Migration Strategy from Legacy to Next Generation Access Network (NGAN) in Brownfield Areas

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Abstract—, The purpose of this paper is to assist planners and designers of incumbent telecommunications operators for the selection of appropriate access technologies for migration from legacy copper network to PON (Passive Optical Network) in brown field areas. The selection will take into consideration required bandwidth to run broadband services such as fast internet, VoIP, IPTV, TVHD, VoD, videoconferencing, telemedicine, online gaming, e-commerce, e-business, e-learning. A number of options are discussed, showing how incumbents' operators can overcome severe issues they are facing such as:

- Existing secondary copper direct buried (not ducted to pull in new fiber).
- Backhaul bandwidth Limitation (SDH based transport layer),
- Co-existence of TDM voice (V5.2) and VoIP within the same network
- Rude telecom market competition (new fixed operators deploy FTTh in Brownfield area)

1. Introduction

In Saudi Arabia cities are growing horizontally and very fast. The expansion in the horizontal direction rather than vertical has a direct impact on the length and cost of the local loop and renders difficult to fulfill broadband demand requirements in several areas. To overcome these issues Multi-Services Access Node (MSANs) are often deployed in the main cities in a ring or point to point topology. Figure 1 shows how customers (below and beyond 5dB) are served. Although MSAN can provide ADSL2+ (speed up to ~25Mbps) it will fail to fulfill the current market demand forecast (>40Mbps) [1]. A large number of customers beyond the xDSL reach are not able to get broadband services to run applications hungry in bandwidth such as multi-channel high definition TV (HDTV), IPTV, Video on Demand (VoD), videoconferencing, online gaming, and VoIP. This situation is mainly linked to the length of the copper wires from the active node to the customer. To meet these requirements in Brownfield, network operators need to rethink and reorganize the design of their access network. Several options are available. Mini MSAN, IP-DSLAM with VDSL services associated with fiber to the cabinet seem to be a promising besides FTTh which is undeniably considered today as the right technology for Greenfield [2]. However in Brownfield areas, the incumbent telecom operator's strategy recommend continue using existing copper network and plan for gradual migration toward FTTh. For that they need reconditioning their access network.

Shortening the last mile from, the Cross Connect Cabinet "CCC" to less than five hundred (500) meters will allow use of VDSL2 and will easily support rates up to 100Mbps per customer.

The purpose of this paper is sharing our vision about migration from legacy to Next Generation Access Network (NGAN). We will discuss all possible options/alternatives in terms of complexity; cost (CAPEX and OPEX) and return of investment (ROI), as well as the recommended solution supported with valuable Lab and Field trials results.

