ADTRAN®

G.FAST

Enabling the Gigabit Society

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Matthew Howett, Practice Leader, Regulation & Policy, Ovum

Introduction: The Gigabit Path Forward

In 2014, the ITU gave its final approval to the G.fast standard ("G" for ITU-T G.9701 and "fast" for Fast Access to Subscriber Terminals). The new standard was initially designed to deliver access speeds of up to 1 Gbps via 100 meter lengths of the millions of existing copper pairs all over the globe. While initially, some saw it as a niche technology, the technology's champions saw G.fast as a key contributor to enabling the emerging Gigabit Society.

Gigabit is indeed the new broadband standard. Customer applications compel it. The arrival of 4K streaming is here, and multiple 4K-capable devices within the home will soon be commonplace. And we're not just talking about entertainment content. Today's devices and apps empower everyone to be their own 4K producer, driving incredible bandwidth demands on the network. The entrance of virtual reality/augmented reality (VR/AR) into the mainstream will only compound this ultra-broadband effect.

But this is not a consumer-driven issue alone. Gigabit broadband is an economic driver for the communities and markets that embrace it. Since becoming a Gigabit City, Chattanooga, Tennessee, (USA) has seen its unemployment rate drop from 7.8 percent to 4.1 percent and has seen significant wage growth.[1] Both examples exceed the U.S. average. It's no coincidence that this favorable economic activity came during one of the most high-profile Gigabit deployments in the world. A pioneer in Gigabit connectivity, incumbent provider EPB now sees multiple Gigabit competitors, including Comcast and AT&T.

1 *The Tennessean, Chattanooga mayor: Gigabit speed internet helped revive city, http://www.tennessean.com/story/money/2016/06/14/chattanooga-mayor-gigabit-speed-internet-helped-revive-city/85843196/*

Chattanooga is not alone. Knowledge Park is a redevelopment project in Rock Hill, South Carolina, (USA) that is transforming a once textile-driven economic zone into a hi-tech, knowledge-based economy. Core to this transformation is a gigabit-capable broadband network, deployed by local service provider Comporium. The results have been indeed transformational, with the creation of 570 new knowledge-based jobs already, and a forecast for hundreds more. The development is expected to create well over $100 million dollars in new real estate development, generating an additional $2.8 million dollars in tax revenue to the city.

This rapid adoption of ultra-broadband driven behavior and the economic benefit it brings has caught the attention of global leadership, including the European Union, who recognizes that past visions for European broadband require updating. It is now calling for a European Gigabit Society, with symmetrical Gigabit-capable anchor institutions across the entire continent and 100 Mbps connectivity for all residences, with a path to Gigabit.[2]

"We need to be connected. Our economy needs it. People need it. And we have to invest in that connectivity now," said Jean-Claude Juncker, president of the European Commission in his State of the Union 2016 address.

Getting There From Here

The gold standard to achieve a Gigabit vision is Fiber to the Premises (FTTP). But FTTP alone can't achieve this vision. A viable copper- and coax-assist is needed to expand the reach of ultra-broadband access to places where FTTP deployment is too expensive or difficult to deploy. Despite FTTP's growth and deployment over the past decade, fiber networks provide service to a relatively small percentage of consumers and small businesses worldwide. To truly achieve the Gigabit Society, something more is needed. G.fast achieves this and its ability to leverage copper and coax wiring gives it tremendous flexibility.

"G.fast is a progressive and logical step for any network operator looking to deliver ultrafast speeds through incremental enhancements to existing infrastructure," said Matthew Howett, practice leader, Regulation & Policy, Ovum.[3] "It allows them to radically improve the available speeds for large numbers of subscribers in a much shorter timeframe than other fibre-based solutions."

