TITLE **Adding "shaped PSDs" capabilities to VDSL2/Cab between full 0 to 2.2 MHz band.**

PROJECTS VDSL2, studypoint SP14

SOURCE: KPN, TNO

SUPPORT: <invited to co-sign this>

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STATUS for Decision

ABSTRACT VDSL/Cab will disturb ADSL2+/Ex when both systems are deployed in the same cable. If VDSL2/Cab will not be equipped with PSD shaping over the full band between 0 to 2.2 MHz, then the national access rules may turn out to be so restrictive that a commercial exploitation of VDSL/Cab will have lost most of its attractiveness. This contribution proposes a solution.

1. The business needs for VDSL2/Cab coexisting with ADSL2+/Ex

To make the next step in offering more bitrate to customers, operators are considering one (or more) of the following solutions:

- **ADSL2+/Ex** (ADSL2+ from the exchange)
- **VDSL2/Ex** (VDSL2 from the exchange, or FTTEx-VDSL2)
- **VDSL2/Cab** (VDSL2 from the cabinet, or FTTCab-VDSL2).
- **VDSL/Ex** (VDSL "1" from the exchange, or FTTEx-VDSL)
- **VDSL/Cab** (VDSL "1" from the cabinet, or FTTCab-VDSL).

VDSL/Cab will disturb ADSL2+/Ex when both systems are deployed in the same cable. Under some conditions the maximum bitrate of ADSL2+/Ex may even be reduced down to the maximum values that can be obtained with "legacy" ADSL as soon as VDSL/Cab is deployed.
Today, the business demand for deploying ADSL2+/Ex is significant. The deployment of ADSL2+/Ex is already announced in several countries, while it is subject of debate in other countries (such as the Netherlands) to allow ADSL2+/Ex in the access network. It is expected that sooner or later ADSL2+/Ex is deployed in many countries. This makes that VDSL/Cab will be seen as a "new" technology disturbing an "existing" technology (ADSL2+/Ex), and not the other way round.

What makes ADSL2+/Ex so booming?
What we observe in the Netherlands (and may hold for other countries as well) is that different competitive operators are selecting different technologies to bring higher bitrates to their customers. This is because a technology that may be optimal from a technical point of view (such as VDSL that maximizes the coverage of customers and total capacity) may not be optimal from a business point of view (maximizing revenues by reducing investments).
Large operators, covering 90% of the potential customers, have the ability to earn back the investments required for deployment from cabinets to offer 10 Mb/s or more. Smaller operators however may not be able to earn back these investments and therefore aim for deployment from the central office – even when this means that many customers in a country cannot be served with 10 Mb/s or more from that location. This may explain why many (smaller) operators have a strong preference for ADSL2+/Ex based solutions and why only a few (bigger) operators are seriously

considering VDSL/Cab. (In addition, ADSL2+/Ex has attractive aspects for bigger operators as well, but this holds mainly for "short" loops.)
Whatever the true reason may be, it is a fact of life that VDSL/Cab is seen as a disturbing technology. If the specifications of VDSL2/Cab do not anticipate well on this, then the result may be that many national access rules become so restrictive for VDSL2/Cab that the commercial exploitation of VDSL/Cab has lost most of its attractiveness.

Current situation in the Netherlands
The current set of (mandatory) access rules in the Netherlands do not allow to make use of spectra above 1.1 MHz, but an extension of these access rules is foreseen. To avoid delay in commercial roll-out of ADSL2+/Ex and VDSL/Cab, the competing operators in the Netherlands (CLECs + ILEC) have decided to start experiments in 2005 on using the band above 1.1 MHz with all the afore mentioned products. The results of the experiments will influence what future deployment above 1.1 MHz will be allowed.
To minimize the negative impact of such a mix, several restrictive access rules are already being considered in the Netherlands as candidate for extending the current set of access rules:

A. *Physical domain separation*. This option is equivalent to prevent the deployment of VDSL/Cab from (many) cabinets that are within "x" kilometre from the exchange. In other words, this approach will prevent coexistence of VDSL/Cab and ADSL/Ex in the same cable, and thus puts mainly a limit to the application of VDSL/Cab.
B. *Spectral domain separation.* This option is equivalent to prevent VDSL/Cab from transmitting frequencies below 2.2 MHz. This approach reduces the maximum bitrate of VDSL, and thus its attractiveness.
C. *Power shaping of spectra.* This option is equivalent to modify the transmit spectra of VDSL/Cab, since ADSL/Ex suffers mainly from VDSL/Cab and not the way round.

