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The Copper Conundrum for Fixed Broadband Operators

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In July, Alcatel-Lucent's research arm, Bell Labs, set a new broadband speed record using ordinary copper telephone lines. With a prototype technology called XG-FAST – essentially an extension of G.fast that uses more frequencies – Bell Labs achieved the amazing speed of 10 Gbps over two bonded copper pairs. But, more importantly, they also showed how to achieve the 'holy grail' for copper broadband: 1 Gbps symmetrical services on a single copper pair over a distance of 70 meters.

Why is this the holy grail? Because many service providers want to use the existing telephone lines to accelerate fiber-to-the-home (FTTH) deployments.

Hold on: using copper to *accelerate* FTTH deployments?

That may sound like a contradiction, but it actually makes sense, as I'll be explaining in this article. But it does cause somewhat of a conundrum for fixed broadband providers. Where once FTTH was considered the only option for ultra-broadband (100 Mbps or more) services, there is now an array of copper technologies to choose from that can also play a role, with XG-FAST even promising speeds that are indistinguishable from full FTTH (see Figure 1).

What's an operator to do?

Figure 1: Comparison of different copper broadband technologies

Technology comparison			
Technology	**Frequency**	**Maximum Aggregate Speed**	**Maximum Distance**
VDSL2*	17 MHz	150 Mbps	400 meters
Vplus**	30 MHz	250 Mbps	300 meters
G.fast phase 1*	106 MHz	700 Mbps	100 meters
G.fast phase 2*	212 MHz	1.25 Gbps	70 meters
Bell Labs XG-FAST***	350 MHz	2 Gbps (1 Gbps symmetrical)	70 meters
Bell Labs XG-FAST with bonding****	500 MHz	10 Gbps (two pairs)	30 meters

* Industry standard specifications. Whereas VDSL2 is fixed, G.fast allows for upload and download speeds to be configured by the operator.

** A new technology currently being developed by Alcatel-Lucent.

*** In a laboratory, reproducing real-world conditions of distance and copper quality.

**** Laboratory conditions.

Copper-bottomed argument

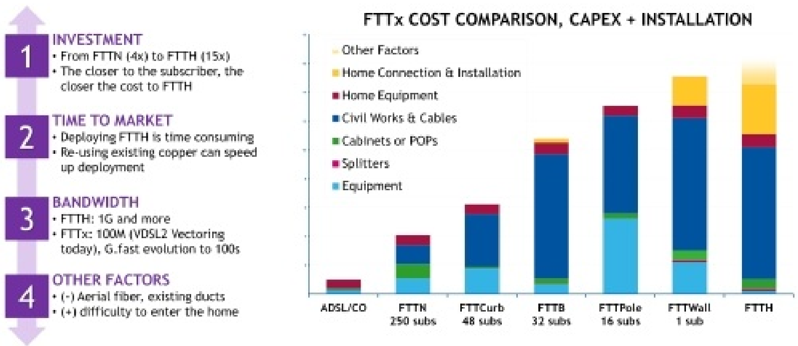
Let's be clear: FTTH remains the ultimate end-goal.

While we are reaching the limit of what can be achieved with copper, we are only just beginning with fiber. With its superior performance and flexibility, FTTH is simply the only future-proof solution. The imminent arrival of TWDM-PON technology will open up a wealth of new services, revenue streams and operational efficiencies for fixed fiber networks, not to mention higher broadband speeds.

But the downside with FTTH is that it is time consuming to deploy. According to a study from Heavy Reading, you need at least 10 years just to cover 50% of households in a nationwide FTTH deployment. Will customers wait that long? Will governments and industry regulators? Indeed, can operators even afford to wait that long in the face of increasing competition?

The answer to all three questions is "no". And that is what is driving continued development of and investment in copper technologies: to ensure operators can meet demand for ultra-broadband without delay while continuing to roll out FTTH over the longer-term.

Figure 2: FTTX Cost Comparison



Time-to-market isn't the only consideration, however. FTTH is also costly to deploy compared to upgrading existing copper lines. That's because it requires digging up every street and/or going into every home to install new fiber infrastructure. Indeed, most of the cost of FTTH can be attributed to civil works and the home connection.

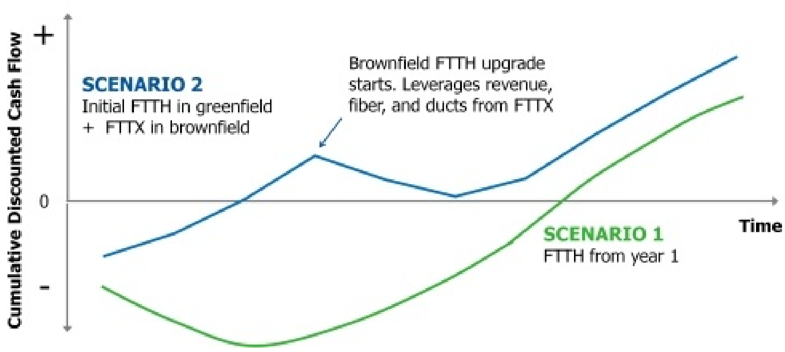
So any scenario that avoids these factors has significant cost advantages. For example, a fiber-to-the-building deployment using G.fast – or in the future XG-FAST – is about 30% cheaper than FTTH. Fiber-to-the-wall is broadly comparable to FTTH as an operator still has to bring the fiber very close to the home and, in addition, cost per subscriber increases as fewer homes are connected to each node.

