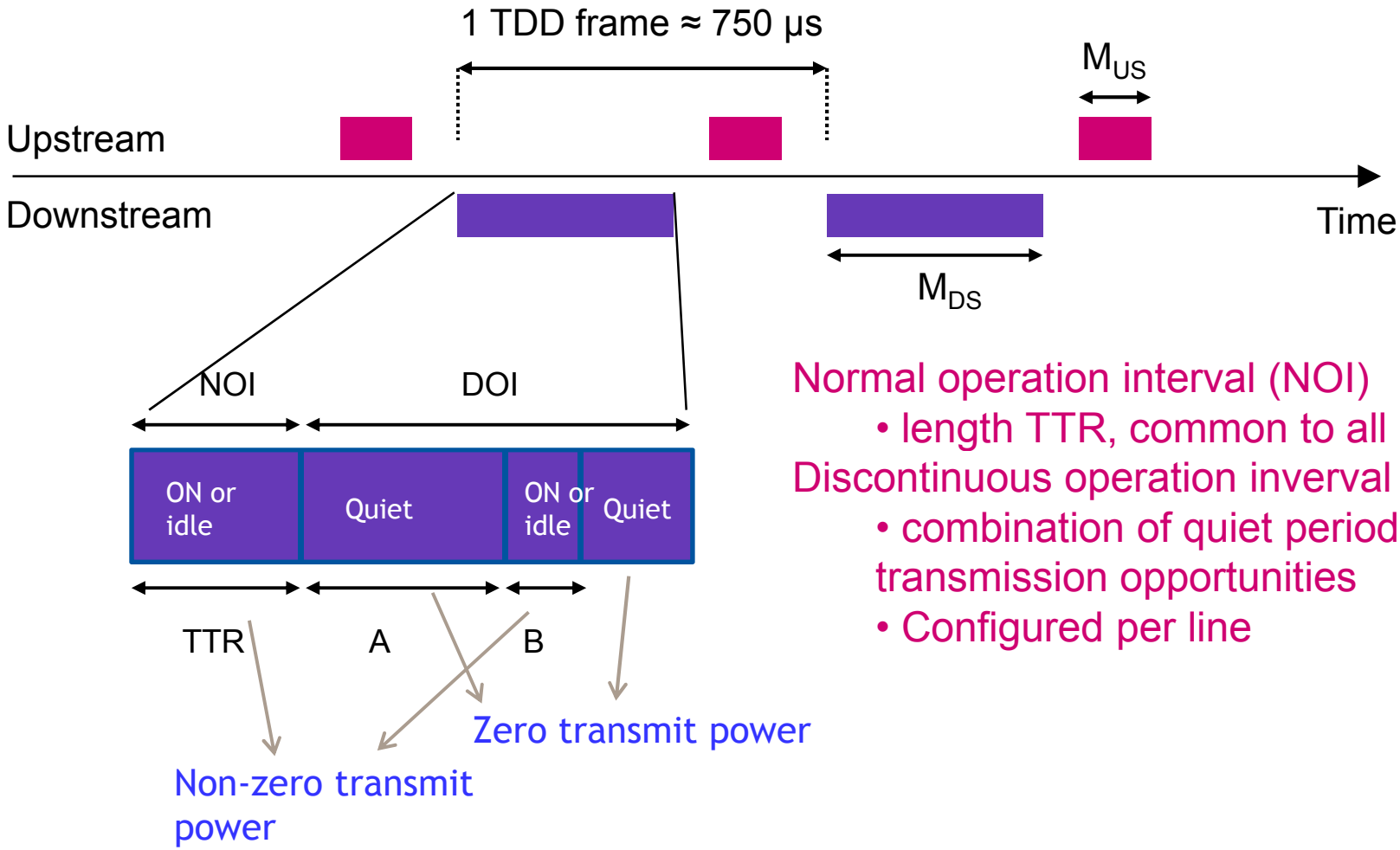
Scalable power consumption

- Proportional to traffic load
- Autonomous or managed
- Ultra-low power for VoIP support

Not just twisted pair

- Alcatel-Lucent proven performance over cable
- For point-to-point coax topologies