The G.fast standard initially was designed to use a fiber to the distribution point (FTTdp) architecture and combine the best aspects of fiber and copper to extend ultra-broadband services to endpoints within 400 meters of each distribution point. Three years later, G.fast is a testimony to engineers' ability to extract even more capability and performance from copper pairs, despite the all-too-familiar obstacles – copper quality, reach, and cross-talk – that must be confronted and defeated for peak performance.

Indeed, improvements in speeds and loop lengths, as well as innovations such as G.fast over coax will help ease and broaden G.fast deployment even more than originally envisioned have all been confirmed. Field trials and deployments are now well underway all across the globe. These innovations include expanding the applications of G.fast to well beyond the original FTTdp architecture making multi-dwelling units (MDUs), for both residential and business applications, an ideal target. In these scenarios Fiber-to-the-Floor (FTTF) and Fiber-to-the-Building (FTTB) architectures come into play.

In a FTTF architecture, fiber is extended to each floor of the MDU and living units are connected via copper or coax cabling, using a low-density DPU (four, eight or 16 ports). This is a medium-cost solution that helps to reduce tenant disruption.

In a FTTB architecture, fiber is extended to the basement or interior wall of the building. Using a medium port count (24 to 48 ports) DPU, service providers can connect multiple living units cost effectively over existing copper riser bundles or coax.

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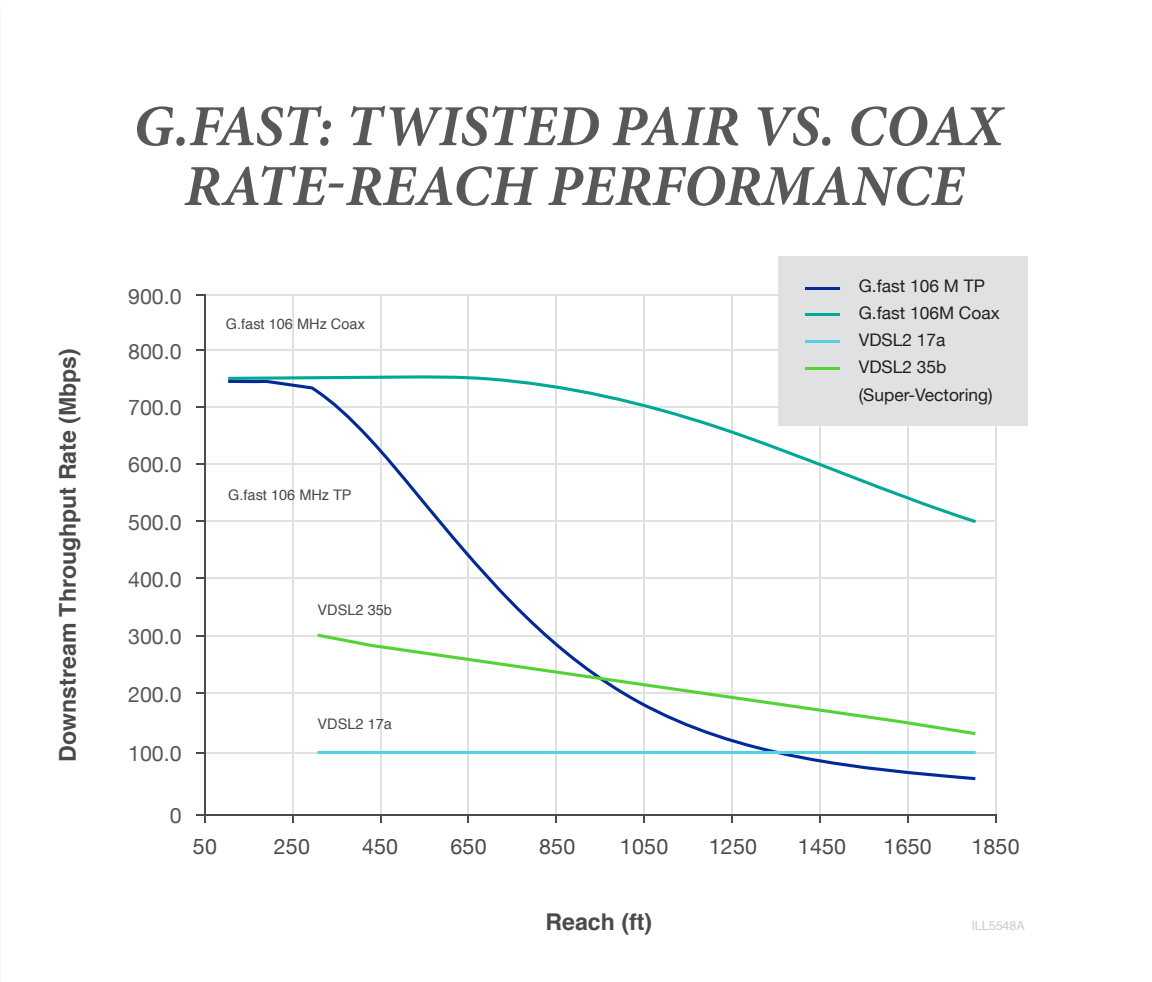
2 State of the Union 2016: Commission paves the way for more and better internet connectivity for all citizens and businesses - http://europa.eu/rapid/press-release_IP-16-3008_en.htm

