VDSL2 VECTORING PERFORMANCE AND DEPLOYMENT ASPECTS

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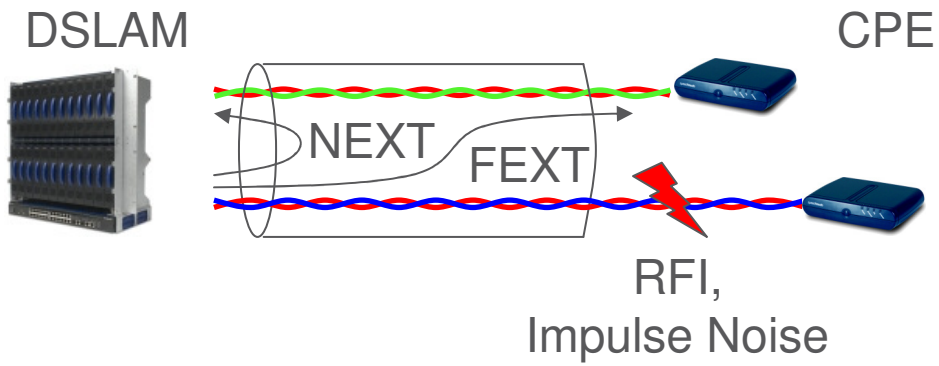
OUTLINE

- VDSL2 Performance
- FEXT cancellation - Vectoring
- VDSL2 with vectoring
- Deployment Aspects
  - How many lines need to be cancelled?
  - Cancelling the “dominant disturbers” may not be enough
- Conclusions

VDSL2 PERFORMANCE

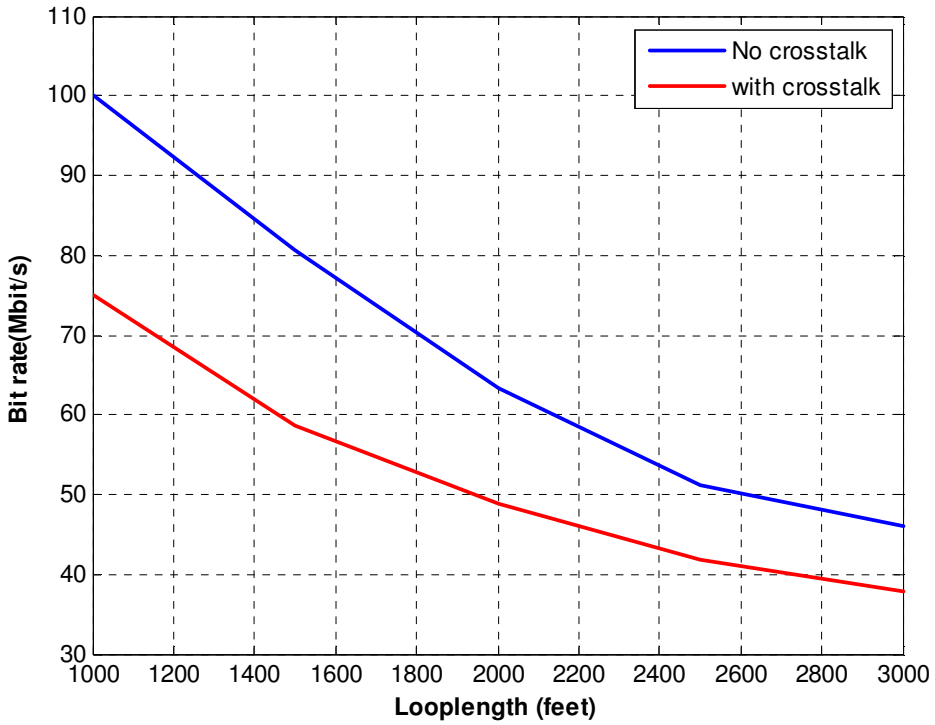
VDSL2 performance is determined by the cable attenuation and the noise in the cable



- There are two types of crosstalk:
  NEXT (Near-End X-talk) and FEXT (Far-End X-talk)
- In an environment where several VDSL2 systems are in the same cable binder it is FEXT that severely limits the performance.

