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The revival of fixed infrastructure

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Fiber technology and the future of mobile networks

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Executive summary

Smartphones and tablets are proliferating, and the data moving over these devices is growing at a compound annual rate of 20 to 40 percent in developed markets. The rapid growth is putting the capacity of mobile networks under enormous strain, in particular because customers generally want better service but resist paying more for their connections. For the most part, network operators are not taking full advantage of a solution that in many cases lies right under their feet: renewed investment in fixed lines.

A modern, high-performance fixed infrastructure can improve the capabilities of a mobile network, especially in the developed markets of Western Europe, North America, and Australia, where extensive fixed networks already exist. The fixed infrastructure can backhaul data and offload a substantial amount of the data now going over mobile networks. It offers operators a way to upgrade and create products and services for customers, and fixed-line infrastructure costs have decreased in recent years.

Still, there are certainly costs to consider, and operators need internal capabilities to build, operate, and maintain this infrastructure. In certain historic European cities, the network can be a complex maze, and the cost of digging lines can run as high as €300 (US$340) per meter. But that is the exception. In general, whether running fiber to the home, fiber to the curb, or hybrid fiber coaxial cable systems, the fixed infrastructure is affordable in most regions. In fact, we believe that over the next decade cloud technologies such as network virtualization and software-defined networks could reduce fixed-line costs per bit by as much as 90 percent. By 2030, the winners will be those operators with the largest installed base of fiber. They will be able to use their fiber bases to serve retail customers (fixed-line and business), as well as to connect mobile base stations serving their own mobile operators, and they will be able to offer backhaul for other operators.

Fixed-line infrastructure improves mobile

For years, integrated operators in developed countries have focused their investments on the mobile network infrastructure and licenses. That made sense, given the fantastic growth rates for mobile voice and data. But now the industry is bumping up against the limits of the current network design rules. For example, only about 1 percent of the German population could use their mobile devices to watch a video at the same time because of bottlenecks in the backhaul, aggregation, and core network. When one considers the proliferation of devices and the 20 to 40 percent compound annual growth of data over these devices (*see Exhibit 1, next page*), it's easy to see how the industry could face a debilitating capacity bottleneck in the near future if no solution is found.

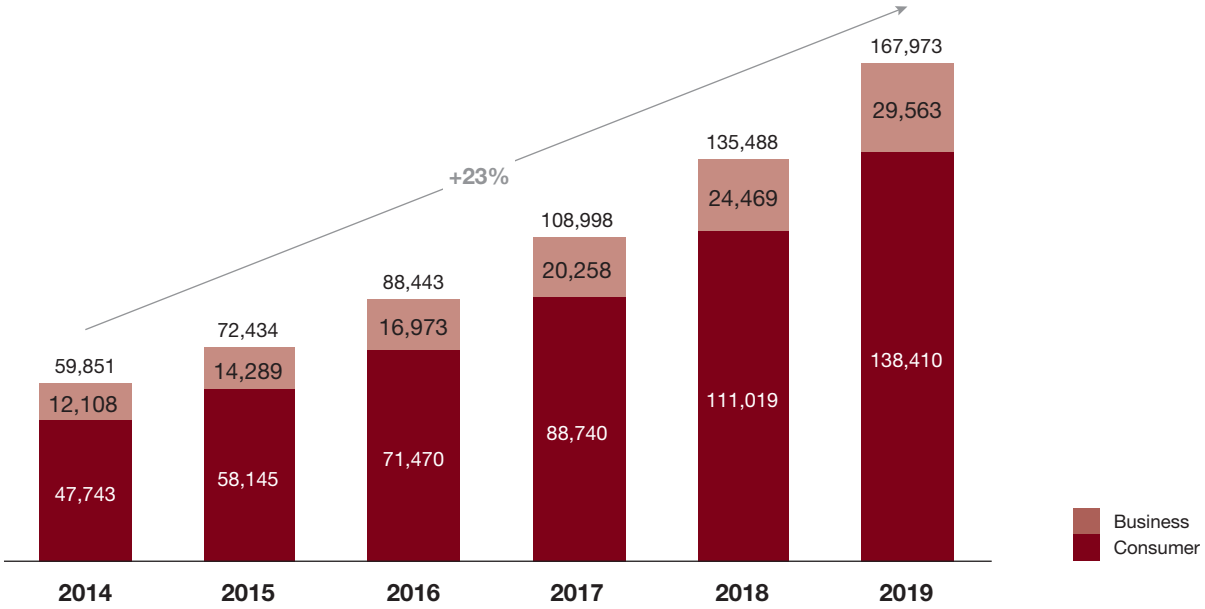
For many operators, renewed investments in the fixed-line infrastructure can be the answer. A modern, high-performance fixed infrastructure can backhaul the data and even offload a substantial amount of the data now going over mobile networks, and it offers operators a way to upgrade and create products and services for their mass-market customers (i.e., consumers and small businesses) and corporate customers.

