Gigabit your way

Increase your competitive advantage by delivering Gigabit services in the best way for your business.

NOKIA

Contents

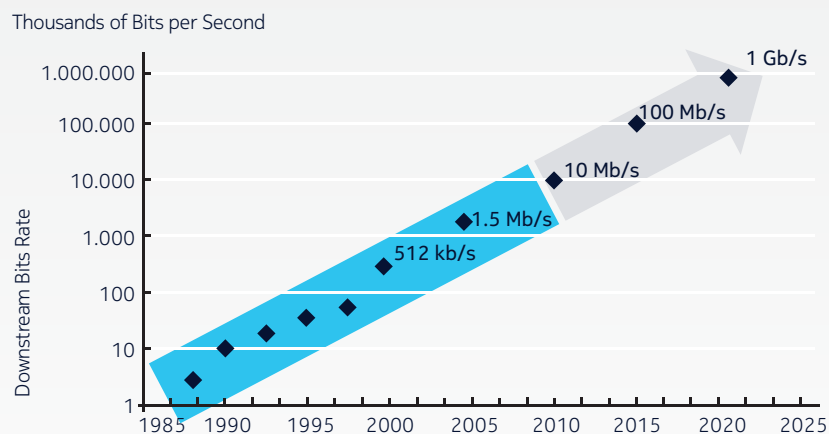MARKET   TECHNOLOGY   BUSINESS   LEADING THE WAY   SUMMARY

Why Gigabit, why now?

Download speeds since 1985[1]

Thousands of Bits per Second

Downstream Bits Rate

1.000.000 — 1 Gb/s
100.000 — 100 Mb/s
10.000 — 10 Mb/s
1.000 — 1.5 Mb/s
100 — 512 kb/s
10
1

1985 1990 1995 2000 2005 2010 2015 2020 2025

Since the beginning of the internet age, residential broadband speeds have approximately doubled every five years. Predictions made way back in the 1990s said that Gigabit speeds would be the norm in 2020, and we're on track to fulfill that prediction. Recent changes in consumer behavior and mass-adoption of new services and applications mean the world is getting ever-closer to needing gigabit broadband.

On average, U.S. internet households own and operate slightly more than 11 internet-connected devices that all consume bandwidth. 49% own a smart TV and 80% of smart TVs are connected to the internet[2].

By far the biggest contributor to the rapid increase in bandwidth is the rise of unicast streamed video. TV screens continue to increase in size and resolution (4K to 8K). Families now simultaneously stream different content to multiple devices and catch up with friends and relatives through HD video conferencing.

The increasing consumption of video is not just a consumer phenomenon. Industries are dependent on video to manage everything from production lines to emergency situations. As bandwidth connectivity becomes less of a restraint, companies are switching to 4K video streams to provide more value to their operations.

Online gaming is now the world's favorite pastime when combining hours played and watched[3] and another major contributor to

bandwidth demand. Virtual reality gaming ups the bandwidth ante even further. The addition of a single VR device increases a household's peak bandwidth requirements from 45 Mb/s to 275 Mb/s[4].

A final, critical driver behind Gigabit services is an innate human behavior: impatience. While customers might only occasionally generate a 1 Gb/s spike in network traffic, they have become so used to broadband that they now expect their connections, downloads, and streaming services to work instantly, consistently and reliably. Impatience is an overhead that every broadband network needs to consider in their capacity planning.

Gigabit is good for business

Gigabit and even multi-gigabit services are appearing around the world. The major drivers   are competition, market positioning and superior Quality of Experience. Early adopters initially used Gigabit services as a marketing tool but are now reaping the business benefits.

Customer loyalty and churn

Once a business or a residential customer enjoys the benefits of fast upstream and downstream speeds, they are very unlikely to churn. Higher bandwidth also enables a better range of bundled services. Customers like getting fixed data, voice, video and mobile from the same provider. Good bundled offers significantly reduce customer churn (<3%).

An important factor in loyalty is coverage. Unserved or under-served portions of a coverage area give competitors an opportunity to enter the market. In the US, those providers adding the most broadband subscribers in 2018 were those with ubiquitous high-tier broadband services. Consistency of service within an operator's footprint is important for protecting the subscriber base.

Increased ARPU

Numerous studies show that consumers, particularly in rural areas, are willing to pay more for high-speed broadband. Gigabit services are an opportunity to increase average revenue per user (ARPU): on average,

gigabit is 2.5 times more expensive than 100 Mb/s[5]. The increased bandwidth also encourages consumption of additional services – bundled services, entertainment, education, security, smart home, health and wellbeing, etc. – from which service providers can prosper.

