Body of European Regulators for Electronic Communications

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Case Studies on Regulatory Decisions regarding Vectoring in the European Union

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Executive Summary

In several EU Member States operators plan or have already begun to introduce vectoring in their networks while in others there are no such plans. With vectoring the achievable bandwidth of VDSL2 subscriber access lines can be increased significantly based on a further use of the existing copper access network infrastructure. Unfortunately, in order to achieve the full advantages of vectoring, at least currently, only one and not several operators can use vectoring on VDSL2 subscriber access lines of a cable (binder). This is a significant drawback as it may have a negative impact on current competition based on local loop unbundling (LLU) and/or sub-loop unbundling (SLU). As a response to this development some NRAs have already taken decisions regarding the introduction of vectoring. In order to get a deeper insight into these decisions and to foster the exchange of experiences and contribute to the harmonisation of regulatory instruments used in the European Union, this document aims to give an overview of the regulatory decisions regarding vectoring based on the experiences of four countries (Austria, Belgium, Denmark and Germany). The analysis is descriptive and does not aim at being normative. It is not intended to recommend a best practice, as there still is not sufficient experience to draw stable conclusions.

All of the four countries examined promote the rollout of vectoring by ensuring that the operator deploying vectoring can do so exclusively. But apart from this, different regulatory approaches to the introduction of vectoring are used reflecting the national circumstances. The regulatory decisions which enable a single operator to use vectoring exclusively on the sub-loop depend on the SLU penetration:

- No SLU and no future SLU demand expected and, in addition, the SMP operator plans to roll-out vectoring rather quickly and broadly: in this situation the SLU obligation is entirely lifted on the national market and the regulatory decision regarding vectoring is asymmetric, i.e. only the SMP operator can use vectoring exclusively (BE)
- Low SLU penetration and low SLU demand expected: the SLU obligation is lifted on a case-by-case basis and the regulatory decision regarding vectoring is also asymmetric (AT, DK)
- Relatively high SLU penetration and relatively high future SLU demand expected: the SLU obligation is also lifted on a case-by-case basis but the regulatory decision regarding vectoring is symmetric, i.e. an ANO can also use vectoring exclusively (DE)

The regulation which enables a single operator to use vectoring exclusively on the (full) loop is only established if demanded by an operator (AT, BE) and depends on the VDSL2 LLU penetration: (i) No VDSL2 LLU penetration: the obligation to unbundle loops for the use of VDSL2 is lifted on the national market (BE) (ii) Relevant VDSL2 LLU penetration: the LLU obligation is lifted on a case-by-case basis and only in areas with no LLU (AT). In both cases, the regulatory decision regarding vectoring on the full loop is asymmetric which reflects that only the SMP operator demanded the exclusive use of vectoring.

If a case-by-case approach applies, SLU/LLU can be refused if all the following conditions are fulfilled: (i) The (SMP) operator has either already implemented vectoring or plans to implement vectoring within a certain time period[1], (ii) the (SMP) operator has to offer as a substitute to SLU/LLU a VULA/layer 2 access service and (iii) the (SMP) operator has to inform the other operators where it already has implemented vectoring and to some extent also on its plan to implement vectoring.

Since the vectoring roll-out is just beginning (or has just begun) in the countries considered in this report, it remains to be seen how these rules work in practice.

[1] In Austria, the refusal of LLU and in Denmark the refusal of SLU is only allowed if the SMP operator already deploys vectoring (not if it plans to implement vectoring).

1 Introduction and objective

Vectoring is a rather new technology used on VDSL2 subscriber access lines, which significantly increases the achievable bandwidths on copper lines and is currently tested or has recently been rolled out by operators in several EU Member States. For operators it is attractive that this significant increase of bandwidths can be achieved based on a further use of the existing copper access network infrastructure. On the other hand, in order to achieve the full advantages of vectoring, at least currently, only one and not several operators can use vectoring on VDSL2 subscriber access lines of a cable (binder). From a regulatory point of view, this is a significant drawback as it may have a negative impact on current competition based on local loop unbundling (LLU) and/or sub-loop unbundling (SLU). As a response to this development some NRAs have already taken decisions regarding the introduction of vectoring. In order to get a deeper insight into these decisions and to foster the exchange of experiences and contribute to the harmonisation of regulatory instruments used in the European Union, this document aims to give an overview of the regulatory decisions regarding vectoring based on the experiences of four countries (Austria, Belgium, Denmark and Germany). The analysis is descriptive and does not aim at being normative. It is not intended to recommend a best practice, as there still is not sufficient experience to draw stable conclusions.

The document starts with an introduction to the technical aspects of vectoring (section 2) and a short overview on the market situation (section 3). Then the regulatory decisions with regard to the introduction of vectoring are analysed in detail (section 4). After a short introduction (section 4.1), an overview of the criteria used for the analysis of the regulatory decisions on vectoring is presented (section 4.2). Following this, impacts on both the sub-loop (section 4.3) and the (full) loop (section 4.4) are successively analysed based on these criteria. This analysis ends with a look at future technologies similar to VDSL2 vectoring (section 4.5). Finally, conclusions are drawn (section 5).

2 Technical aspects of vectoring

Vectoring is a rather new technology (standardised in 2010[2]) that can be used on VDSL2[3] lines and

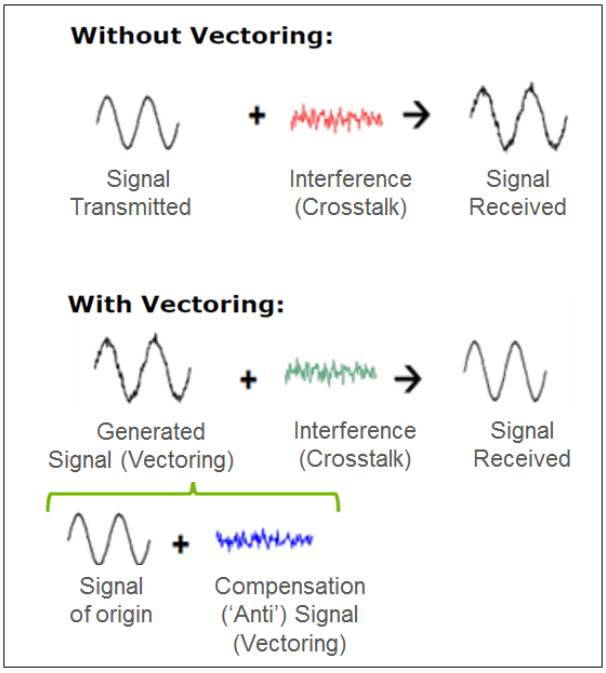
- Significantly increases the achievable bandwidths in down- and upstream direction,
- Substantially increases the filling factor and makes it possible to use all copper pairs of a cable with VDSL2 and
- Makes the achievable bandwidths more predictable.

