Achieving 1 Gbps Symmetrical Service

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May 20th, 2015

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G.fast timeline

2012 — G.fast proof of concept
Early operator lab tests

2013

2014 — G.fast prototype
More lab tests
Early field tests

2015 — First G.fast products
Larger field trials

2016 — Early G.fast deployment

With G.fast Austrian Subsidiary A1 Achieves Data Rates of Over 1 Gbit/s via the Existing Copper Network for the First Time

Vienna, 02 July 2013

G.fast field trials

21 G.FAST TESTED WITH 21 OPERATORS

+7 MORE TRIALS PLANNED

652 Mbit/s US+DS traffic
(74m in-house cable)

Ultrabreitband mit G.fast

Four Acres
test facility

Every success has its network

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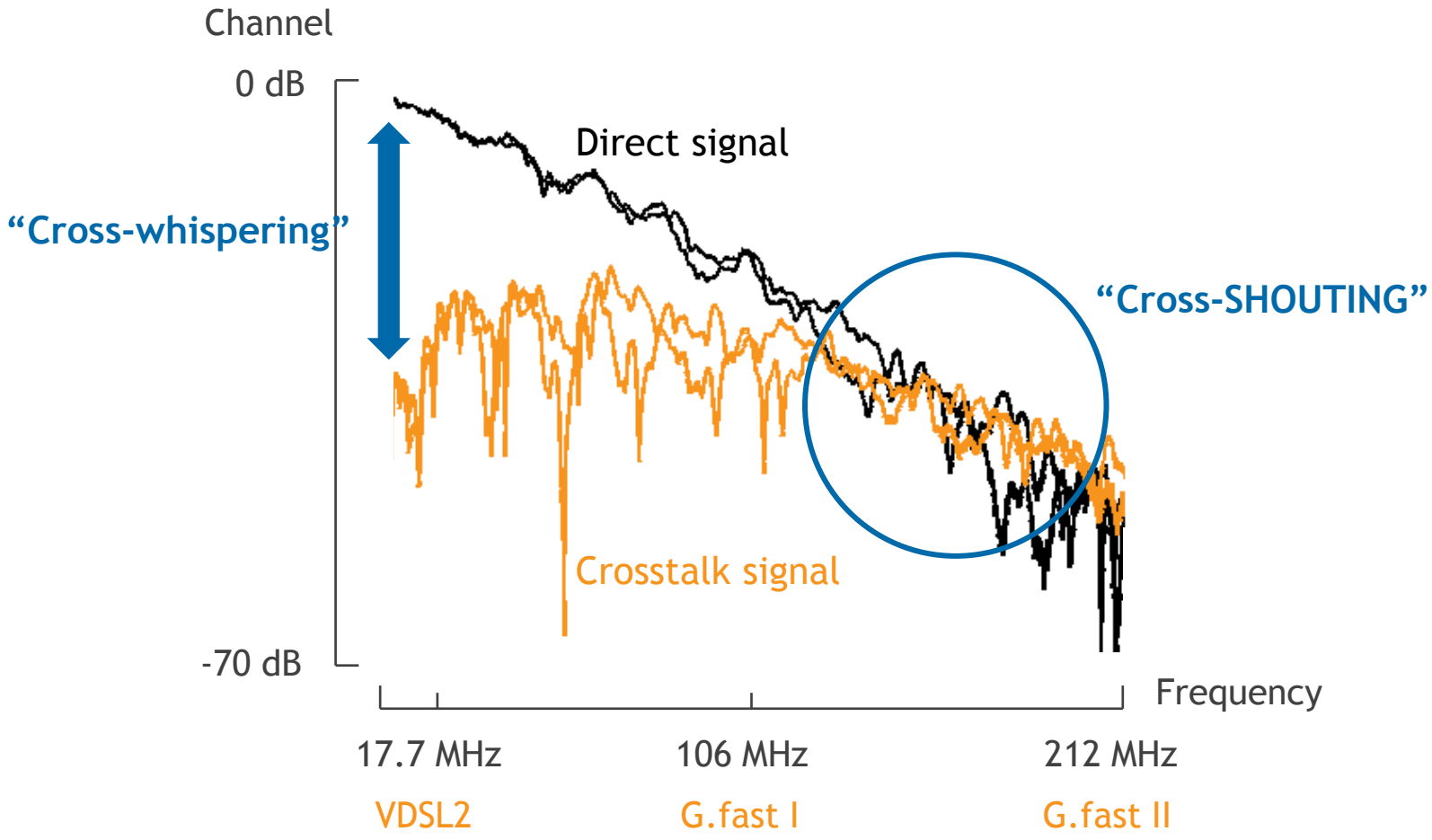
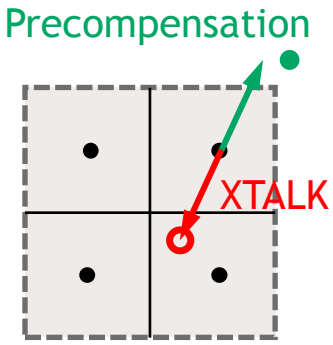
Crosstalk in G.fast has a much bigger impact than in VDSL2