Marketing advantage

Few can doubt the buzz created by Google Fiber's appearance in the US market. Gigabit services capture the imagination and create a first-mover advantage for those operators deploying them. Gigabit services also create pull-through for other services and encourage subscribers to move up a level. With only 20% of US homes within reach of Gigabit services[6], there is plenty of opportunity for market differentiation with Gigabit offers.

Investment in the future

Immediate revenues for Gigabit services today – for example, through a quick-to-market technology like G.fast or 5GTTH – can be reinvested in full fiber deployments in the mid- to long-term.

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Deliver Gigabit your way

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Gigabit your way

It's easier and cheaper than ever before to deliver Gigabit services. The desired end-goal is still ubiquitous fiber-to-the-home (FTTH). Costs have declined substantially in recent years due to mass deployments: analyst firm Ovum estimates costs have fallen in some regions from $2500 to under $300 per home in less the 10 years[7]. Field-proven network design tools, greater experience in end-to-end project management and network building, and new methods to lower deployment costs (e.g. trenching etc.) are contributors. In addition, governments and independent investors are keen to fund FTTH deployments as a reliable, long-term investment.

However, there are several other technologies for DSL and Hybrid-Fiber Coax (HFC) networks that are capable of delivering Gigabit services where it is not yet possible to deploy FTTH for economical, time-to-market, geographic, political or other reasons. Recent advances in software-defined networking (SDN) make it far easier to create and manage a multi-technology network, allowing you to do Gigabit your way, mixing-and-matching Gigabit technologies to ensure broad coverage and a business case that works.

Smart mix of fiber, DSL, cable and wireless is key to the operator's business case

FTTH: Evolve to NGPON on the same fiber plant **1G, 10G today**	G.fast: Leverage copper in last meters **1G**	Coax: From DOCSIS3 to full spectrum **>1G**	Fixed Wireless Access: LTE and 5G **1G**

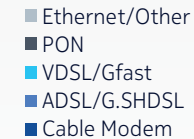| FTT Node	FTT Amplifier	FTT Distribution Point	FTT Antenna	FTT Building	FTT Home
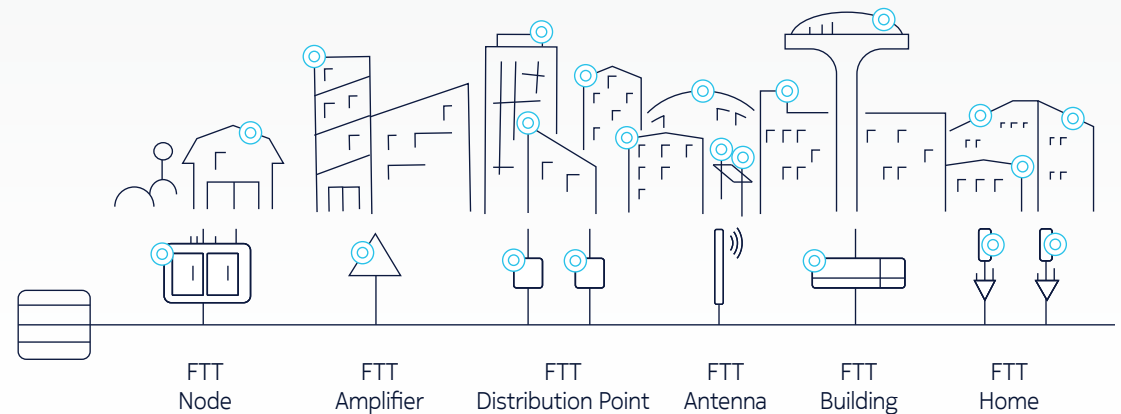
GPON

Gigabit passive optical network (GPON) is the most common and fastest-growing fixed access technology in the world today. Many operators use GPON to provide residential services of 1 Gb/s as well as business services, mobile backhaul and aggregation of remote FTTx micro-nodes. Initial capital expenditure is generally higher than other technologies, but there is a strong return on investment given the longevity of fiber and the potentially unlimited capacity for future services.
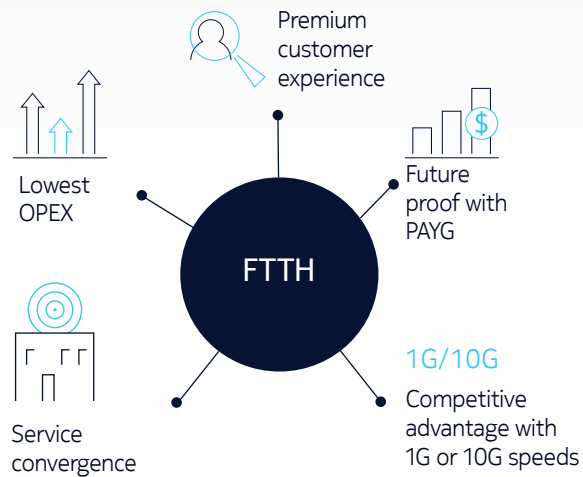
Fiber drives broadband access forward

