G.fast – Shifting the limits of copper

Bell Labs, Alcatel-Lucent - Jochen Maes

19 January, 2012 @ UKNOF

Alcatel·Lucent

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FTTH - the next big thing for decades ...

FIBER TO THE HOME: PRACTICALLY A REALITY

John Bourne 1988

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

Marvin A. Sirbu and David P. Reed 1988

Carnegie Mellon University

Optical fibers reach into homes 1989

Paul W. Shumate Jr. Bell Communications Research Inc.

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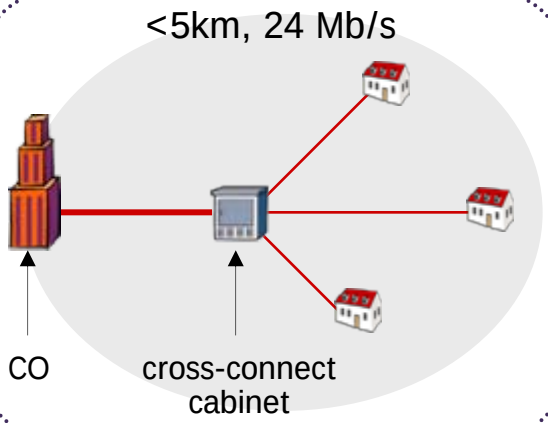
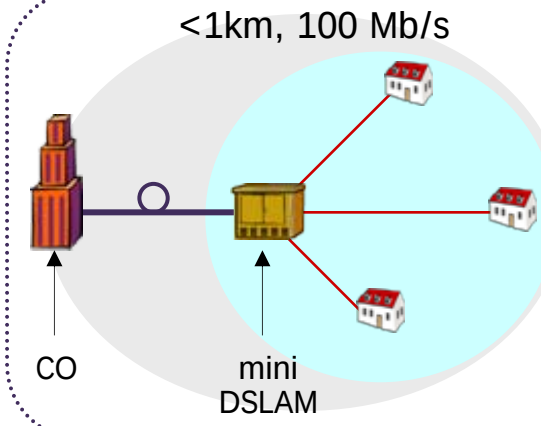
Reality
gradual deployment of fiber deeper in network

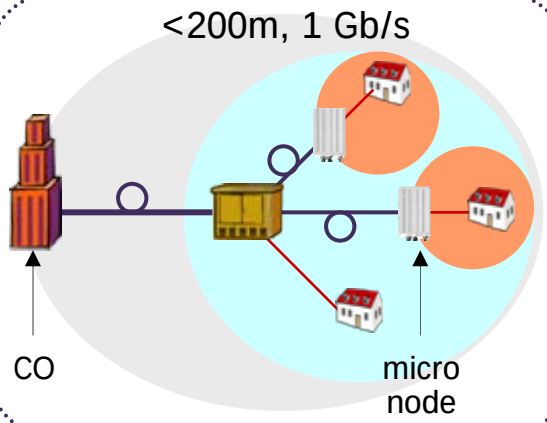
CO deployment



Fiber to the Node / Cabinet



Fiber to the Curb / Distribution Point



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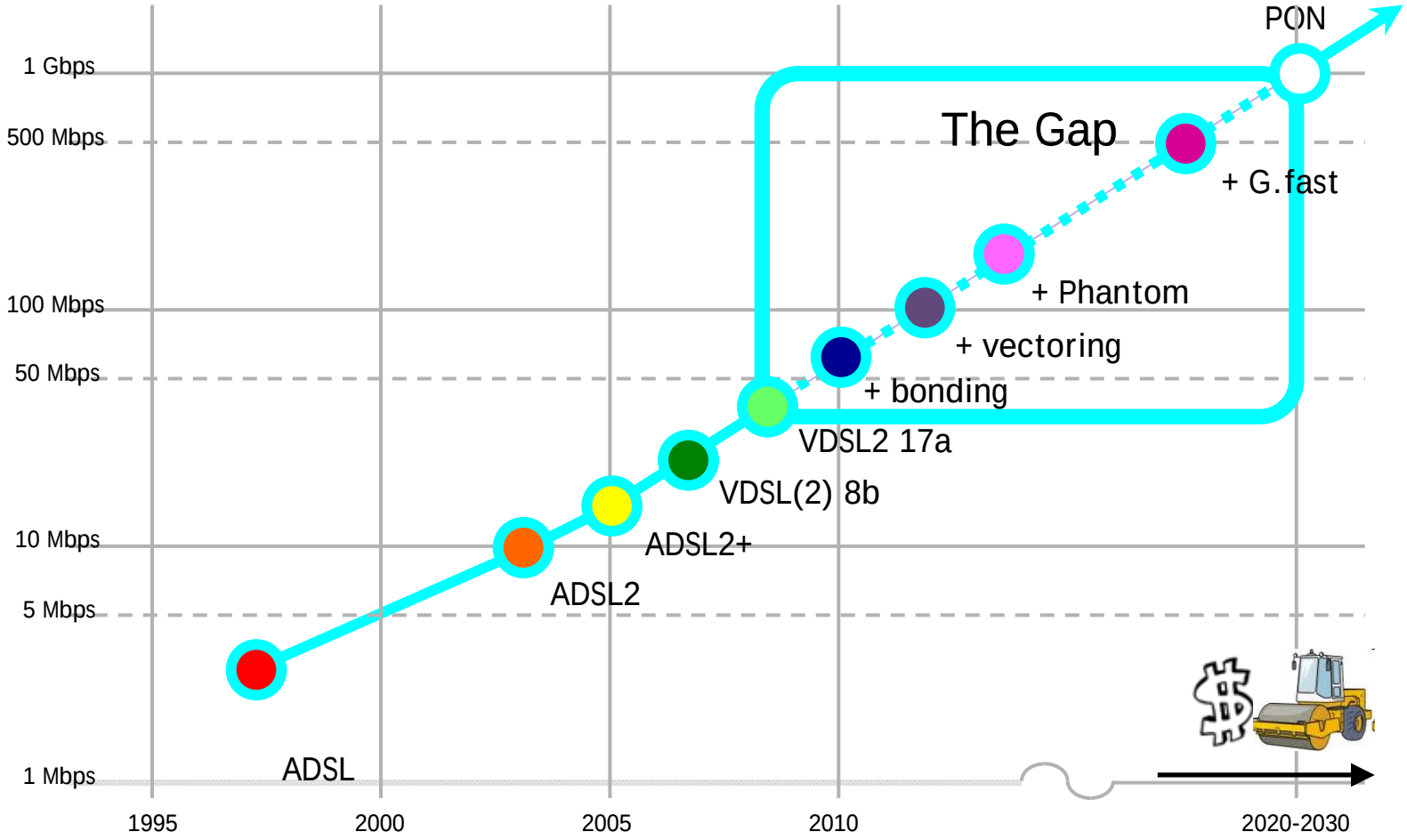
Shifting the limits of copper