Vendors claim that vectoring can boost the VDSL2 bit rates by approximately 100%. According to them, downstream speeds of roughly 100 Mbps can be achieved at distances of up to 400 m and 50 Mbps can be supported with loops as long as approx. 800 m which is a multiplication of the loop length that can be achieved without vectoring.[4] In field trials[5] in Belgium, a downstream bandwidth of 70 Mbps was achieved on 98% of all vectored lines with a length less than 400 m. This bandwidth will be further increased to 100 Mbps with Dynamic Line Management.[6]

[2] ITU-T G.993.5 (April 2010)
[3] VDSL2 systems according to ITU-T G.993.2, not on VDSL systems according to ITU-T G.993.1 and not on ADSL systems (e.g. ADSL, ADSL2, ADSL2plus)
[4] See Alcatel-Lucent (2011), ECI (2012), Broadband Forum (2012), BREKO (2013), Deutsche Telekom (2014) and KPN (2014).
[5] In-depth technical field trials were conducted involving 1000+ customers with moderate, high and excessive crosstalk.
[6] For the shortest and most stable lines (with limited resynchronisations per day)

Vectoring is a relatively fast and cheap method to increase bandwidths compared to a full FTTH roll-out. The investment costs are limited to FTTC investments (if vectoring is applied from the street cabinet) plus the investments in vectoring capable equipment.[7] This is attractive at least in the short to medium term primarily in countries or areas where the costs of FTTH are especially high e.g. due to less existing duct infrastructure or low population density. Nevertheless in the long run it is likely that vectoring is only an intermediate step to full FTTH deployment.[8]

Technically, vectoring works in the following way: the DSL signals of the copper lines in a cable (binder) interfere with each other (called crosstalk) which leads to a major reduction of the achievable bandwidths and makes the achievable bandwidths dependent on the number of lines used within a cable and of the position of a line within a cable. VDSL2 vectoring calculates for each line the interference generated by all other lines of the cable based on measurements and generates a compensation signal ('anti signal') in real-time. The compensation signal is added to the original signal and both are transmitted. During the transmission the interferences of all the other lines in the cable are ideally completely cancelled out by the compensation ('anti') signal and the original signal can be received without any interference (see Figure 1). Therefore, each line can perform nearly as if only one line of the cable is used and the advantages described above can be gained.



Source: A1 Telekom Austria (2013), slide 4

Figure 1: Basic principle of vectoring

Unfortunately, if the vectoring system does not compensate the interferences of all VDSL2 lines in a cable (binder) the vectoring gain can be reduced significantly.[9] In order to avoid this, the vectoring system has to control all VDSL2 lines of a cable. This means it is not possible that more than one operator can use vectoring on VDSL2 lines in the same cable (binder). Furthermore, if only a single operator uses vectoring on VDSL2 lines of a cable, the other operators not only cannot use vectoring but also not VDSL2 systems without vectoring on lines of the same cable. Therefore, the introduction of vectoring may require modification of the

[7] DSLAM/Vectoring processor card, CPE/modem
[8] The bandwidth that can be achieved on the existing copper based infrastructure can be further increased with new technologies e.g. G.Fast or if more than one copper pair is available per subscriber (pair bonding, phantoming) which will prolong the use of the copper based infrastructure and delay the need for FTTH.
[9] See e.g. Alcatel-Lucent (2012)

existing regulation to take this into account and to enable a single operator to use VDSL2 vectoring exclusively.

The countries analysed consider multi-operator vectoring, at least currently, not as an appropriate option. In order to allow more than one operator to use vectoring on VDSL2 lines within the same cable (binder) a multi-operator vectoring system needs to span across more than one DSLAM (multi-node vectoring). If the DSLAMs are from different vendors, a standard is needed for the interworking, which is not available today. If the DSLAMs are from the same vendor, such a solution, although technical feasible, would need to overcome the following challenges:[10]

- One operator may choose the vendor of the DSLAM but the other operators have no choice and therefore they are possibly not able to achieve reasonable prices for the DSLAM. An alternative would be co-investments, but this may not be easy to coordinate between different competing operators.
- An upgrade of the network with regard to vectoring needs an agreement, coordination and implementation at the same time of all involved operators.
- The responsibilities need to be correctly separable and the operation needs to be strongly coordinated which complicates e.g. troubleshooting and guaranteeing quality of service. An alternative would be a centralised operation and maintenance by one operator with the consequence that all involved operators need to use the same service level agreements.
- The strong coordination needed between the involved operators reduces the possibilities of the involved operators to differentiate their products and to innovate i.e. the advantage of multi-operator vectoring.

VDSL2 vectoring cannot cancel interferences from ADSL lines. ADSL systems (e.g. ADSL, ADSL2plus) can continue to be used from the CO by ANOs based on LLU and also the SMP operator, if VDSL2 at the SC uses DPBO (PSD shaping).[11] In this case, if VDSL2 is used with vectoring at the SC, the ADSL systems at the CO only slightly reduce the vectoring gain. If both ADSL and VDSL2 vectoring systems are deployed at the CO (without DPBO/PSD shaping) the ADSL systems reduce the vectoring gain only slightly on short loops and clearly noticeable on longer loops.

3 Market Situation

In order to better understand the different regulatory approaches resulting from the introduction of vectoring in the Member States considered, it is important to be aware of differences in the respective FTTC market situations.