Broadband subscribers per technology [M]
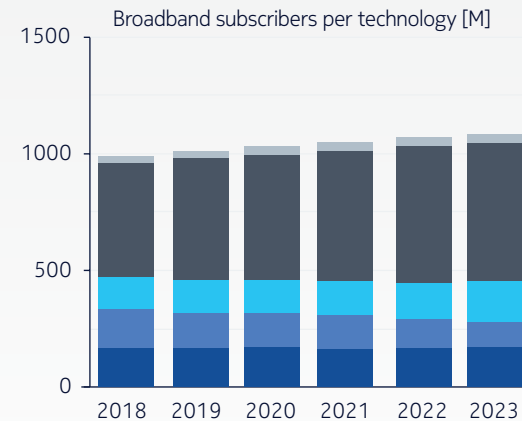
PON is the fastest growing access technology
10G Next gen PON accelerates
5G Anyhaul is a strong driver for fibre
SDAN brings new markets and business models

- Ethernet/Other
- PON
- VDSL/Gfast
- ADSL/G.SHDSL
- Cable Modem

- Premium customer experience
- Lowest OPEX
- Future proof with PAYG
- Service convergence
- **1G/10G** Competitive advantage with 1G or 10G speeds

FTTH

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Next-generation PON

Operators can easily upgrade existing GPON networks to support next-generation passive optical network technology. Next-generation PON enables you to increase the capacity to 10 Gb/s and more, driving increased utility with these higher speeds.

XGS-PON has become the next-generation PON technology of choice, providing a cost-effective option supporting 10/10G and 10/2.5G bit rates with fixed wavelength optics. TWDM-PON provides four or more wavelengths per fiber, each capable of delivering symmetrical or asymmetrical bit rates up to 10 Gb/s. Nokia's unique universal next-generation PON solution supports all flavors of PON on a single line card and existing fiber access nodes.

Next-generation PON will overtake current PON by 2022

PON forecast ($B)

Legend:
- 10G EPON
- EPON
- NG-PON2
- XGS-PON
- GPON
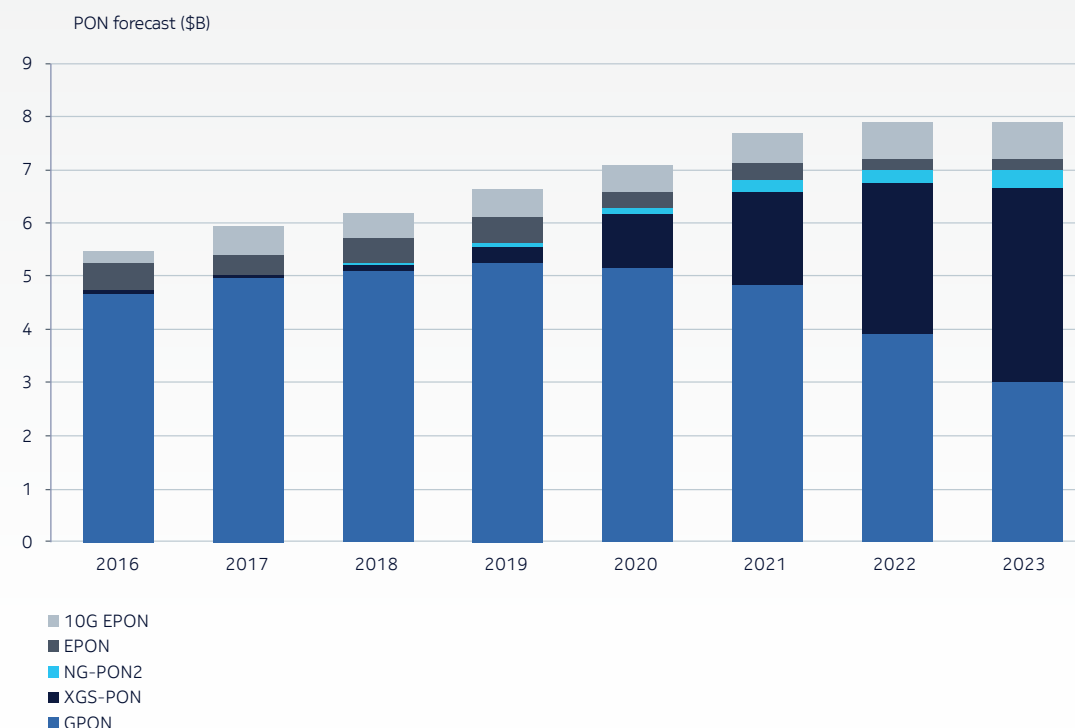
Further reading:
White paper: Next-generation PON

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G.fast

G.fast technology makes gigabit-level aggregate bit rates possible by adding spectrum to copper lines. Current VDLS2 lines use spectrum up to 35 MHz. G.fast widens this spectrum to 212 MHz to enable true 1 Gb/s services downstream, even in a VDSL2 overlay deployment.