VDSL2 PERFORMANCE

Measured downstream bit rate
on a 26 AWG (0.4mm) cable



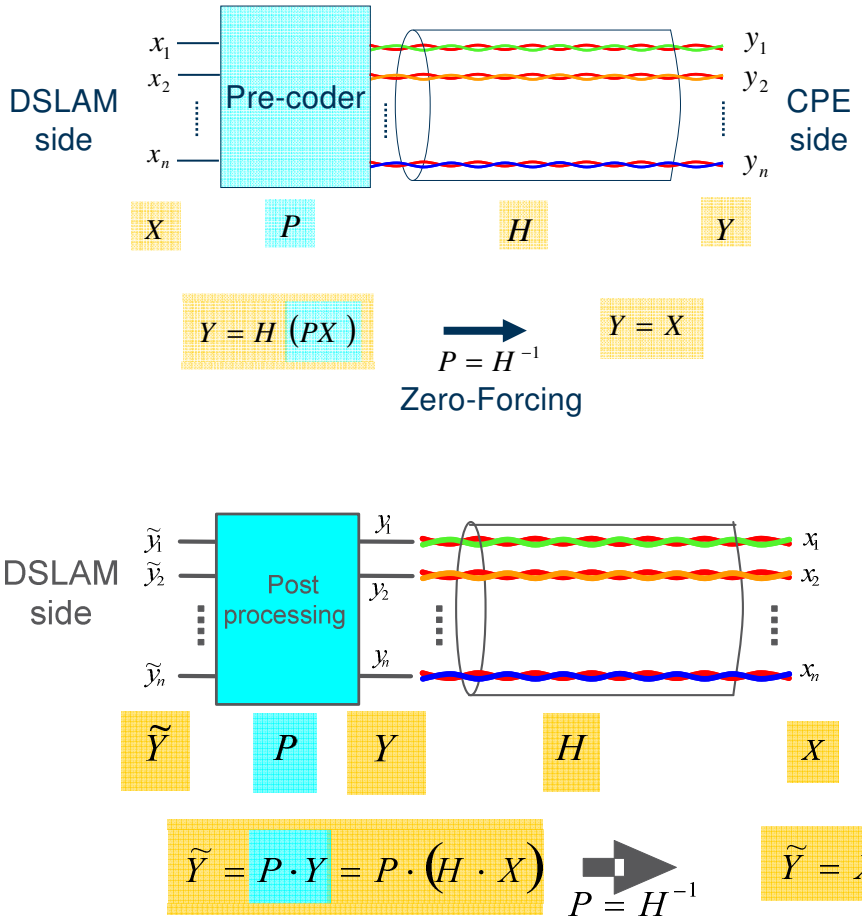
Crosstalk from 23 VDSL2 systems. 17a profile, Annex A EU-32