An important factor influencing the regulatory approach seems to be the current and future use of LLU and SLU (see Table 1 in the Annex). With regard to SLU, three cases may be distinguished in this report:

(i) Currently no SLU and no future SLU expected: BE
(ii) Currently very low SLU and very low SLU expected: AT, DK
(iii) Significant SLU and significant further demand for SLU expected: DE

Also, LLU is of different importance in the Member States examined with a low penetration (and no VDSL2 deployment by ANOs) in Belgium and relevant/significant penetration in AT, DE and DK.

[10] See WIK (2013) and Alcatel-Lucent (2012)
[11] See Alcatel-Lucent (2012),and WIK (2013)

As described in detail below, the higher the LLU/SLU penetration is, the more the decisions regarding vectoring are taking into account the future possibility of LLU/SLU and a deployment of vectoring by ANOs.

Currently, vectoring is still in the trial stage or the roll-out has just begun in the four Member States described below (see Table 2). In Belgium, where the development is already more advanced compared with the other Member States analysed, VDSL2 vectoring with bandwidths of up to 70 Mbit/s has been launched by Belgacom in several cities in February 2014.[12] The roll-out target is 80% of households by 2016. In Austria, the commercial launch has been announced by A1 Telekom Austria for August 2014. A1 Telekom Austria intends to deploy vectoring in the future from street cabinets (in FTTC/B roll-out areas) as well as from the CO/MDF. Also in Germany vectoring has not yet been commercially launched, however, Deutsche Telekom has already announced a target coverage of 65% of households by 2016. The commercial launch in Denmark is expected for the beginning of 2015.

It is also worth noting that all of the countries considered have significant cable network coverage (ranging from 50% of homes passed in Austria to >95% in Belgium) which might increase the need for copper incumbents to upgrade their networks.[13] On the other hand, FTTH coverage/penetration is quite low in the four Member States.

4 Regulatory decisions on vectoring

4.1 Introduction

Vectoring has a couple of important advantages (see section 2) and therefore, several operators – mainly incumbents – are interested in the introduction of vectoring in their networks. In the short to medium term vectoring increases the potential for operators to better compete with alternative NGA technologies such as cable broadband and FTTH at relatively low investment costs.

Unfortunately, at least from a regulatory point of view, vectoring has a major drawback. It requires that all copper pairs of a cable (binder) are controlled by only one vectoring system and currently also by only one operator (see section 2). This means that other operators no longer can use VDSL2 in the same cable, otherwise the full advantages of vectoring could not be achieved.

In three countries analysed (AT, DE, DK), the SMP operator already demanded an exclusive use of vectoring and in response to this regulatory decisions regarding vectoring were taken. In Belgium, such a decision was taken without concrete demand by an operator based on a forward looking approach. In two countries (AT, BE), the regulation is the outcome of market analysis (Market 4 or 5 of the 2007 recommendation) while in the other two countries (DE, DK) separate decisions were taken (see Table 3 in the Annex).

4.2 Criteria for the analysis of the regulatory decisions on vectoring

The regulatory decisions on vectoring are analysed based on the following criteria (see Figure 2).

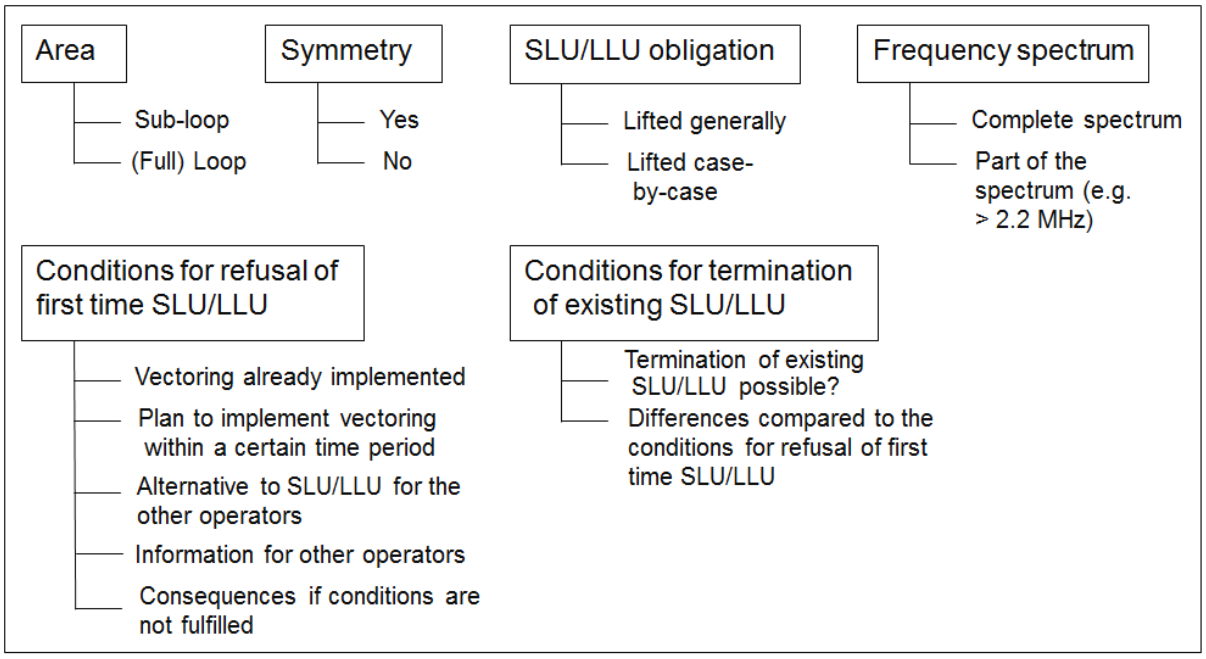
- . Area: a single operator is enabled to use vectoring exclusively on the sub-loop and/or the (full) loop.
- Symmetry: the exclusive use of vectoring may be based on either symmetric or asymmetric regulation. In the first case either the SMP operator or an ANO can use vectoring

[12] see http://www.belgacom.com/be-en/newsdetail/ND_20140219_alcatel_lucent.page

[13] It needs to be mentioned that in Denmark the SMP operator not only owns the (only) copper network but also the largest cable network and a fibre network. Therefore, the SMP operator might have the incentive not to upgrade the copper network in areas with cable (and/or fibre).

exclusively; in the second case only one operator, typically the SMP operator, can use vectoring exclusively.