Copper innovations allow operators to gradually build up their fiber network

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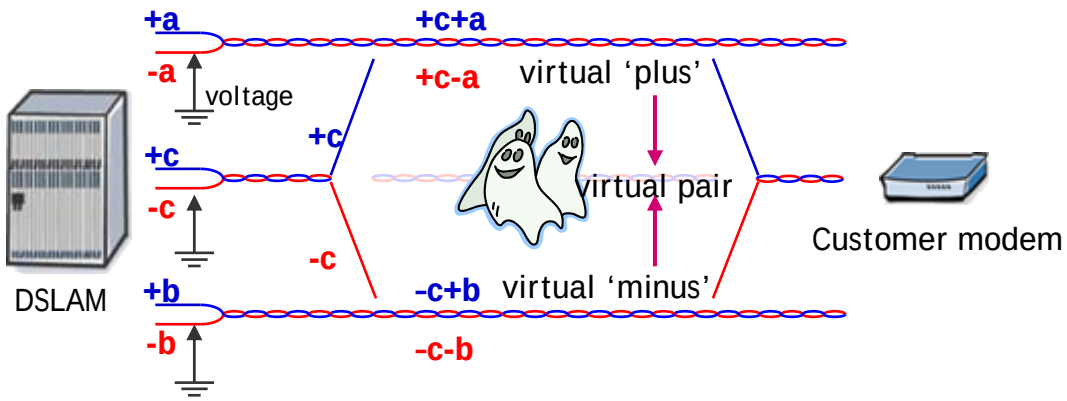
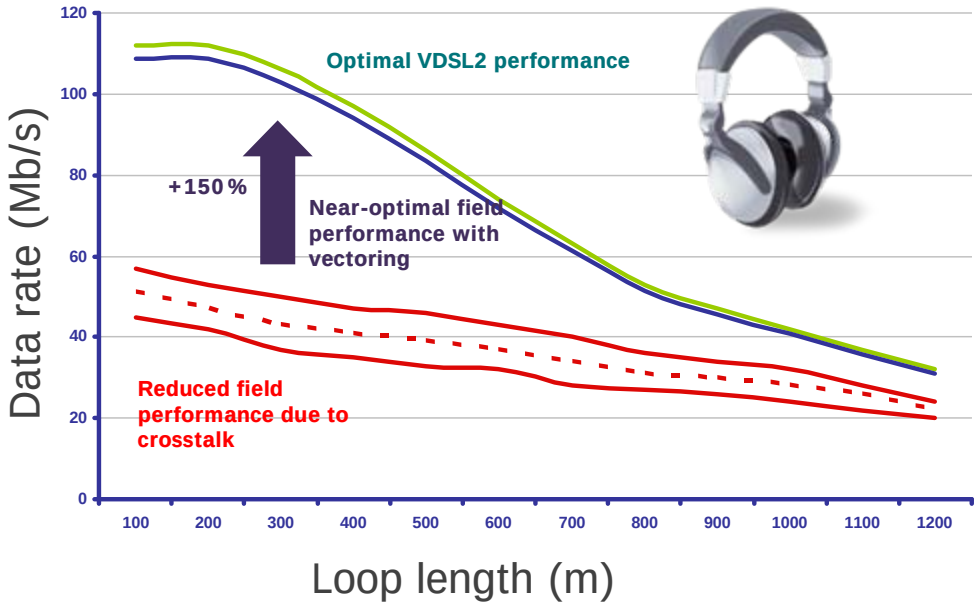
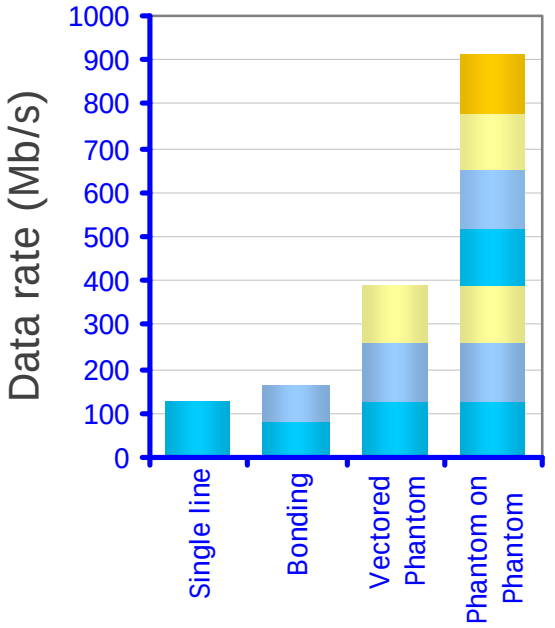
Vectoring