What's more, fixed infrastructure is an economically viable undertaking because the incremental costs for additional capacity in fixed networks are extremely low — whereas incremental capacity for air interface requires significant additional investment. That's a crucial consideration for operators that are already suffering from generally flat revenue and pressure on earnings. Though customers demand the latest products and services — which require expensive investment by carriers — they are unwilling to pay more for these upgrades. Even increased flexibility and virtualization of the mobile networks (S-RAN, C-RAN, HetNet, etc.) alone cannot push down the production cost per bit enough to compensate for the stagnant revenue. In this environment, operators must find ways to make their investments as cost-efficient as possible. The fixed infrastructure is their best option.

Exhibit 1

Traffic growth forecast, 2014–19

Worldwide monthly traffic, in petabytes



Source: "Cisco Visual Networking Index: Forecast and Methodology, 2014–2019"; Strategy& analysis

Base relief

To increase the performance of mobile networks, operators need to make changes to the infrastructure on two fronts: They need to increase both the number of base stations and the capacity per base station.

There are two ways to increase the number of base stations (*see Exhibit 2, next page*). One is to combine Wi-Fi and 4G (and future 5G, which is expected to be commercially available in 2018), and to roll out small cells in densely populated places, such as high-rise buildings, airports, and shopping malls. The other way is to increase the density of the current macro cell grid — essentially building more base stations of the same type.

To increase the capacity per base station, operators need to take three steps: Use all available mobile radio technologies (i.e., 3G, 4G, and carrier Wi-Fi) in parallel and constantly upgrade to the latest standard; ensure that they are efficiently using sufficient spectrum across all mobile radio technologies; and, finally, avoid the backhaul and aggregation network bottleneck.

The backhaul and aggregation networks have become a bottleneck after 20 years of neglect. Instead of investing in backhaul and aggregation, most mobile operators have focused their investments on additional mobile base stations, new technologies, and spectrum licenses, relying on leased lines and microwave radio links to backhaul traffic from base stations. But leased lines have become more and more unaffordable with increasing traffic speeds, and the daisy chains of mobile base stations over microwave radio links no longer provide enough backhauling capacity. It's difficult to increase the number of microwave links in urban settings because they require a clear line of sight, and it's increasingly hard to find free frequencies.

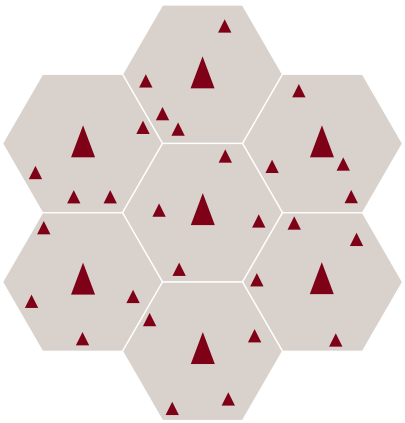
Daisy chains of mobile base stations no longer provide enough backhauling capacity.