G.FAST USES TIME DIVISION DUPLEXING



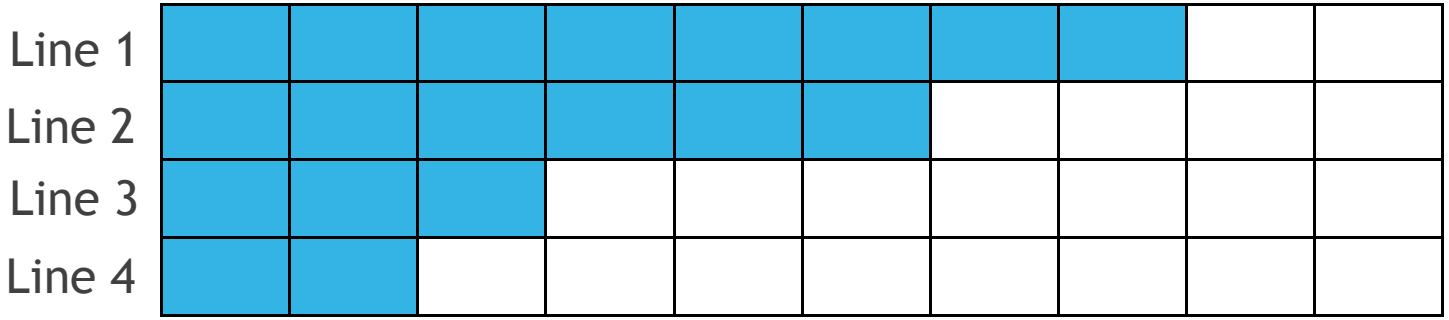
Normal operation interval (NOI)
- length TTR, common to all lines

Discontinuous operation inverval (DOI)
- combination of quiet periods and transmission opportunities
- Configured per line

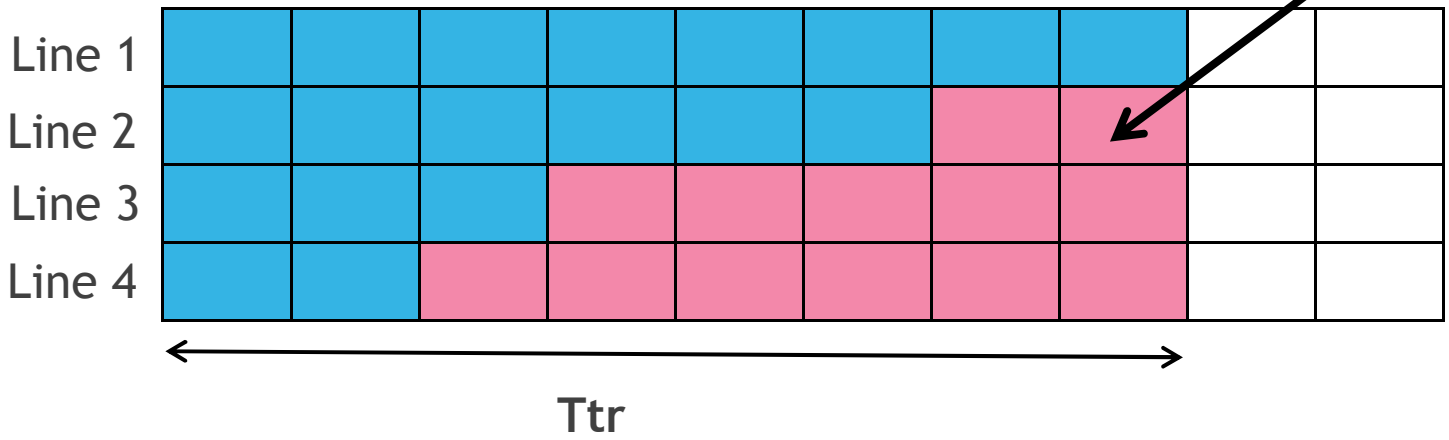
NOI and DOI configured by DRA (Dynamic Resource Allocation)

USE CASES FOR NORMAL AND DISCONTINUOUS OPERATION

Minimum number of DMT symbols required:



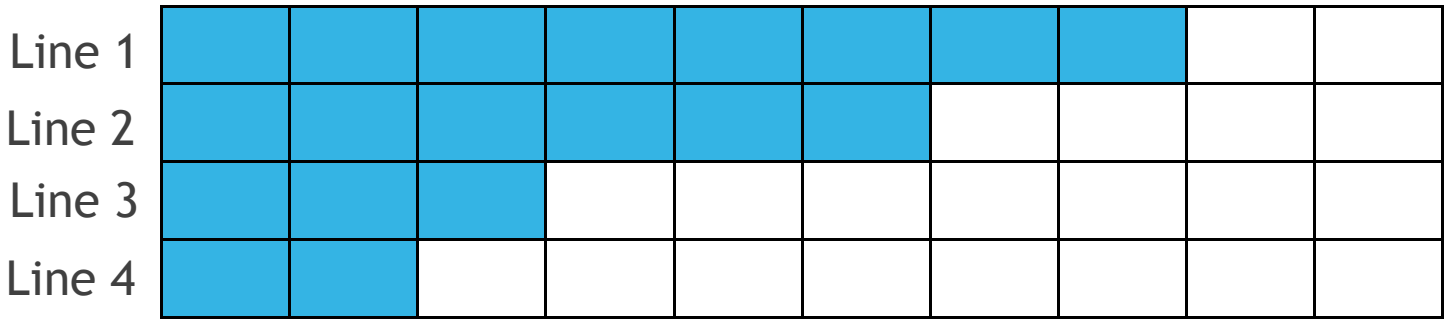
DRA control, example 1: full vectored in NOI, off in DOI



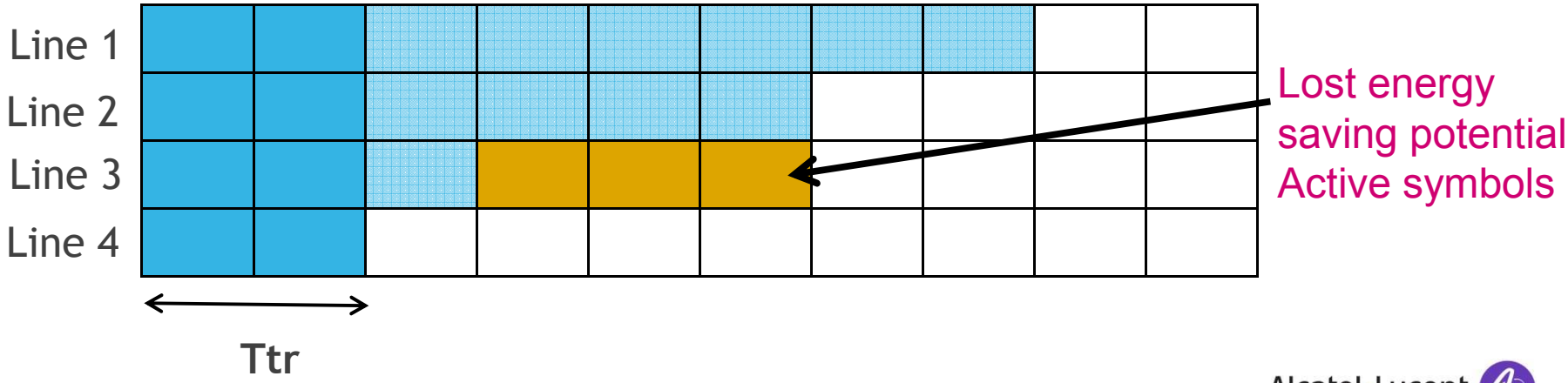
Lost energy saving potential Idle symbols

USE CASES FOR NORMAL AND DISCONTINUOUS OPERATION

Minimum number of DMT symbols required:

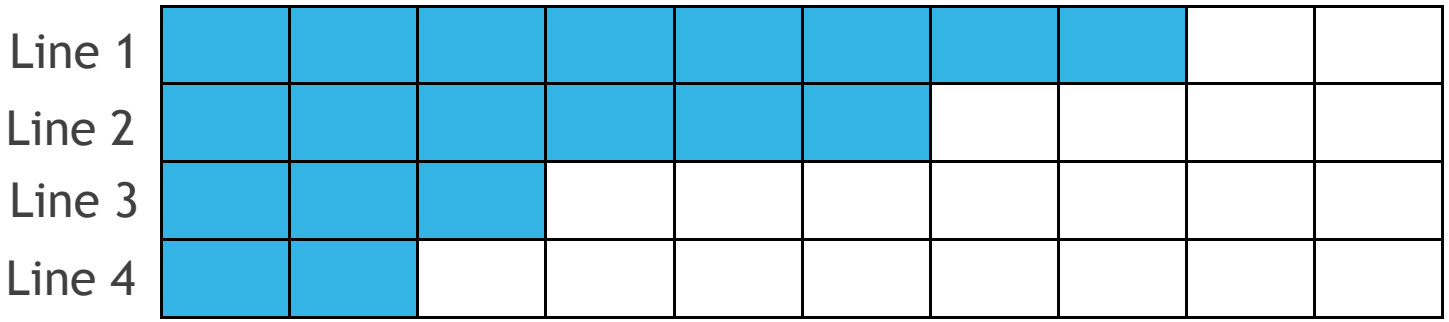


DRA control, example 2: full vectored in NOI, reduced vectored group in DOI

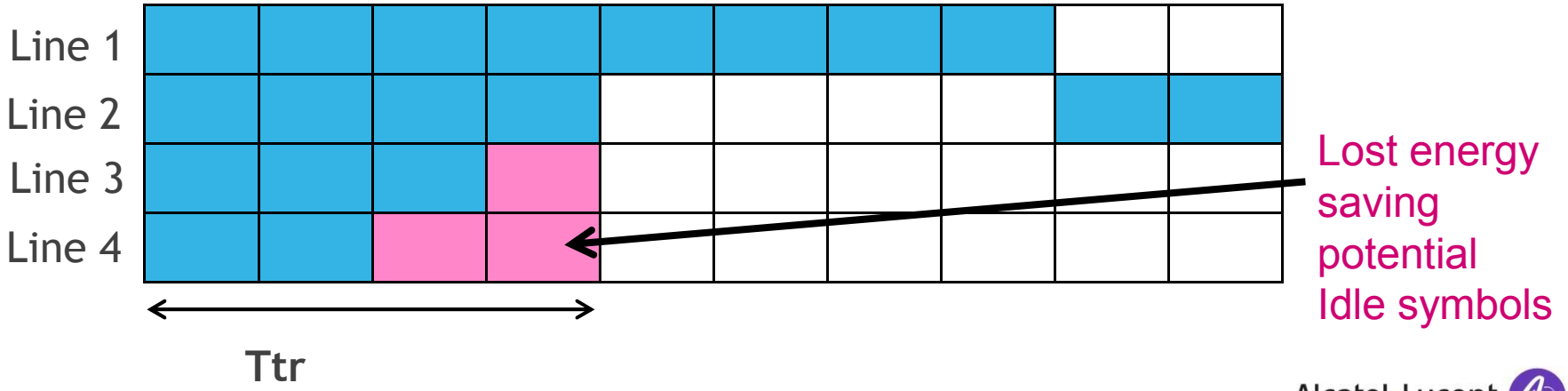


USE CASES FOR NORMAL AND DISCONTINUOUS OPERATION

Minimum number of DMT symbols required:

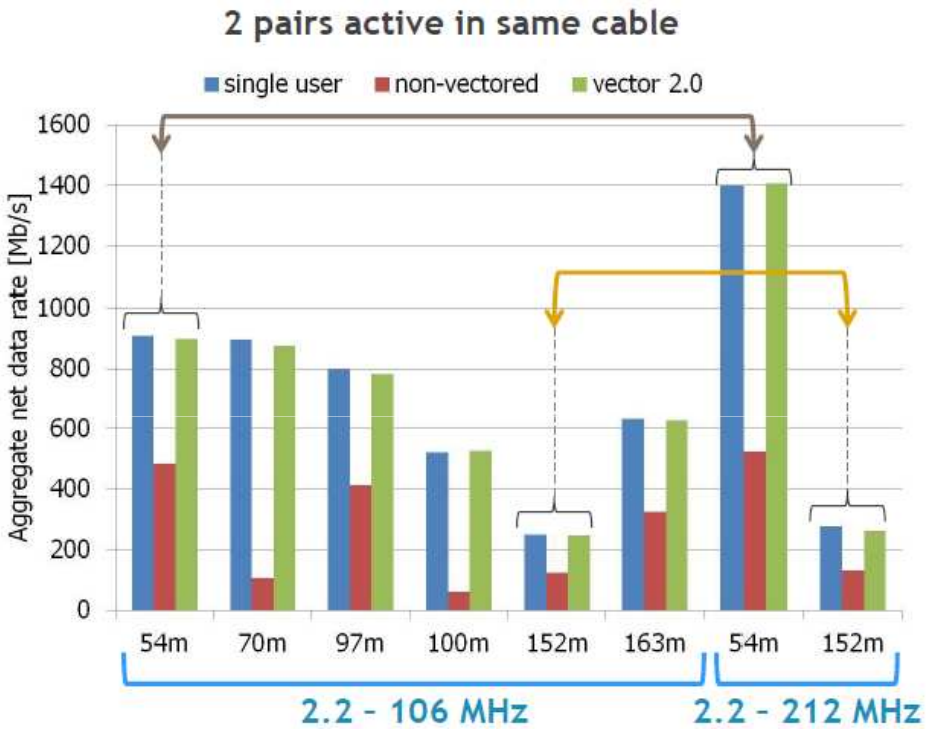


DRA control, example 3: full vectored in NOI, TDMA in DOI

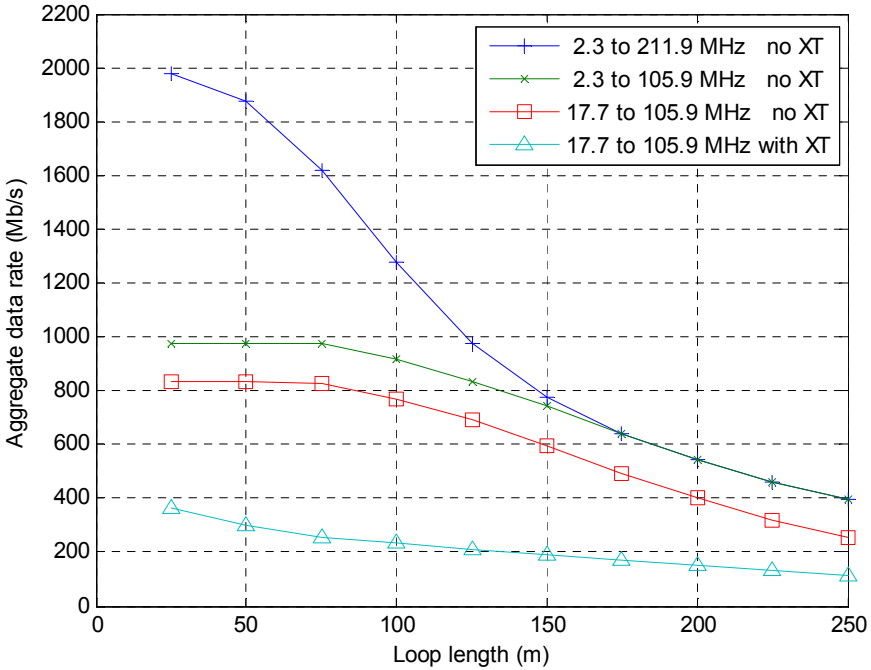


VECTOR 2.0

MEASURED



SIMULATED



The numbers are in

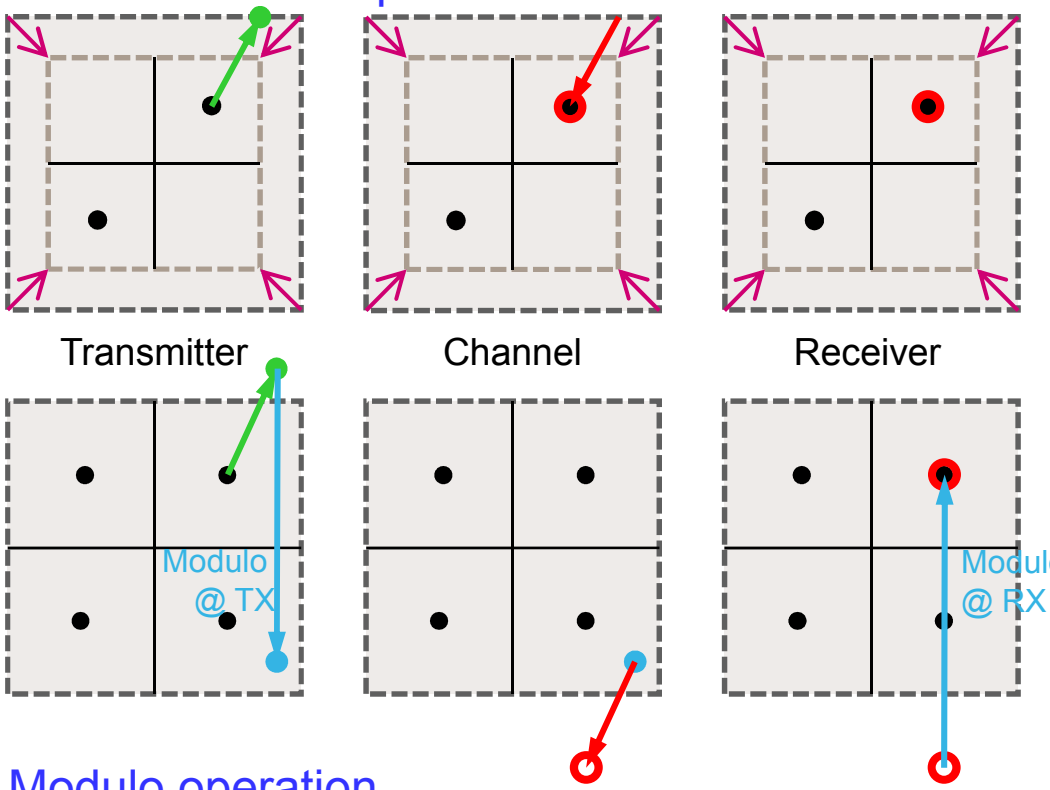
- Trials show huge impact of crosstalk
- And huge benefit of Vector 2.0
- High variability in cable quality, both single user and crosstalk

Rate/reach

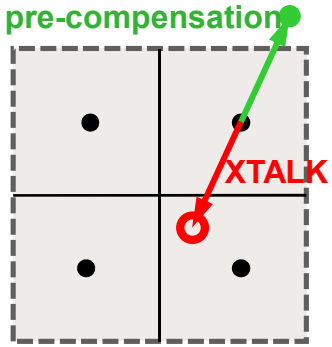
- G.fast cable model (CAD55)
- One 99% worst case crosstalker