G.fast is a valuable tool in any operator's toolkit to ensure that high-speed services can be delivered to subscriber locations that are impractical for fiber. For example, fiber can be drawn to the basement of an apartment block and G.fast used over the existing in-building copper or coax cabling.

G.fast is evolving to cover more use cases

Extend Gigabit reach in the network

- Fiber-like service: up to 1 Gb/s aggregate
- High density, modular technology
- Large vectoring group size
- Longer reach

FTTH complement in MDUs

- Fiber like service: 1 Gb/s in downstream
- Small to medium density
- Reverse powered
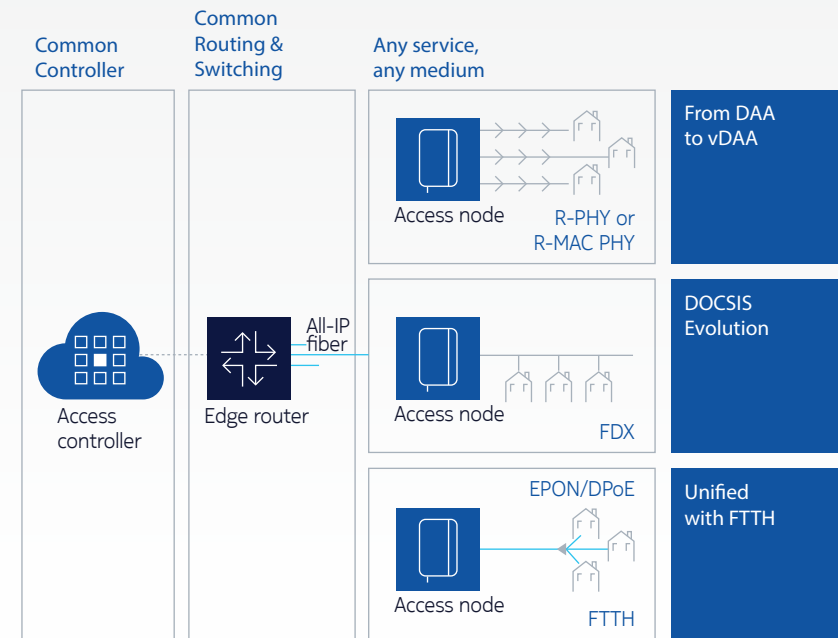- Application on twisted pair and coax

Further reading:
White paper: Achieving full Gigabit FTTH coverage with G.fast

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DOCSIS/DAA

To provide Gigabit services, cable operators must improve performance in the outside plant and increase capacity at the headend. To address these issues, MSOs are using a combination of strategies including Distributed Access Architectures (DAA), DOCSIS 3.1, taking fiber deeper into the network, and deploying FTTH in greenfield deployments. DOCSIS® provisioning of EPON (DPoE™) makes it possible to deploy fiber networks while managing the Optical Network Unit (ONU) in the same way as cable modems.

Nokia's virtualized distributed access architecture (vDAA) takes things further by eliminating cable-specific hardware from the headend, delivering greater flexibility and scalability while reducing headend space and power requirements. vDAA introduces a virtual CMTS, allowing the MAC function to be placed in the node, the cloud or anywhere else. This gives MSOs far greater flexibility in their network architecture. The combination of virtualization, digitalization of the outside plant and flexible placement of the MAC drastically reduces the amount of equipment in the headend and hub facilities, increasing coax fidelity and speeds.

Common Controller

Common Routing & Switching

Any service, any medium

Access controller

Edge router

All-IP fiber

Access node   R-PHY or R-MAC PHY

From DAA to vDAA

Access node   FDX

DOCSIS Evolution

EPON/DPoE

Access node   FTTH

Unified with FTTH

Fixed Wireless Access

There have never been so many opportunities for operators to use standards-based wireless technology to connect homes and businesses. 5G with its high speeds and low latency captures a lot of attention today enabling gigabit peak speeds with mid-band frequencies and multi-gigabit speeds with mmWave. For operators deploying 5G, FWA is a key use case delivering early returns on their investment in 5G along with fast time to market for new services.