It is obvious that option A and B will restrict the commercial exploitation of VDSL/Cab significantly, and this should be avoided. Option C is the most promising one, but is more sophisticated and requires a change of VDSL2/Cab.

Conclusion
We believe that the Dutch situation is not unique, and may hold for many other countries.

To prevent that restrictive national access rules will block a useful deployment of VDSL2/Cab, it is essential to extend the functional requirements of VDSL2 with the shaping capabilities, as proposed in this contribution.

2. The solution for VDSL from the cabinet

The request of changing the spectra of VDSL2/Cab, compared to VDSL1/Cab, has been addressed before in ETSI-TM6:

A. In [1] Telecom Italia proposes to leave the full band between 138 kHz and 2.2.MHz unused for VDSL, to enable the coexistence of VDSL2 from the cabinet and ADSL2+ from the exchange. A similar request was raised in 2003 by Broadcom [2]. However, such a measure will cause a significant reduction of the VDSL performance in terms of bitrate and/or reach.
B. In [3] Swisscom proposes to add flexibility to VDSL2 for enabling VDSL2/Cab to use frequencies below 1.1 MHz (in the ADSL downstream band). Their studies showed a potential increase of about 10Mb/s in downstream direction when applying this band. However, such a measure may cause a significant change of existing VDSL/Cab implementations. See VDSL2 study point SP14 [4].

We believe that proposal A is too drastic since the loss of capacity is too significant. A modified variant, where the power between 1.1 MHz and 2.2 MHz is reduced ("shaped"), is preferred. Such a modification can reduce the loss of capacity while coexistence is facilitated as well.
In addition, we believe that proposal B is an essential addition to compensate for the above-mentioned loss in capacity, and should be combined with A.

We propose to change the functional requirements of VDSL2/Cab by the following enhancements:

PSD shaping from 0 to 2.2 MHz:

- Append an option for spectral shaping between 1.1 MHz and 2.2 MHz to enable a frequency dependent reduction of transmit power. This enables coexistance with ADSL2+/Ex (when the shape is well-chosen), at the cost of capacity.
- Enable the use of additional transmit frequencies, between 0 (138 kHz) to 1.1 MHz. This enables a compensation of above loss in capacity, without unfair disturbance of systems from the exchange (when the shape is well-chosen).
- Make the shape programmable during installation (from the management system) since the "optimal" shape is different for different cabinets (location, cable characteristics, national regulations, etc).

It is essential that these shapes are *programmable* so that **VDSL2/Cab** is suitable for all countries, including those who (a) forbid the use between 0-2.2 MHz, (b) only forbid the use between 0-1.1MHz or (c) allow adequate shaping of all frequencies below 2.2 MHz.

2.1. How could these shapes look like?

The characteristics of an "optimal shape" are subject of debate. There are different options for "optimal", including:

- *Zero impact*: "Optimal" could be that the impact of a VDSL2/Cab disturber to an ADSL2+/Ex victim is zero.
- *Equal disturbance*: "Optimal" could be that the impact of a VDSL2/Cab disturber to an ADSL2+/Ex victim is equal to the performance degradation cause by a neighbour ADSL2/Ex disturber
- *Equal pain*: "Optimal" could be that the loss in bitrate for VDSL2/Cab and ADSL2+/Ex is equal when VDSL2/Cab capacity is reduced to favour ADSL2+/Ex.
- …????....

