Benefits and regulatory challenges of VDSL Vectoring (and VULA)

FSR Communications Media 2014 Scientific Seminar „Economics and Policy of Communications and Media, Policy Challenges in Digital Markets“,

Florence School of Regulation, 28. - 29.03.2014

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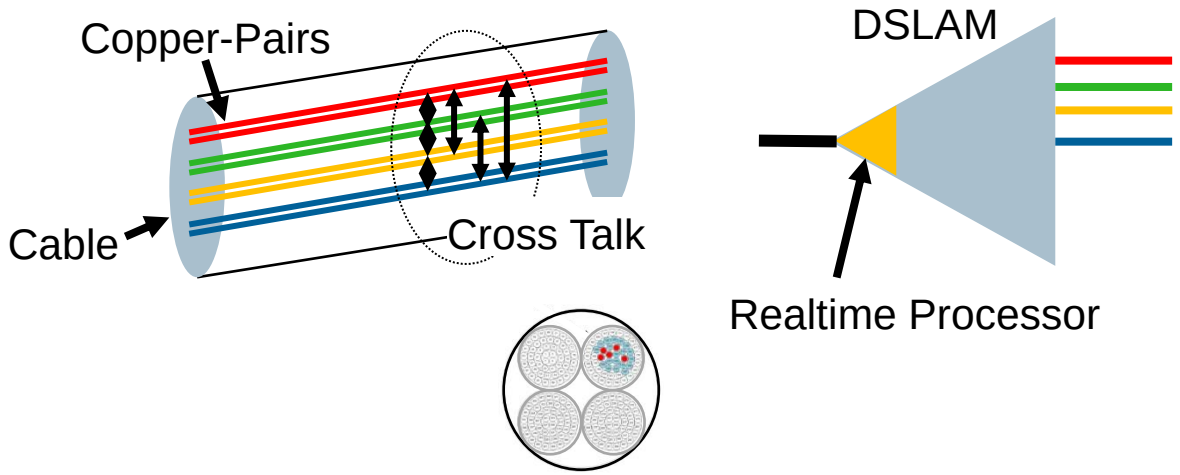
Content

- Vectoring advantages in transmission behavior
- Investment and financial advantages of Vectoring
- Vectoring disadvantages
- Regulatory challenges of Vectoring (and VULA)

Vectoring strongly reduces cross talk interference from neighboring copper pairs of a bundle

Assumption: Signals of the neighboring copper pairs are well known.
The cross talk effect of each of the neighboring pairs can be well estimated.

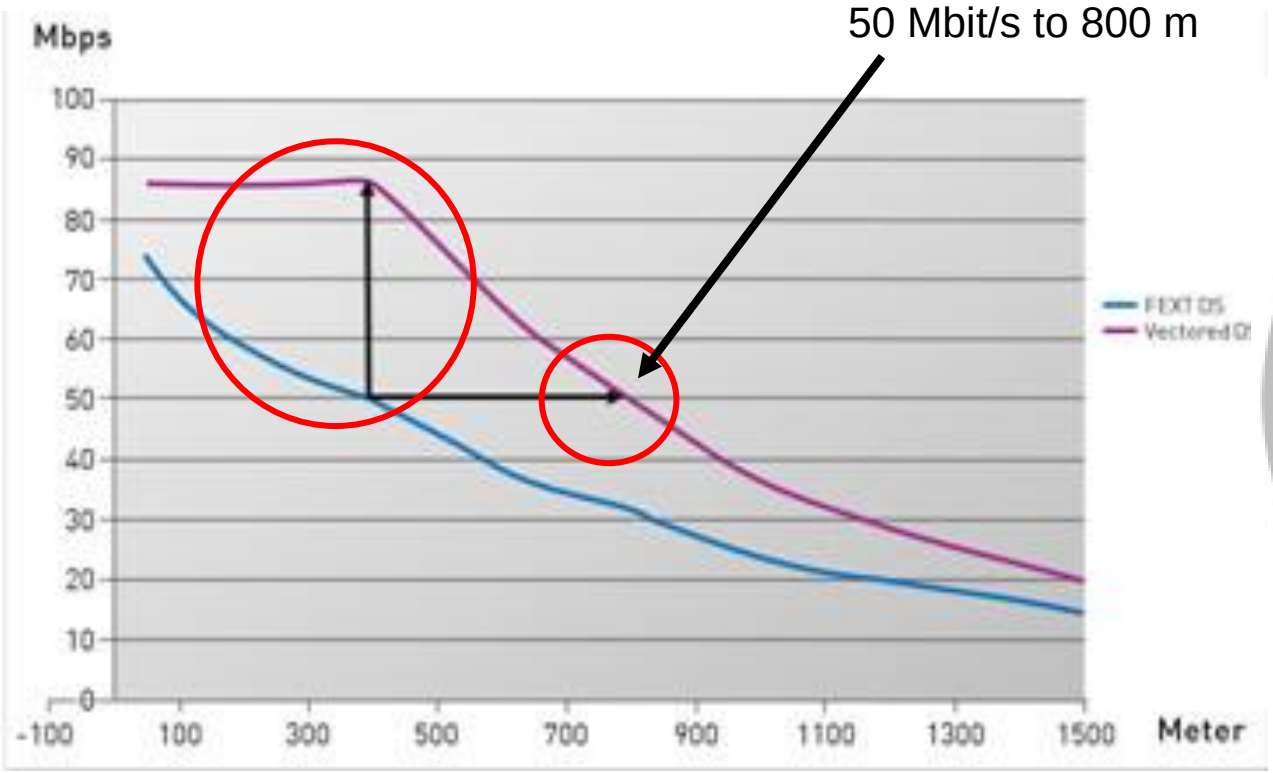
A fast real time process computer allows to subtract the cross talk signals of the neighboring copper pairs from the original signals of a copper pair (computing complexity is growing exceptionally with the number of pairs).