4G remains a wireless workhorse delivering solid broadband speeds wherever 4G networks exist. Ideal for under-served areas, 4G FWA can support broadband speeds in the 25-100Mbps range depending on the RAN supporting it. Now, with CBRS (Citizens Broadband Radio Services), any operator can use unlicensed LTE Band 48 (3.5 GHz) to connect homes and businesses. With CBRS, any operator can bring broadband speeds to underserved communities.

Spectrum of 3GPP FWA options

4G	5G mid-band	5G mmWave
ADSL grade	End user sustainable speed	Fiber grade
10km (32.800ft)	Inter-cell distance	100m (328ft)

Further reading:
White paper: 5G Fixed Wireless Access for fixed-grade gigabit services

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In-home Wi-Fi: Gigabit inside

There is little point providing Gigabit broadband to the home, if it is undone by poor connectivity inside the home. A high-performing in-home Wi-Fi solution increases brand loyalty, reduces churn and reduces costs associated with help-desk calls and truck rolls for Wi-Fi problems.

Technical considerations for selecting an in-home Wi-Fi network must include:

• True, intelligent meshing for 100% coverage and a reliable, robust Wi-Fi network.

• Detection and identification of Wi-Fi and non-Wi-Fi interference sources for highest performance.

• Non-destructive network performance when adding access points.

• Network intelligence for dynamic path selection, fast re-routing and seamless roaming for a glitch-free experience.

• Detailed information about the needs of every device in every location in the home.

Further reading:
White paper: Make and save money with in-home Wi-Fi

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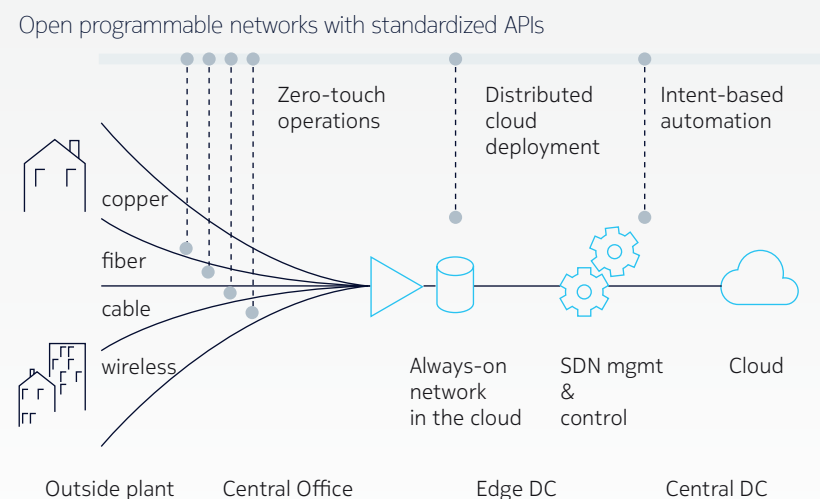
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Software-defined access networks

Software-defined access networks (SDAN) simplify and automate network operations by applying SDN/NFV at the edge of the network. Introducing Gigabit services is a good time to evaluate the pragmatic application of SDAN, where and when it makes sense for your business. Near-term opportunities for SDAN include unifying network management across multiple technologies, managing a multivendor nodes, automating node provisioning, and introducing network slicing to separate traffic types or service providers sharing the same infrastructure.

NFV centralizes functions in the cloud, creating an always-on network with the ability to add capacity and modify service parameters even when equipment is off-line. SDN provides automated and intelligent control over nodes, making it quick and easy to roll out new capabilities and services.

SDAN solutions are technology and vendor agnostic meaning that a single SDAN solution can provide unified management for all network elements and operations. Nokia SDAN also supports hybrid physical/virtual network environments, allowing you to adopt virtualization at your own pace.

Further reading:
White paper: Software-defined access networks

SDAN is key to automate and evolve your broadband network

Open programmable networks with standardized APIs

Zero-touch operations

Distributed cloud deployment

Intent-based automation

copper

fiber

cable

wireless

Always-on network in the cloud

SDN mgmt & control

Cloud

Outside plant   Central Office   Edge DC   Central DC

Open and programmable with always-on, multivendor, zero-touch broadband access

Introduce new capabilities quickly using IT/cloud/DevOps and elastic scaling in datacenters

Analytics and automation to improve business outcome and operational efficiency

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Making the business case

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Business case considerations

As with any network investment, the decision to invest in Gigabit services must have sound financial reasoning. Next to the usual financial calculations (costs, revenues), you also need to evaluate the potential cost of not upgrading your network. Will customers churn? Will competitors steal market share? Will new entrants move into your service area? And how soon are any of those scenarios likely to happen?