Single user performance: without crosstalk

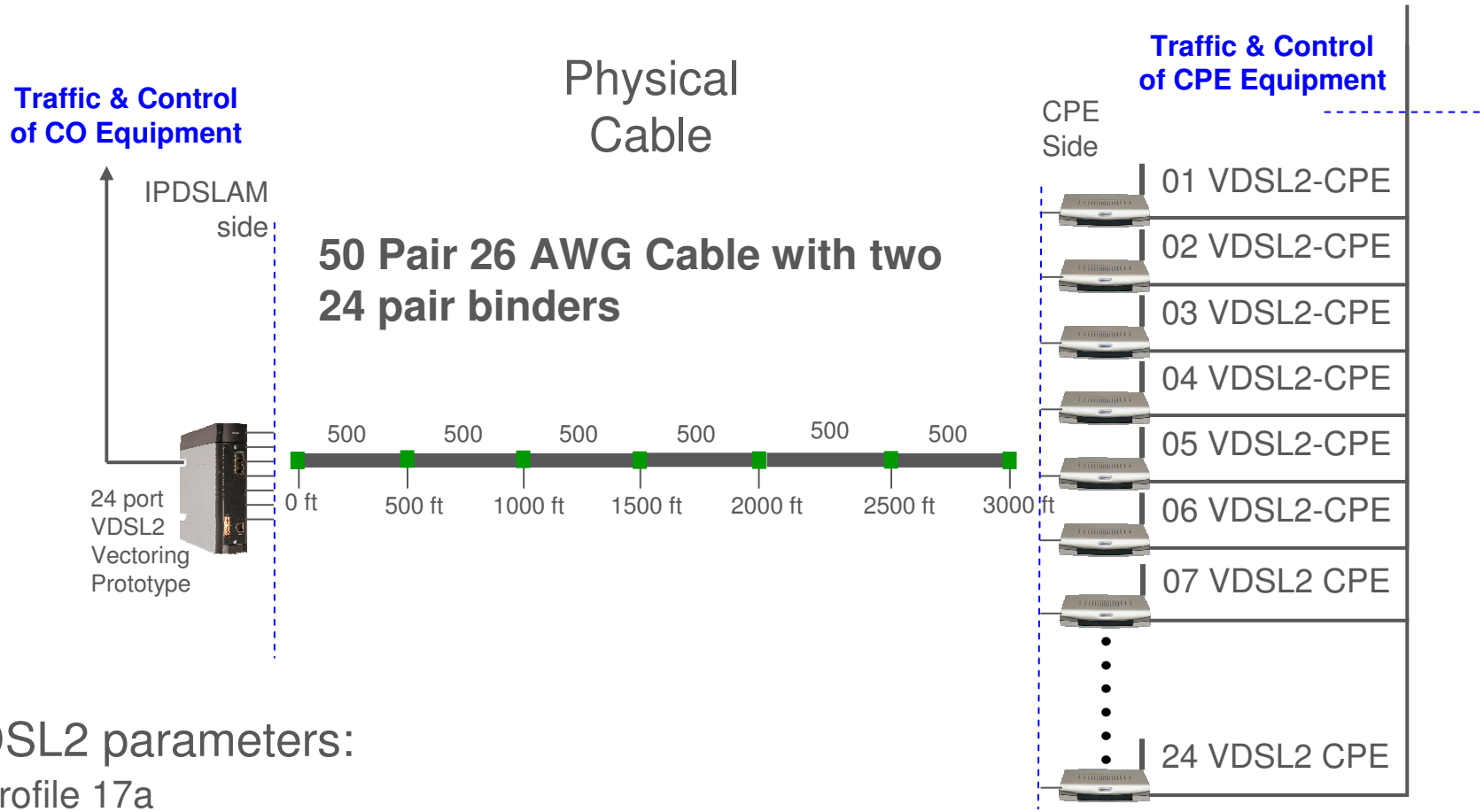
Goal with vectoring: get as close as possible to the single user performance by self FEXT cancellation

VECTORING PRINCIPLE

- Vectoring is a technique for FEXT cancellation
- The channel matrix (*H*) describes the cross talk couplings between the individual pairs in the cable
- Precoder for downstream cancellation
- Postprocessing for upstream cancellation



TEST SETUP – VDSL2 VECTORING



VDSL2 parameters:

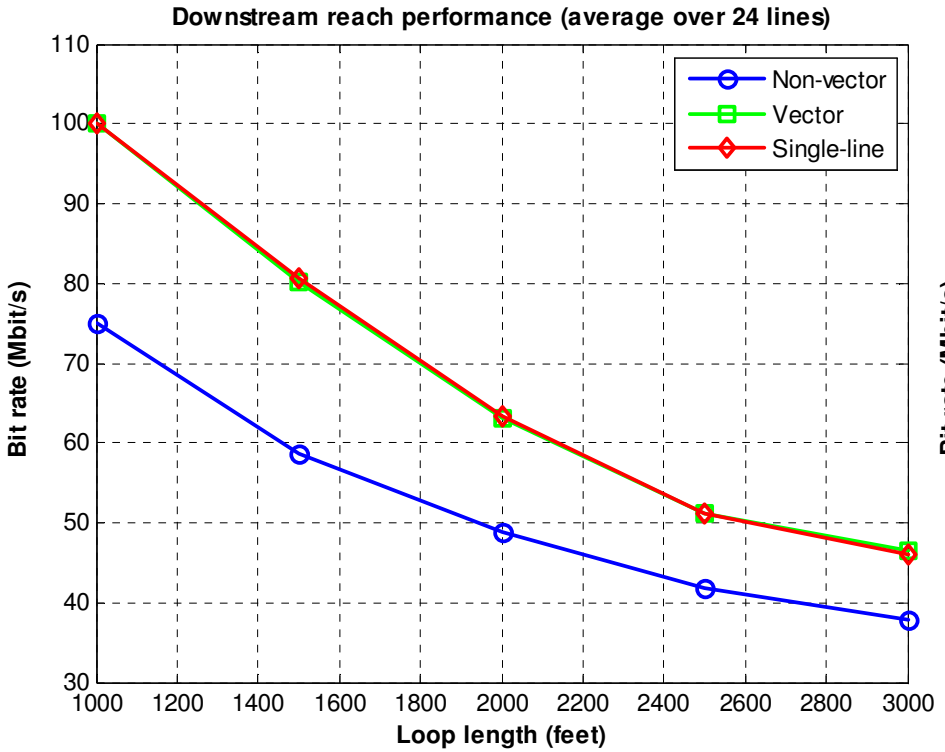
- Profile 17a
- Annex A-EU-32
- INP=0
- Fast mode

