Telzed Limited

The need for speed

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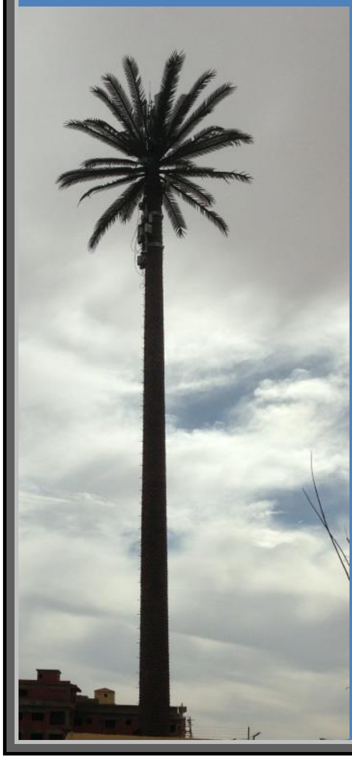
A discussion paper



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A brief study of broadband speed to assist strategic understanding

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The values shown are illustrative only. They still provide a basis on which strategic level analysis can be made and provide insights on how the industry might develop.

Alternative values for any speed numbers are easy to find. Telzed provides values here for illustration, to test industry thinking and provoke debate. Counter claims are welcomed.

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Broadband speed is key to many business, policy and strategy decisions

This paper is concerned with the physical access speed. This speed value is often discussed. The needs and factors affecting this speed are discussed. The values and insights provided assist anyone who needs to understand the strategic issues and the key underlying factors. It is emphasised that the aggregate **average speed** from many users **must** also be also understood, along with the average usage made of each individual broadband service. As well as impacting costs, the average usage impacts the physical speed, as demonstrated by slowdowns at times of the day and when other customers are active.

There are sometimes huge variations in the target access speeds that are required, depending on the source and the view taken. The actual speeds obtained also vary enormously, depending on the country, location and technology. The speeds may also depend on measurement method and time of day. The requirements and the deployed speeds both increase over time. Requirements can be both desired speed and the speed really needed. Since faster services do cost more, even if the marginal increase with speed might be low, a deeper understanding these factors can contribute to better strategic plans.

Numbers are provided in this paper to help understand key issues. These are not intended to be precise values; these can be developed based on more detailed analysis.

Key messages

For many consumers "adequate" broadband speed is less than 50Mit/s, often well less.

The primary driver for speed is real time video streaming applications.

A secondary driver is need to download large files/data in convenient time. For some customers this is a primary need.

Real time service speed-demands will of course rise, but if ultra HD can be done today at <20Mbit/s (needing up to ~50Mbit/s service to give headroom and for more than one user), then *mass market* demands for 100Mbit/s+ speed in the near term, are surely unlikely.

Specialist applications do need 100M-1+Gbit/s in order to download large volumes in a short time. Good strategies allow Gbit/s options for *some* customers. Most such applications will surely not also result in enormous downloads and high average speed – that incurs core network costs.

The additional cost needed for a higher speed service is often relatively small, unless it triggers a major technology upgrade. The additional cost can still be significant when considering millions of premises.

Gbit/s type applications that *also* have large volumes such as for large scale streaming at 100sMbit/s are surely specialised and likely to be more for businesses and exceptional SOHO premises. The costs in the core network due to the high average usage, may be more of an issue than the access line itself.

Mobile-based high-speed solutions can be addressed by large spectrum allocation and technical standards (these define the available Mbit/s/Hz), but mobile costs are strongly driven by the download volume (related to the *average* download speed). Costs are chiefly related to the mast numbers – which are driven by Mbit/s/Hz, spectrum and average speed.

What is the broadband access speed?

This is generally understood to be the physical access speed from a home broadband to the internet or from a mobile device to the internet. Ideally data will download at this speed. It ought to be measured over a reasonable period (not just a second or two). There are some additional factors to consider:

- The speeds obtained are not usually the speeds advertised: an issue for regulators and advertising standards authorities
- It is rarely guaranteed. It might slow down at some times of the day. As with many telecom services, it is *statistical*. It is only achieved X% of the time during the busy period and speeds can vary between customers on the same service
- Mobile broadband is much more variable than a fixed service. Factors include: the signal strength (is there a signal?); the GSM technology (3G or 4G); and whether other consumers in the same cell are also active – this can overload the local network/mast[1]
- The upload speed is rarely mentioned. Many situations require high speed. Why is this so often much less than the download?