Exhibit 2

Two network densification options

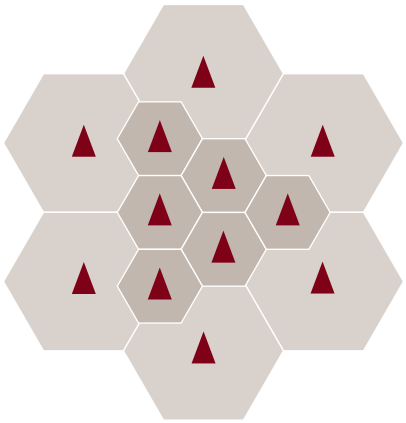
Option A:
Heterogeneous network with small cells

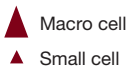
Small cell densification ratio
(four small cells to one macro cell)



Option B:
Macro grid densification

Macro cell densification ratio
(one new site to each existing site)





Source: Strategy& analysis

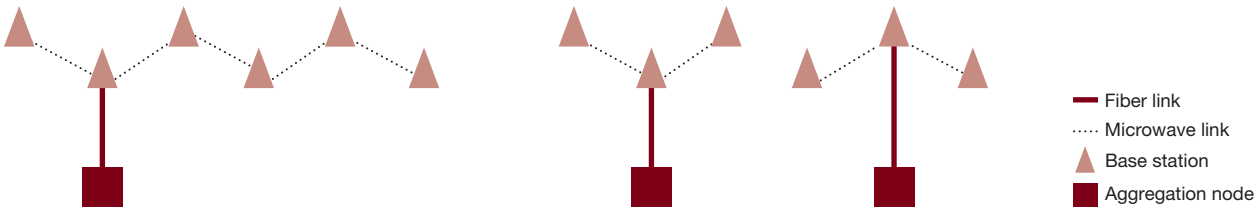
A microwave link can serve a daisy chain of as many as 10 base stations, but only if the base stations are not working at maximum capacity. As a result, it is the microwave backhauling networks that are the real bottleneck in mobile data communication. However, an operator can break up the daisy chain with fiber. Every base station served with fiber can serve one base station to its right and one base station to its left. With that in mind, we believe that at least every third mobile base station needs to be connected with the fiber of a fixed network — an upgrade process known as fiber to the station (*see Exhibit 3, next page*).

Exhibit 3

Breaking up the daisy chain

Currently, many base stations are connected to the fixed network via a daisy chain based on microwave.

To eliminate daisy chains, approximately every third base station needs to be connected to the fixed network. Microwave backhaul capacity is then sufficient.



Source: Strategy& analysis

The cost advantage

The proliferation of Ethernet from PCs and local area networks to wide area networks (WANs), as well as the evolution of Internet Protocol to replace previous WAN routing/switching protocols (such as ATM, frame relay, and X.25), has taken significant costs out of the system over the last 15 years and made the fixed-line infrastructure very affordable. However, costs might creep back into the system, mainly through expensive "intelligent" components in the network elements, such as routing engines and network processors required to analyze the payload quickly and make the right quality-of-service forwarding decisions. High research and development costs for these fast central components diminish the cost saving on the Ethernet port cards.

Despite the legitimacy of concerns that intelligent components make the network more expensive, we believe that cloud technologies can reduce the cost of these central components and also make operating the fixed network dramatically cheaper. Over the next decade we believe cloud technologies such as network virtualization and software-defined networks could reduce fixed-line costs per bit by as much as 90 percent.

We believe cloud technologies could reduce fixed-line costs per bit by as much as 90 percent.

With the cloud, all of the network intelligence can reside in one data center instead of being built into thousands of telecom routers. The central data center is based on commercial off-the-shelf equipment, and it's typically very cost-effective to operate. That saves a lot of money and also allows better scalability. The boxes out in the field become merely fast-forwarding engines taking full advantage of low-cost but high-speed Ethernet technology.