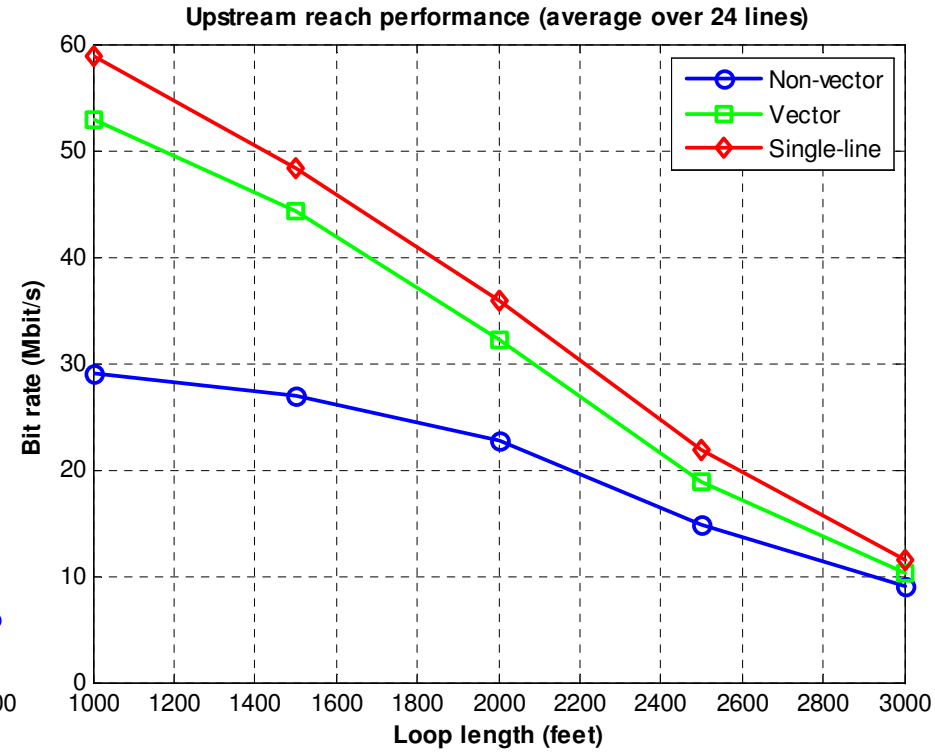
Vectoring enabled VDSL2 CPEs

PERFORMANCE OF VDSL2 WITH VECTORING

Our measurements show that with vectoring it is possible to achieve very close to the single user performance