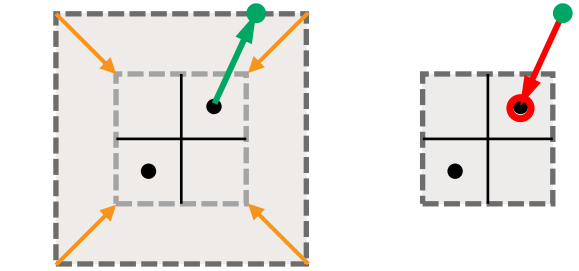


Different precoding strategies exist to cope with this high crosstalk



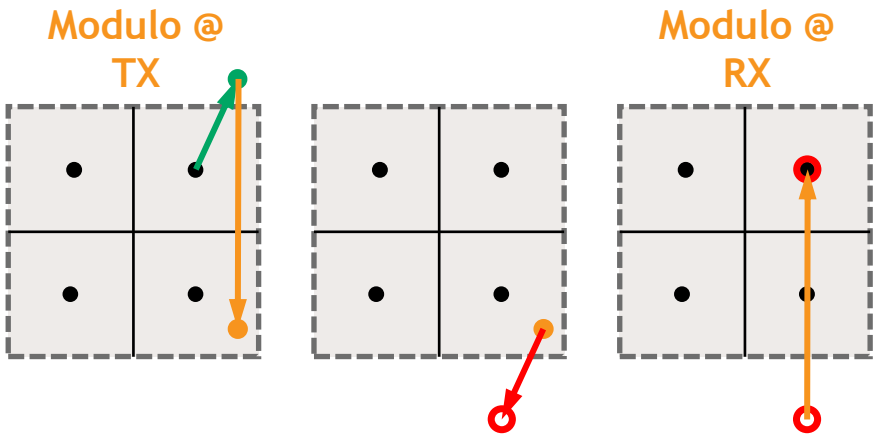
Transmitter Channel Receiver

Linear precoding



Scaling causes SNR loss

Nonlinear precoding

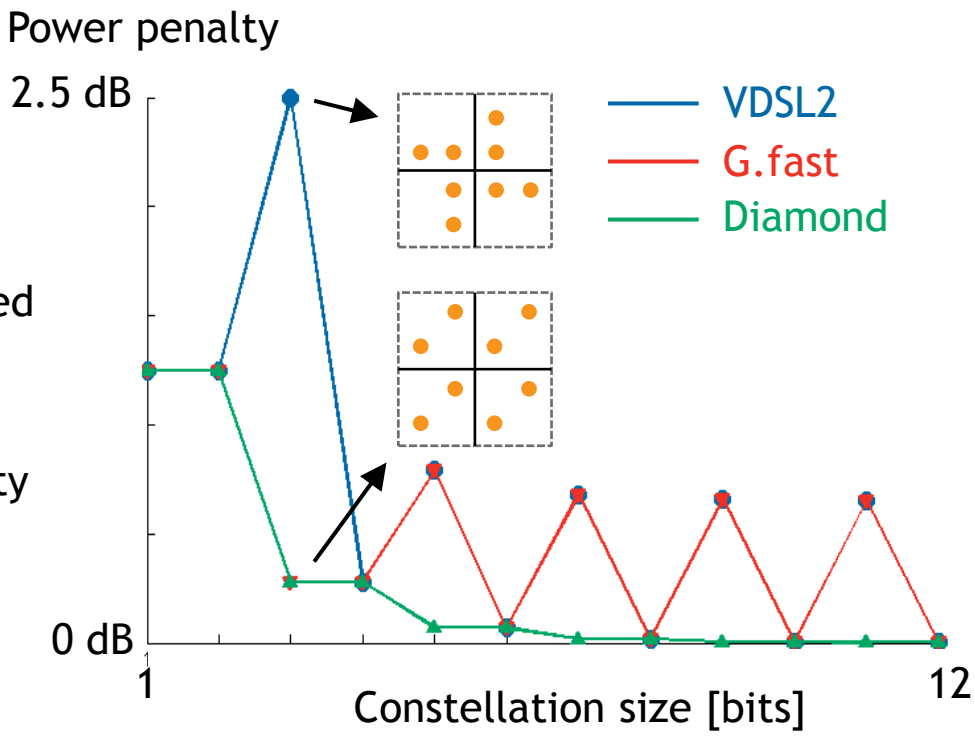


Modulo reduces transmit power

Higher bitloading

Modulo operation introduces a power penalty to guarantee PSD mask compliance

- Modulo bounds transmit signal to square constellation