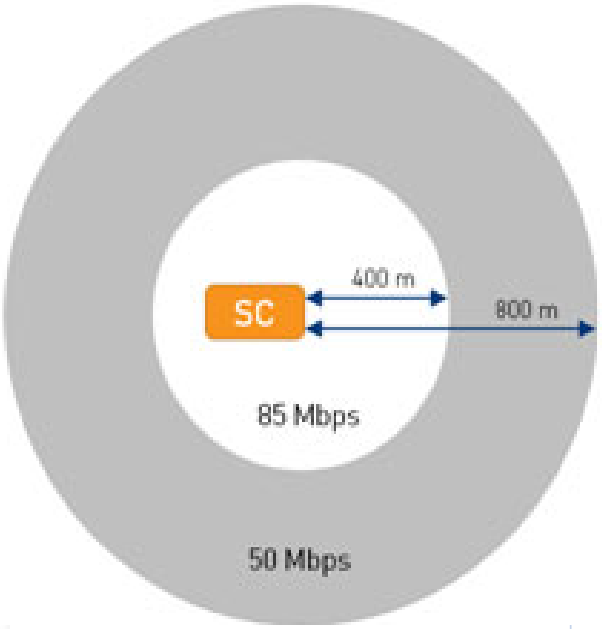


Source lower graphic: Frank van der Putten, Alcatel Lucent, answer to BIPT 18.02.2011, WIK

VDSL Vectoring increases distance and coverage

Larger distance with increased bandwidth



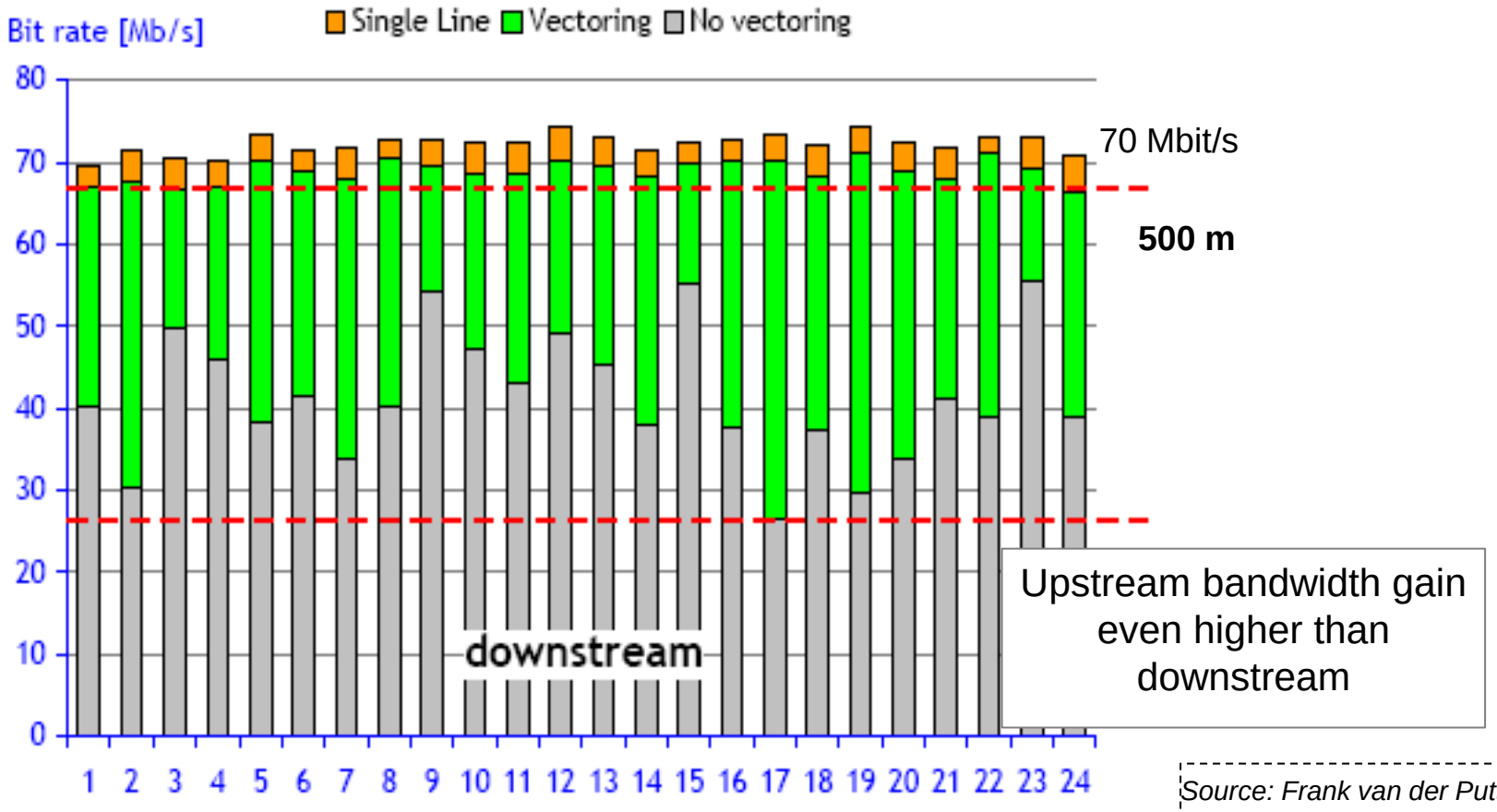


Area increase up to 300%

Source of Figures: Ariel Caner, ECI Telecom, telecomengine.com 1.5.2012

VDSL Vectoring increases bandwidth of all copper pairs towards a comparable high level

- The cable serves all customers in a comparable manner and can be fully loaded with high bandwidth customers.