Choosing the right technology for a deployment, therefore, requires careful consideration of several factors including, but not limited to, the existing infrastructure, household density, time-to-market, capital expenditure, and operating expenditure.

Calculating the business case is complex: it must include CAPEX and OPEX for each technology choice, increased ARPU, projected subscriber increases, additional financial benefits of lower customer churn, enhanced brand value, the opportunity cost of being fast or slow to market, the advantages of competitor lock-out as the deployment reaches 100% coverage, and so on. These variables are obviously unique to each deployment. CAPEX is especially

sensitive to subscriber density, measured in households per square kilometer (HH/km2).

For the purposes of this eBook, we will examine the more predictable cost elements, namely CAPEX and OPEX, in a typical urban deployment scenario.
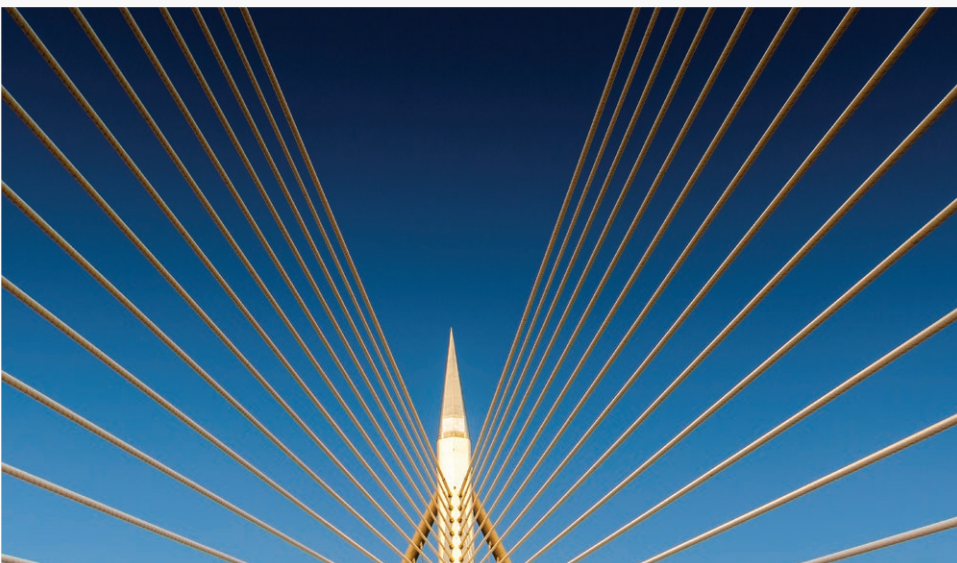
CAPEX

Cost is, of course, a critical factor when considering FTTH/FTTx alternatives and they vary widely based on the existing infrastructure, labor costs and the ease at which fiber can be deployed (buried, aerial, conduit, etc.).

The CAPEX modeling shown here is the result of detailed analysis by Nokia Bell Labs based on years of consultation with operators large and small. The analysis shows relative costs of different technologies in a typical urban deployment scenario with a density of 2500 HH/km². Bell Labs Consulting provides a service to create detailed and personalized business modeling for individual operators.
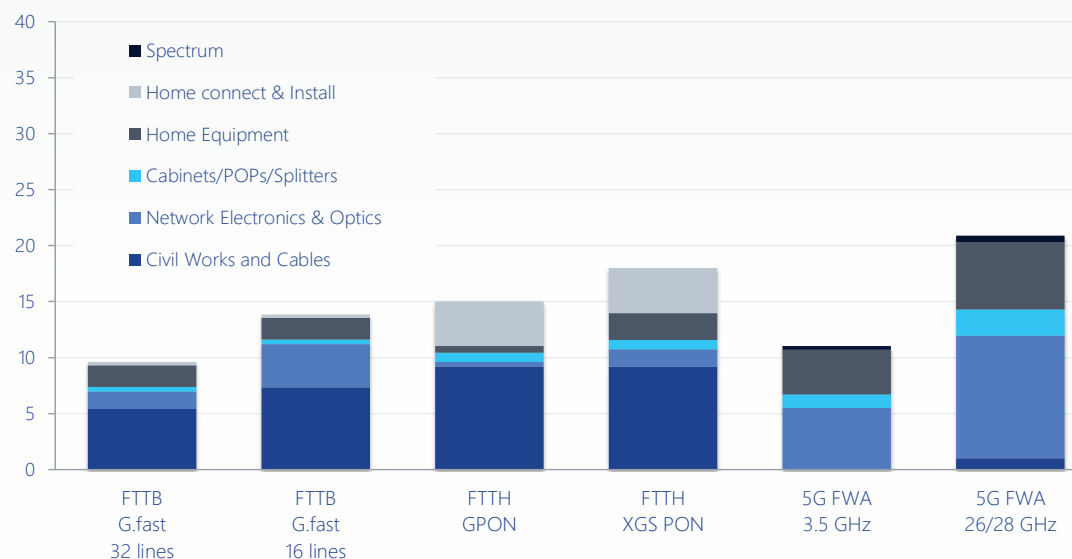
Civil works and cabling are by far the most costly aspect of G.fast and PON deployments. Home equipment and installation represent a significant factor for fiber and 5G connections while network elements, electronics and optics are an important cost contributor in HFC and fixed-wireless connectivity.