- Uniform distribution within square is assumed to guarantee PSD mask compliance
- The G.fast standard defined new 3-bit constellation to lower excessive power penalty
- G.fast constellations are “NLP-ready”

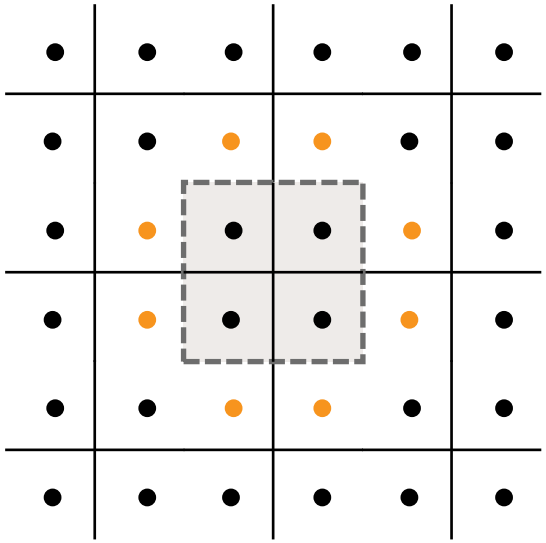


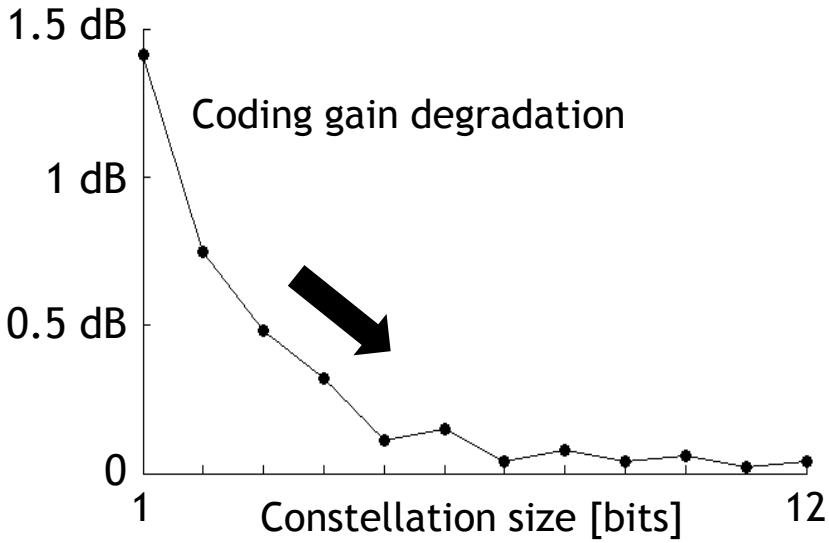
Neckebroek *et al.*, IEEE ICC 2015,

The nonlinear modulo operation increases the gap to capacity for small constellations

The modulo operation creates additional nearest neighbors for the outer constellation points