Phantom mode







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ITU project G.fast

- Standardizing copper physical layer aspects of FTTdp
- Initiated February 2011
- Earliest opportunity for consent: e.o. 2012
  - Means, earliest, standard could be approved in 2013; products could be available in 2014
- Contributions by DSL and G.hn vendors

- Main requirements
  - High peak data rate, e.g. 500 Mb/s at 100 m
  - Suited for reverse powering
  - Allowing for customer self-install
  - Optimized for short loops - not a substitute for FTTCab

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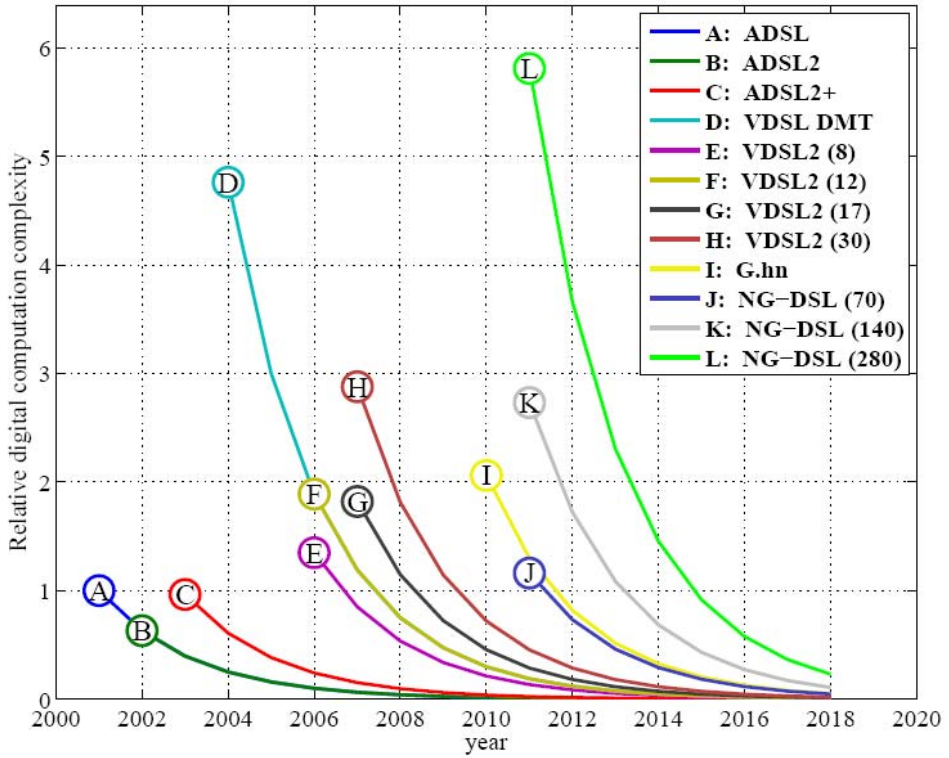
G.fast is becoming technologically feasible