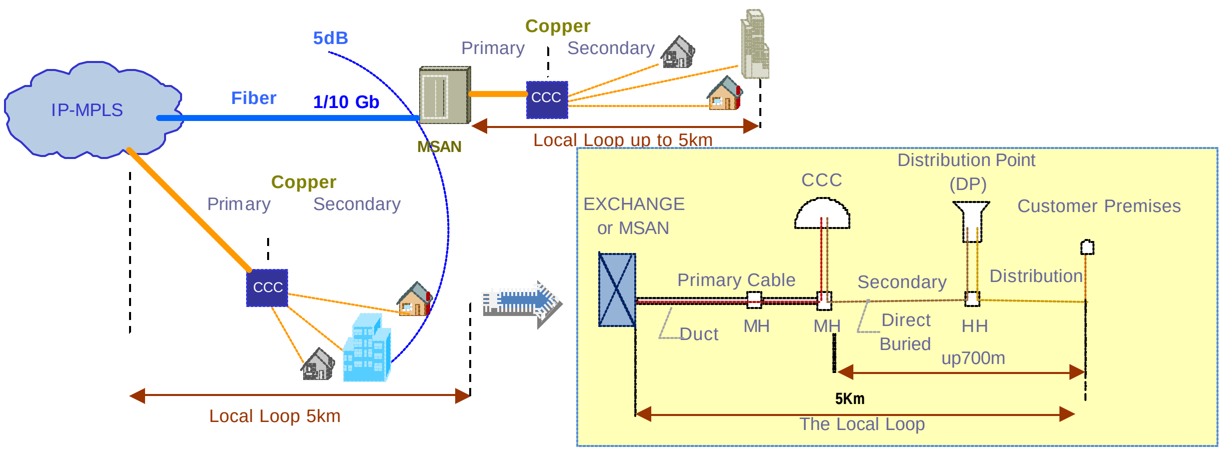

Figure 1: Current Copper and FTTc access network architecture

2. Migration Considerations

The migration from existing access network to NGAN is expected to solve two major issues:

1. Overcome the drawbacks of existing access network to support a minimum of 40 Mbps per customer
2. Furthermore to that requirement, the migration option has to be flexible, scalable and cost effective.

To do so migration consideration has to be taken to:

- Shorten the copper local loop length to few hundred of meters from the cabinet to the customer premise,
- Reuse the existing infrastructure such as the primary ducts, and secondary copper,
- Digging new trenches not allowed except for business and key account customers (if required)

- New infrastructure shall satisfy current and future market demand and allow smooth migration to pure FTTh in the next phase (with pay as you grow concept).

3. The proposed Approach

The Cross Connect Cabinets are disseminated within the “HAYY” (or quarter) on a customer density basis. The area served from one CCC called “SUB-HAYY” (or “sector” resulting from the HAYY segmentation into smaller areas almost 500mx500m in size).

The primary cable usually consists of around 1200 pairs copper from the exchange, split between 3 binders of 600 pairs cables ducted up to each CCC. The secondary portion of the access network is about 500m of buried copper cable.

The new approach consists to pull new 96/144 fiber cables within the existing primary duct. Each fiber cable will be split (at a splicing point) in a number of 12/24 fibers cables connected to a Fiber Distribution Terminal (FDT) located near the CCC. The feeder is then ready for future FTTh deployment. Each strand of fiber will be terminated at one end at the Optical Line Terminal in the Central Office (CO) and at the other at an active node as depicted in figure 2.

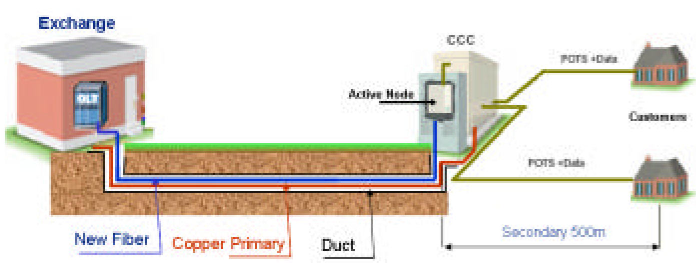

Figure 2: VDSL over PON from the copper cabinet

3.1 The Active Node

The active node hosts the newly standardized VDLS2 to enable very high speed internet access of up to 100Mbps and to interface to next generation networks. There are several possible options for the active node: *Hardened IP-DSLAMs*, Mini- *MSANs, Ethernet switches, and Outdoor Multi-Dwelling Units (MDUs).* To avoid point to point connections, and eventually reduce cost Mini MSANs and Hardened IP DSLAM can be backhauled via CWDM transport techniques.

Option 1: Hardened IP-DSLAM

The hardened IP DSLAM can be uplinked to the existing Ethernet switch Aggregator at the CO via GE backhauling interfaces (up to 4x1GE, 2GE Uplink/2GE Downlink) [3, 4]. Voice calls can be TDM or VoIP standard. The second option (VoIP) requires a Voice Access

Gateway (VAG) as an interface to the Class 5 switch if NGN service (Softswitch / IMS) not yet available in the core *network*. This *solution consumes fibers, ODFs (Optical Distribution Frame) and space at the CO.*

Option2: Mini- MSAN

This option is similar to the IP-DSLAM option. Further to VDSL2 cards the mini MSAN can host (if needed) traditional services such as (POTS, ADSL, G.SHDSL, Leased Lines…). The uplink can support currently up to 4x1 GE .