Results for single pairs, Nos. 1 - 24

Source: Frank van der Putten, Alcatel Lucent, answer to BIPT 18.02.2011

VDSL Vectoring, summary technical characteristics

VDSL Vectoring increases the bandwidth per end customer and thus the minimum bandwidth and decreases the asymmetry between Up- and Downstream
It allows to meet the DAE targets (30 Mbit/s)

VDSL Vectoring allows to exploit the access cables by up to 100% with high bandwidth Transmission

VDSL Vectoring enables comparable bandwidth for all customers of comparable distance from street cabinet

VDSL Vectoring increases the reach per access line, e.g. for 50 Mbit/s
Resulting in over proportional increase of end customer coverage (πr^2)

(VDSL-Signals*, not being included in Vectoring, significantly reduce advantages)

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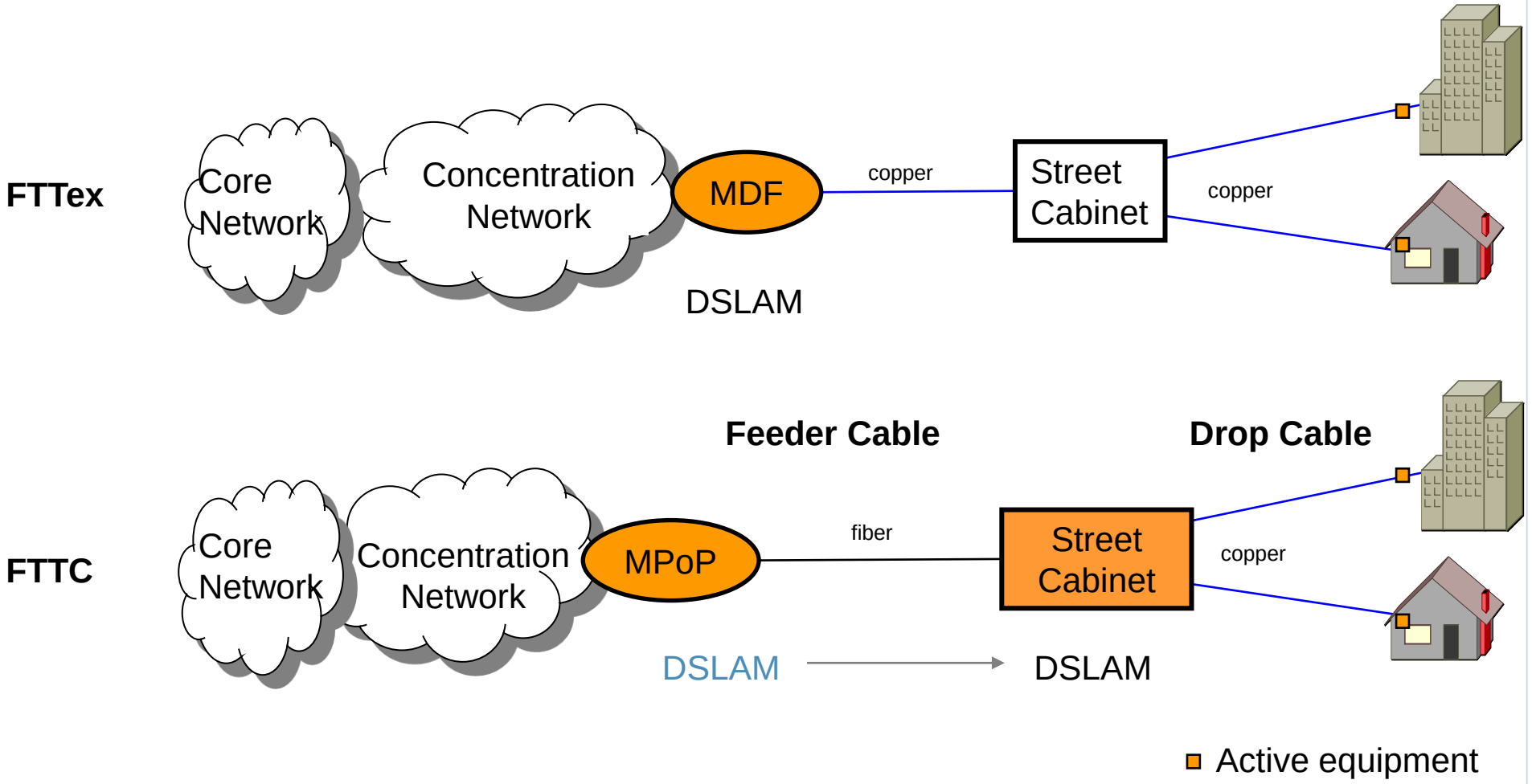
Operators extend fiber towards the customer to overcome bandwidth limits of the copper loop – FTTC/VDSL shifts the DSLAM to the street cabinet



MDF – Main Distribution Frame
SC - Street Cabinet
DSLAM - Digital Subscriber Line Access Multiplexer

MPoP – Metropolitan Point of Presence
DP – Distribution Point

VDSL Vectoring requires significantly less investment

No investment in feeder network segment required

17 Bio. € invest in total (Germany)

Cluster	FTTH/P2P	FTTC Vectoring	Delta in %
1	1,440 €	320 €	78%
2	1,650 €	350 €	79%
3	1,740 €	370 €	79%
4	1,780 €	370 €	79%
5	1,840 €	370 €	80%
6	1,940 €	380 €	80%
7	2,010 €	410 €	80%
8	2,180 €	420 €	81%
9	2,230 €	440 €	80%
10	2,410 €	480 €	80%
11	2,440 €	500 €	80%
12	2,480 €	520 €	79%
13	2,560 €	560 €	78%
14	2,640 €	600 €	77%
15	2,650 €	590 €	78%
16	2,710 €	640 €	76%
17	2,670 €	680 €	75%
18	3,030 €	830 €	73%
19	3,410 €	1,020 €	70%
20	4,310 €	1,390 €	68%
Total Av	2,410 €	560 €	77%

- Germanies MDF areas clustered in 20 groups of comparable population density
- All clusters have comparable size (~ 2.1 Mio HH and Businesses)
- Ordered according to declining density

- FTTC investment reduction by ~ 75% compared to FTTH
- Copper infrastructure in feeder segment is reused
- For business case: SLU rental to be considered

100% homes passed, 70% penetration

VDSL Vectoring offers some economic benefits for the operators

- Significantly lower upfront investment, better capital market position
- Shorter time to market due to significant less civil engineereing compared to FTTB/ H
- Better cash flow position
- Sooner competition with CA-TV network operators
- Significantly better profitabiliy during ramp up due to SLU rental on demand

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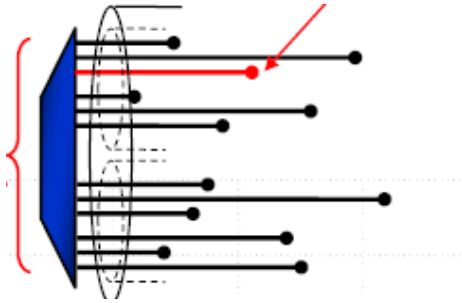
Vectoring requires access to all pairs of a bundle, CPE have to be capable (except Zero Touch) „Aliens“ strongly destroy results