4-QAM example

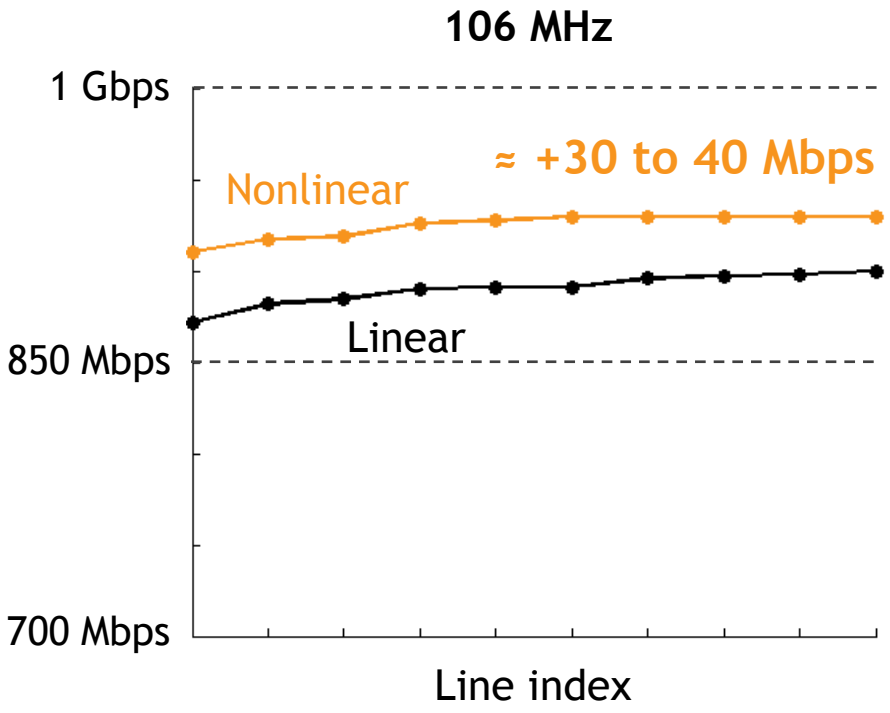


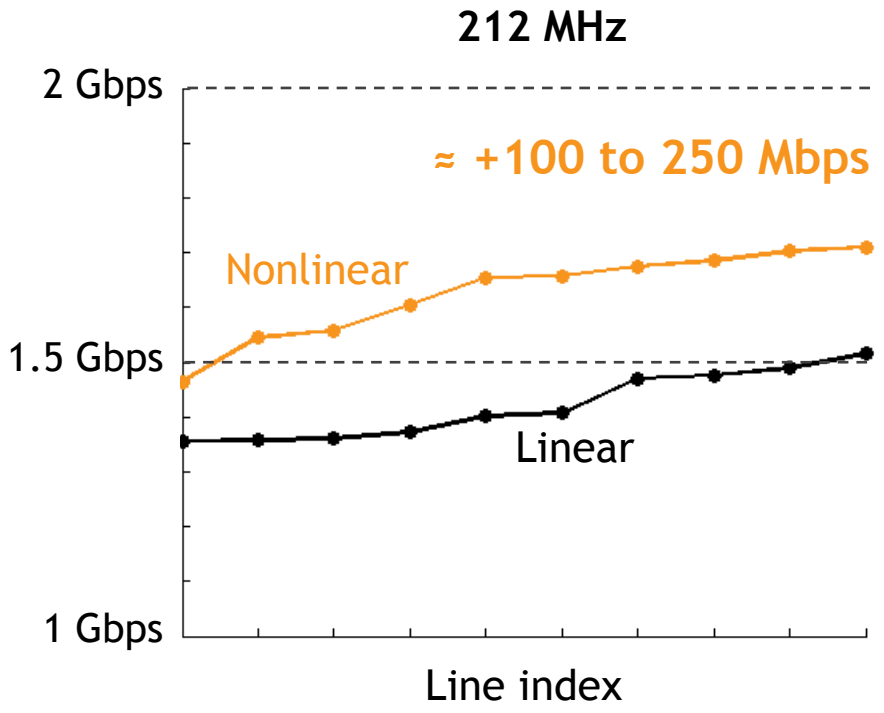


Impact is largest for the smallest constellations, due to the larger fraction of outer constellation points