Option 3 Hybrid Solution using an Ethernet switch

An Ethernet switch which provides gateway function between the fiber-based GPON access network and the copper-based access network (IP-DSLAM). With its 2.48 GPON uplink and 4x1GE port downlink aggregates the end-user traffic on the fiber-based GPON uplink. This solution will save 75% of fiber, ODFs and space at the CO.

Option 4: Outdoor Multi-Dwelling Unit (MDU)

The MDU is an Optical Network Terminal (ONT) GPON uplink interface which host VDSL2 cards. Existing products support 24, 36 or 48 VDSL2 ports. Four MDUs can therefore share one fiber strand using 1:4 splitters to provide a guaranteed 30Mbps.

3.2 Business Study

The business model consists of an area with eleven (11) 600 pairs CCC to serve VDSL2 with a penetration rate range of 25%, 50%, and 70%. We planned providing a minimum of 40 Mbps per customer with the ability to increase the rate up to 100 Mbps on simple demand basis (provisioning) without any new hardware requirement or delay. We used three (3) feeders 2x96 fiber cables and 144 fiber cable laid within the existing primary duct. Three splicing points are located at manholes MH_2, MH_5, MH_{12} (see figure 3) [5]. These locations are supposed to be at the optimal distance to the served cabinets (CCC). The distribution of fiber cable (from splicing point to the FDT) can have different sizes 12/24 or 36 strands depending on the number and type of customers (residential or business) and eventually on expected bandwidth requirements and growth of demand. Here we used 24 fibers per cabinet, four (4) fibers are used for the current upgrade, two to four (2 to 4) to serve point to point FTTh for key account customers (Key Account Customers are served immediately by FTTh using micro trench technique). The remaining strands are spares available for future upgrade to FTTh for the whole area. The cost per port is less than 600$ including the inside plant (OLT, GPON card, uplink, ODF, patch cord,…**)**, FDTs, fibers, splicing, pulling, and the active node (MDU). Compared to current MSAN deployment which costs 930$ (12Mbps max) the new approach generates a saving of 330$ per line. Furthermore to that cutover is not required and some of released twisted pairs in the primary can be reused for remote powering (from the exchange) of the MDU.