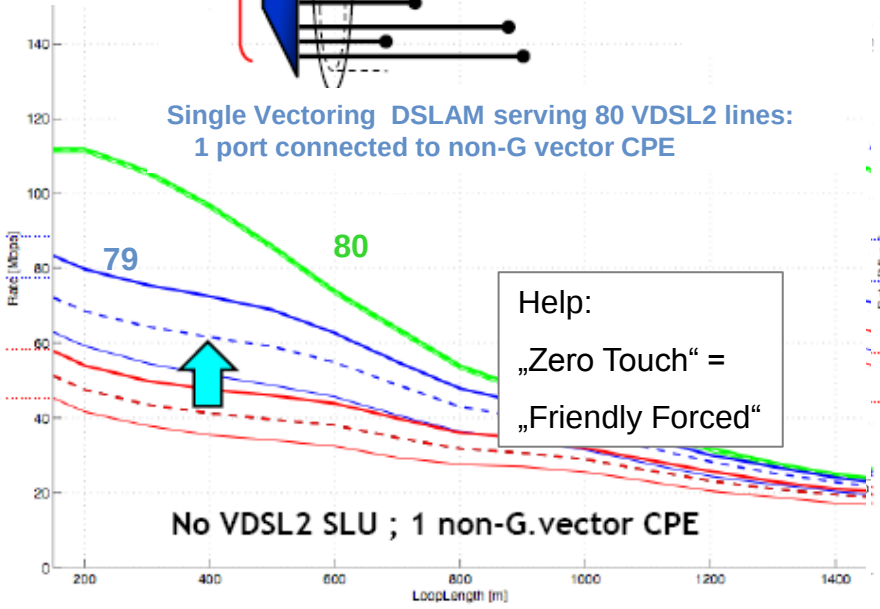
One not Vectored Disturber

Two independent DSLAMS

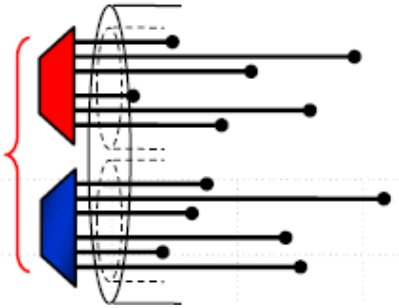
Full Vectoring coordination except for 1 line

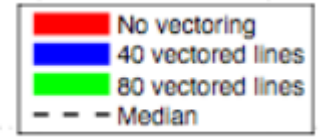


Single Vectoring DSLAM serving 80 VDSL2 lines:
1 port connected to non-G vector CPE

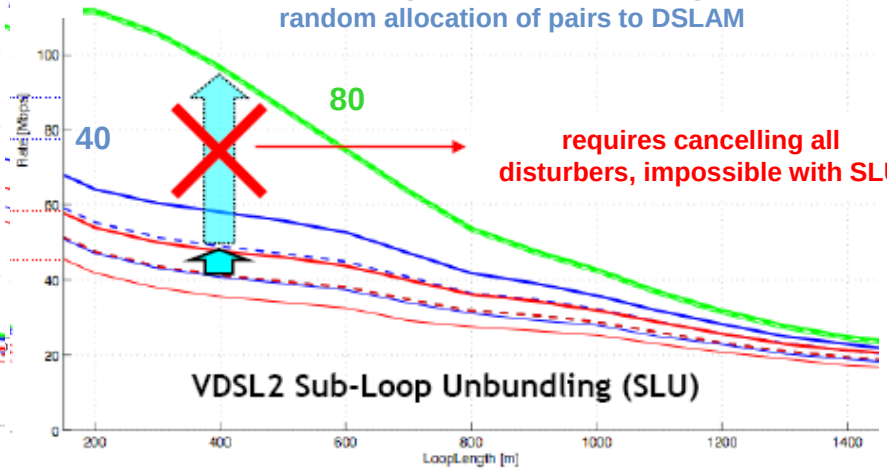


No Vectoring coordination between DSLAMS





LLU/ SLU with 2 Vectoring DSLAMs each serving 40 VDSL2 lines:
random allocation of pairs to DSLAM



Source of Figures: Frank van der Putten, Alcatel Lucent, answer to BIPT 18.02.2011

Vectoring cannot meet all future requirements

- Even with crosstalk correction VDSL Vectoring bandwidth is line length dependand, e.g. 30 Mbit/s expected not beyond 1,200 m
- VDSL Vectoring is limited up to appr. 100 Mbit/s over short distances (future G.Fast up to 1 Gbit/s asymmetrical)
- Vectoring requires G.Vector enabled CPE, zero touch = Friendly Forced may circumvene single non-vector CPEs
- Vectoring requires access to all copper pairs of a bundle and restricts SLU to one operator, regulatory intervention required, remonopolization of subloop access infrastructure, no unbundling = step back in the ladder of investment towards bitstream

- Vectoring as interim technology on the path towards full fibre networks, bridging towards higher bandwidth use and first and fast customer satisfaction

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Regulation can prevent VDSL-Vectoring conflicts at a location

3 Options

1. Incumbent Monopoly

   SLU unbundling obligation withdrawn

   Incumbent gets subloop monopoly,

   No driver for Innovation und Investment in new infrastructure*

2. First Mover Monopoly

   SLU unbundling obligation modified

   First Mover in SC gets exclusive for VDSL roll out, if with Vectoring

   Several regional Monopolies

Germany

* BIPT obligation therefore:
  Vectoring roll out within 3 years

Regulation can Prevent VDSL-Vectoring conflicts at a location

3a. Open for Competition

SLU unbundling obligation in force

First Mover Advantage

De Facto Monopoly[1)] of First VDSL Mover

1) Second Mover can destroy Vectoring advantages of the First Movers and his end customers (Investment security?)