- SLU/LLU obligation: the SLU/LLU obligation may either be entirely lifted on the national market or may remain with the right for the SMP operator to refuse SLU/LLU on a case-by-case basis (e.g. per SC or CO).
- Frequency spectrum: a single operator may be allowed to use either the complete frequency spectrum on the sub-loop/loop exclusively or only a part of the frequency spectrum e.g. above the ADSL2plus frequency spectrum of 2.2 MHz.
- Conditions for refusal of first time SLU/LLU: in order to enable one operator to use vectoring exclusively, regulation has to specify on which conditions an SMP operator can refuse SLU/LLU requests of ANOs. Typically it is demanded that either vectoring is already implemented or the operator plans to implement vectoring within a certain time period. In addition, the other operators need an alternative to SLU/LLU, typically a VULA/layer 2[14] access service, and also information on the implementation of vectoring. Finally, regulation also needs to define the consequences if the conditions for the refusal of SLU/LLU have not been fulfilled.
- Conditions for termination of existing SLU/LLU: an operator may be enabled to use vectoring exclusively, although one (or more) operator(s) already use unbundled sub-loop/loops. Then the termination of existing SLU/LLU is necessary and a regulatory decision regarding vectoring has to define the conditions under which this is possible. These conditions may differ from the conditions for the refusal of first time SLU/LLU.



Source: BEREC

Figure 2: Criteria for the analysis of the regulatory decisions on vectoring

4.3 Impact on the regulation of sub-loop unbundling

In all four countries analysed, the introduction of vectoring had an impact on the existing regulation of sub-loop unbundling (see Table 3).

[14] Layer 2 or Data Link Layer according to the OSI reference model

4.3.1 Symmetry

In Germany, regulation on the sub-loop regarding the introduction of vectoring is symmetric subject to some restrictions (see Table 3). In Germany, SLU penetration is rather low (approx. 1 %), but compared with the three other countries, relatively high. More than 300 000 sub-loops are unbundled and further SLU demand is expected in the future (see section 3). Therefore, ANOs may use vectoring exclusively on a significant number of unbundled sub-loops, which implies that symmetric regulatory decisions are relevant in this case. However, to comply with the right of property of the SMP operator, some restrictions on symmetry were considered appropriate: e.g., an ANO does not have the possibility to terminate existing SLUs and to take-over sub-loops which are used by the SMP operator with VDSL2, while the SMP operator has the right to terminate existing SLUs, if specific conditions are fulfilled (see section 4.3.5).

In the other three countries (AT, BE, DK) analysed, regulation regarding vectoring is asymmetric. Only the SMP operator can use vectoring exclusively (not an ANO). The reason is that in these three countries, the number of unbundled sub-loops is very low. In Denmark less than 200 and in Austria approx. 340 sub-loops are unbundled. In Belgium there is no SLU at all. Furthermore, the future SLU demand is expected to be zero in Belgium and very low in Denmark and Austria (see section 3). Therefore, it is likely that ANOs will never have any demand or only in very rare cases to use vectoring on the sub-loop exclusively.

But in Denmark, the ANOs can initiate the implementation of vectoring by the SMP operator. The SMP operator is – in addition to the exclusive use of vectoring – obliged to meet reasonable requests from ANOs regarding the use of vectoring. ANOs can request VULA with higher and more predictable speeds due the use of vectoring and will therefore be able to initiate the use of vectoring in the same way as the SMP operator. The SMP operator has to make the necessary investments and will be compensated for this by VULA price.[15] The SMP operator is required to announce up to two years in advance the number of street cabinets it is capable to upgrade with vectoring each quarter. The ANOs can determine the street cabinets which should be upgraded with vectoring up to 50% of this capacity.[16]

In the following, the case of exclusive use by the SMP operator (sections 4.3.2 - 4.3.5) is treated first and then the differences if the ANO has the possibility to use vectoring exclusively are described (section 4.3.6).

4.3.2 SLU obligation entirely lifted?

In Belgium, the SLU obligation has been entirely lifted on the national market (see Table 3). The reason is that no sub-loop has been unbundled so far and it is also expected that there will be no SLU demand in the future. Furthermore, in Belgium the current VDSL2 coverage is with 88% (end of 2013) already very high and the SMP operator plans to use vectoring on 80% of all lines by end of 2016 which is a rather quick and broad vectoring roll-out (see section 3).

In the three other countries (AT, DE, DK), the SLU obligation remains but the SMP operator may refuse SLU on a case-by-case basis (e.g. per SC) if certain conditions are fulfilled. In these countries, unbundled sub-loops are used at least to some extent and regulation aims at lifting the sub-loop unbundling obligation only in those cases where it would prevent the roll-out of vectoring.

[15] The cost for upgrading to vectoring is spread over all VULA lines.
[16] The ‘first come first-served’ principle applyies but ANOs can agree on other principles.

4.3.3 Frequency spectrum

Since in Belgium the SLU obligation is entirely lifted on the national market and there is currently no sub-loop unbundling, the SMP operator is enabled to use vectoring exclusively and also the entire frequency spectrum (see Table 3).

In Austria and in Germany, the refusal of SLU encompasses only the spectrum above 2.2 MHz i.e. an SMP operator cannot refuse SLU if an ANO uses e.g. ADSL2plus on the unbundled sub-loop.[17] If the SMP operator uses vectoring only above 2.2 MHz then there is no need to refuse SLU with a spectrum of up to 2.2 MHz anyway. In Denmark, refusal of SLU aims to allow the roll-out of vectoring and, therefore, encompasses de facto the frequency spectrum above 2.2 MHz like in Austria and Germany. However, this issue is not addressed in detail in the Danish vectoring decision from 2013 (DK/2012/1339).