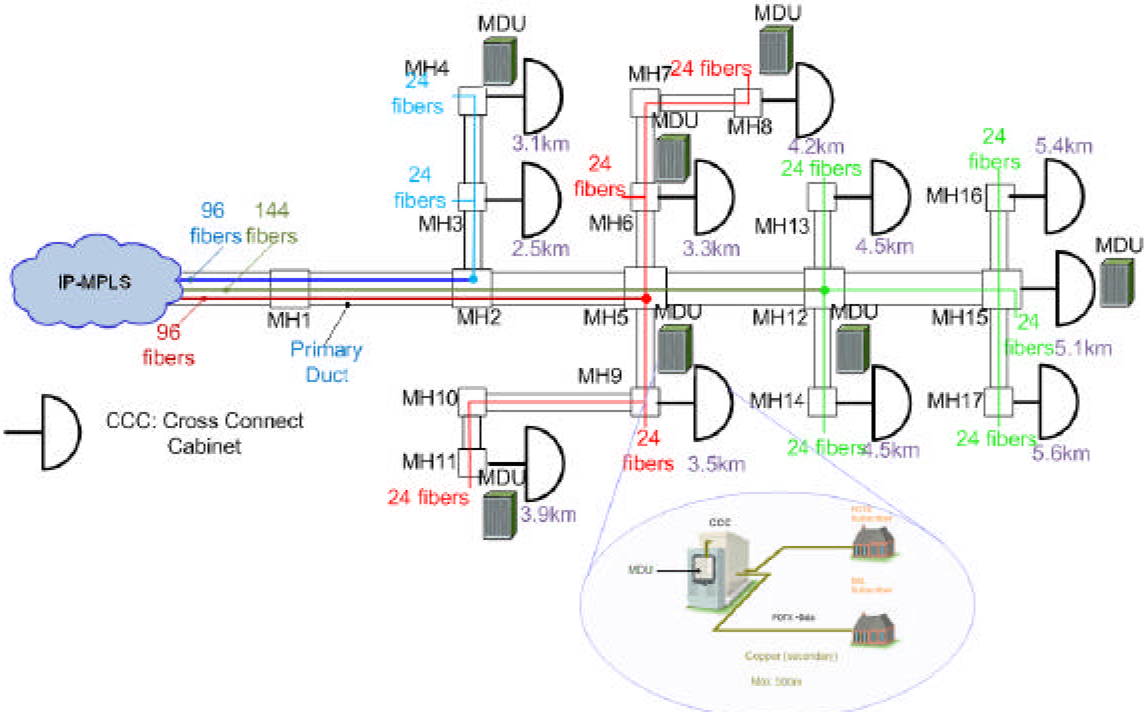

Figure 3: Business Model - MDUs at the copper cabinet

4. Lab Trial

The trial encompasses two VDSL2 products (from *Vendor* $_1$ and *Vendor* $_2$): the first one using indoor MSAN cabinet and the second via indoor IP DSLAM. The rate vs. distance performance test was performed using a traffic generator and line simulator as depicted in the trial setup paragraph. The cables cage was 24 and 26 (0.5 and 0.4mm). A "drum" of copper cable AWG 24 (0.5 mm) providing different lengths (250 - 1500m) was also used during the tests.

Since it is expected to deliver VDSL2 services to customers either around the Central Office (CO) or served from remote cabinet (outdoor MSAN or Hardened IP-DSLAM) we used to test two profile 17.a (Remote Nodes) and profile 8.b (from the exchange).
The profile (17.a) frequency is mostly deployed from a remote cabinet over short distances. MDUs also application involves short distances, and the transmit power is kept to a lower 14.5 dBm, whereas Profiles 8.b fits mostly in the CO application. Since these environments may incorporate longer reaches in presence of crosstalk from legacy systems, the downstream transmit power can go up to 20 dBm.

4.1 Lab Trial Set-up

A Traffic Generator was used for generating traffic to the MSAN (downstream direction) and to the CPE (sending stream in the upstream direction) such that (see figure 4):

- Port 1 of EXFO FTB-200 was directly connected to electrical Port 0/4 of CXU card of MSAN/ IP-DSLAM (1GE uplink).

- Port 2 of EXFO FTB-200 was directly connected to the CPE LAN port (VDSL V-4016A modem) installed at the end of the loop.
- The subscriber local loop and CPE were simulated using a Dresden Elektronik Line Simulator VDSL LS20 different ranges from 0 to 1500 meters can be inserted and a VDSL V-4016 modem.