We believe that the first "definition" is discriminating VDSL/Cab in an unfair way, because all other xDSL systems (legacy and ADSL2+/Ex) are allowed to disturb ADSL2+/Ex to some extent.
We believe that the second "definition" should be the least disturbance that is allowed for VDSL2/Cab. For instance, if N customers are connected to the same cable, and one of them changes from an ADSL2+/Ex operator to a VDSL2/Cab operator, then the principle of "equal disturbance" causes that all the others will not notice any difference in performance.

Generic concept:

To achieve "*equal disturbance*" in the cabinet, it is sufficient to apply an "*equal PSD*" approach. This means that the PSD shape of VDSL2/Cab is equal to the PSD shape of ADSL2+/Ex, attenuated by the cable loss between exchange and cabinet.
Figure 1 shows the generic concept of this approach. The solid (blue) curve represents the non-boosted PSD of VDSL/Cab, as it has been defined in the current VDSL1 standard. The dotted (red) curve represents a potential PSD shape of VDSL2/Cab when the cabinet is located on 2 km distance from the local exchange.

- The PSD curve up to 1.7 MHz equals that of a ADSL2+/Ex signal, when it passes the cabinet.
- Above 1.7 MHz, the attenuated PSD of ADSL2+/Ex has become lower then -100 dBm/Hz, and is unable to use the remaining capacity. (One can argue about the precise level, but even when it should be -110 dBm/Hz or so, the principle remains the same). As a result, the VDSL2/Cab PSD can revive up to its original value, since it does not disturb ADSL2+/Ex anymore.
- VDSL2/Cab will lose capacity due reduction of its PSD level between 0.9 MHz and 1.7 MHz will cost capacity, however the usage of signal between 0.15 MHz and 0.9 MHz may compensate for this. The result is that VDSL2/Cab can coexist with ADSL2+/Ex in the same cable, at a minimum of performance loss.

Of course, other shapes may do a similar or even better job, but the curve in figure 1 is illustrative of how the shaped PSD may look like.

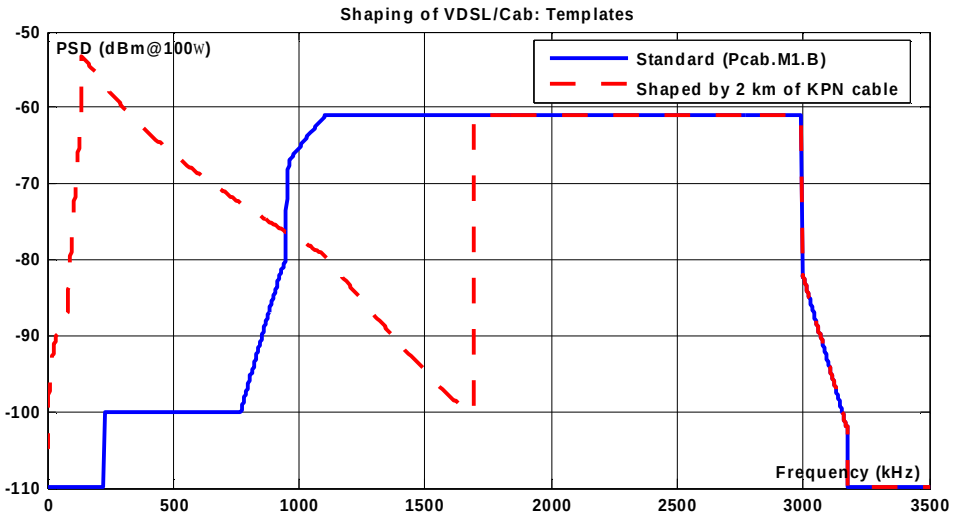

Figure 1: Generic concept of PSD shaping of VDSL2/Cab over the full band between 0 to 2.2MHz

Length dependency of the concept:
A shape that facilitates "*equal disturbance*" will be dependent on the distance between cabinet and local exchange. Figure 2 illustrates how the PSD shape could look like when VDSL2/Cab is deployed from "near" cabinets (1 km from local exchange) and "far" cabinets (4 km from local exchange).