4.3.4 Conditions for refusal of first time SLU

Countries where SLU obligation is lifted on a case-by-case basis (AT, DE, DK)

In the countries analysed where SLU obligation is lifted on a case-by-case basis, the SMP operator is allowed to refuse a SLU request of an ANO if the following conditions are fulfilled (see Table 4 and Table 5):

(i) The SMP operator has already implemented vectoring at the SC where an ANO requests SLU (AT, DE, DK) or
(ii) The SMP operator has announced the introduction of vectoring within a certain time period (AT: 16 weeks, DE: 12 months, not DK[18]).
(iii) As an alternative to SLU the SMP operator has to provide a layer 2 access service with local handover[19] (AT, DK) and/or with a handover at a higher level than local (DE, DK).
(iv) The SMP operator has to provide adequate information to the ANOs (AT, DE, DK).

The SMP operator has to cumulatively fulfill either the conditions (i), (iii) and (iv) or the conditions (ii), (iii) and (iv).

Regarding point (iii):

In Austria and Denmark, the SMP operator is only obliged to offer a layer 2 access service in accordance to the reference offer. There is no additional obligation to offer also a specific layer 2 access service with regard to vectoring. The layer 2 access service has a handover in Denmark at the SC, CO or more central points in the network (the ANO can choose) and in Austria at the CO.[20] In Denmark, if an ANO chooses the handover at the SC, uncontended backhaul has also to be provided from the SC to the CO (e.g. dark fibre). The characteristics of the layer 2 access services do not depend on the use of vectoring with the following exception. Vectoring enables higher and more predictable bitrates which need to be reflected in the layer 2 access service offer.[21]

[17] In Austria, this is only the case as long as the SMP operator uses vectoring only above 2.2 MHz. If the SMP operator starts to use vectoring below 2.2 MHz, then the SMP operator can refuse SLU requests also for lines on which the ANO would like to use this spectrum.
[18] In Denmark, SLU can only be refused if vectoring is already implemented and the SMP operator still has to offer SLU in the time period between announcement to implement vectoring and the actual deployment of vectoring. In Denmark, this notification period is six months and in cases where alternative operators are present at the SC the notification period is 18 months.
[19] VULA
[20] In Denmark, the uncontended VULA/layer 2 access service has the handover at the SC or CO and the contended layer 2 access service at CO and more central points in the network.
[21] For more information on VULA services, see BEREC internal report on “Layer 2 Wholesale Access Products in the European Union” approved at plenary 1 2014.

In Germany, the SMP operator is only obliged to provide a single access service and not in addition, a separate access service with regard to vectoring. In the case of refusal of first time SLU, the SMP operator has to offer only the usual bitstream services that he has to provide anyway as obligation based on Market 5 (wholesale broadband access). This means the SMP operator has to provide a layer 2 access service with approx. 900 handovers at Metro PoP locations (for the interim period until the end of 2015 a layer 3 service with handovers at 73 PoPs is sufficient).

Regarding point (iv):

In Austria and in Denmark, the SMP operator publishes a list of SCs where it already deploys vectoring or plans to implement it within the announced time.[22] In Denmark, the SMP operator is also obliged – when notifying the use of vectoring at a given SC – to provide additional information to affected ANOs.

In Germany, all undertakings can have access to information at which locations the SMP operator has already implemented vectoring from a vectoring register[23] provided by the SMP operator.[24] In addition, the SMP operator has to make its plan to implement vectoring available to an ANO, if the ANO registers its plan to implement vectoring in the vectoring register and its plan collides with the plan of the SMP operator. In any case if an ANO requests SLU-collocation the SMP operator has – before granting collocation – to inform the ANO about a registered implementation or registered implementation plans for vectoring. Otherwise there is no right of refusal of first time SLU.

The consequences if vectoring is not realised within the announced time period (see above) are as follows:

- Economic disadvantages:
    - The VULA service has to be offered with lower prices (same as SLU) until vectoring is realised (AT).
    - SMP operator has to pay compensation to the ANOs until vectoring is realised (DK).
    - The SMP operator has to pay a contractual penalty (only if applications of ANOs to the vectoring register had to be declined) (DE)
- Delay of vectoring roll-out: The SMP operator is prevented from filing new registrations in the vectoring register for a certain time (DE)

Where SLU obligation is entirely lifted on the national market (BE)

In Belgium, where SLU obligation has been entirely lifted on the national market, the market analysis decision also obliges the SMP operator to provide to ANOs a layer 2 wholesale access service with local (CO/MDF) and also regional handover. If higher bitrates can be achieved with vectoring this needs to be reflected in the bandwidths of the layer 2 access product.

The SMP operator has the obligation to provide the following information to the ANOs:

- A list of all modems of the installed base which are unreachable through TR-69 protocol and therefore cannot be automatically updated to vectoring friendly mode,
- A list of SCs that migrate to vectoring (6 months beforehand),
- A list of VDSL2 modems which are not vectoring friendly or vectoring compliant and therefore has to be replaced (6 months beforehand) and

[22] In Denmark, six months if no ANO is present at the SC otherwise 18 months. In Austria, the list is only available for ANOs and the NRA.
[23] It is operational since 31/07/2014. Within the first month of operation more than 30 operators filed registrations for around 1000 local telephone networks relating to more than 40 000 street cabinets.
[24] Based on the principle of Chinese walls and monitored by the NRA.

- A planned work order[25] (10 days beforehand).

The reason is that if the SMP operator starts to use vectoring on a subscriber access line, this would necessarily lead to an interruption of the layer 2 access service of the SMP operator and possibly also the CPE/modem at the customer premises has to be replaced with a modem which is fully compliant with the vectoring standard. Furthermore, modems that are not vectoring friendly or full vectoring compliant will be put in repair mode (only ADSL2+ frequencies) before the activation of vectoring. Therefore, the customers of the ANOs are affected and ANOs need appropriate information from the SMP operator in due time before.

According to the market analysis decision the SLU obligation can be re-imposed if vectoring is not implemented according to plan. The SMP operator provides a general network evolution outlook for the next five years and updates this outlook on an annual basis.

4.3.5 Conditions for termination of existing SLU

In two countries (DE, DK), the SMP operator can not only refuse (new) requests of ANOs for unbundled sub-loops but also terminate existing SLUs if certain conditions are fulfilled (not in AT[26] and BE[27], see Table 3 and Table 6). In Germany, this was foreseen to accommodate the right of property of the SMP operator.