Digital computation complexity relative to ADSL in 2001

Along x-axis, cost of complexity is scaled with Moore's law



Timmers et al., proceedings of Access2011

Technologically feasible – analog will be limiting design factor

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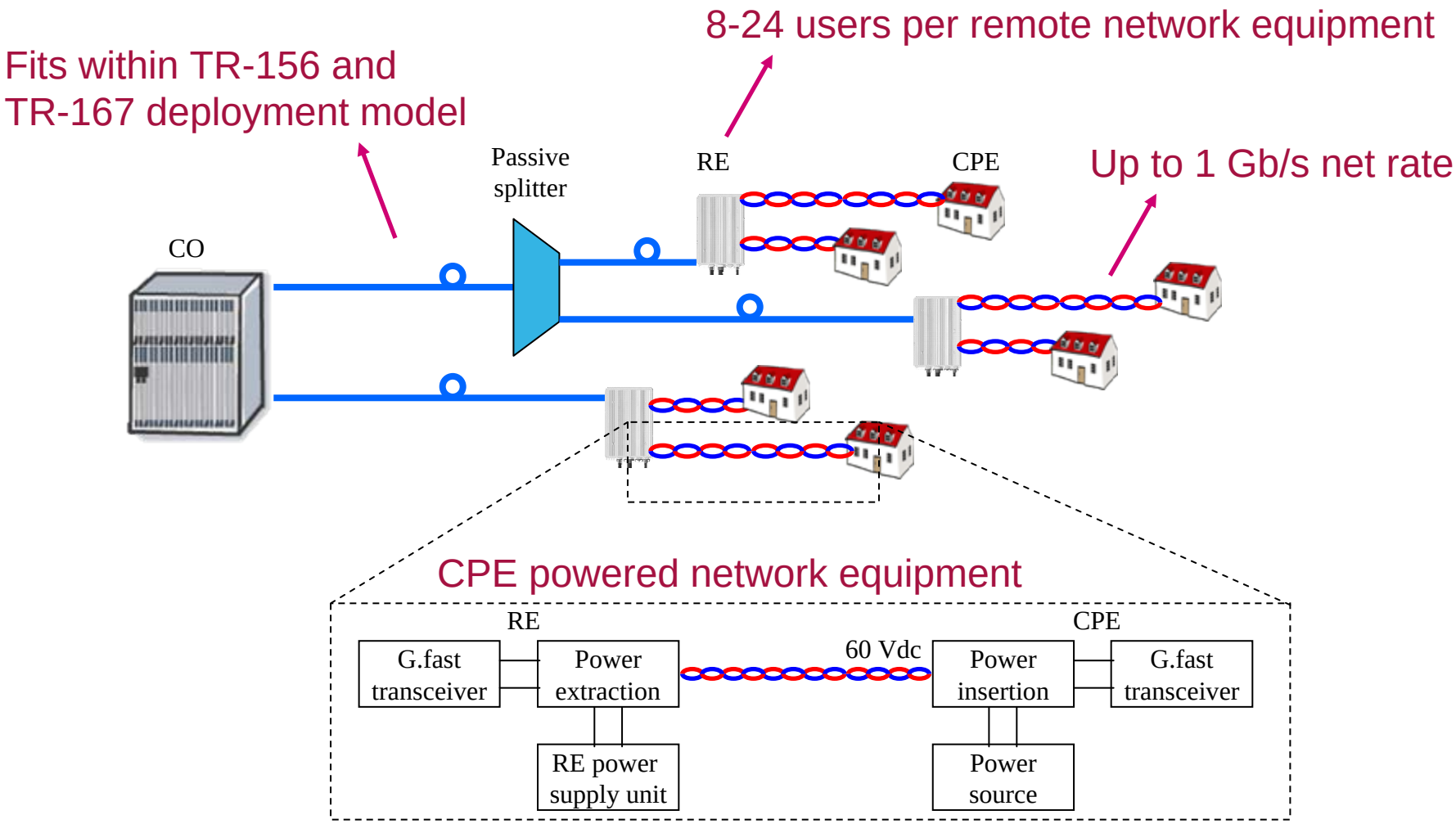
FTTdp architecture



