WIRELINE MOBILE BACKHAUL FOR METRO CELLS

LEVERAGING GPON AND VDSL2 FIXED BROADBAND ACCESS FOR METRO CELL BACKHAUL

APPLICATION NOTE

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ABSTRACT

A new role is emerging for wireline operators who are prepared to leverage their fixed broadband access network to provide wireline mobile backhaul. Explosive growth both in the number of wireless subscribers and bandwidth consumed poses a tremendous challenge to mobile network operators (MNOs). By deploying small cells in dense urban areas, MNOs hope to relieve congestion on their macro cell sites while increasing network performance in critical areas. This widely accepted "metro cell" approach poses its own set of challenges not least of which is providing a backhaul connection to the growing number of small cell sites.

For wireline operators, this shift in wireless deployment models provides an opportunity. With the number of cell sites drastically increasing, MNOs will be looking to fixed access for answers to the mobile backhaul challenge. This paper explores the role of fixed broadband assets in meeting the emerging demands of metro cell backhaul.

FIXED BROADBAND MEETS THE CHALLENGE

Using fixed broadband assets for mobile backhaul is not a new concept. In fact, GPON, VDSL2 and SHDSL have been used for macro cell backhaul for years. In this case, operators faced a number of challenges including increased bandwidth demand and the need to migrate from TDM to IP backhaul while increasing capacity.

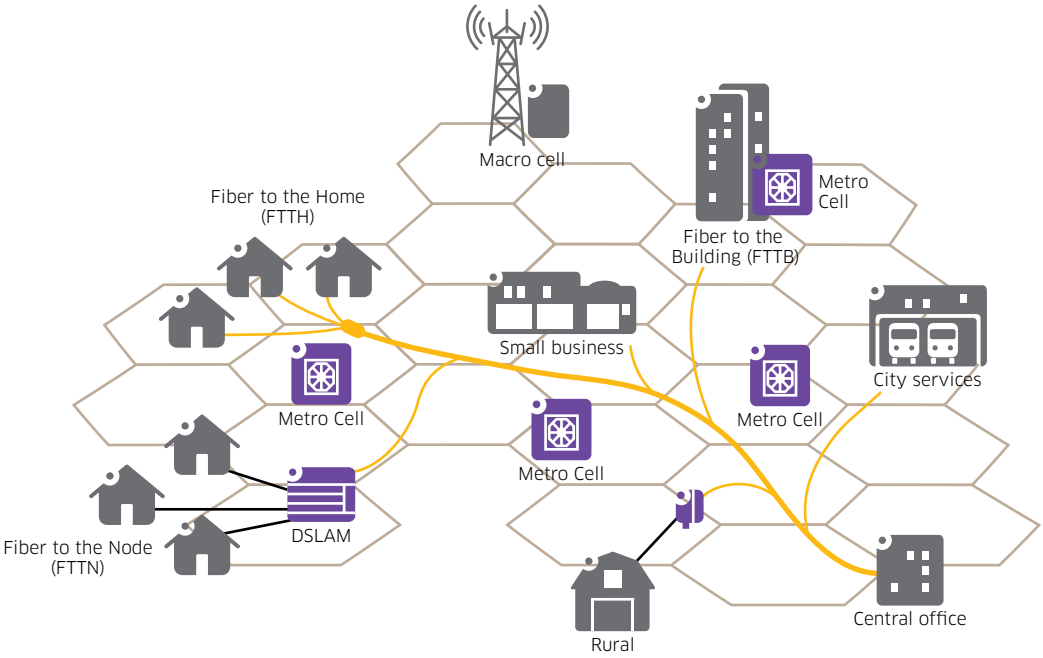
However, metro cell backhaul has its own unique set of challenges that operators must tackle if they intend to enjoy the additional benefits to be gained from metro radio. With metro cells, operators need:

- Increased scale to support more (potentially tens of thousands) cell sites at higher capacities
- Flexibility to deliver any mobile service over any access technology
- Simplified deployment and operations to minimize total cost of ownership (TCO)

As MNOs struggle to meet these new backhaul demands, they will increasingly look to backhaul alternatives — including packet microwave, Carrier Ethernet and fixed broadband access — for answers. Fixed broadband access networks are ideally suited for metro cell backhaul due to their close proximity to those areas where wireless congestion and expansion occur. Current broadband access nodes already meet the bandwidth and QoS needs for video, voice and data. The stringent requirements that these services place on the access network greatly align with those for mobile backhaul and broadband business services. Thus, in the course of pursuing their own residential broadband service roll-outs, wireline operators have actually been deploying a wireline mobile backhaul-ready infrastructure with the requisite QoS and multiservice transport capabilities.