Neckebroek *et al.*, IEEE ICC 2015

Nonlinear precoding gain is only significant at high frequencies





Very short cable with very high crosstalk

1 Gbps is today's marketing weapon

1 Gbps

Every success has its network

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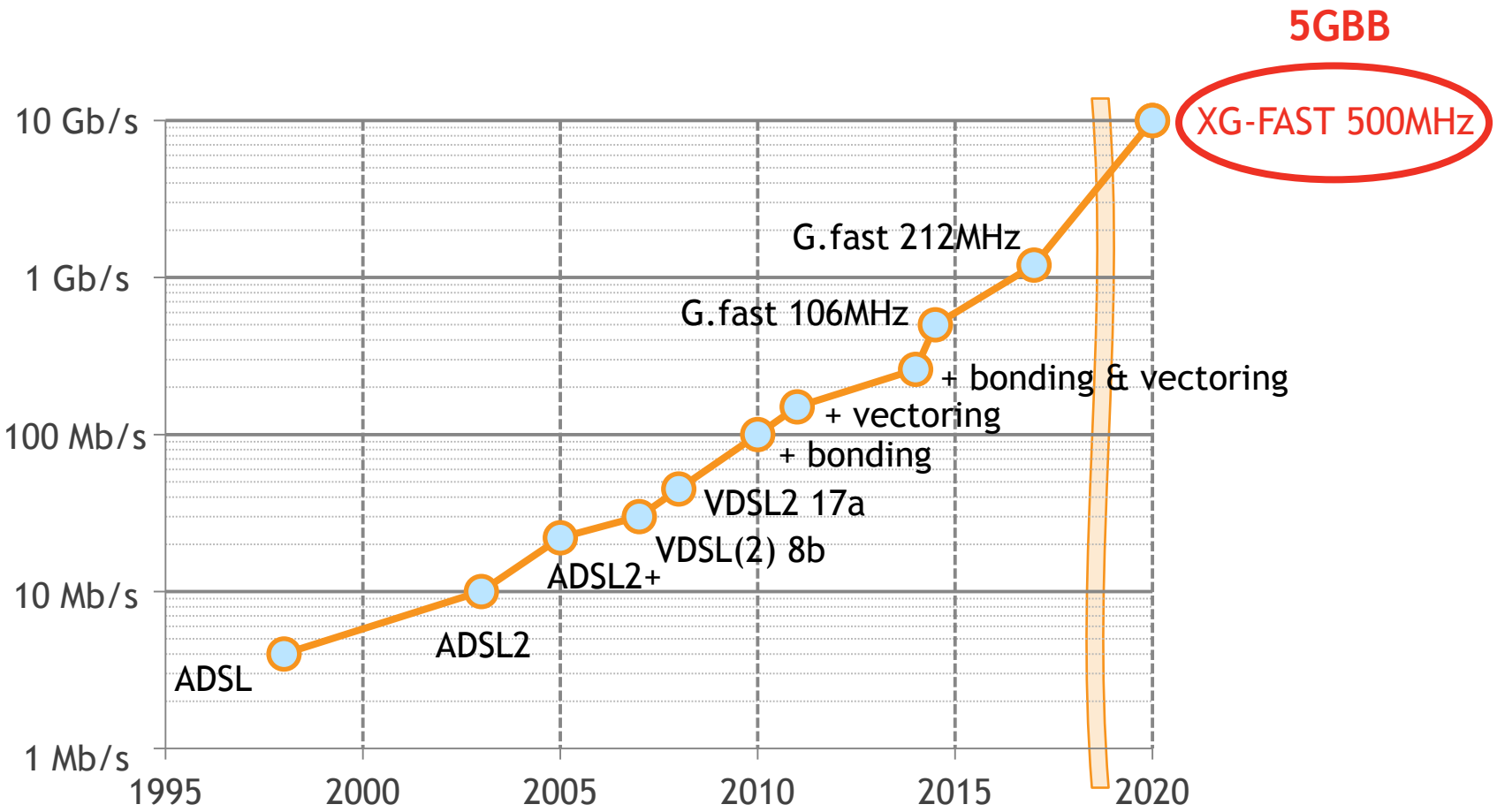
XG-FAST = “gigabits for all”



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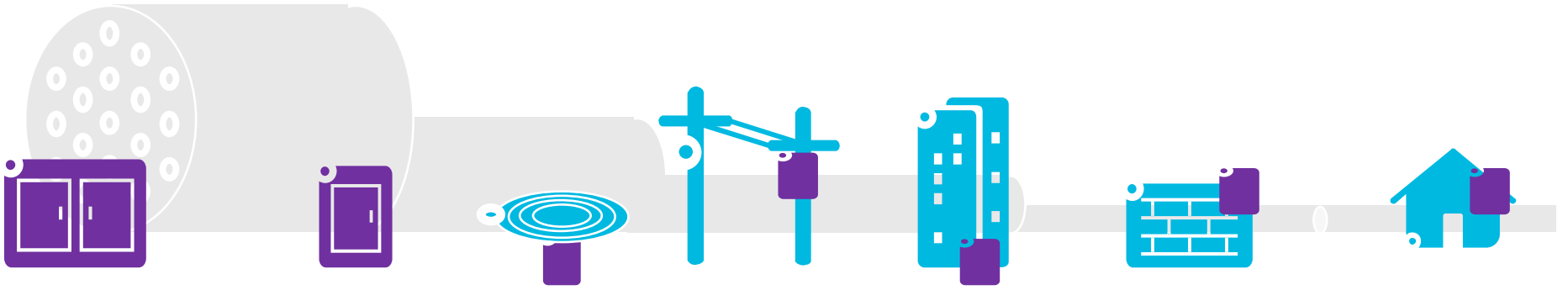
Fiber To The ...