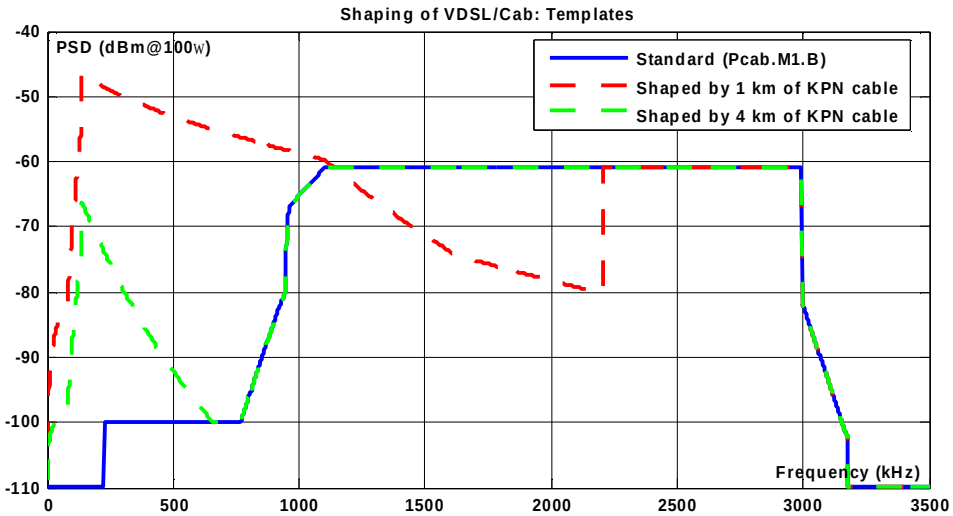

Figure 2: Length dependency of PSD shaping of VDSL2/Cab. Examples for 'near' cabinets (1 km) and 'far' cabinets (4 km)

The ability of fully programmable shapes for DMT carrier 1 to 511, may be too flexible for the operational practice. A restriction that could be considered is to identify a fixed number of predefined shapes. The shapes are then based on a hypothetical frequency dependent curve for cable loss, parameterized by their loss at 300 kHz. Predefined shape "1" to "20" could then mean 3, 6, 9, 12, .. to 60 dB at 300 kHz. The need for such a restriction is left for further study.

3. Proposal

VDSL2 (FTTCab only) shall have an optional capability that DMT carrier 1 to 511 have programmable power levels, that can be controlled (preferably from the management system) during installation.

- The maximum power of these programmable tones is <**TBD**> (for instance the ADSL2+ spectrum, attenuated by 500m cable).
- The minimum power of these programmable tones is <**TBD**> (for instance –100 dBm/Hz).
- The maximum aggregate power to enable this equals <**TBD**> (a value of 14 dBm seams to be adequate).

The exact settings of these tone levels are cabinet specific, and the domain of regional regulations.

NOTE a pragmatic reduction of above flexibility could be the definition of 15-25 predefined shapes, evaluated for a hypothetical cable curve, and the associated loss of that hypothetical cable at 300 kHz, in steps of for instance 3 dB. This is left for further study.

4. References

[1] **044t22**: *Proposal for a FTTCab VDSL2 mask applicable in networks where ADSL2+ from the Exchange is deployed*; Flavio Marigliano and Rosaria Persico; Telecom Italia, ETSI-TM6 meeting, Sophia Antipolis, nov 2004

[2] **031t26**: *VDSL from the Cabinet must not impact on ADSL2PLUS performances* Olivier van de Wiel, Broadcom Corp, TM6 meeting, Sophia Antipolis, march 2003

[3] **044t27**: *Analysis of modified downstream PSDs for FTTCab;* Andreas Thöny and Philippe Repond, Swisscom, ETSI-TM6 meeting, Sophia Antipolis, nov 2004

[4] Study point **SP14** of VDSL2: *FTTCab masks for compatibility with ADSL*