VECTORING IN G.FAST

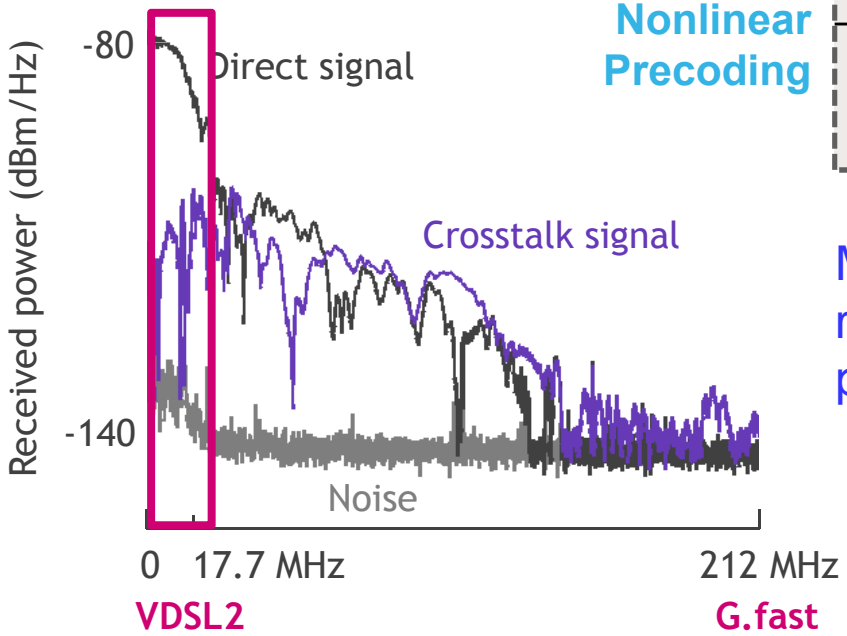
Gain Adjustment
reduces transmit power



Gain Scaled
Linear
Precoding



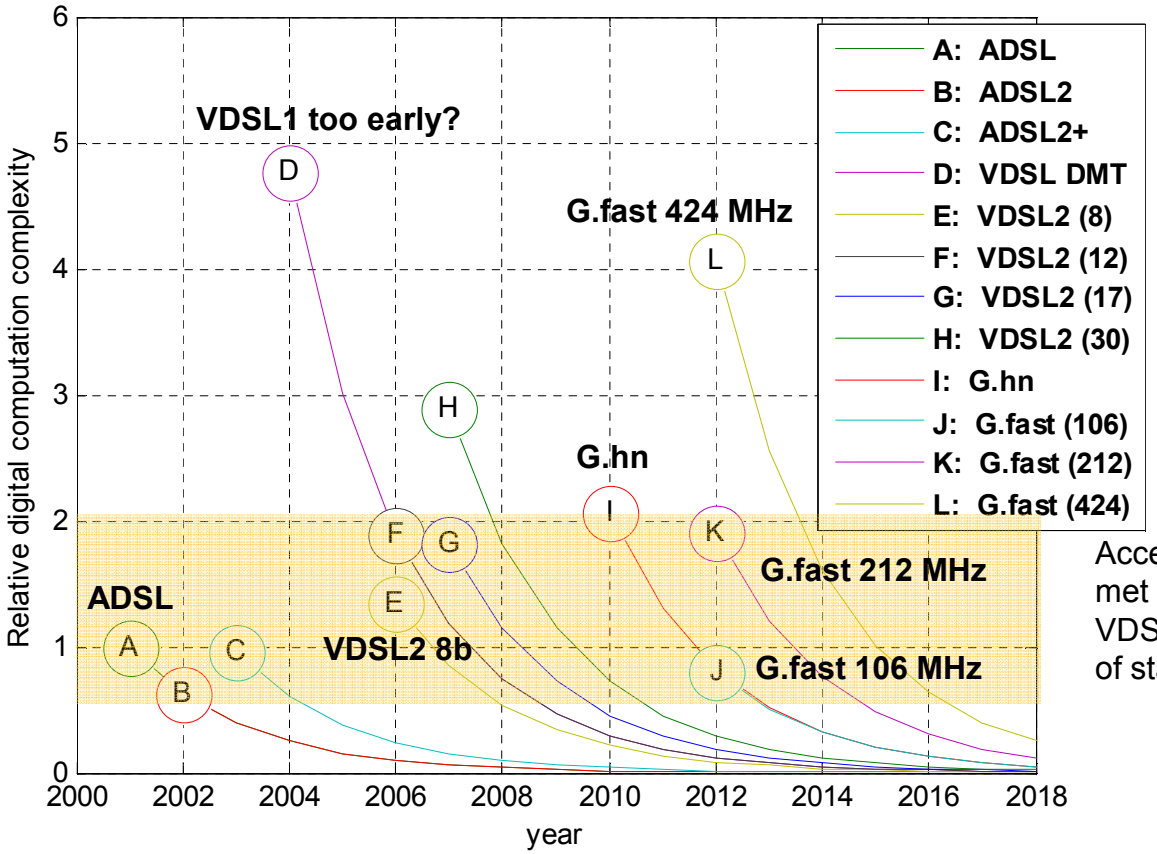
Nonlinear
Precoding



Modulo operation
reduces transmit
power

Higher bitloading
with nonlinear
precoding.