3b. Open for Competition (limited)

As above, but obligations for a Second Mover

Second Mover only allowed to install VDSL, if NLV available and agreed upon

First Mover determines supplier[2)] and operates Vectoring processor, is obliged to offer NLV

2) Increased complexity for operators: Network operations, system maintenance, Service-Provisioning of an operator over systems of different suppliers and different release levels

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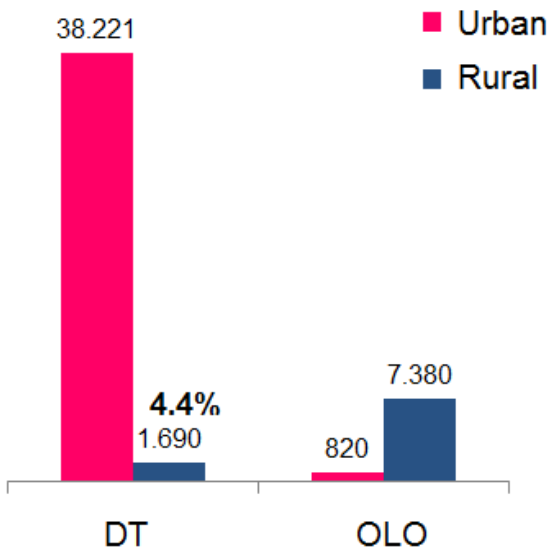
Germany: Fair/ unfair regulation may encourage or discourage future investment of alternative operators

- First Mover has exclusive rights for SLU at street cabinet (SC)
- Priority accessing a SC is organized by Vectoring List of the incumbent, so far debates about operating the list in a fair manner
- Incumbent may replace existing alternative operator at street cabinet, if he deploys more cabinets than the AltNet in the related local access area and if a second broadband infrastructure (e.g. CA-TV, FTTB/ H) exists at the SC passing more than 75% of homes
- In areas of VDSL Vectoring a L2 bitstream with handover close to the MDF has to be offered
- In case of replacement at SC a L2 bitstream with handover at or close to the SC has to be offered
- Bitstream interim solution up to 2015, IP-bitstream with handover at up to 73 central sites

Germany: announced roll out scenarios

- TDG intends 6 Bil. € investment in FTTC/Vectoring
- Roll out target: 25 Mio. households ≙ 65% coverage of population
- Preferred regions of TDG: today‘s VDSL-areas and CA-TV areas
- Preferred regions of AltNets: outside TDG areas



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Germany: Future Investment of AltNets depend on investment motivating regulation

		Year 2014 – 2018 [in Bio. €]
▪ Scenario I:	AltNets keep on track („Status quo Scenario“)	**3.25**
▪ Scenario II:	AltNets reduce investment due to negative regulatory investment incentives („Pessimistic Scenario“)	**1.02**
▪ Scenario III:	Altnets intensify investment due to positive regulatory and investment friendly impulses (“Dynamic Investment Path“)	**5.21**

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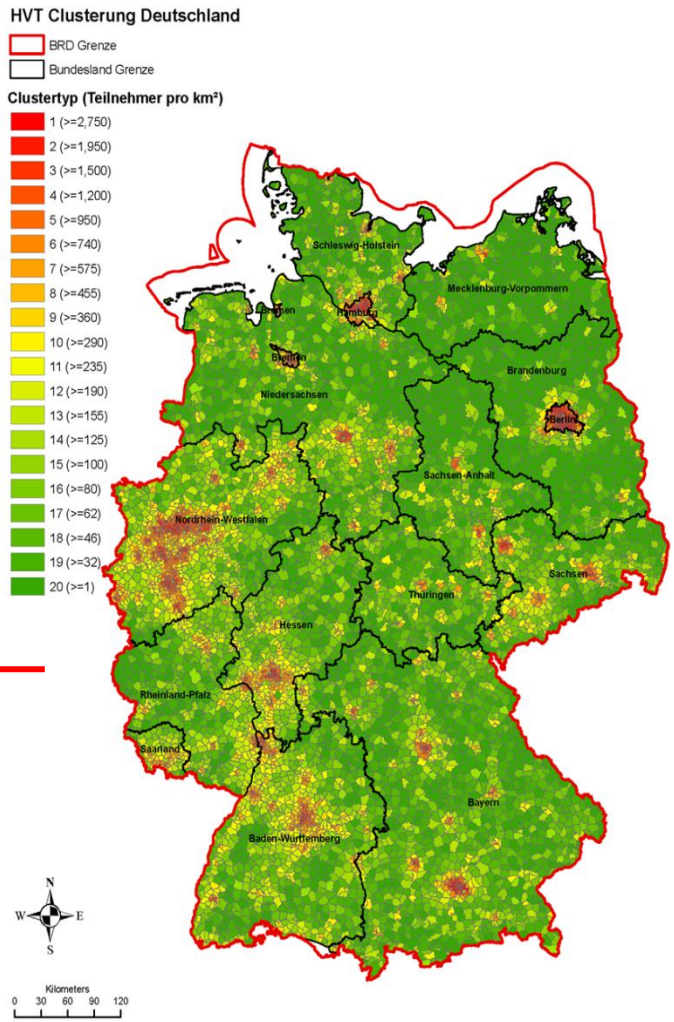
Germany: TDG will cover clusters 1 – 13
AltNets invest in clusters 14 - 19

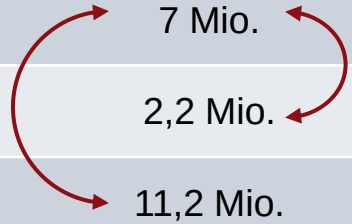
	Cluster	Potentielle Teilnehmer in Mio.	Investitionen in Mrd. €
TDG	1	2,2	0,43
	2	2,2	0,48
	3	2,1	0,49
	4	2,1	0,49
	5	2,2	0,50
	6	2,2	0,51
	7	2,2	0,56
	8	2,2	0,59
	9	2,1	0,59
	10	2,1	0,63
	11	2,1	0,69
	12	2,1	0,70
AltNets	13	2,3	0,82
	14	2,0	0,79
	15	2,3	0,90
	16	2,1	0,87
	17	2,2	0,98
	18	2,3	1,27
	19	2,2	1,48
	20	2,1	2,02
	Gesamt	43,2	15,78



100% homes passed, 40% penetration

Germany: AltNet coverage = additional citizens served

	Investment budget for FTTC/Vectoring	Achievable coverage in Clusters 13-19	Homes passed
Scenario I	3,25 Bio. €	46%	7 Mio.
Scenario II	1,02 Bio. €	14%	2,2 Mio.
Scenario III	5,21 Bio. €	73%	11,2 Mio.