Besides lower investment and operational costs, the cloud migration will also offer more centralized real-time control of network functions and service profiles, creating new opportunities to monetize quality of service in the network. Although net neutrality rules do put some limits on the types of possible business models, there is still room for innovative thinking.

For example, in the future the application server might notice during a Skype interaction that the quality of the video call has deteriorated. In response, it could pop up a window offering premium video call quality for 2 cents per minute. When the user accepts the offer, a high-definition service profile could be enabled within milliseconds to provide premium quality to that user. The payment would be deducted from the Skype account, with the telecom provider getting, say, 70 percent of the service fee and Skype keeping 30 percent as a brokerage fee. Even with net neutrality rules, this business model would be legal since Skype directly charges the customer. The additional fees are not imposed "through the back door" of higher subscription fees for customers or kickbacks paid by over-the-top players, whose services don't go through the customer's Internet service provider.

Going to the mass market

Besides the capacity and cost benefits of investing in fixed-line infrastructure, there is another major advantage. By increasing the density of their optical fiber footprint, the integrated operators can deliver a superior customer experience and gain market share in the traditional B2B and B2C fixed-network market segments. There are basically three ways that operators can accomplish this upgrade: fiber to the home/building; fiber to the curb; and hybrid fiber coax.

1. Fiber to the home (FTTH) or fiber to the building (FTTB) with GPON or p-t-p Ethernet connectivity to the Internet. In this scenario, fiber goes either to the living room or to the basement of the building. With FTTB, only the final meters in the building are over the copper network, and for these very short distances, copper wires don't slow down the connection as long as the operator has the right transmitting technology. However, FTTH/B is very expensive to build, especially when the population is less dense — as it is in suburban and rural areas — because you have to dig to every building. But it provides the best connection to the mass market. Any operator can pursue this upgrade strategy. FTTB helps avoid the time-consuming and expensive in-house process of upgrading to fiber. However, the FTTB operator needs to obtain access to the in-house cable networks of twisted copper pair cables or coaxial cables as well as to install active equipment in the basement, requiring more space and power supply. Many of these expenses might be somewhat less for new construction.

2. Fiber to the curb (FTTC) with mini-DSLAMs in street cabinets, reusing the existing copper network in the drop. In this scenario, fiber is run up the street to a telecom cabinet where a digital subscriber line access multiplexer (DSLAM) is located. The multiplexer terminates the signal on the optical fiber and generates a DSL signal on the copper network. With today's protocols of VDSL and vectoring, the DSLAM also allows 50 Mbps within half a mile or 100 Mbps within a quarter of a mile, respectively. The more street cabinets an operator puts in the community, the shorter the residual copper cable length and the faster the speed. The FTTC option is

available only to incumbent telecom operators because they own the copper networks. However, alternative operators can take advantage of FTTC through Bitstream wholesale products based on virtual unbundling of the local loop, so that subscribers can receive telephone and Internet services from different providers. Alternatively, telecom operators can even set up their own street cabinets (e.g., where the incumbent operator doesn't intend to upgrade to FTTC) through unbundling the sub-loop (i.e., subsections of the local loop). In many cases, however, this option is not commercially viable, due to the high level of regulated wholesale prices for the sub-loop.