RELATIVE DIGITAL COMPLEXITY OF XDSL TECHNOLOGIES
SCALED WITH MOORE'S LAW



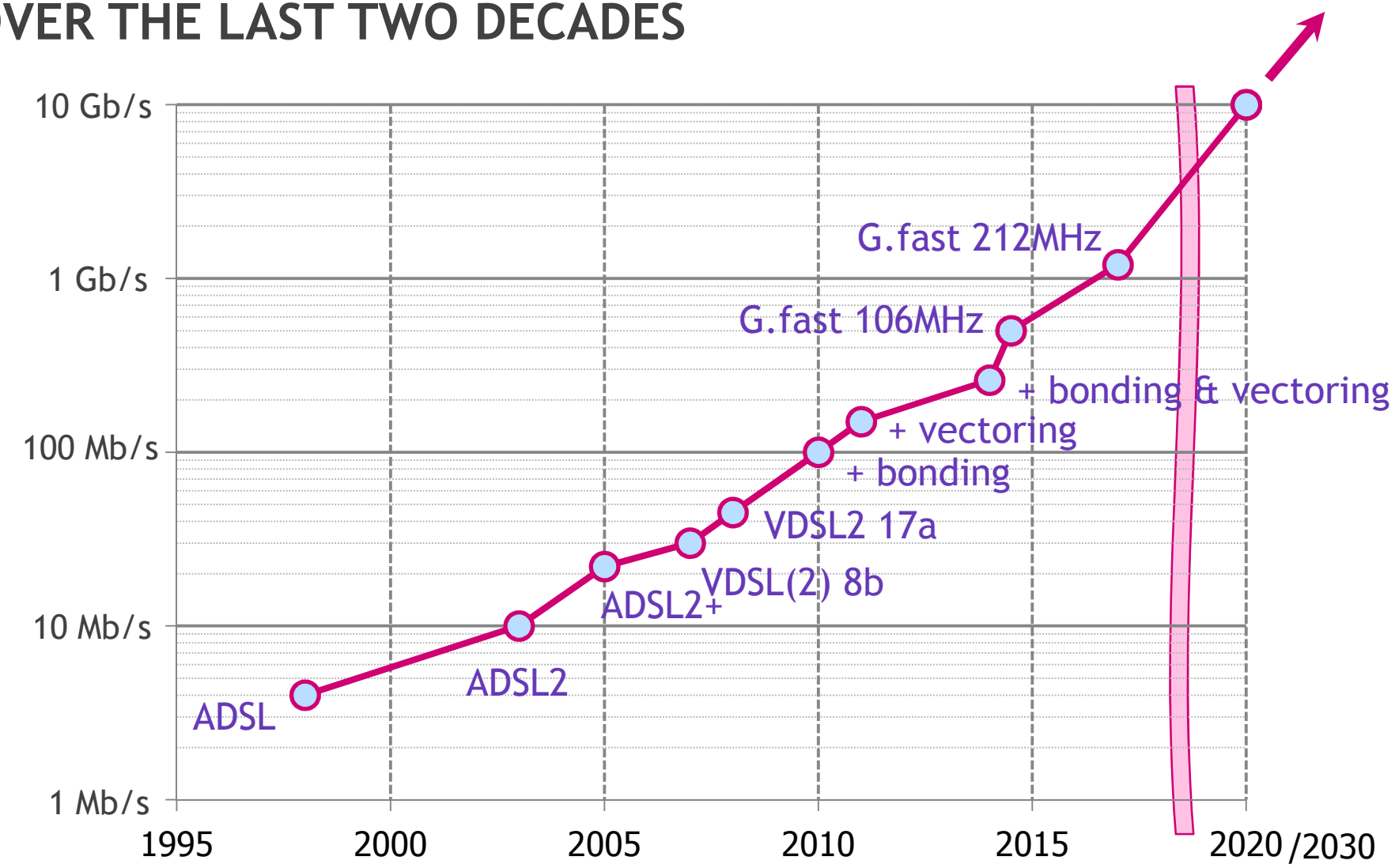
Acceptable complexity range: met by ADSL, ADSL2+, VDSL2 (8b-17a), G.hn at time of standardization by ITU-T.

Note: Similar results for memory requirements. But analog complexity does not obey Moore's Law

G.fast technologically feasible – analog will be limiting design factor

Alcatel·Lucent

DSL DATA RATES HAVE BEEN CONSISTENTLY INCREASING OVER THE LAST TWO DECADES



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VDSL2 VECTORING AND G.FAST
ACCELERATING FIBER DEPLOYMENTS

VERY HIGH SPEEDS, VERY SHORT DISTANCES

- Hundreds of Mbps at very short distances
- 1Gbps+ at tens of meters
- Fiber “nearly” to the home
- Designed for self-install & any type of wiring

COMPLEMENTS FTTH AND VDSL2 VECTORING

- G.Fast can accelerate FTTH deployments
- Promising evolution for short-loop FTTx models
- VDSL2 vectoring for loops exceeding 200m

TECHNOLOGY STILL EVOLVING

- Ratified standard 2014
- Chipsets 2015, products earliest 2016
- Challenges remain: need for vectoring, power management ,etc.

BUSINESS CASE VARIES PER OPERATOR

- The closer to the end-user, the higher the cost
- … but avoid entering the home (costly & time-consuming)

www.alcatel-lucent.com