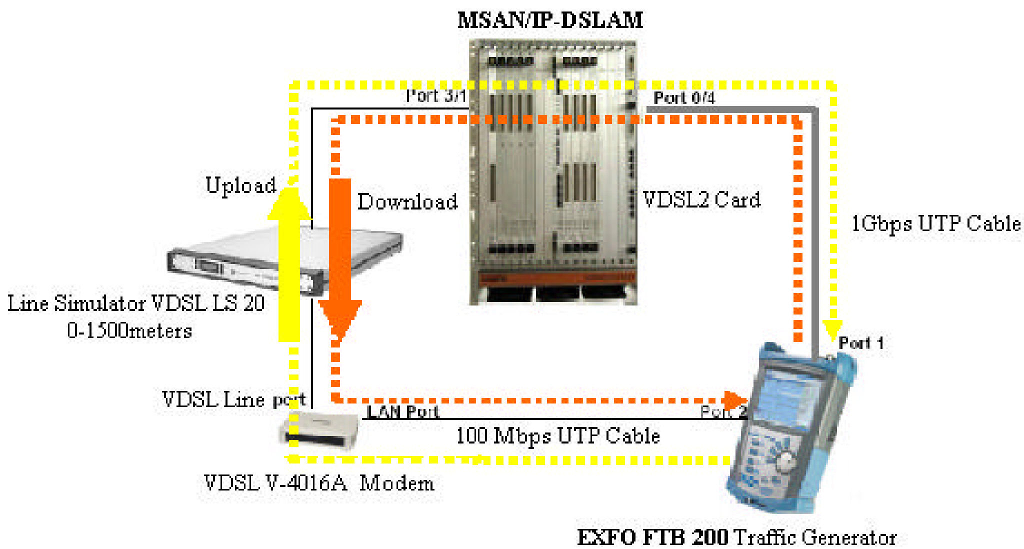

Figure 4: VDSL 2 Lab trial setup

4.2 Lab Trial Results

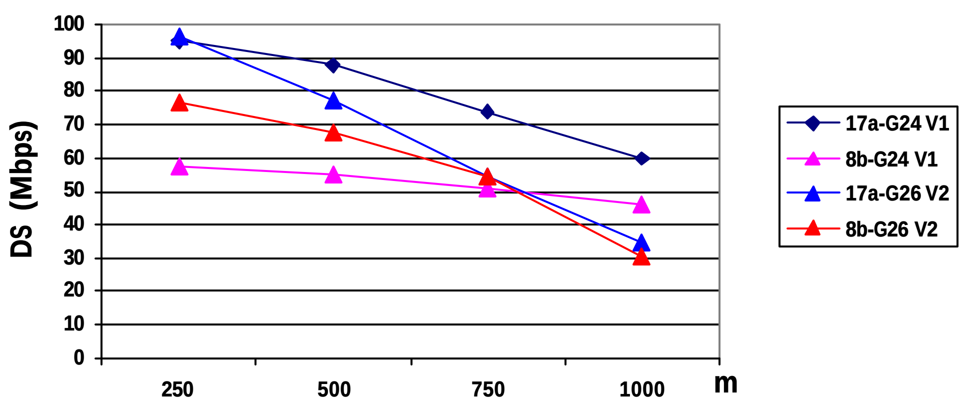

Figure 5: VDSL2 Rate vs Distance for 2 vendors (V1, V2)

It is easy to see from figure 5 that 50Mbps can be easily provided for customers located around the CCC at nearly 750m.

5. Field trial

The ITU – T G.993.2 standard specifies eight (8) different implementation VDSL2 profiles providing different upstream and downstream rates based on DSLAM location either at the CO, or at remote sites (remote nodes) such as remote cabinets or customer premises (multi-dwelling unit). See Table 5 [6]. It allows vendors to limit implementation complexity and develop implementations that target specific service requirements.

Profile	Max. DS Power (dB)	Max. DS Freq. (MHz)	Max. US Power (dB)	Max. US Freq. (MHz)	Typical Application
8a	17.5	8.5	14.5	5.2	RN
8b	20.5	8.5	14.5	5.2	CO+RN
8c	11.5	8.5	14.5	5.2	CO
8d	14.5	8.5	14.5	5.2	CO
12a	14.5	8.5	14.5	12	CO+RN
12b	14.5	8.5	14.5	12	CO+RN
17a	14.5	17.664	14.5	12	RN
30a	14.5	18.1	14.5	30	MU

Table 1: VDSL2 profiles (RN; Remote Node)

In our case we used a remote IPDSLAM and tested profile 17a only. Figure 6 gives the rate vs. reach performance for copper Gauge 26 (0.4mm). Customers within the range of 800m from the CCC can get almost 50Mbps.