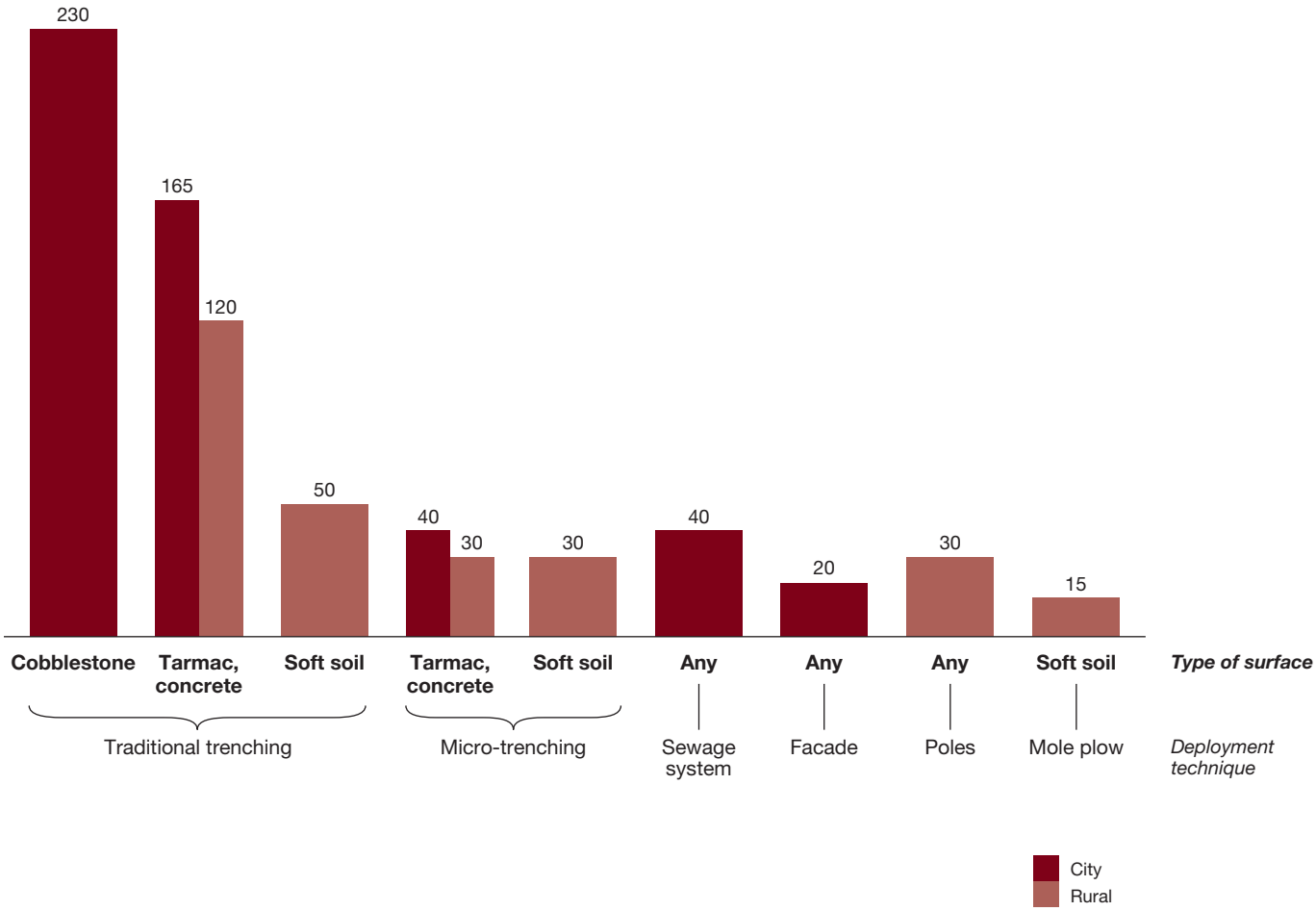
3. Hybrid fiber coax (HFC), which is network technology used by cable TV operators. In this case, the data moves over the hybrid fiber coaxial system. The current version of the data transmission protocol DOCSIS is super-fast, as much as 400 Mbps per user. A big advantage is that new fiber extensions in HFC networks can be deployed on demand and are more cost-efficient than FTTX scenarios. This is feasible only for cable companies, however.

When considering these three options, the question that integrated operators must ask themselves is what kind of network they can afford to build. The answer will depend very much on the geography. In a country like the Netherlands, where soil is muddy and permits for digging are just a formality, it's relatively easy to deploy fiber, and the cost could be as low as €5 per meter. But if the deployment is in a very old, historic city, with stone pavement that must be torn up and then replaced, the costs can run as high as €200 to €300 per meter (*see Exhibit 4, next page*).