3 G.Fast set for nearly 30 million end users by 2021 - http://www.nbnco.com.au/corporate-information/media-centre/media-releases/GFast-set-for-nearly-30-million-end-users-by-2021.html



G.fast: Twisted Pair Vs. Coax Rate-Reach Performance

Trials and deployments involving 22 carriers are ongoing in 18 countries, according to a recent report, *Gigabit Networks: The Future of G.fast & XG-FAST Services*, which was commissioned by Australia's National Broadband Network (nbn) and BT, and researched by Ovum.[4] In the U.S., trials are underway at AT&T, Windstream and CenturyLink.

The G.fast Road to Symmetrical Multi-Gigabit Performance

In the U.K. and worldwide, BT Openreach has played a leading role in making G.fast a reality by launching large trials in recent years. In late 2016, BT Openreach announced its intention to make G.fast available to

4 *ZDNet, G.fast broadband expected at 39m premises by 2021: Ovum, http://www.zdnet.com/article/g-fast-broadband-expected-at-29m-premises-by-2021-ovum/*

approximately 140,000 homes and businesses by March 2017 as part of pilot projects in 17 locations across the U.K., with commercial deployments to follow the pilots' success. The carrier's goal is to reach a total of 12 million homes by 2020. BT Openreach also announced initial wholesale pricing for ISPs for the pilots – 160 Mbps and 330 Mbps – line rental of £9.95 ($12.10) per month for both speeds, and installation costs of £49 ($59.60) without modem or £99 ($120.43) with modem supplied by BT Openreach.[5]

Recognizing its potential, BT wants to provide G.fast from its 90,000 existing street cabinets saving money on CapEx[6] and reducing time to market. Toward that end and based on its own research, BT advocated modifications to G.fast chipsets that would enable higher bits-per-tone, lower the noise floor and double the aggregate data rate that G.fast can achieve in the broader band of spectrum.

These modifications are included in G.fast Amendment 2 of the standard, which supports near-gigabit download speeds over distances of 50 meters (200 feet) and provides symmetrical Gigabit service over dual copper pairs, according to Kurt Raaflaub, head of strategic solutions marketing for ADTRAN.[7]

"Our aim is to make ultrafast broadband available to 12 million homes and businesses in the UK by the end of 2020, and we're embracing a mix of technologies with G.fast and FTTP to achieve that," said Clive Selley, CEO of BT Openreach.[8] "We have pioneered G.fast in our labs, driven the global standards, and have been working closely with our communications provider customers on the trials, so we're very excited that it's time to start rolling this technology out nationwide."