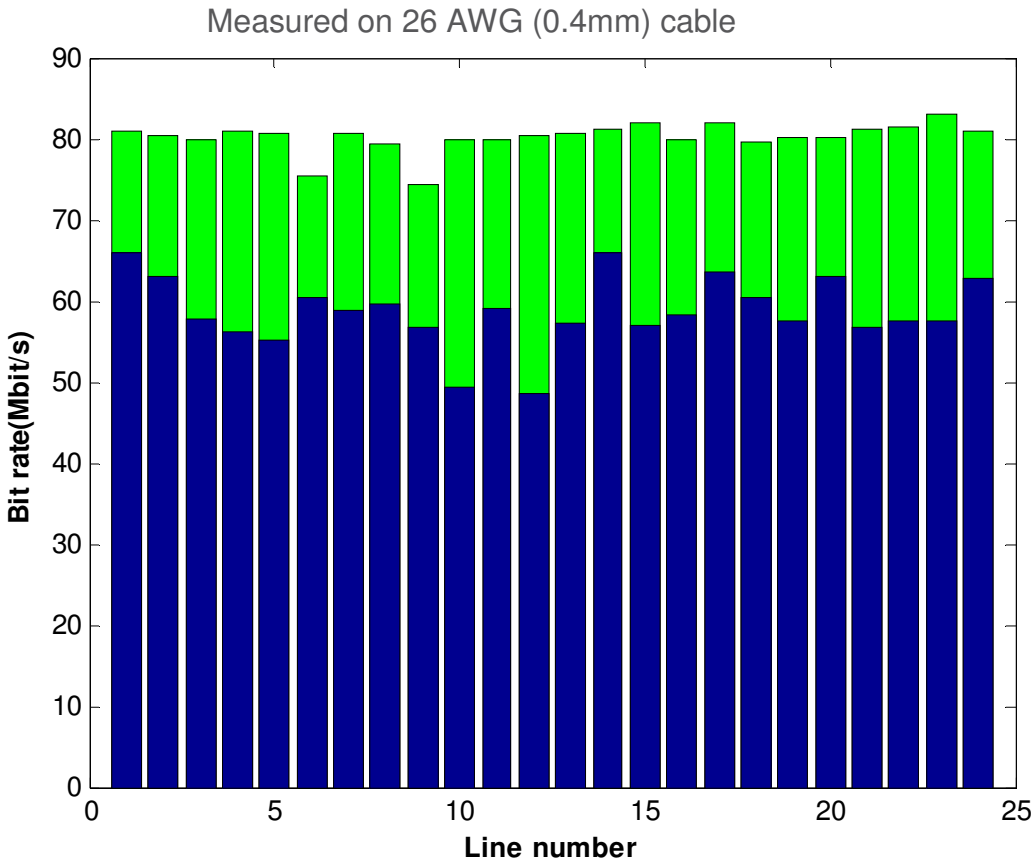
Measured on 26 AWG (0.4mm) cable





VECTORING REDUCES RATE VARIATION

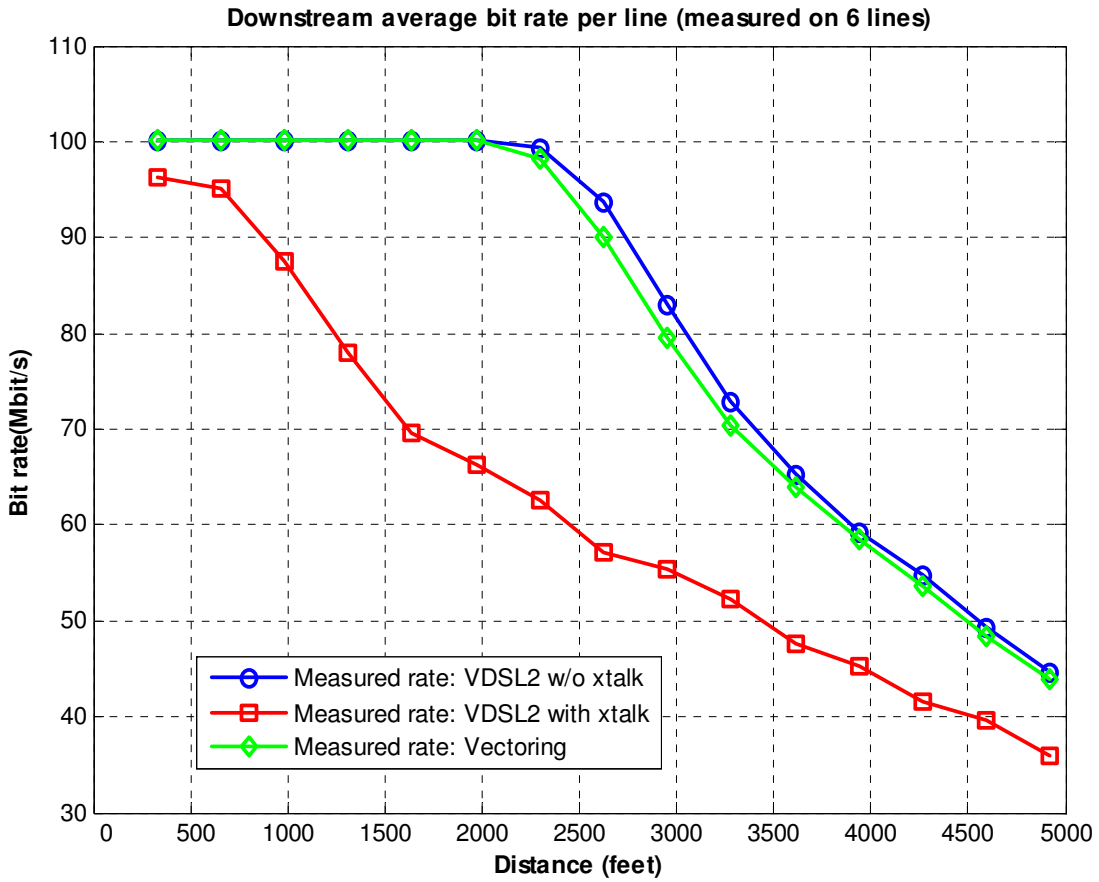
Measured downstream rate at 1500 feet



- The green bars shows the rate with vectoring and the blue bars with crosstalk
- Crosstalk variation gives a spread in rate between the lines
- Vectoring eliminates crosstalk and reduces the rate differences between the lines assuming the CPEs are on equal length