VDSL2 VECT

>200 METER

>100 SUBSCRIBERS

G.fast

<200 METER

10s OF SUBCRIBERS

XG-FAST

10s OF METERS

1 SUBSCRIBER

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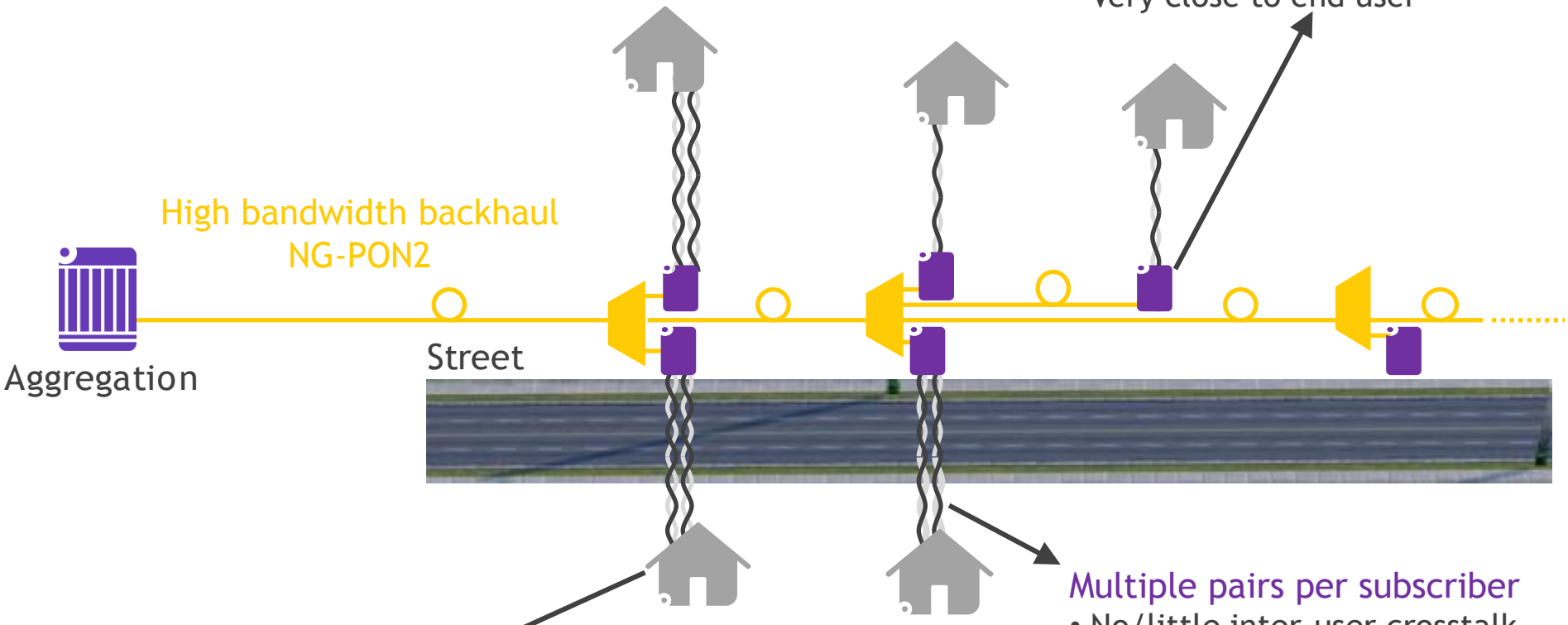
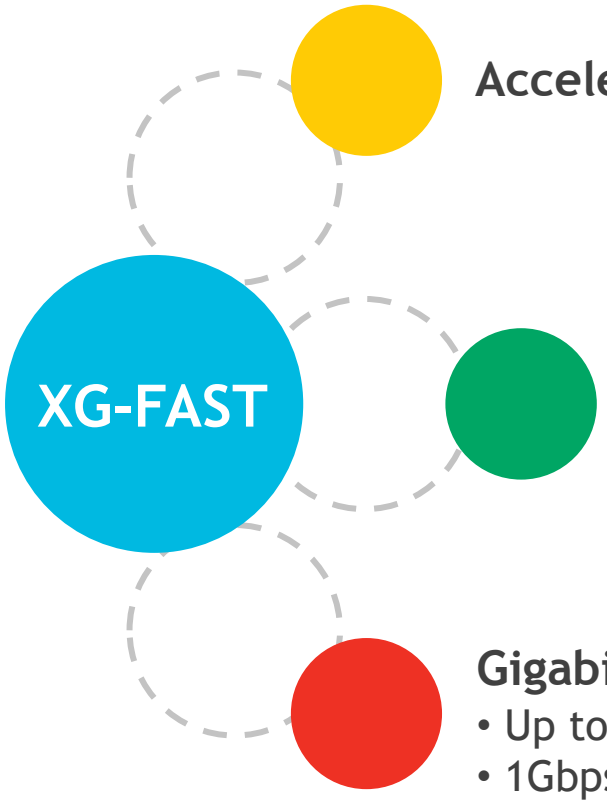
A homes passed fiber network
A homes connected copper network