Making all this activity possible are the many chipset and product suppliers that are deeply focused on making G.fast a mass-market solution. For example, Sckipio, an Israel-based semiconductor company has a 50-member team designing new G.fast products, according to David Baum, president at Sckipio.[9] At present, the company makes approximately 50 products for nearly 30 customers.

For example, in 4Q 2016, Sckipio introduced a single-port G.fast DPU that can support dynamic time assignment (DTA). The result is support of symmetrical 1 Gbps broadband connectivity that acts as a 'virtual' fiber, extending GPON networks across copper or coax facilities in MDUs or single family units (SFUs).

"Sckipio is opening up an entirely new use case for G.fast," said Teresa Mastrangelo, principal analyst, Broadbandtrends. "By combining DTA and unmanaged G.fast, Sckipio makes it effortless to add G.fast to any GPON network."[10]

These and other innovations extend G.fast to both copper and coaxial environments, greatly improving performance and reach, and conforming to Amendment 3 of the G.fast standard, which increases spectrum use up to 212 MHz.

With Amendment 3, G.fast is now operating at 212 Mhz and is capable of providing 2 Gbps over copper wiring, providing true fiber-like speeds. G.fast now has sufficient capacity to also maintain spectral compatibility with VDSL2, while providing symmetric Gigabit services, giving operators tremendous flexibility. This allows them to switch between G.fast and VDSL2 as business conditions dictate.[11]

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5 *Choose.net, BT announce prices for G.fast Broadband, http://www.choose.net/media/guide/news/bt-gfast-broadband-price-fibre.html*

6 *NewElectronics, Fighting fibre with G.Fast broadband, http://www.newelectronics.co.uk/electronics-technology/fighting-fibre-with-g-fast-broadband/146176/*

7 *Telecompetitor, Adtran: G.fast Amendment Aims to Deliver Two-Fold Copper Broadband Performance Boost, http://www.telecompetitor.com/adtran-g-fast-amendment-2-aims-to-deliver-two-fold-copper-broadband-performance-boost/*

8 *G.Fast set for nearly 30 million end users by 2021 - http://www.nbnco.com.au/corporate-information/media-centre/media-releases/GFast-set-for-nearly-30-million-end-users-by-2021.html*

9 *G.fast News, Light Reading, Video Interview with David Baum, CEO, Sckipio, http://gfastnews.com/index.php/88-sp/240-country-by-country-g-fast*

10 *Ibid*

11 *ITU standards deliver 2 Gbit/s G.fast broadband, SDN management-control, timing and synch for 5G, and state-of-the-art optical fibre, http://newslog.itu.int/archives/1400*

Likewise, Broadcom is building a chipset with a broad range of port count that enables the creation of a complete portfolio of G.fast systems with simultaneous VDSL and G.vector capability ranging from supporting reverse-powered DPUs serving single-family homes to high-capacity solutions launching G.fast from existing street cabinet DSLAMs. This new, higher port count chipset also expands the addressable market for G.fast point-to-point coaxial cable that is often installed in high-density housing.

"As we move from G.fast field trials to an expanded pilot, Openreach requires a flexible silicon platform that covers the full range of line densities in our diverse infrastructure and maximizes rate and reach performance," said Peter Bell, director network portfolio, Openreach, British Telecom's local network business.[12]

G.fast uses the concept of Time Division Duplex (TDD), and Amendment 3-compliant DTA technology 'disrupts' it and dynamically allocates time slots for better symmetrical performance. DTA senses and responds to user activity by the millisecond, creating a full-capacity, symmetric broadband experience. This approach can effectively double the speed of an equivalent symmetric G.fast broadband service delivered without DTA.