- Area-wide FTTC/Vectoring coverage in clusters 13 to 19 requires 7,1 Bio. € investment
- 15,3 Mio. potential customers (homes passed)
- Δ of scenarios describe potential impact of regulation

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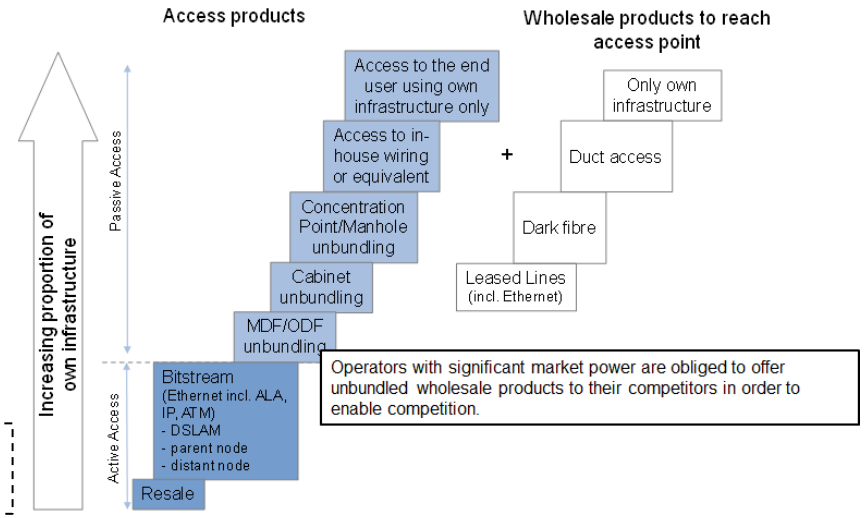
Framework for investment competition and a dynamic investment path

1. Clear commitment of politics and regulation to competitve market model also in case of NGA
2. Short term implementation of Vectoring regulation
3. Creation or symmetric start conditions for investment in NGA
4. Creation of efficient investment triggers by competition improving wholesale prices
5. Consequent prevention resp. combating of competition distorting behavior
6. Guaranty of positive investment triggers also in case of ex post access denial

Regulatory challenge

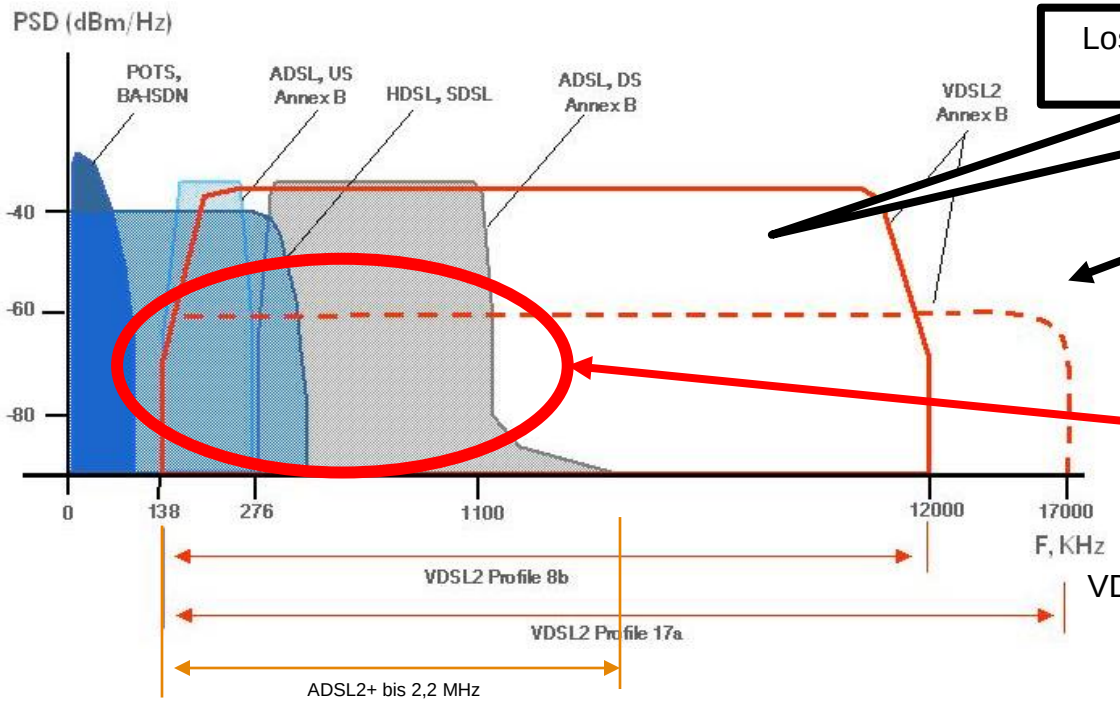
- Balance the (faster) increase in Broadband against the advantages of free competition based on physical infrastructure
- Outweight a bitstream access based against physical infrastructure based competition:
  - Either due to faster broadband roll out (Vectoring)
  - Or due to freedom to choose fibre topology (Point-to-Point vs. Point-to-Multipoint („GPON“))



Source: ERG 2009 Report on NGA – Economic Analysis and Regulatory Principles

Exclusivity on subloop use over all frequencies or over relevant frequency spectrum (> 2.2 MHz)?