Of course, the distances vary as well. In some instances, an operator might need to dig a kilometer to get to the next base station; in other cases, the operator might need to dig only 10 meters. Other considerations are the density of the fixed infrastructure and the coordinated planning of fixed and mobile infrastructures. All these costs and complexities contribute to the operator's investment decision.

Exhibit 4

Benchmark for fiber deployment costs (€/meter)



Note: Prices are for Western European developed markets and include digging, deployment of cable, and reinstatement (if necessary). Prices do not include project management, contractor supervision, etc. Total costs may be as low as €5 or as high as €300.

Source: Strategy& analysis and benchmarks

Meeting corporate needs

It's important to remember that different drivers are behind mass-market and business demand. Consumer demand will be dominated by streaming, downloads, browsing, and cloud applications. Among business customers the demand drivers on the employee side will be office applications, cloud storage and backup, client-based applications, "thin" clients that rely on a server or the cloud for data storage and processing, online collaboration, and software delivery (*see Exhibit 5, next page*).

However, these employee needs are just one side of the corporate story. Even more relevant is data traffic that customers generate and the bandwidth demands they will create for businesses. Companies across various industries are adopting digital business models. In other words, their interfaces with the mass market are moving to the Internet — and this is driving a surge in business customer data. This trend toward digitization will further drive demand for high-speed fiber (*see Exhibit 6, page 18*).

For example, a retail store that sells milk mostly interacts with customers who walk into the store and buy bottles of milk. In the future, more of those orders may come over the Internet through smart devices such as refrigerators. Eventually, thousands or hundreds of thousands of customers will send their requests for milk into a distribution center and the company will need to deal with a huge amount of traffic that did not exist before. Therefore, most mobile data traffic growth among businesses will come from customers, not employees. We expect the volume associated with this digitization of industries to grow at a compound annual rate of 50 percent or more and drive demand for high-speed fiber.

Given this level of customer traffic, the business community is also pushing for more fixed-line investment as a way to get to the customer faster. In addition to the three upgrades to the mass markets described above — fiber to the home, fiber to the curb, and hybrid fiber coax — businesses are also looking at dark fiber, through which businesses can connect data centers directly, and Ethernet VPNs. However, for businesses with multiple premises or data centers, these direct connectivity services will not suffice. They will need operators to make fixed-line investments as well.

The business community is pushing for more fixed-line investment to get to the customer faster.

Exhibit 5

Drivers and future bandwidth for consumers and enterprises

Consumers

Streaming ..... up to 30 Mbps
Downloads ..... up to 40 Mbps
Browsing ..... up to 10 Mbps
Cloud ..... up to 10 Mbps

Enterprises

Current

Office, including large emails ..... up to 10 Mbps
Cloud storage and backup ..... up to 20 Mbps
Client-based applications ..... up to 20 Mbps

Upcoming

Thin clients ..... up to 30 Mbps
Online collaboration ..... up to 20 Mbps
Software delivery ..... up to 30 Mbps