CAPEX per subscriber is highly sensitive to subscriber density. As density falls, CAPEX per subscriber rises, illustrating the challenges of serving low density areas.

Costs can be mitigated by increasing take rates and the business case improved by considering convergence e.g. mobile backhaul and business services alongside residential broadband.

Operators need to consider their existing assets, available CAPEX, and whether time-to-market is a critical competitive criteria. Mixed-technology deployment strategies can contain costs and tactically protect the subscriber base.

Relative CAPEX per subscriber (2500 HH/km²)

Legend:
- Spectrum
- Home connect & Install
- Home Equipment
- Cabinets/POPs/Splitters
- Network Electronics & Optics
- Civil Works and Cables

Categories: FTTB G.fast 32 lines, FTTB G.fast 16 lines, FTTH GPON, FTTH XGS PON, 5G FWA 3.5 GHz, 5G FWA 26/28 GHz

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OPEX

OPEX is a constant challenge for operators. While OPEX seems small when compared with the CAPEX spend on a large network upgrade project, it represents a significant ongoing expense that can take years to show its cumulative effect.

One of the clear benefits of FTTH is that it has by far the lowest operational cost of any access technology. This is because fiber is robust, the outside plant uses all-passive components, and high-density fiber access nodes have smaller central office footprint and power consumption needs in comparison to other technologies. Operators report 20-30% lower OPEX with GPON compared to DSL, depending on whether aerial cabling is allowed.

Deeper fiber deployments with many remote nodes (either copper, coax or FWA) make for higher OPEX as each of these nodes must be powered and maintained. G.fast has double the OPEX and fixed-wireless technologies even more. However, with 5GTTH,

costs are shared with 5G mobile services so the incremental part related to fixed services is rather small.

G.fast OPEX can be reduced with reverse powering, resulting in savings of $100 per node per year.

SDAN can be applied to any network to lower OPEX through automated operations. SDAN intent-based networking relies on policies to automatically put the network into desired state, allowing you to efficiently provision and troubleshoot networks.

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Time-to-market

A final consideration should be given to time-to-market (TTM). This can be a critical consideration, especially in a competitive environment: taking too long to deploy Gigabit broadband services can drive end-users towards competitors. However, some access solutions are worth the wait, both for the end-user and the operator; for example, FTTH with its unlimited bandwidth and future-proof potential.

While FTTH networks cannot be built overnight, there are technology migration strategies that operators can pursue to drive increased revenues today that can be used to finance longer-term FTTH deployments. Both telco and cableco operators can begin with the "low-hanging fruit" and deploy fiber where it is relatively quick and easy. Other areas can be served with 5GTTH or G.fast to deliver increased broadband speeds. This secures the subscriber base and increases average revenue per user (ARPU) in these difficult to reach areas, until sufficient penetration justifies further fiber investment.

Gigabit your way with Nokia

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Powering Gigabit networks in the US

The world is moving quickly towards Gigabit consumption and those first to provide Gigabit services are reaping the rewards and gaining a competitive advantage.

There's no single technology that's right for everyone. Nokia can help you combine different technologies to deliver Gigabit your way.

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Nokia, your Gigabit partner

Nokia is a global technology leader at the heart of our connected world. From the enabling infrastructure for 5G and the Internet of Things, to emerging applications in virtual reality and smart cities, we are shaping the future of technology that is transforming the human experience.

We are the worldwide leader in fixed broadband technology. You may not know it, but our solutions power the biggest, fastest and best-performing fiber networks in the world. In fact, we are the only broadband technology vendor with a leading position in every region of the planet.

At your service

We connect millions of households and businesses around the world with our state of the art FTTH solutions. All 20 of the world's biggest network operators trust us for their broadband networks, including AT&T, Verizon, Telefónica, Vodafone, Orange, China Telecom, and Deutsche Telekom.