PERFORMANCE OF VDSL2 WITH VECTORING

Measured result with 0.5 mm cable which is more common from the cabinet than 0.4 mm



DEPLOYMENT ASPECTS - SOME QUESTIONS

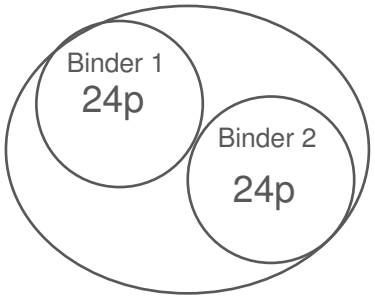
- How many lines need to be cancelled?
- Is it enough to cancel only the “dominant disturbers” in a binder?
  - Often there are 5-6 dominant crosstalkers limiting VDSL2 performance
  - The number of lines that are not cancelled contribute to remaining crosstalk
  - The sum of many weak crosstalkers could become considerable
- Impact of lines in adjacent binders (inter-binder crosstalk)
  - Typical *assumption* in standards is 8-10dB less coupling from adjacent binder
  - However, effects from pairs close to each other may result in stronger coupling
    - We have seen that at least a few pairs tend to always have a stronger coupling

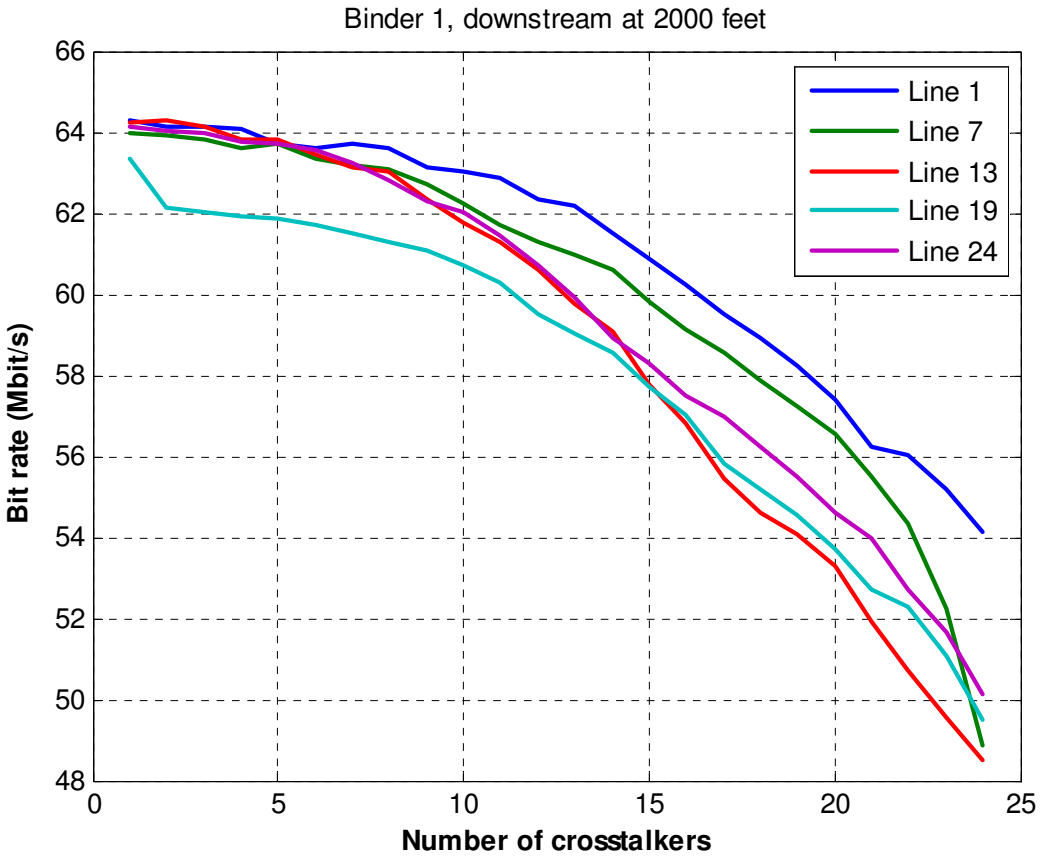
HOW MANY LINES NEED TO BE CANCELLED WITHIN A BINDER?