Copper improves ROI

But here's an interesting point to consider. The quick time-to-market of upgrading copper broadband means operators can generate an immediate increase in revenues. Customers will pay more for a faster connection but also subscribe to premium services like IPTV. These new incremental revenues then help fund FTTH deployments.

Take a look at the scenario in Figure 3. Initial capital investment is lower as there's a mix of FTTH and FTTX, so the return to positive cash flow is faster. The profits accrued then offset the second wave of capital investment, which again accelerates a return to positive cash flow. " style="background-color:#ffffff">And, of course, a big part of the FTTX investment – the outside plant infrastructure – can be leveraged when an operator goes to full FTTH.

Figure 3: Simulated profitability of FTTH and FTTX Strategies



Source: Bell Labs modeling

So while it's obvious that a greenfield deployment should get FTTH from the word go, the business case is not so clear cut in brownfield deployments. That's why, over the last 12-18 months, we've seen many operators starting to complement their FTTH strategies with FTTX. In fact, it might not be possible for many years – if ever – to draw fiber to the living rooms of customers in the protected apartment buildings of old city centers. In these cases, FTTX is clearly the best option.

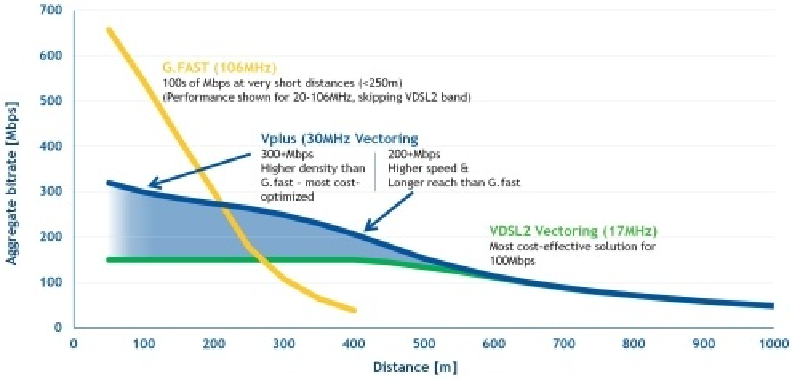
In other words, as long as it can provide ultra-broadband speeds, there is a copper-bottomed argument for continuing to invest in copper: not to replace FTTH but as an accelerator in longer-term FTTH deployments.

The copper to fiber evolution

Of course we have to consider availability of the different technologies. VDSL vectoring is available today and commercial G.fast products, based on phase 1 of the standard, will be available in 2015. Phase 2 G.fast product should be with us in a few years, as could XG-FAST if standardization and product commercialization go smoothly.

So we are still left with a variety of migration paths from existing copper broadband services to FTTH, and new technologies continue to be added to the mix. For example, based on strong market demand, Alcatel-Lucent is working on a new technology called ‘Vplus’ that could be a very simple and cost-effective way to **double** VDSL2 vectoring speeds from existing cabinets. Indeed VDSL2 vectoring, Vplus, G.fast and XG-FAST could *all* play a part in an operator’s network. Let’s have a look at some scenarios.

Figure 4: Speed vs Distance by Technology



With G.fast deployments where a shorter loop length is required, distribution points need to be deployed very close to the customer, in any FTTX location where the operator has access to the copper cable: curb, building, wall, or the generic Fiber to the Distribution Point (FTTdp). These deployment models share similar characteristics: micro nodes, very short loops, a small number of subscribers (tens or fewer), and very high bit rates. They are basically the fixed networks equivalent of wireless small cells.

Beyond bit rates

There are a number of other advantages with G.fast and XG-FAST that go beyond the headline-grabbing bitrates. Reverse powering for the distribution units; flexible downstream/upstream capacity ratios thanks to the use of time division duplexing; easy customer self-installation. The list goes on.

There are inevitably some challenges as well. For example, the frequency range used by G.fast extends into those used for FM and digital radio, and XG-FAST even extends into some military communications frequencies. G.fast ensures harmony by providing a highly-configurable power spectral density (PSD) mask. Operators can use the PSD mask to notch out frequencies that could potentially harm any of the coexisting services. Also, to allow coexistence with VDSL2, operators can configure a starting frequency that allows them to spectrally separate the two technologies and avoid crosstalk.

Powering of micro nodes will also present challenges. Since operators will be deploying thousands of these nodes close to the customer, reverse powering (where you power the device over the telephone line from the customer’s home) is the most practical approach. However, these nodes will need to draw sufficient power and operate efficiently regardless of how many users connect to them or how much load is placed on them. Additionally, they will need to balance power consumption between the users – it would be unfair to draw more power from one customer than from another.

Although not a new challenge, crosstalk is much greater — more like cross-shouting — with G.fast. Vplus, G.fast and XG-FAST will require new approaches to vectoring to cancel the noise.

So super-fast copper broadband technologies promise a lot of benefits, a few deployment headaches and a somewhat bigger problem with regard to which technology operators should choose.

But choice is a good problem to have.