"With DTA, configuration symmetry becomes irrelevant," said Ronan Kelly, CTO for EMEA and APAC Regions at ADTRAN. "Operators can deploy responsive broadband for the first time, transparently and dynamically bursting to the full bandwidth potential of the subscriber connection in either direction, as the user requires."[13]

Service providers can now extend up to 2 Gbps of symmetrical broadband to each of the residences or offices within an MDU using existing coax and copper wiring. The solution also provides coexisting management layers for G.fast and GPON, which in turn, speeds up combination G.fast/GPON/FTTP rollouts. The result is a broadband access solution that gives operators tremendous agility and an ability to meet competition from DOCSIS 3.1 cable broadband head on, while preserving existing satellite TV service delivery on those same coaxial cable assets.

The push is on for next-generation G.fast (G.mgfast). At the April 2017 ITU-T meeting held in Huntsville, AL, G.mgfast was discussed, with G.fast offering 10 Gbps per cable at 848 MHz, and 5 Gbps at 424 MHz. The need for higher speeds from G.fast is being driven by competition from the cable industry as they move toward Full Duplex Docsis 3.1 (FDX), which offers the promise of 10 Gbps downstream and 5 Gbps upstream, shared between approximately 50 households.[14] G.mgfast will be superior to FDX as it will offer dedicated versus shared bandwidth.

As proposed, G.mgfast will use aggregate net data rate (i.e. the sum of the net rate for upstream and downstream). With preferable transmission techniques, such as full duplex, it is possible to achieve a net data rate of 10 Gbps per single line using frequency spectrum up to 848 MHz. For the 424 MHz spectrum, the same aggregate bit rate can be reached over two bonded lines (with maximum net data rate of 5 Gbps for a single line). It should, however be noted that these advancements lie well in the future with lab trials predicted in 2019 and early deployments in 2020.

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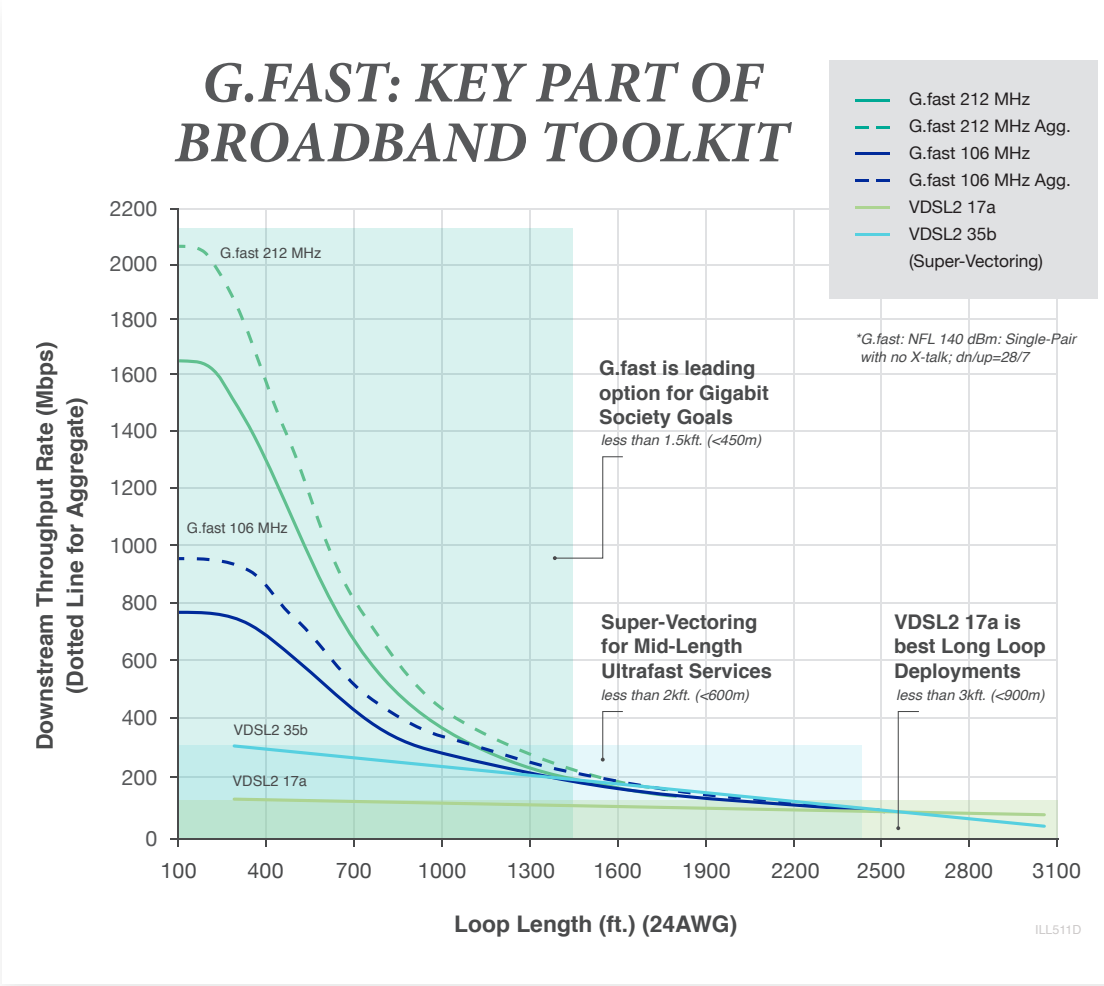
12 Broadcom Drives G.fast into the Mainstream with New DSL Infrastructure Device Family, https://www.broadcom.com/company/news/product-releases/2211222