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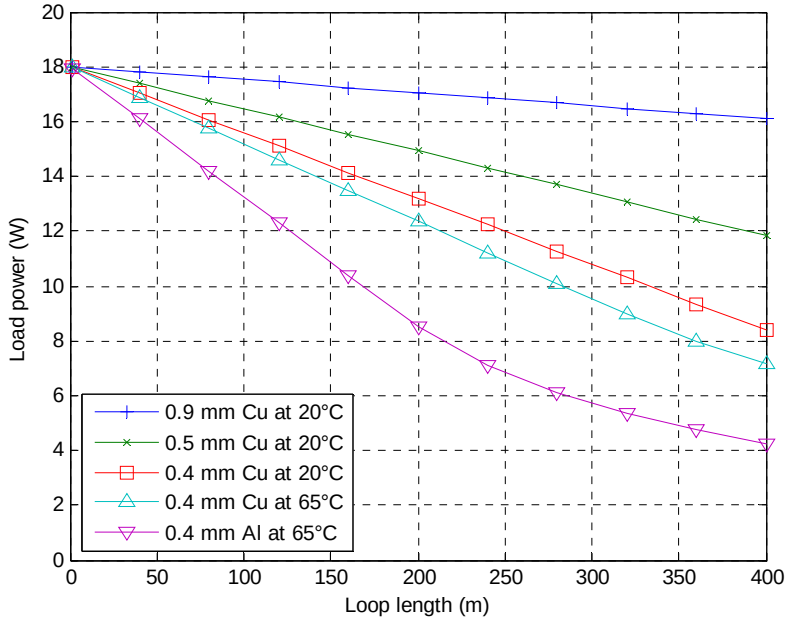
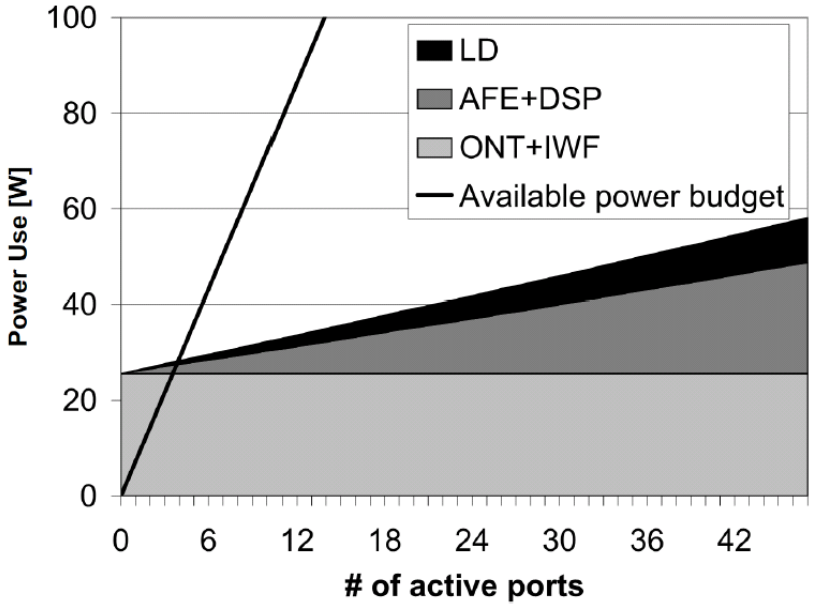
Reverse power feed
power transfer capability

ETSI TR 102 629 : Reverse Power Feed for Remote Nodes

Source voltage 60 V, within SELV limit, current < 300 m





System design for worst case – when single long line is connected

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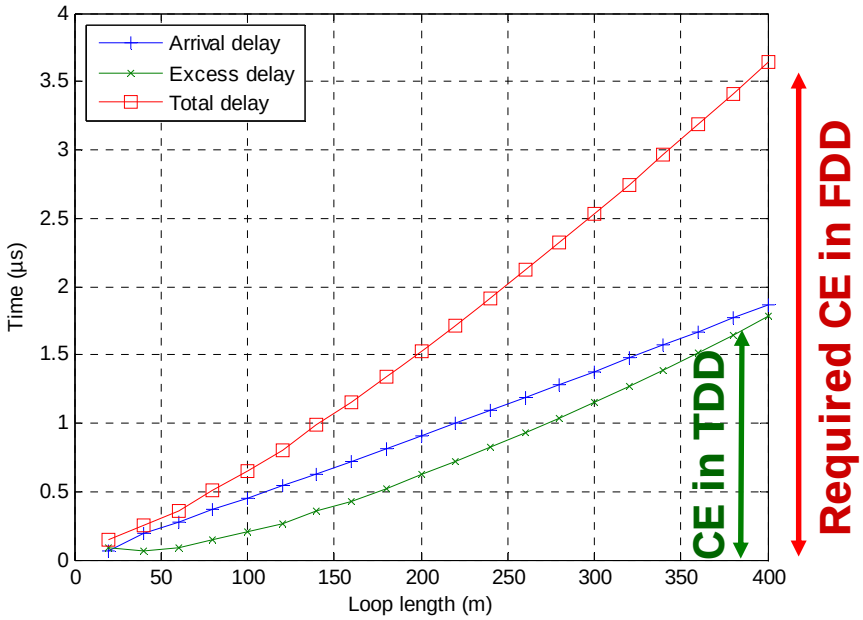
Time division duplexing

- Advantages of TDD:
  - Reduction in analog complexity
  - Increases transmission efficiency
  - Halves the modulation complexity
- Starting frequency above VDSL2, for legacy compatibility