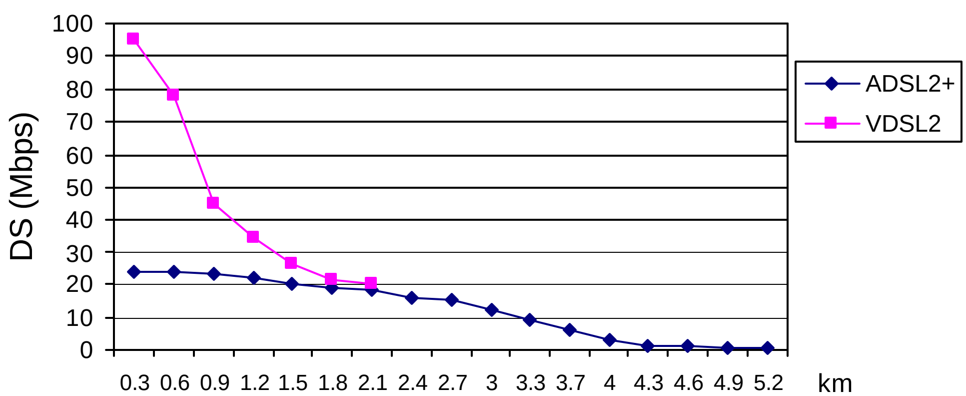

Figure 6: VDSL2 Rate vs Distance performance

6. Prospective Solution (MSAN + MDU)

The growing competition and extreme demand for broadband services compel incumbent operators to sustain the existing infrastructure to provide as fast as possible broadband services in populated areas. A potential solution consists to install small size IP-DSLAM (or MDU: 12, 24, 36 VDSL2 ports) close to the CCC as a complementary solution to the MSAN to fulfill scattered high bandwidth demand (see figure 7). The incumbent should track the increase of broadband demand among customers served from a single MSAN to choose the right moment to "switch" definitely from legacy to FTTh. This stage is very critical to face competition, and to maintain the market leadership as a driver not a follower.

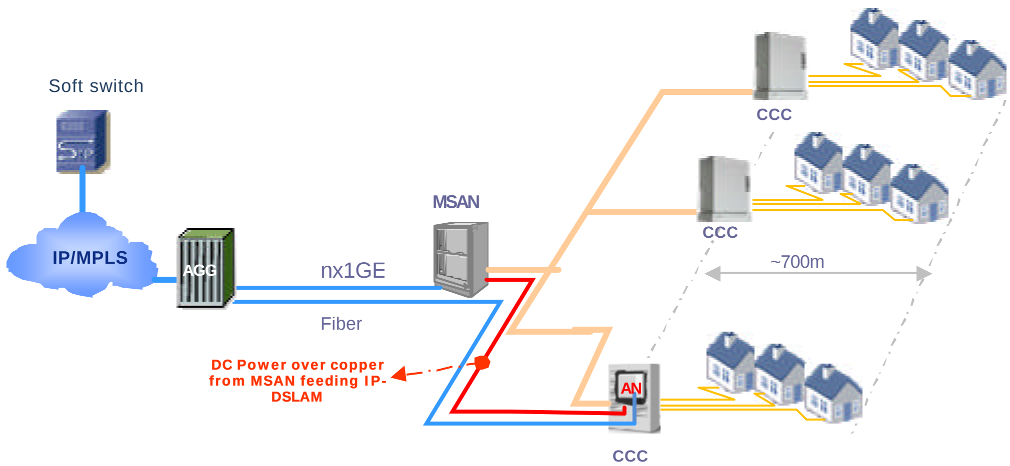

Figure 7: Mixed solution MSAN + Active Node (AN)

7. Conclusion

To provide high data rates, FTTh is undeniably the appropriate technology for Greenfield situations. In Brownfield areas issues related to lack of regulation, high CapEx (digging new trenches and pulling new fibers in the secondary) and time consuming activities compel incumbent operator's network planners and designers to remodel their network for gradual migration to NGAN – FTTh via hybrid solution (FTTc). The proposed solution reuses optimally the existing infrastructure by pulling new fiber within the existing primary ducts and installing whenever it is required small size active node nearby the cross connect cabinet and reuse of the secondary copper loop to serve customer with VDSL 2 services. It is flexible, scalable to fulfill future growth demand, cost effective (pay as you grow) and easily supports triple play services: VoIP, IPTV, and Data with bit rate up to 100Mbps. This concept should not be implemented systematically near to each CCC in the loop (time, cutover, CapEx and OpEx will be extremely high). Therefore attention should be made to this issue and any step toward FTTh must be justified economically. Business study is the best way to make the decision either to go immediately or gradually FTTh in brownfield areas.

References

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