As Figure 1 illustrates, broadband access networks have evolved to provide reliable, high bandwidth, all IP/Ethernet access to residential, business, multi-dwelling unit and rural locations. With GPON and VDSL2 assets at their disposal in these locations, service providers can easily meet the needs of metro cell backhaul.

Figure 1. Fixed Broadband coverage



FIXED BROADBAND ACCESS ARCHITECTURES

Deploying fiber access

MNOs are not alone in feeling a bandwidth crunch. Wireline operators have been challenged with increasing demand for high-speed fixed broadband for many years. Today, two access technologies stand out with the promise of meeting service requirements now and in the future. Both options require an investment in fiber infrastructure.

- Fiber to the Home (FTTH) offers unlimited bandwidth potential and the operational benefits of an all-passive network when technologies like GPON are used. The advantages of an all-fiber network make FTTH an attractive architecture for wireline operators.
- Fiber to the Node (FTTN) utilizes VDSL2 to reuse the operator's existing copper infrastructure, usually in the final 1000 meters or less of the access network. By not trenching fiber to every home, operators are able to save time and money in comparison to FTTH while providing a competitive service to end users.

Wireline operators typically combine these deployment models based on their own unique business case taking into consideration their existing infrastructure, service offering, bandwidth targets, time-to-market and return-on-investment objectives.

IP/Ethernet access

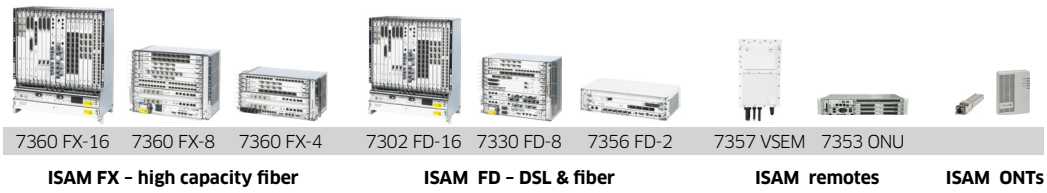
Alcatel-Lucent's access portfolio is built on the Intelligent Services Access Manager (ISAM) family of IP/Ethernet access nodes. The Alcatel-Lucent ISAM access portfolio offers high-density, premium broadband services for the most demanding wireline operators. Stringent mobile backhaul capabilities require an end-to-end solution that scales well; excels in availability, troubleshooting and monitoring tools; and offers advanced

SLAs. The ISAM delivers on all of these capabilities while providing a flexible mix of advanced access technologies such as VDSL2 with vectoring, GPON, 10G XG-PON1, and point-to-point fiber.

The diverse ISAM portfolio of access products (Figure 2) provides full flexibility for wireline operators to deploy the access technology mix that best fits their particular needs, including:

- **ISAM FX –** High capacity fiber applications with exceptional shelf capacity
- **ISAM FD –** Converged access supporting mixed fiber and copper
- **ISAM remotes –** Suite of small form factor remote nodes for FTTx deployments
- **ISAM ONT –** Broad portfolio of Optical Network Terminals (ONTs)

Figure 2. ISAM product family



LEVERAGING GPON FOR WIRELINE MOBILE BACKHAUL

GPON bandwidth

GPON networks support 2.5 Gb/s downstream and 1.25 Gb/s upstream. GPON bandwidth is shared by all subscribers connected to the same PON (usually a maximum of 32), although in practice take-rates lower than 100 percent usually lead to less sharing. Residential video drives bandwidth needs. In a worst-case scenario, every residential subscriber is simultaneously streaming multiple and unique high-definition video channels at about 10 Mb/s each. Assuming this scenario and a high video service take-rate, a rough calculation shows that about half (or more) of the downstream bandwidth is still available to serve multiple metro cell locations.