TDD allows relaxing analog requirements

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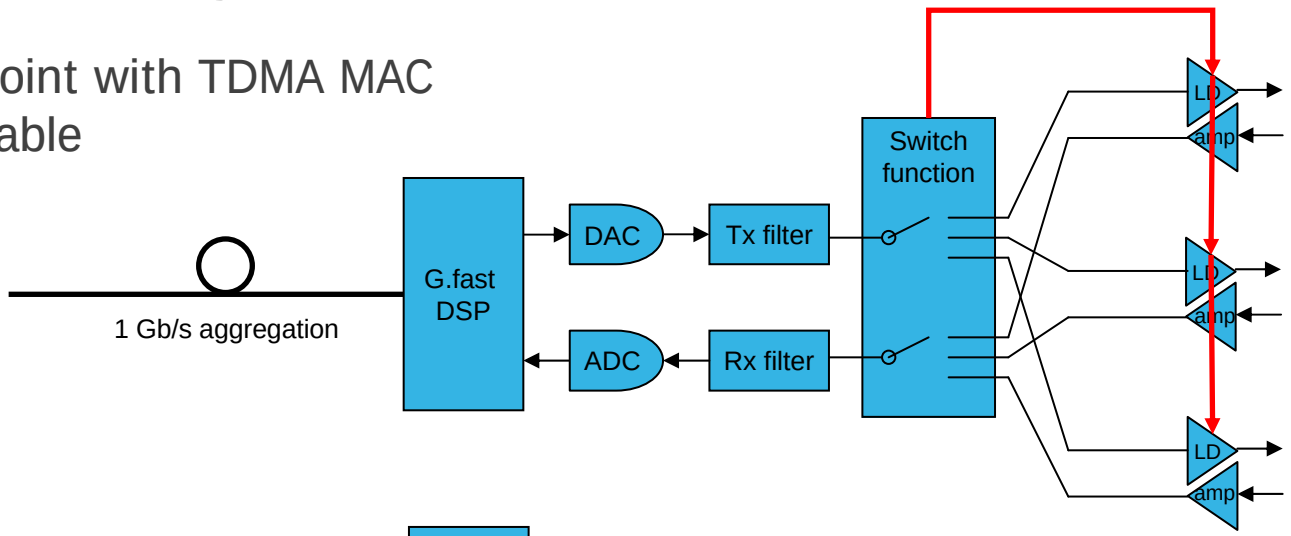
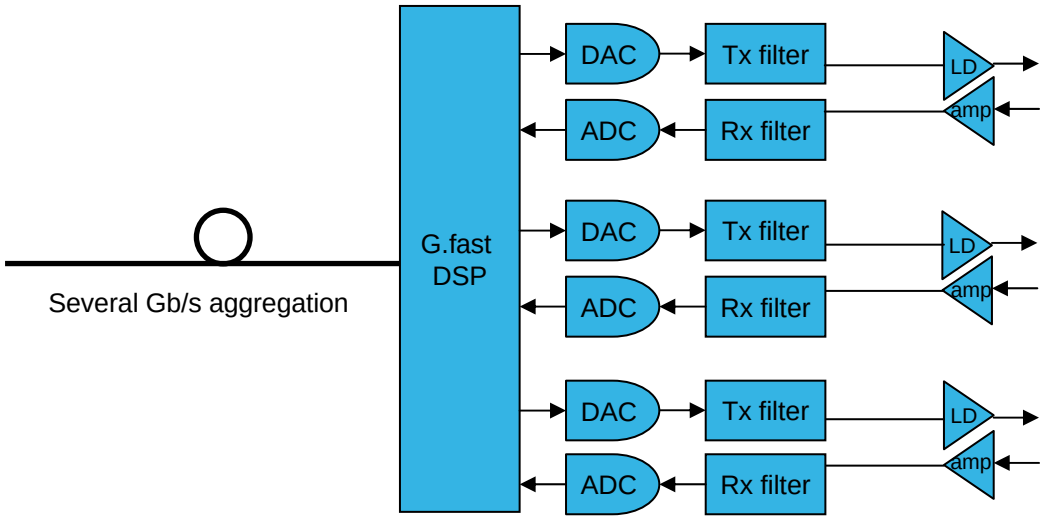
P2P and P2MP system architecture

Point-to-multipoint with TDMA MAC
Analogy with cable



Point-to-point



Options under consideration in ITU G.fast

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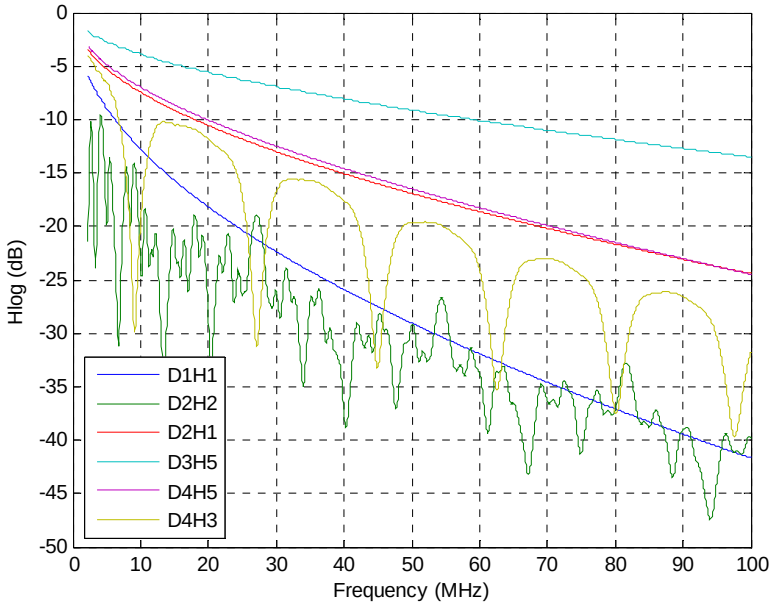
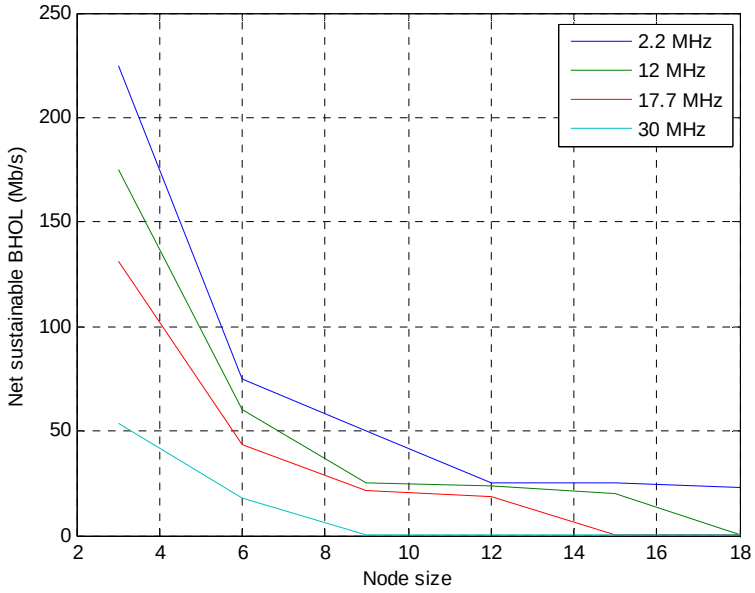
UK Reference loops