The SMP operator has to fulfil, in addition to the conditions for the refusal of first time SLU (see section 4.3.4) further conditions:

In Denmark the SMP operator has

- to migrate the affected unbundled sub-loops of the ANOs to VULA/layer 2 access service,
- pay for the migration and
- compensate stranded investments made by ANOs.

In Germany the SMP operator has to fulfil the following further conditions:

- In a given area (defined by a local area code), the SMP operator needs to have developed more SCs with vectoring than an ANO with VDSL2 or vectoring and at least 75% of the buildings connected to the relevant SC are connected to a second fixed telecommunications infrastructure (e.g. cable).
- The SMP operator has to provide to the affected ANO layer 2 access service at the relevant SC.
- The SMP operator has to provide layer 2 access service with a special charge determined in BNetzA's decision (corresponding to the charge for SLU plus electricity and operational costs, but not including further costs of the concentration network or the DSLAM).
- The SMP operator has to announce the termination at least one year in advance and has to bear its own migration costs.
- Also, there are a few 'counter exceptions' that soften the rights of the SMP operator to terminate third party access to a street cabinet. The SMP operator cannot terminate the access to street cabinets that have been developed with state aid funds. The other cases relate to grandfathered rights.

[25] Hardware swap, port reconfiguration, vectoring activation etc.
[26] In Austria, future changes of RUO/contracts may permit the SMP operator to terminate existing SLUs.
[27] In Belgium, the termination of existing SLU is not relevant, because currently no sub-loop is unbundled (see section 3).

4.3.6 Exclusive use of vectoring by ANO

Regulation on the sub-loop regarding the introduction of vectoring is symmetric in Germany only (with some restrictions) and not in the three other countries analysed (AT, BE, DK) (see section 4.3.1). This section only deals with the differences compared to the case where the SMP operator is the exclusive user of vectoring. The conditions to be fulfilled by an ANO are the same as for the SMP operator (see section 4.3.4) with the following exceptions: access services have to be comparable with those of the SMP operator but the number of point of handovers is not specified and will depend e.g. on the network infrastructure of the ANO.

But the regulation regarding vectoring is not fully symmetric, because an ANO does not have the possibility to terminate existing SLUs and to take-over sub-loops which are used by the SMP operator with VDSL2. This was provided to comply with the right of property of the SMP operator.

4.4 Impact on the regulation of the full loop unbundling

In two countries (AT, BE), the regulation regarding the introduction of vectoring enables operators to also use it exclusively on the (full) loop (see Table 3). In these countries, the SMP operator has already demanded the exclusive use of vectoring on the (full) loop. In Germany, this has not been the case. The SMP operator had only requested a vague caveat regarding LLU on the full loop which however was not granted by the regulator. Therefore, no operator is enabled to use vectoring on the (full) loop exclusively. In Denmark, a draft decision regarding the use of vectoring on the (full) loop (at the CO) was submitted to public consultation in 2014. Based on the incoming responses, it has been decided to carry on further analysis to be able to assess the competition issues with regard to this specific situation before a decision may be taken.

In countries with an exclusive use of vectoring on the (full) loop (AT, BE), regulatory decisions regarding vectoring where taken on an asymmetric basis and only the SMP operator (not an ANO) can use vectoring exclusively on the (full) loop.[28] One reason is that only the SMP operator and no ANO demanded the exclusive use of vectoring on the (full) loop so far.

4.4.1 LLU obligation lifted regarding VDSL2 on the national market

In Belgium, the obligation to unbundle (full) loops for the use of VDSL2 is entirely lifted (in whole Belgium), on the contrary to Austria (see Table 3). In Belgium, no ANO has used VDSL2 at the CO before the decision regarding vectoring. Furthermore, in Belgium the current VDSL2 coverage is with 88% (end of 2013) already very high and the SMP operator plans to use vectoring on 80% of all lines by end of 2016 which is a rather quick and broad vectoring roll-out (see section 3).

The impact of vectoring on LLU regulation does not differ from the impact on SLU regulation (see section 4.3 and Table 3 to Table 6 in the Annex) with the following exception. LLU obligation is only lifted for VDSL2 and the frequency spectrum above 2.2 MHz (SLU: whole spectrum).

4.4.2 LLU obligation lifted on a case-by-case basis

In Austria, the LLU obligation remains but the SMP operator can refuse LLU at COs with no unbundled loop (currently approx. 1,100 smaller COs out of approx. 1,480 COs) if specific conditions are fulfilled (see Table 3). Therefore, ANOs can continue to use VDSL2 on their unbundled lines and can even unbundle new lines at both COs with currently at least one unbundled loop and COs where the SMP operator does not fulfil the conditions for the refusal of LLU.

[28] In Austria, theoretically also an ANO has the possibility to use vectoring exclusively under the same conditions as the SMP operator based on non-discrimination.

In Austria, regulation regarding LLU enabling the introduction of vectoring does not differ from SLU's ones (see section 4.3 and Table 3 to Table 6 in the Annex) with the following exception. The SMP operator can only refuse LLU if it already deploys vectoring at the CO (at the same condition as for SLU) but not if it plans to implement vectoring (which differs from the regulation with regard to SLU).[29]

4.5 Future technologies

In two countries (AT, DK), the regulatory decisions regarding vectoring apply analogously also to future technologies which demand exclusivity (e.g. potentially G.fast[30]). In Austria, this is the case if the Austrian Telecom Control Commission (TKK) explicitly extends the validity of rules concerning vectoring implementation on request by the SMP operator and in Denmark, the decision concerning vectoring mentions VDSL2 as the relevant technology together with vectoring, but encompasses all DSL technologies similar to VDSL2.

Of course, each country has the possibility to start a new market analysis procedure if technological developments indicate that the existing regulation regarding the introduction of vectoring may no longer be appropriate e.g. if exclusivity is no longer be needed.