13 ADTRAN Doubles G.fast Speed with Dynamic Time Allocation, http://www.adtran.com/index.php/adtran-doubles-g-fast-speed-with-dynamic-time-allocation

14 J. Baumgartner, 'Cable-Tec Expo: 'Full Duplex' DOCSIS Speeds Ahead', September 2016. [Online: http://www.multichannel.com/news/cable-tv-conventions/cable-tec-expofull-duplex-docsis-speeds-ahead/407847 Accessed: 16 Jan. 2017.



G.fast: Key part of a broadband toolkit

G.fast Track

G.fast has now started on its track to deliver speeds of up to 500 Mbps to an addressable market of nearly 30 million customer premises, 3 percent of global fixed broadband connections, by 2021, according to an Ovum report. Actual subscribers are expected to grow from 330,000 in 2017 to approximately 11.5 million in 2021.[15]

G.fast subscriber growth by region shows significant momentum between 2018 and 2021, with Europe leading the way. The Americas and APAC will begin to catch up in the last two years. Ovum notes that deployment across Western Europe will no doubt be boosted by the aforementioned European Gigabit Society initiative.

"We need a Gigabit infrastructure for a Gigabit economy and Society," noted EU Commissioner Günther H. Oettinger at the 2016 CeBIT Global Conference.

G.fast is poised to take its rightful place as an enabler of the Gigabit Society in 2017 with growing commercial deployments. Expect the momentum in both the lab and the field to continue as more carriers look to further leverage their extensive copper and coaxial networks. Indeed G.fast may prove to be the most important contributor to a global Gigabit reality.

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15 ZDNet, G.fast broadband expected at 39m premises by 2021: Ovum, http://www.zdnet.com/article/g-fast-broadband-expected-at-29m-premises-by-2021-ovum/

ADTRAN, Inc.
901 Explorer Boulevard
Huntsville, AL 35806
256 963 8000

General Information
800 9ADTRAN
www.adtran.com/contactus

Canada Headquarters—Toronto, Ontario
+1 877 923 8726
+1 905 625 2515
sales.canada@adtran.com

Canada—Montreal, Quebec
+1 877 923 8726
+1 514 940 2888
sales.canada@adtran.com

Mexico and Central America
+1 256 963 3321
+1 52 55 5280 0265 Mexico
sales.cala@adtran.com

South America
+1 256 963 3185
sales.brazil@adtran.com
sales.latam@adtran.com

TL9000 TL19.1270

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