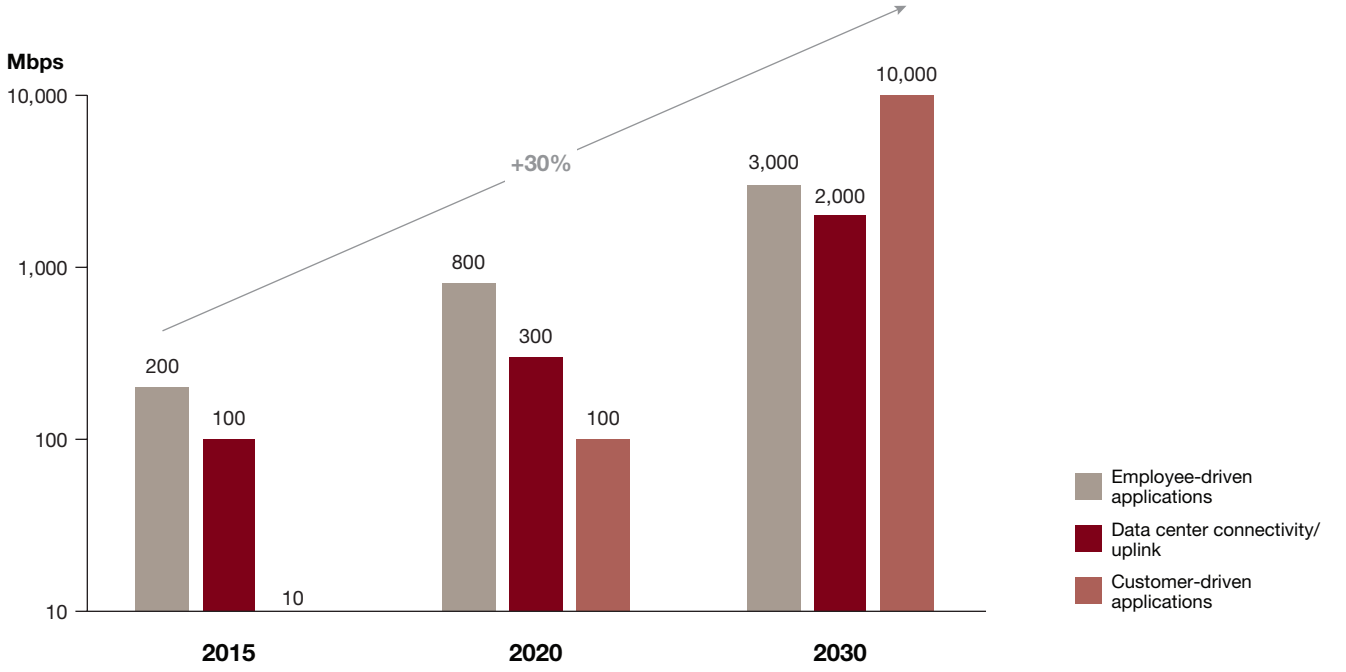
Business digitization (future main driver) ..... up to 10 Mbps

Note: Consumer figures are bandwidth per household. Enterprise figures are bandwidth per seat/employee. Business digitization figure is bandwidth per customer/user/client.

Source: Strategy& analysis

Exhibit 6

Typical enterprise connectivity requirements



Note: Enterprise with 100 employees in an industry that is undergoing digital transformation. Number of digital customers growing from 10,000 to 1 million in 2030; customer-centric digital applications growing from 1 kbps to 10 kbps concurrent bit rate.

Source: Strategy& analysis

The endgame

There is a strong likelihood that the intense need for fixed infrastructure to compete now and in the future will drive further consolidation of network operators, as well as deals to share networks and sites. This means even more customers will be served from each mobile site, creating greater demand for the kind of stable and scalable backhauling infrastructure that only fiber can provide.

We predict that by 2030 more than half the population in developed countries will need capacity of 100-plus Mbps. By that point, only the following technologies will have the potential to survive: FTTH; fiber to the station and 4G/5G; FTTC with short residual copper lengths of less than 100 meters; and HFC with less than 32 users per cable.

In the short to medium term, the winners will be operators that can fulfill the bandwidth demand of their customers in the most adaptive way at the lowest deployment cost, and develop new revenue streams from consumers. In the longer term, by 2030, the winners will be those operators with the largest installed base of fiber for the consumer segment (with the highest FTTH/B deployment density) and for the business segment (with the highest density of fiber access points).

The bottom line for integrated operators is that to meet the demands of digitization and data and position themselves for success by 2030, they need to shift their investment focus from mobile to fixed. Although customers are generally unwilling to pay more for more capacity, operators must continue to make these investments in fiber in the most cost-efficient way possible or lose out to competitors. Corporate executives may find it frustrating that they have to spend and invest more just to hang on to the customers and revenue they have. But if they invest wisely, with an eye toward new products and services, operators can use their new capacity and cost advantage to unlock additional revenue streams.

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