Measured downstream rate as a function of the number of cancelled crosstalkers

Adding crosstalkers one by one, starting with the weakest first

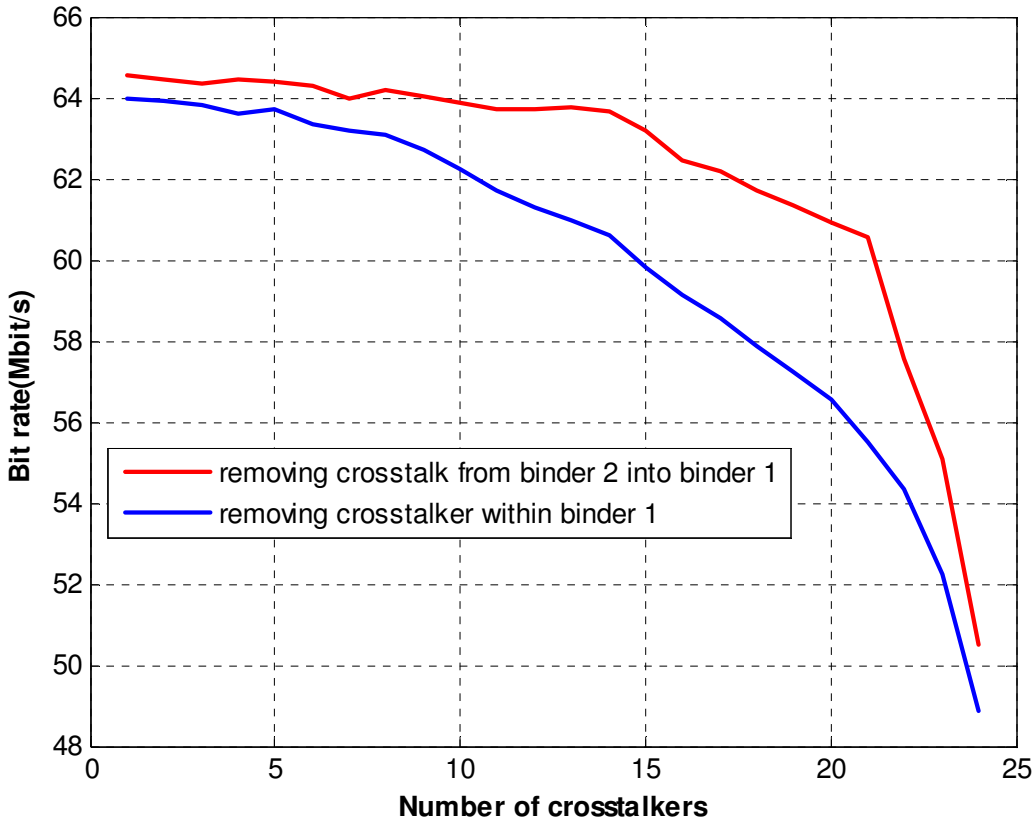
50 pair 26 AWG cable, 24 pairs used





IMPACT FROM ADJACENT BINDER

Measured downstream rate as a function of the number of cancelled crosstalkers

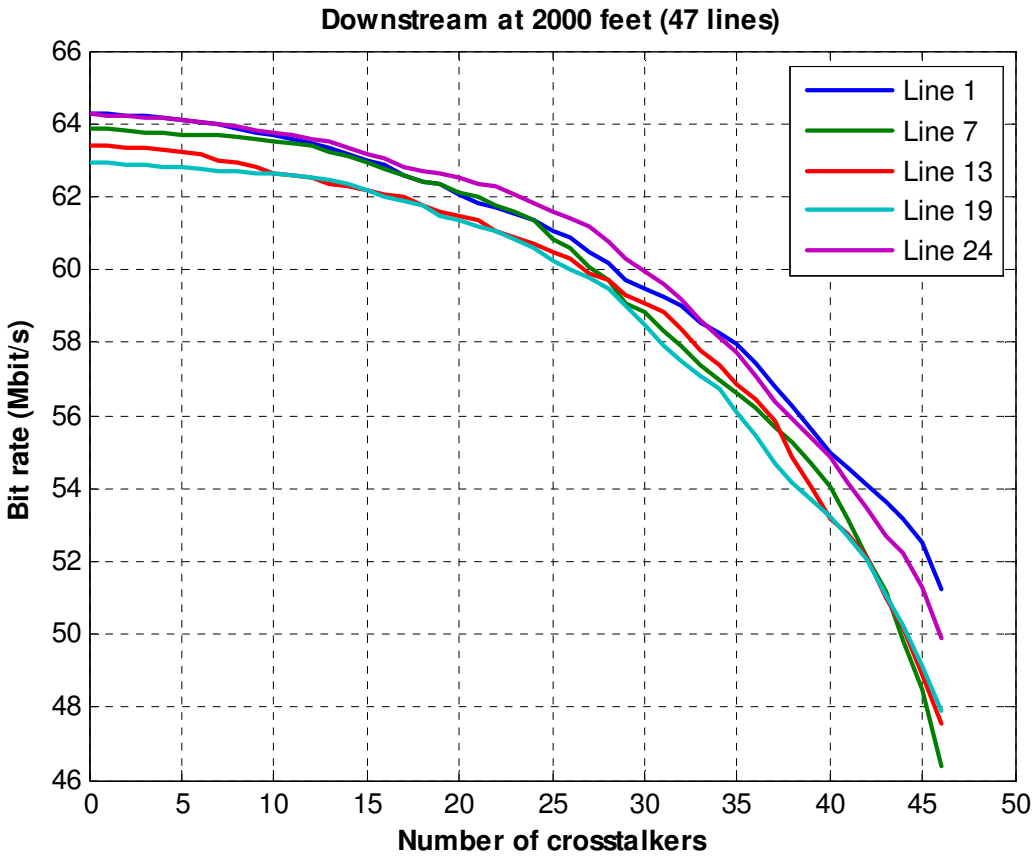


Red curve:
inter-binder crosstalker
(No crosstalk from binder 1 , maximum crosstalk from binder 2)

Blue curve:
intra-binder crosstalker
(crosstalker are all located in binder 1)

MULTIBINDER EXAMPLE

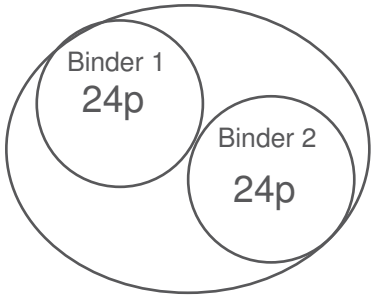
Measured downstream rate as a function of the number of cancelled crosstalkers



Binder 1: One measured line and 23 crosstalkers

Binder 2: 23 crosstalkers

50 pair 26 AWG cable,
48 pairs used



DEPLOYMENT ASPECTS – SOME ANSWERS

- Is it enough to cancel only the “dominant disturbers” in a binder?
  - No, to get the best performance it requires that most of the disturbers in the same binder are cancelled
- Impact of lines in adjacent binders
  - Measurements indicate that crosstalk from adjacent binders has to be considered
    - There are a few strong crosstalkers from the adjacent binders that could compromise the vectoring performance
    - This means that also a few lines from adjacent binders should be cancelled
- How many lines need to be cancelled?
  - Optimal performance is achieved by cancelling all crosstalkers
  - However, cancelling strongest crosstalkers is sufficient to achieve close to optimal performance
    - The strongest crosstalkers include most of crosstalker from the same binder and a few from the adjacent binder

CONCLUSIONS

- Vectoring achieves close to single user performance
- Vectoring eliminates the differences in rate between users, which is caused by the difference in crosstalk coupling
- Cancelling the strongest crosstalkers is sufficient to achieve close to optimal performance
  - The strongest crosstalkers include most of crosstalker in the same binder and a few from the adjacent binder

AREAS FOR FURTHER STUDY

- Multi-binder vectoring solutions: From theory to practice analyze different deployment scenarios and investigate possible solutions
- High frequency vectoring: Extend vectoring to frequencies >> 30 MHz for to short loops e.g. Last distribution point to subscribers (~ 100m)
- Vectoring with bonding: Enabling very high data rate aggregation >>100 Mbit/s, even for longer loops
  - E.g. copper backhauling for LTE and business applications

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