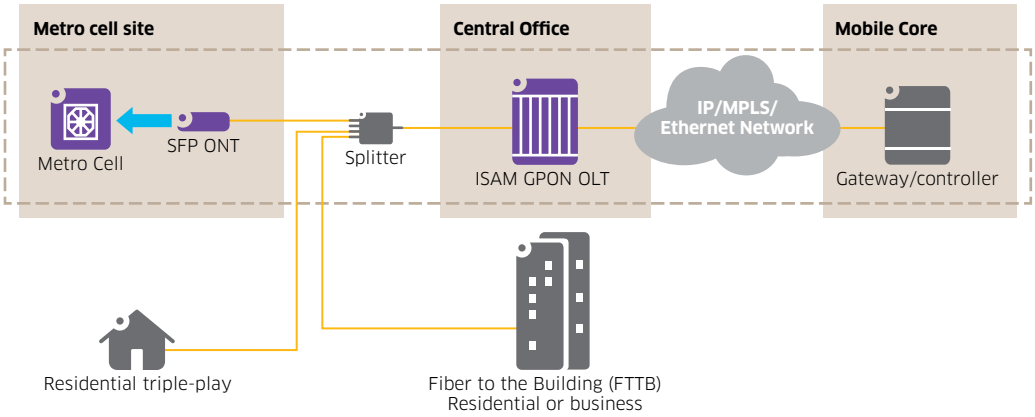
In the unlikely event that GPON bandwidth becomes scarce, the well-known PON engineering technique of reducing the fiber split ratio can decrease sharing and free up bandwidth for high-bandwidth users.

Alcatel-Lucent now also supports 10G XG-PON1 on the Alcatel-Lucent 7360 ISAM FX platform. Migration to 10G PON interfaces can provide an even fatter pipe on the same fiber network via a wavelength overlay. Consequently, from a bandwidth perspective, GPON represents a strategic long-term solution for any bandwidth-intensive service including metro cell backhaul.

Optical Line Terminals

Alcatel-Lucent 7360 ISAM FX shelves are high-capacity access shelves in the Alcatel-Lucent ISAM family of IP access products. The shelves address the need for mass-market, high-capacity fiber deployments. All 7360 ISAM-FX shelves are ready to support any future fiber-based access application, with full flexibility for mixing 10G XG-PON, EPON, GPON and point-to-point access technologies on the same platform. High-bandwidth service throughput is guaranteed by backplane technology that enables dual 100 Gb/s backplane connections to each line termination slot. As a result, operators are not locked into a certain fiber access technology or shelf density: they can choose to deploy different options based on techno-economics, local regulations or services offered.

Figure 3. GPON metro backhaul architecture



Optical Network Terminals

With GPON-based metro cell backhaul, MNOs need access to ONT options that fit the unique needs of the application. Already challenged with space and power restrictions, metro cell sites require low power, high bandwidth solutions that occupy the smallest possible footprint.

Alcatel-Lucent's extensive portfolio of ONTs includes models that are ideally suited for deployment in metro cell backhaul scenarios. These include indoor and outdoor ONTs engineered to support up to 1 Gb/s of sustained throughput to the end user.

The Alcatel-Lucent 7705 Service Aggregation Router (SAR) is optimized for multiservice adaptation, aggregation and routing. It comes in multiple form factors to suit different applications. The 7705 SAR-M is a compact and hardened variant that is ideally suited for business and mobile backhaul applications. The 7705 SAR-M makes the best use of operators' existing network access infrastructure by supporting a number of network interfaces including GPON and VDSL2. When equipped with a GPON module, the 7705 SAR-M supports a GPON uplink from any ISAM GPON line card. The 7705 SAR-W is a small form factor version that is designed to address metro cell backhaul requirements. In this case, GPON uplinks are supported with a Small form-factor pluggable (SFP) ONT.