5 Conclusions

In conclusion it can be said that all of the four countries examined promote the rollout of vectoring by ensuring that the operator deploying vectoring can do so exclusively. But apart from this, different regulatory approaches to vectoring are used reflecting national circumstances. The impact of the introduction of vectoring on regulatory decisions regarding the sub-loop depends on the SLU penetration:

- No SLU and no future SLU demand expected and, in addition, the SMP operator plans to roll-out vectoring rather quickly and broadly: in this situation the SLU obligation is entirely lifted on the national market and the regulatory decision regarding vectoring is asymmetric, i.e. only the SMP operator can use vectoring exclusively (BE)
- Low SLU penetration and low SLU demand expected: the SLU obligation is lifted on a case-by-case basis and the regulatory decision regarding vectoring is also asymmetric (AT, DK)
- Relatively high SLU penetration and relatively high future SLU demand expected: the SLU obligation is also lifted on a case-by-case basis but the regulatory decision regarding vectoring is symmetric, i.e. an ANO can also use vectoring exclusively (DE)

The regulation which enabels a single operator to use vectoring exclusively on the (full) loop is only established if demanded by an operator (AT, BE) and depends on the VDSL2 LLU penetration:

- No VDSL2 LLU penetration: the obligation to unbundle loops for the use of VDSL2 is lifted on the national market (BE)
- Relevant VDSL2 LLU penetration: the LLU obligation is lifted on a case-by-case basis and only in areas with no LLU (AT)

[29] The SMP operator is only allowed to refuse LLU if it deploys vectoring at the CO not if it deploys (or plans to deploy) vectoring at SCs.

[30] G.fast is a new technology which uses a significant wider frequency spectrum than VDSL2, also (but more complex) vectoring and therefore higher bandwidths of approx. 1 Gbps (downstream plus upstream) on copper loops up to approx. 100 m should be possible. The standardisation is expected in 2014 and commercial availability and field trials in the coming years.

In both cases, the regulatory decision regarding vectoring on the full loop is asymmetric which reflects that only the SMP operator demanded the exclusive use of vectoring.

If a case-by-case approach applies, SLU/LLU can be refused if the following conditions are fulfilled:

- The (SMP) operator has either already implemented vectoring or plans to implement vectoring within a certain time period (AT: 16 weeks, DE: 12 months).[31]
- The (SMP) operator has to offer as a substitute to SLU/LLU a VULA /layer 2 access service.
- The (SMP) operator has also to inform the other operators where it already has implemented vectoring and to some extent also on its plan to implement vectoring

If vectoring is not realised within the announced time period, the following measures are taken:

- SLU/LLU is made mandatory again (BE)
- Economic disincentives (AT: VULA with lower price, DK: compensation payment to ANOs, DE: contractual penalty[32])
- (SMP) operator is prevented from implementing vectoring in new areas for its exclusive use for a certain time (DE).

Since the vectoring roll-out is just beginning (or has just begun) in the countries considered, it remains to be seen how these rules work in practice.

[31] In Austria, the refusal of LLU and in Denmark the refusal of SLU is only allowed if the SMP operator already deploys vectoring (not if it plans to implement vectoring).
[32] Only if ANOs were negatively affected.

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Abbreviations

ADSL	Asymmetric Digital Subscriber Line
ANO	Alternative Network Operator
AT	Austria
BE	Belgium
CO	Central Office
DE	Germany
DK	Denmark
DPBO	Downstream Power Back Off
FTTC	Fibre To The Cabinet
FTTH	Fibre To The Home
LLU	Local Loop Unbundling
MDF	Main Distribution Frame
NGA	Next Generation Access
OSI	Open Systems Interconnection
PoH	Point of Handover
PoP	Point of Presence
PSD	Power Spectral Density
SC	Street Cabinet
SLU	Sub-Loop Unbundling
SMP	Significant Market Power
VDSL	Very High Speed Digital Subscriber Line
VULA	Virtual Unbundled Local Access

Annex

Table 1: LLU and SLU penetration

MS	Austria	Belgium	Denmark	Germany
LLU penetration as percentage of total DSL lines	Approx. 12%	< 6%	Approx. 13%	Approx. 40%
SLU penetration as of percentage of total DSL lines	Approx. 0.02%	None	Approx. 0.01%	Approx. 1%
Number of unbundled sub-loops	Approx. 340 (Q4/13)	None	Less than 200.	More than 300.000
Future SLU demand likely?	Very low	None	Very low.	Yes
Ducts available	• From the SMP operator between SC and CO/MDF within the same or an adjacent CO/MDF area[33] • Symmetrical (non-SMP depending) obligation for any duct-owner to grant access[34]	Between CO/MDF and SC, but not between house and SC.	In case of the establishment of own equipment at street cabinets, otherwise not.[35]	Sometimes between CO/MDF and SC, but not between house and SC.

Source: BEREC

[33] Market analysis decision (Market 4)
[34] Section 8 Telecoms Act
[35] If ANOs buy uncontended VULA at the street cabinet, dark fibre is regulated from street cabinet to central office (with presence of alternative transport providers) regardless establishment of own equipment at street cabinet. This is the case with or without vectoring at street cabinet.

Table 2: Incumbent NGA roll-out and role of cable

MS	Austria	Belgium	Denmark	Germany
Actual FTTC coverage	10%-15% of households (estimate)	<88% of households	Approx. 20% of households	Approx. 30% of households
Actual vectoring coverage	Currently very low (trial stage); Actual deployment announced by A1 Telekom Austria as of August 2014	Launched Feb 2014[36]	None.	None
Planned vectoring coverage	In the long term at all SCs and COs (current regulation only allows at COs which are not unbundled)	80% of households by end of 2016[37]	Planned launch at the beginning of 2015 (regulated access will enter in force on 1 January 2015).	65% of households by end of 2016
Actual FTTH coverage	Approx. 3% of households	Less than 3.000 FTTH and FTTB lines	Approx. 4% of households.	414.000 homes passed
Actual cable coverage	Approx. 50% of households	> 95% coverage	63% coverage of cable broadband	65% coverage
Cable share of fixed broadband lines	Approx. 30%	51% (end of 2013)	28% (Q2 2013) The largest cable network operator in DK is TDC	Approx. 17%

Source: BEREC

[36] http://www.belgacom.com/be-en/newsdetail/ND_20140219_alcatel_lucent.page
[37] See footnote 36