XG-FAST does not replace FTTH, but is to be considered an integral component of FTTH deployments



Accelerates the roll-out of FTTH services

Complementary to FTTH

Avoids the logistic nightmare of installing fiber on each customer premise

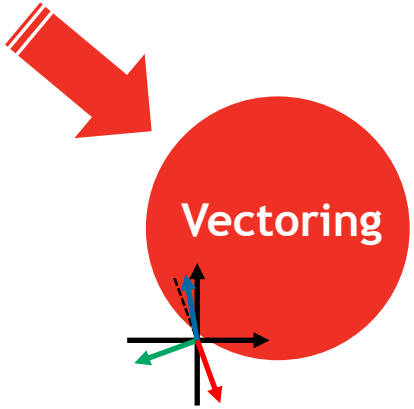
Gigabits for all

- Up to 10 Gbps on shortest loops
- 1Gbps symmetric for all

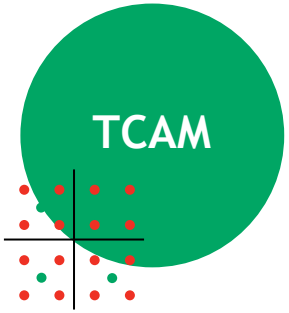
XG-FAST physical layer concepts

Bonding

- 2 twisted pairs
- **High crosstalk at high frequencies**



- Crosstalk contains detectable signal energy
- We **use crosstalk to increase the capacity** (constructive interference)
- Two sided coordination



- Transmitter Controlled Adaptive Modulation
- Automatic adaptation to varying channel conditions
- **Allows operation at 0 dB SNR Margin**
- **Increases spectral efficiency**

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Transmitter Controlled Adaptive Modulation (TCAM) enables fast and autonomous rate adaptation

- Each DTU is assigned to one hierarchic layer
- RX acknowledges successful DTU receptions
- TX notices when some layers are not received
- TX autonomously shuts these layers down and retransmits the DTU in a more robust layer