- Cross talk only occurs overlapping frequency bands



Loss of Vectoring gain because of frequency overlap

typ. Used by VDSL2 Vectoring

VDSL2 overlap with ADSL up/ downstream

VDSL2 profile 30a up to 30 MHz

- POTS/ ISDN not affected in LLU or SLU
- DSL LLU/ SLU marginally affected only, due to lower VDSL signal levels, can be reduced further by VDSL power reduction in low frequencies (< 2,200 KHz)

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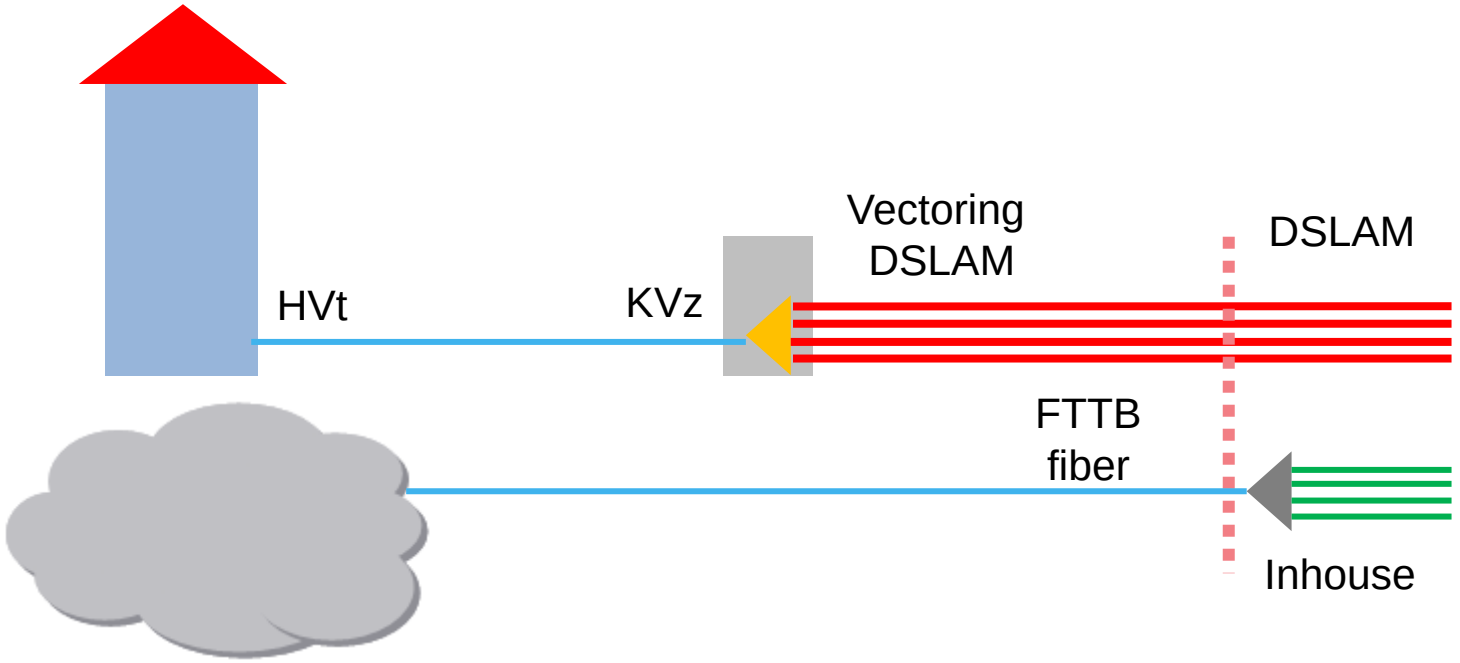
Source of grafic: A.H. Wulf, VDSL Access Options, WIK VDSL Conference March 2007

Coexistence of FTTC and FTTB?
Bonding: Competition for free copper pairs?

Vectoring: Inhouse regulation required, when FTTB VDSL-inhouse systems interfere with FTTC VDSL Vectoring systems?



Bonding: How will spare copper pairs be allocated in case of competition (Existing Bonding?, in case of Bonding with Vectoring one operator only?)

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Physical Unbundling may be replaced by a Virtual Unbundling Local Access (VULA)

- **If:**
  - Physical unbundling is ***not economically feasible***
  - Due to network ***technology*** (e.g. Vectoring)
  - Network ***topology*** (Point-to-Multipoint GPON (economic reason also))
- Many cases notified at EC: They admitted a VULA (bitstream) with features close to the physical unbundling:
  - "*should be made available at a location close to the end customer premises, similar to LLU,“*
  - "*should allow product differentiation and innovation similar to LLU and thus give access seekers a sufficient degree of control including the quality of service, over the local connection to the end-user"*
  - Source: EC to UK VULA decision, UK/2010/1065, EC C(2010)3615, 01.06.2010, p.7

Recent EC decisions: overview

Country	NRA	Year	Virtual unbundling obligation in case of …	Local bitstream obligation in the case of …	Consequences for the physical unbundling obligation
UK	Ofcom	2010	FTTC/B/H	-	Non imposition of (physical) unbundling in case of FTTH-GPON
AT	RTR	2010	FTTC/B	-	Release of SLU in case of overlapping coverage
BE	BIPT	2011	-	FTTC	Release of SLU in case of FTTC and VDSL Vectoring
IT	AGCOM	2011	FTTC/B/H	-	Non imposition of (physical) unbundling in case of FTTH-GPON
SK	TÚSR	2012	FTTH	-	Non imposition of (physical) unbundling in case of FTTH-GPON
DK	DBA	2012	FTTC/B	-	no
MA	MCA	2012	FTTC (during migration to FTTC only) FTTH (after ongoing Roll-out)	-	 Non imposition of (physical) unbundling in case of FTTH-GPON
IE	ComReg	2012	-	FTTC/B	Release of SLU in case of FTTC and VDSL Vectoring
AT	RTR	2013	FTTH/B/C; Copper network with Vectoring at MDF **Market 4 or 5?**	-	Non imposition of (physical) unbundling in case of FTTH-GPON Release of SLU in case of FTTC without (s. 2010) and with VDSL Vectoring Release of SLU in case of FTTC and VDSL Vectoring at MDF without LLU demand
DE	BNetzA	2013	-	FTTC	Release of SLU for frequencies above 2,2 MHz in case of FTTC and VDSL Vectoring

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Characteristics of VULA (bitstream) demanded by EC so far:

- Local
- Service agnostic
- Uncontended product
- Sufficient control of the access connection
- Control of customer premise equipment

Austria: Layer 2 VULA shall be close to SLU/ LLU characteristics

- Layer 2 product with Ethernet interface
- Handover at MDF location, offer for all access lines of the MDF, higher level handover as volunteer option
- Harmonized characteristics, covering all NGA variants (FTTx)
- Multicast enabling
- CPE is provided by wholesale seeker
- Contention rate is determined by wholesale seeker
- Last Mile status analysis enabled for wholesale seeker
- Traffic handover on behalf of third parties is admitted
- Detailed protocol specifications, i.a. for VLAN handling
- Process quality surveillance by KPI-Definition/ -Monitoring