P2MP vs. P2P comparison



Average TDMA rate of N-1 users if 1 user is at 500 Mb/s 'peak rate'



P2P rate (vectored)

	D1-H1	D2-H2	D2-H1	D3-H5	D4-H5	D4-H3
Loop length	176.1 m	137.1 m	113.1 m	45.6 m	83.3 m	93.3 m
2.2 MHz	740	642	1076	1270	1084	922
12 MHz	616	541	944	1138	953	805
17.7 MHz	552	493	868	1062	876	734
30 MHz	428	384	714	895	720	599

Start frequency

UK reference loops

Key question: 'up to' or 'guaranteed' bandwidth

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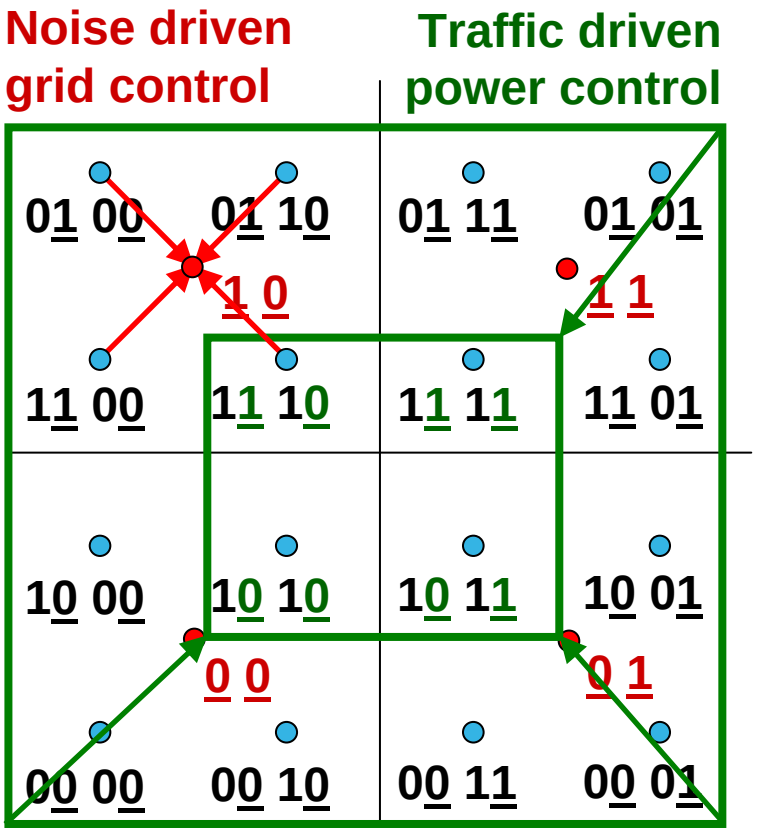
Transmitter Controlled Adaptive Modulation

Operator benefit:

- **Robustness → Self-install**
- **Spectral efficiency → Throughput**
- **Green → Reverse powering**