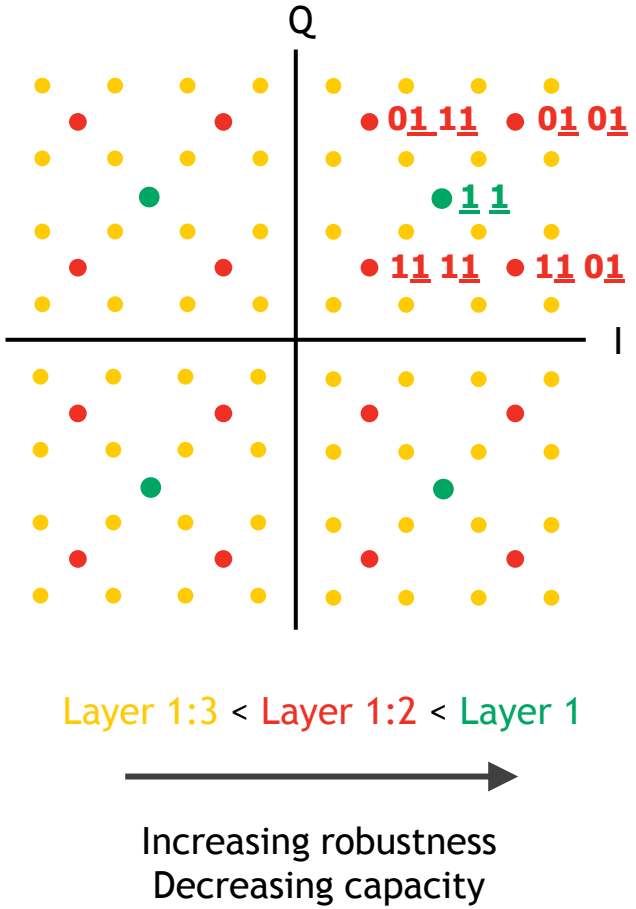
Fast and autonomous rate adaptation

↓

Lower SNR margins

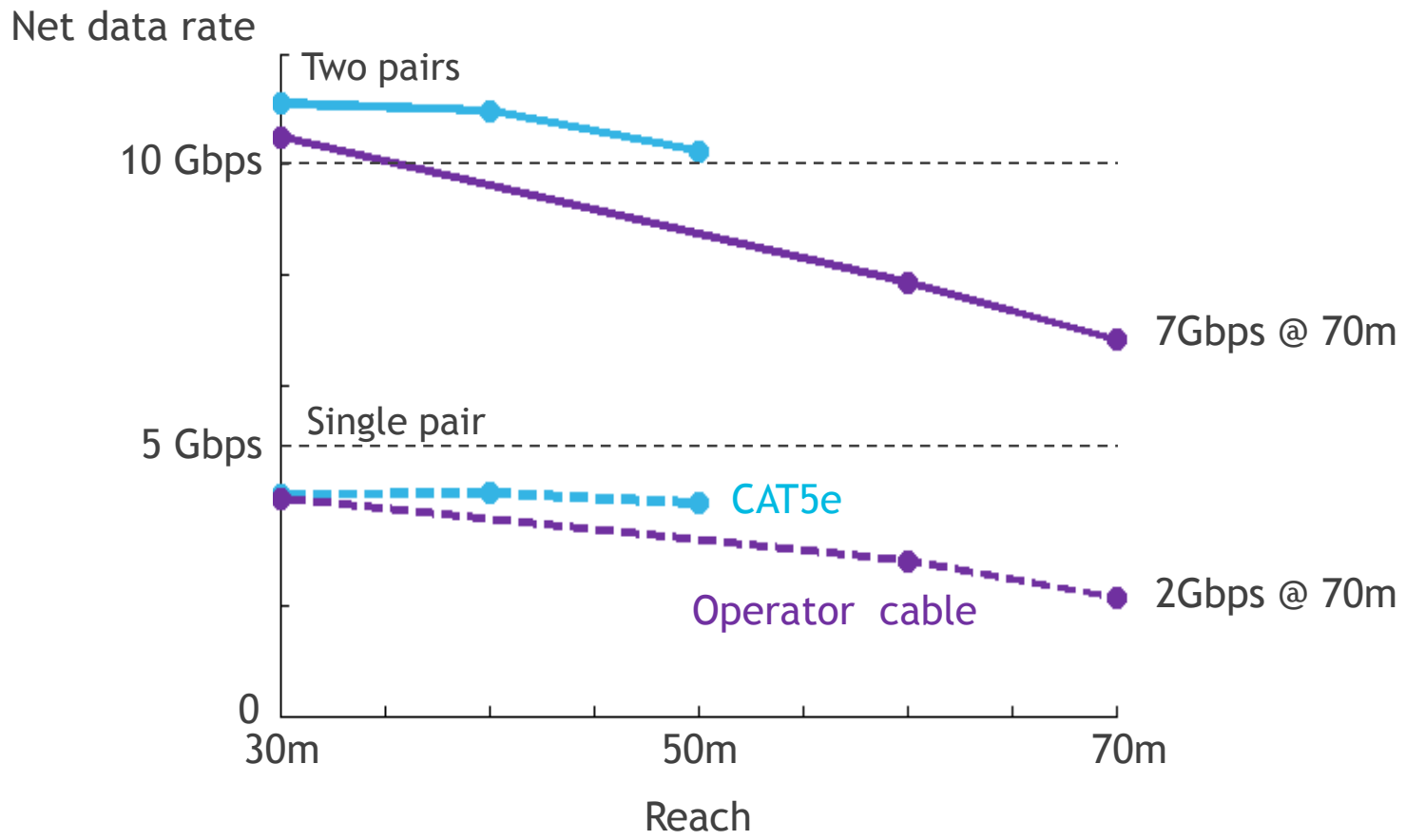
↓

Higher throughput



Timmers *et al.*, Bell Labs Tech. J. 18(1), pp. 153–169, 2013

Proof-of-concept measurement results



W. Coomans *et al.*, IEEE Globecom 2014

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