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Withdrawing existing SLU/ LLU due to NGA roll out requires migration of competitors‘ end customers

Example Austria

- If migration is enforced at some cabinets within an MDF area, the complete MDF area may be migrated on demand of the competitor in order to prevent the operation of two parallel access infrastructures within one area.
- The cost of the migration is borne by the incumbent operator.
- The price of the access product remains unchanged if the access line speed is not upgraded.
- The competitor’s frustrated investment (bookvalue of the no longer usable access equipment) has to be refunded by the incumbent.
- The steps of the migration process have to be mutually agreed upon in lines and dates.
- LLU charge remains unchanged except the access line speed is upgraded
- KPI-Monitoring of the migration process

New EU-VULA (L2 bitstream) proposed by EC in draft Single Market/ Connected Continent regulation[1]

EU-wide harmonized

- Closer to the end customer premises than the national or regional level
- Flexible allocation of VLANs
- Service agnostic connectivity, control of download and upload speed
- Security enabling
- Flexible choice of customer premise equipment (CPE) (as long as technically possible)
- Remote access to the CPE
- Multicast functionality (where demanded)

Also: Features or business processes, ancillary services, IT-Systems.
In future more detailed characteristics expected

Substituting SLU/ LLU on equal level or subordinated compromise?

Regulation: immediately binding national law

[1] EC proposal for a Regulation "Single Market/ Connected Continent", COM(2013) 627 final, 11.09.2013

EC proposal includes risks and challenges

- Challenges:
  - Harmonize access products to the benefit of transnational wholesale access seekers and multinational (virtual) companies/ corporations, which determine a large scale of the European GDP
  - Harmonized platform for EU-wide harmonized services
- Risks:
  - Replacing the infrastructure competition may have negative effects on competition in telecommunications and the wide choice of products and services
  - May reduce broadband penetration growth
  - Cannot be implemented in any region due to lag of NGA deployment, thus target cannot be met anyhow
  - Who defines the harmonized products in detail?

NGA and Vectoring: Regulatory challenges and open questions remain

Examples:

- Where handover local bitstream (VULA)?
  TDG 900 locations instead of 7,900 MDF
- How to handle Multicast? 1:1 vs. 1:n
- Contention? How to handle traffic bursts?
- Importance of infrastructure based competition, ranking of VULA?
- Can LLU also be replaced by VULA? (Vectoring at MDF locations?)
- ….

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Vectoring decision in Germany: DT files for being released out of physical full unbundling

- File of 19.12.2012 proposes to change physical unbundling of subloop
- Transmission methodology H18 (VDSL2) shall be excepted
- In all regions where DT plans to roll out VDSL2 Vectoring
- Already existing competitors shall be protected, when upgrading to VDSL Vectoring
- Layer 2 bitstream replaces right of unbundling in future monoply areas (SC per SC)
- How many conflicts may occur?

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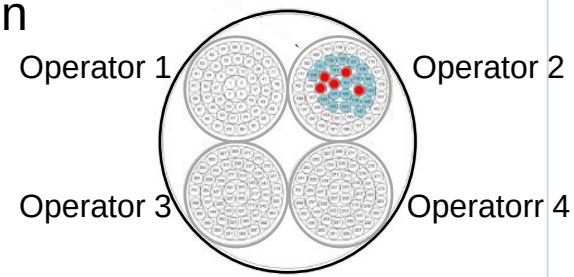
Regulatory Problem: Vectoring gains only achievable with exclusive use of access lines vs. physical infrastructure unbundling principle

2 Options

Organizing bundles within an access cable per operator

- Changing pairs between bundles, service interruption
- Area served by bundle now monopolized?
- Customer changes operator = change of bundle?
- Questionable practicability



Source of graphic: Frank van der Putten, Alcatel Lucent, Answer to BIPT 18.02.2011

Supplier independant Node Level Vectoring

- Standardization required – not recognizable
- Possible future solution
- Intermediate step: Supplier independent NLV, not yet available or publicly announced , not by different suppliers

Who is willing to define the technical characteristics of a VULA for Europe?

Class of Service	Technical QoS parameters	
"Interactive" Examples: Voice Telephony / Conferencing Video Telephony / Conferencing Online-Gaming Interactive TV Feedback	Peak Bit rate:	2000 Kbps
	Sustainable bit rate	100-2000kbps
	Minimum bit rate upgrade options)	100kbps (and further
	Delay (one way):	36 ms
	Jitter:	<6 ms
	Packet Loss:	<1 %
"Multimedia" Examples: Broadcast TV Video on Demand Streaming Audio Internet Radio Voice Messaging	Peak bit rate: downgrade options)	20Mbps (and further
	Sustainable bit rate options)	5Mbps (and further
	Minimum bit rate upgrade options)	100kbps (and further
	Delay (one way):	400 – 1000 ms
	Jitter:	< 1000 ms
	Packet Loss:	< 0,1 %
"Critical Data" Examples: Business Application e.g. SAP, eHealth	Peak bit rate: further downgrade options)	16 Mbps (and
	Sustainable bit rate options)	4Mbps (and further
	Minimum bit rate upgrade options)	512kbps (and further
	Delay (one way):	36 ms
	Jitter:	<20 ms
	Packet Loss:	< 0,1 %

Class of Service	Technical QoS parameters	
"Less Critical Data" Examples: Business Application e.g. Office, mail, large file transfers	Peak bit rate:	20Mbps
	Sustainable bit rate options)	4Mbps (and further
	Minimum bit rate further downgrade options)	512kbps (and
	Delay (one way):	400 – 1000 ms
	Jitter:	<500 ms
	Packet Loss:	< 1 %
"Best Effort" Examples: E-Mail Web-Browsing P2P Internet Downloads	Bandwidth:	up to line rate
	Sustainable bit rate	/
	Minimum bit rate	/
	Delay (one way):	< 2000 ms
	Jitter:	n.a.
	Packet Loss:	n.a.

Derived from St. Gallen university suggested services classes, Telecom Italy's bitstream draft offer and the application specific level of criticalness highlighted beginning of WP 3