The Alcatel-Lucent SFP ONT was specifically designed to address the critical issues for metro cell backhaul — space and power — and it is easy to deploy in virtually any environment. The SFP ONT provides a simple alternative to the traditional ONT, which would occupy additional space in a metro cell deployment. The SFP ONT is GPON standard compliant and supports Ethernet packet forwarding. Industrial temperature ranges are supported allowing it to be used both indoors and outdoors. Since the SFP ONT resides in an SFP cage in a host device, no additional power or cabling is required. The SFP ONT is part of the Alcatel-Lucent Wireline Mobile Backhaul solution and can be used in conjunction with several products, including the Alcatel-Lucent 9764 Metro Dock and 7705 SAR-W.

LEVERAGING VDSL2 FOR WIRELINE MOBILE BACKHAUL

VDSL2 bandwidth

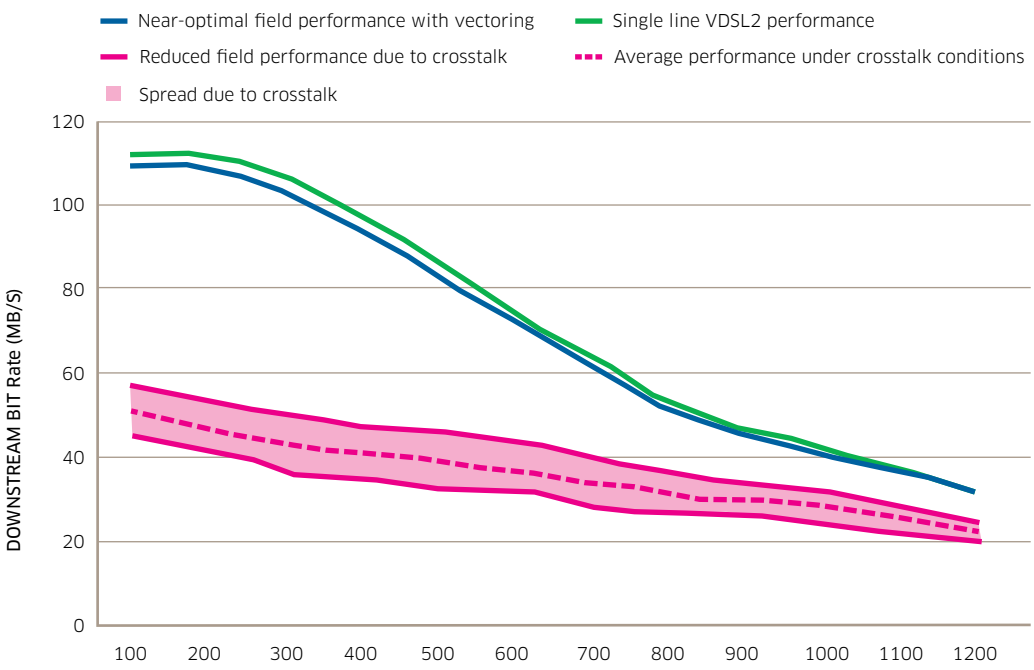
There are a number of DSL technologies available today including ADSL2 + , G.SHDSL.bis and VDSL2. Each of these technologies has a place in the network based on its unique attributes. ADSL2 + is the workhorse of high speed Internet today with a bandwidth limit of 25 Mb/s. G.SHDSL.bis is widely deployed for Ethernet in the first mile services for business applications. It offers symmetrical bandwidth up to 22 Mb/s over long distances using multi-pair bonding. In recent years, VDSL2 has gained mass adoption by fixed broadband access carriers for its ability to support triple play services with bandwidth exceeding 100 Mb/s in some cases. Of course a number of factors in the outside plant can make it difficult to achieve these numbers.

Due to its widespread adoption for the delivery of triple play services and continued innovation and attention in the industry, VDSL2 is the DSL technology to focus on for wireline mobile backhaul.

The bandwidth of DSL technologies, including VDSL2, is inversely related to distance, as typically indicated in rate-reach curves like the one show in Figure 4. Standard VDSL2 downstream rates are represented by the pink highlighted band, which shows down-stream performance of approximately 40 Mb/s at 400 m and 30 Mb/s at 1000 m. While these numbers are effective for delivering triple play services, they are nowhere near the 100 Mb/s that VDSL2 promises. This is where VDSL2 vectoring comes into play.