With minimal implementation impact



Automatic adaptation to traffic load and channel conditions

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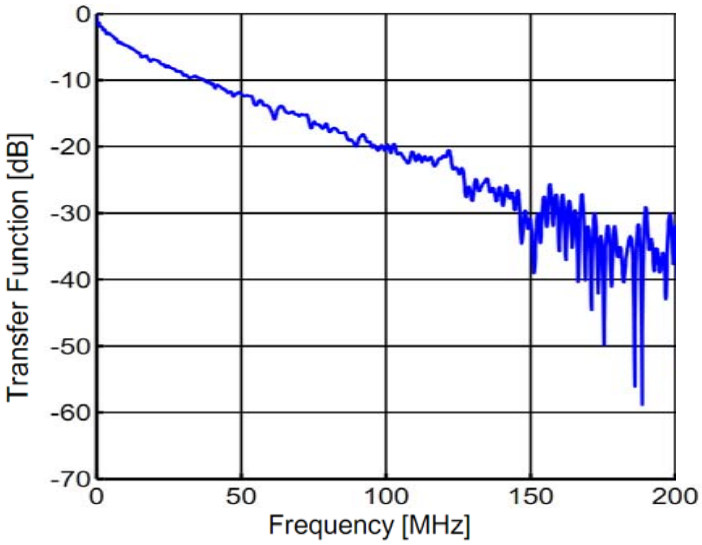
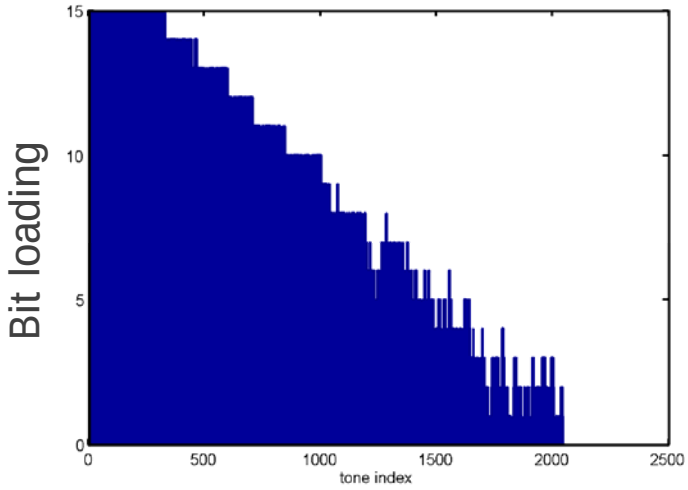
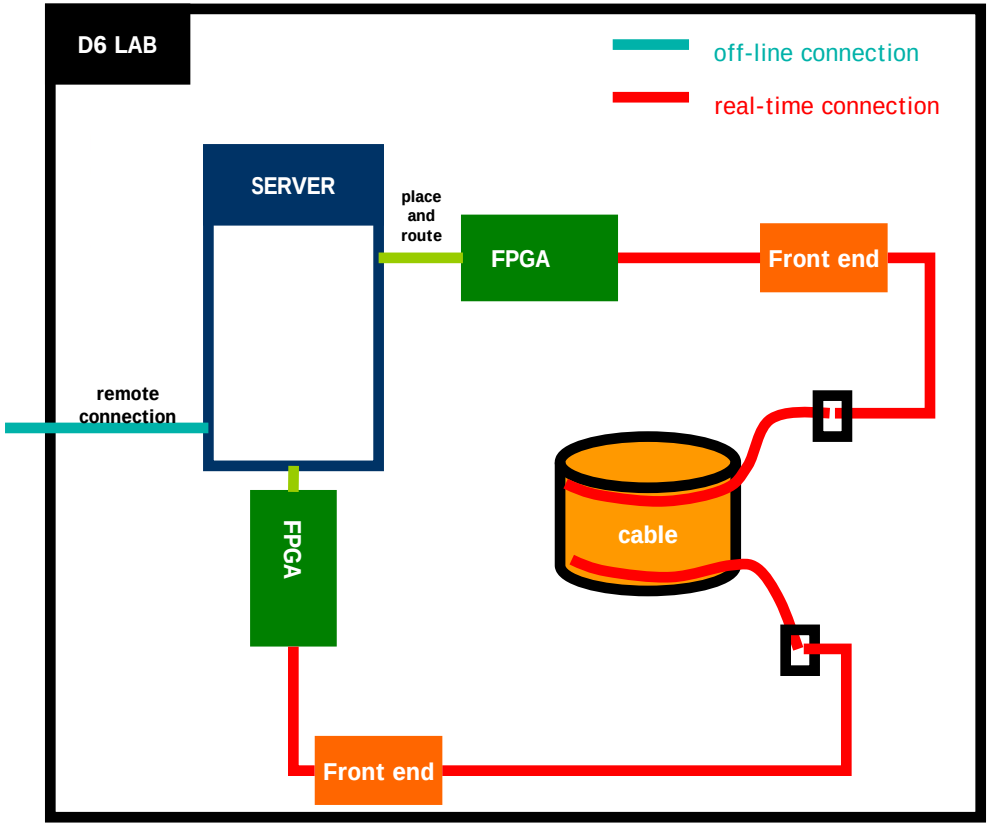
CuGAR

Copper Gigabit Access Research evaluation platform







Test bed for candidate technologies

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FTTdp - G.fast

- Continued copper access innovations facilitate operators to spread fiber investments
- G.fast is targeted for short loops up to 200 m from the last distribution point
- Being standardized in ITU-T, promising up to 1 Gb/s

- Transmitter controlled adaptive modulation is proposed, enabling high throughput, self-install and reverse powering
- P2P and P2MP system architectures under study in ITU
- TDMA offers high peak rate, but lower sustainable rate applied to UK reference loops – behaves like cable or PON

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AT THE SPEED OF IDEAS