But we're also trusted by small local providers, communities, utility companies and municipalities. Many municipalities across the Americas, Europe and Asia have partnered with Nokia to make ultra-broadband a reality for their citizens. The fastest community broadband network in the US, Chattanooga's Gig City, relies on Nokia's fiber solution, as do Lus Fiber, Bristol Tennessee, Opalika Alabama and many others.

Nokia Gigabit Smart Build is a set of professional services dedicated to supporting your Gigabit network evolution, from business case development through deployment, management, upgrades and optimization. This support is adapted to suit your specific challenges, needs and market context. It enables you to manage wide-reaching change and avoid costly errors and delays as you transition to new ultra-broadband technologies.

Nokia Gigabit Smart Build makes building your Gigabit network predictable, which delivers assured quality, the fastest time-to-market and maximum return on investment.

Further reading:
White paper: "Making ultra-broadband transformation simple"

Nokia powers the biggest, fastest and best-performing broadband networks in the world

The **#1 FTTH vendor in the US** and > 80 million ports shipped worldwide – we can help you deliver 1G services to all your customers

Trusted by 20 out of 20 of the largest broadband operators in the world – you can trust us, too

The best technology, we power the fastest residential broadband service in the world (52 Gb/s, SK Broadband, South Korea)

Become a leader in broadband; we were 1st with Gigabit and 10 Gigabit networks in the US and the rest of the world

Independently recognized as the leader in broadband access, with the most competitive and comprehensive portfolio (Current Analysis, 2018)

Keep at the cutting edge; we have 3,000 fixed broadband patents and are consistently 1st to market with new technology
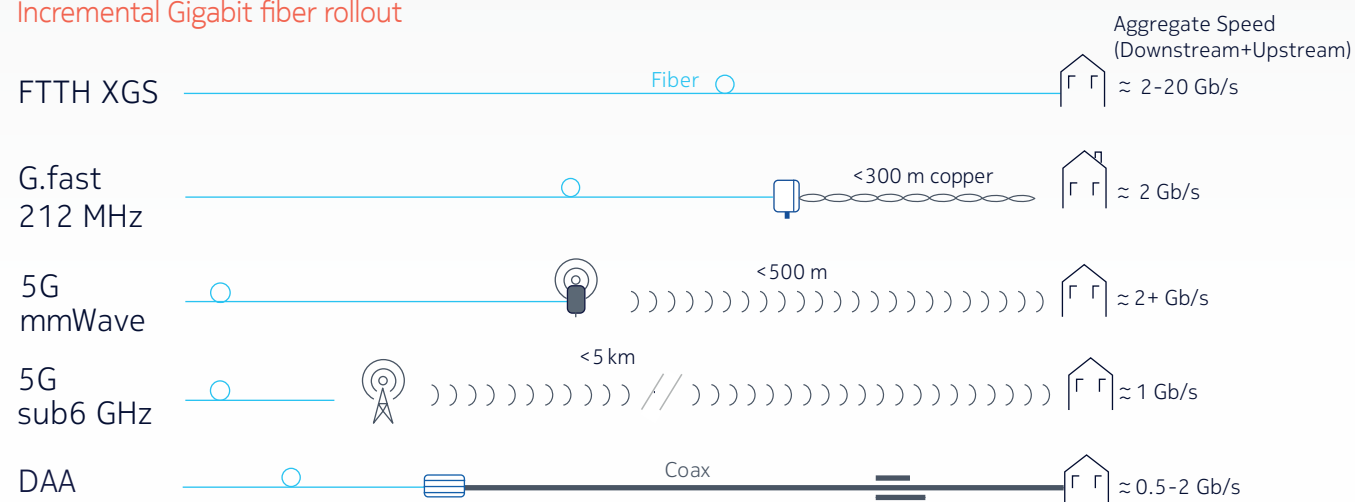
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Technology comparison

	CAPEX	OPEX	Fast to market	High speed
G.fast	◗	●	●	◗
PON	●	◖	◖	●
FWA (LTE/CBRS)	○	◗	●	○
FWA (5G sub 6 Ghz)	◗	◗	●	◗
DOCSIS	◗	◗	◗	●

Incremental Gigabit fiber rollout

Aggregate Speed (Downstream+Upstream)

FTTH XGS — Fiber — ≈ 2-20 Gb/s

G.fast 212 MHz — <300 m copper — ≈ 2 Gb/s

5G mmWave — <500 m — ≈ 2+ Gb/s

5G sub6 GHz — <5 km — ≈ 1 Gb/s

DAA — Coax — ≈ 0.5-2 Gb/s

Ready for Gigabit your way?

GET IN TOUCH

Discover Nokia Gigabit broadband solutions and services in more depth

LEARN MORE

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