VDSL2 vectoring drastically improves VDSL2 performance by canceling interference between copper lines in a cable. This “crosstalk” is one of the most significant factors limiting the achievable bit rate. In a dynamic process, vectoring continually measures and cancels crosstalk, so that all lines can operate at much higher capacity, as indicated by the blue line in Figure 4. With vectoring, downstream speeds of 100 Mb/s can be achieved at distances of up to 400 m, and 40 Mb/s can be supported with loops as long as 1000 m. Alcatel-Lucent supports ITU standard VDSL2 vectoring (G.vector) on all ISAM DSLAMS.

Figure 4. VDSL2 downstream rate and reach with vectoring



In addition, pair bonding can be used to either increase bandwidth or extend the reach of a given line. With Alcatel-Lucent, up to 8 VDSL2 pairs can be logically bonded together using vectored or non-vectored lines. Bandwidth can now be increased simply by adding copper pairs. For our 400 m vectoring example, we could expect to see 200 Mb/s by bonding only two pairs.

IP DSLAMS

The Alcatel-Lucent 7302 Intelligent Services Access Manager (ISAM) FD is a full-service, high-capacity access node, designed to deliver a superior service experience to all subscribers in both copper- and fiber-based access networks. For copper-based services, the 7302 ISAM supports POTS and all traditional flavors of DSL. VDSL2 with vectoring and pair bonding are also supported, enabling broadband speeds of 100 Mb/s and beyond. For fiber-based services, 10G XG-PON1, GPON and point-to-point access technologies are available.

Alcatel-Lucent's VDSL2, vectoring and bonding solutions come in a variety of form factors and shelf sizes, ranging from large systems for central office deployments (up to 768 subscribers); to medium-sized shelves (96 to 384 subscribers) for cabinet deployment; to micro-cabinets and FTTB deployments serving as few as 48 subscribers.

VDSL2 CPE

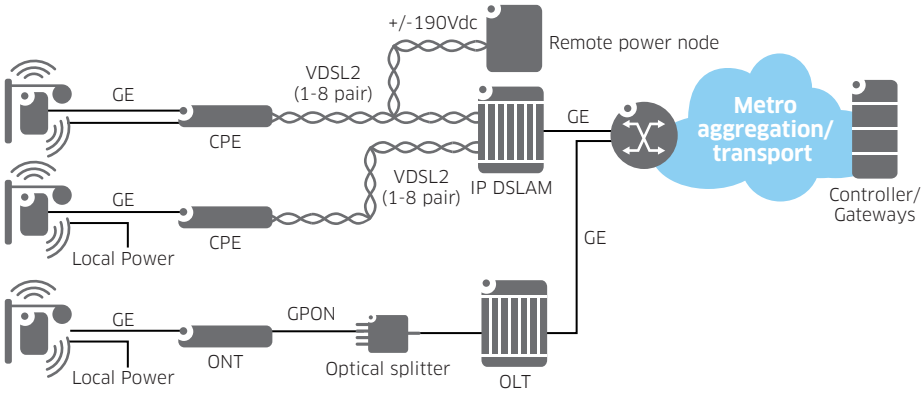
VDSL2 is widely deployed today with a vast number of CPEs available that can meet the needs of wireline mobile backhaul. These include hardened outdoor units capable of supporting up to two bonded pairs. Widely deployed in North America for residential broadband applications, these same CPEs are ideally suited to metro backhaul.

The Alcatel-Lucent 7705 SAR-M outlined in the GPON ONT section above also supports an xDSL module with up to 8-pair bonding over VDSL2, boosting data speeds over copper access networks. This approach provides a clear evolutionary path to even higher data throughputs with VDSL2 vectoring technology in the future.

The VDSL2 CPE can also play a role in metro cell power distribution. The sheer number of metro cell sites (typically tens of thousands) will pose a unique challenge to MNOs as they look for ways to deliver power to each location. There is an opportunity to use copper pairs to power metro cells in dense urban areas where VDSL2 backhaul is being used.