Table 3: Overview on the regulatory decisions on vectoring

MS	Austria	Belgium	Denmark	Germany
Legal basis of the specific decisions regarding vectoring	Market analysis decision (Market 4) as of Dec 2013 (stipulated scope of SLU-/LLU-access obligation due to possible vectoring deployment; AT/2013/1475-1476) • Detailed vectoring 'deployment rules' by A1 Telekom Austria (publicized 03/2014)	• Market analysis decision of July 1st 2011 (BE/2011/1227-1228) • Reference offer decision of February 19th 2014	Extra decision (of 19 December 2013) concerning vectoring at street cabinets to the Market 4 decision of 16 August 2012 (DK/2012/1339)	Extra Decisions: • Regulatory Order BK3d-12/131 from 29/08/2013 (DE/2013/1484) • Reference Offer from 29/07/2014 (DE/2014/1628)
Area	Sub-loop and (full) loop	Sub-loop and (full) loop	Sub-loop	Sub-loop
Symmetry	No, only SMP operator	No, only SMP operator	No, only SMP operator[38]	Yes (with some restrictions)
SLU/LLU obligation entriely lifted or on a case-by-case basis	SLU/LLU: Remains, but lifted subject to conditions	Entirely lifted for • SLU (all DSL systems) and • LLU VDSL2	SLU: Remains, but lifted subject to conditions	SLU: Remains, but lifted subject to conditions
Frequency spectrum	SLU/LLU: > 2.2 MHz[39]	• SLU: whole spectrum • LLU: > 2.2 MHz[40]	SLU: Not specified in detail[41]	SLU: > 2.2 MHz
Refusal of first time SLU/LLU possible	SLU/LLU: Yes	N/A	SLU: Yes	SLU: Yes
Termination of existing SLU/LLU possible	• SLU: No[42] • LLU: N/A[43]	• SLU: N/A (no SLU) • LLU: N/A (no LLU VDSL2)	SLU: Yes	SLU: Yes

Source: BEREC

[38] But the ANOs can initiate the implementation of vectoring by the SMP operator (see section 4.3.1)
[39] See footnote 17
[40] The obligation to unbundle loops for the use of VDSL2 is entirely lifted (in whole Belgium)
[41] See section 4.3.3
[42] See footnote 26
[43] The exclusive use of VDSL2 vectoring is only possible at COs without any LLU.

Table 4: Conditions for refusal of first time SLU/LLU – part 1

MS	Austria	Belgium	Denmark	Germany
Refusal is possible of first time	SLU and LLU	SLU and LLU	SLU	SLU
Vectoring already implemented	Yes	Yes	Yes	Yes
Plan to implement vectoring within a certain time period	• SLU:16 weeks • LLU: No	N/A (SLU/LLU VDSL2 obligation entirely lifted)	No[44]	12 months
Alternative for SLU/LLU for the other operators	VULA/ Layer 2 wholesale access service with handover at the CO/MDF	Layer 2 wholesale access service with local (CO/MDF) and regional handover	Layer 2 wholesale access service with handover at • at the SC (including uncontended backhaul from SC to CO) • at the CO/MDF and • at more central points in the network[45]	Layer 2 wholesale access service with approx. 900 handovers at Metro PoP locations (for the interim period until the end of 2015 a layer 3 service with 73 PoHs is sufficient)

Source: BEREC

[44] See footnote 18
[45] See footnote 20

Table 5: Conditions for refusal of first time SLU/LLU – part 2

MS	Austria	Belgium	Denmark	Germany
Provision of information to other operators	SMP operator publishes a list of SCs/COs • where it already deploys vectoring or • plans to implement vectoring within 16 weeks (only SCs)	SMP operator has to provide a list of SCs/COs • where vectoring is already used or • that migrate to vectoring 6 months beforehand and also additional information (see section 4.3.4)	SMP operator has to publish a list of SCs • where it already deploys vectoring or • plans to implement vectoring within 6 or 18 months[46] and also additional information (see section 4.3.4)	A vectoring register[47] provides the information • where the SMP operator already has implemented vectoring and • where it plans to implement vectoring, if an ANO registers its plan to implement vectoring and the plans collide • If an ANO requests SLU-collocation the SMP operator has – before granting collocation – to inform the ANO about a registered implementation or registered implementation plans for vectoring. Otherwise there is no right of refusal of first time SLU.
Consequences if conditions are not fulfilled	VULA has to be offered with lower prices (same as SLU)	SLU/LLU obligation can be re-imposed if vectoring is not implemented according to plan	SMP operator has to pay compensation to the ANOs until vectoring at SC is realised. Vectoring cannot be cancelled.	• SMP operator has to pay a contractual penalty (only if applications of ANOs to the vectoring register had to be declined) • SMP operator is barred from new registrations in the vectoring register for a certain time

Source: BEREC

[46] See footnote 22

[47] The register is kept by the SMP operator and based on the principle of Chinese walls and monitored by the NRA. It is operational since of 31/7/2014. Within the first month of operation more than 30 operators filed registrations for around 1000 local telephone networks relating to more than 40 000 street cabinets.

Table 6: Conditions for termination of existing SLU/LLU

MS	Austria	Belgium	Denmark	Germany
Termination of existing SLU/LLU possible?	No	Not relevant (no SLU, no LLU VDSL2)	SLU: Yes	SLU: Yes
Differences compared to the conditions for refusal of first time SLU/LLU	N/A	N/A	In addition the following conditions apply: SMP operator has • to migrate the affected unbundled sub-loops of the ANOs to VULA • pay for the migration and • compensate stranded investments made by ANOs	In addition the following conditions apply: In a certain region (defined by a local area code), the SMP operator needs to have developed more SCs with vectoring than an ANO with VDSL2 or vectoring and at least 75% of the buildings connected to the SC in question are connected to a second fixed telecommuni-cations infrastructure (e.g. cable). The SMP operator has to • provide to the affected ANO the layer 2 access service at the relevant SC. • provide the layer 2 access service with a special charge determined in BNetzA's decision.[48] • announce the termination at least one year in advance • has to bear its own migration costs. There are a few 'counter exceptions' [49]

Source: BEREC

[48] Adequate to the charge for SLU plus electricity and operational costs, but not including further costs of the concentration network or the DSLAM

[49] The SMP operator cannot terminate the access to street cabinets that have been developed with state aid funds. The other cases cover grandfathered rights.