Figure 5 illustrates how power over VDSL2 pairs can be used to provide power to a metro cell site. Standard line powering equipment can be located at the IP DSLAM site or other location in the network. The +- 190v from the line power unit is delivered to the metro cell site over the same copper pairs that support the VDSL2 backhaul. The CPE itself is powered by this network power while providing a standard power over Ethernet connection to the metro cell.[1]

Figure 5. VDSL2 metro backhaul architecture



WIRELINE MOBILE BACKHAUL ECONOMICS

From a cost perspective, backhauling metro cell traffic on the existing residential network will usually be less than the cost of building out a separate overlay network. The savings are mainly derived from:

- Re-use of outside plant copper and fiber assets that have been deployed for residential access
- Low-cost broadband aggregation available from existing access nodes, such as DSLAMs and PON OLTs, minimizing port consumption on relatively expensive switches and routers

Leveraging these assets not only means a lower cost solution but also represents an opportunity for wireline operators to justify their investment in broadband infrastructure. The metro cell revolution will need to be considered in future wireline business plans.

[1] This is an ongoing development effort with service provider partners and is not a generally available today.

For wireline operators that have already invested in broadband access and deployed FTTH, FTTN or both, the assets are in place and the additional revenue generated can increase the return on their fixed broadband access investment. For wireline operators that are still struggling with their business case for deploying fiber, wireline mobile backhaul in general, and metro cell backhaul in particular, can provide the additional revenues to make fiber deployment a compelling business decision.

The challenge is in determining the amount of revenue that can be captured and how that revenue impacts the business case for access. Alcatel-Lucent cost models shows a wide variance in projected revenue and business value based on where each operator is deploying equipment and the metro cell activity in that area.

For example; an urban FTTH deployment of 40 square kilometers and 75,000 households passed might see up to 2000 metro cells deployed over a five year period. Revenues generated from backhaul of this traffic would translate into an 11% reduction in the required residential take rate to see the same business value or Net Present Value for their investment. This quick analysis clearly illustrates the opportunity that metro cell backhaul offers to wireline providers who might need an added edge to justify their fiber deployment.

CONCLUSIONS

Wireline operators will need to leverage all of their network assets to meet the challenges of wireline mobile backhaul. Fixed broadband access with its close proximity to the areas where metro cell site congestion and expansion are likely to occur will be a key low-cost alternative. Both VDSL2 and GPON access technologies have the bandwidth and QoS characteristics to meet this challenge head on.

Wireline operators who have already deployed the Alcatel-Lucent ISAM for residential broadband services over GPON and VDSL2 have a platform in place that can be leveraged to provide a rapid and cost-effective metro cell backhaul solution. For other operators contemplating deep fiber access networks for residential and business services, the fact that GPON and VDSL2 can also help solve the metro cell backhaul problem is just one more factor to improve their business case.

As a leader in fixed access, packet microwave, Carrier Ethernet, and IP/MPLS mobile backhaul, Alcatel-Lucent is in a unique position to provide all of the key elements for delivering a comprehensive, end-to-end, metro cell backhaul solution. With Alcatel-Lucent, service providers can expect a solution that provides:

- More scalability to support more cell sites with more bandwidth
- More flexibility to support any wireless service over any access
- More simplicity to deploy and maintain backhaul services, reducing the total cost of ownership

ABBREVIATIONS

CPE	customer premises equipment
DSLAM	Digital Subscriber Access Multiplexer
FTTB	fiber to the building
FTTH	fiber to the home
FTTN	fiber to the node
FTTx	fiber to the x (x = unspecified location in the network)
GPON	Gigabit Passive Optical Network
IP	Internet Protocol
ITU	International Telecommunication Union
ISAM	Alcatel-Lucent Intelligent Services Access Multiplexer
MNO	mobile network operator
OLT	Optical Line Terminal
ONT	Optical Network Terminal
PON	Passive Optical Network
POTS	plain old telephone service
QoS	quality of service
SAR	(Alcatel-Lucent 7705) Service Aggregation Router
SFP	small form-factor pluggable
TDM	Time Division Multiplexing
TCO	total cost of ownership
VDSL2	Very High Speed Digital Subscriber Line 2
XG-PON1	Ten Gigabit Passive Optical Network 1

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