The average broadband access speed rises by ~50% every 12 months, in many developed countries. Nielsen's law shows this, but it a measure of the outcome and does not necessarily reflect the needs. Nielsen's Law also does not define a target value, but the message is powerful – the required speed for most users must rise very significantly.

The *average usage* made by a customer is much lower. One might download at 20Mbit/s (=the physical broadband speed), but then nothing is downloaded for twenty minutes. This average usage is the key factor that drives costs in many telecom systems (see Telzed paper on broadband usage footnote 1). Current home broadband usage often *averages* only ~3Mbit/s, and mobile broadband about 0.02-0.1Mbit/s. This depends on the user behaviour (TV downloads versus email for example). A rough Telzed rule of thumb is: the average usage speed in the busy period is 0.035Mbit/s per Gbyte downloaded per month. The values vary by country of course. For understanding many issues and costs, the aggregate of many customers' average usage matters most. This drives the need for more mobile masts (see Telzed paper on cell numbers with rising demand) and for larger transmission links or faster routers.

Needs and wants

Almost everyone wants to have Gbit/s speed (why ever should you not want it?). Faster downloads make life easy. Streaming services (TV/video) do not lock up. Large volume data transport enables more sophisticated home working and remote teams. Back-up restoration of home PC and devices is practical – it is almost useless over 5Mbit/s. Graphics files and databases now routinely occupy multiple Gbyte. How long should a user wait for the full download or upload?

[1] See Telzed papers: "A guide to understanding broadband usage" and "Mobile cell site numbers with growing demand and higher capacity per site"

The effect of speed on behaviour is clear. UK (Ofcom) data shows the download per month versus broadband speed. Other countries will surely have similar behaviours. If the speed is low, then less is downloaded. Once a "decent" speed is obtained then the total download per month hardly increases. We can reasonably assume the slow speed stops users from doing certain things (no high-definition TV, or no TV at all etc.). Certainly, some consumers do not need high speed or do not want to pay any extra: so they pay less and use less and are not really held back by the slow speed. In this paper we assume the majority of low-download users are being held back by the lack of speed.

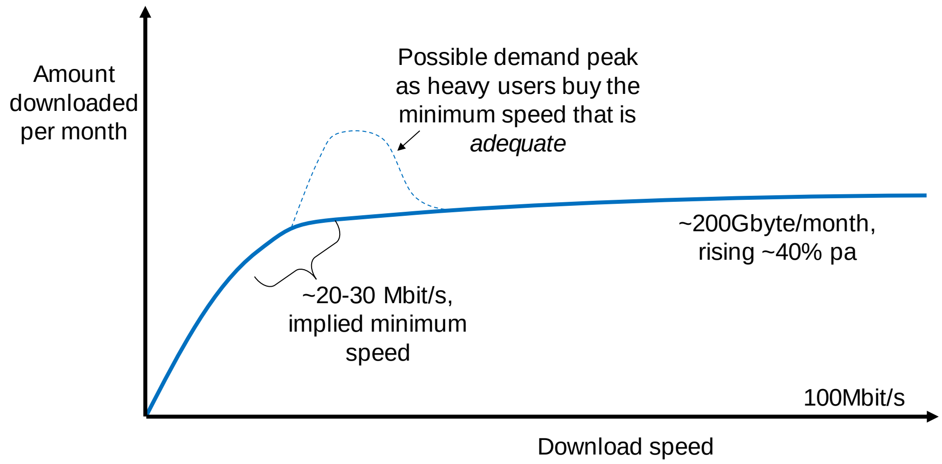

Figure 1. Download behaviour is affected by speed. Source: Telzed, based on Ofcom data: Connected Nations 2017 Detailed Analysis "Figure 20: Distribution of average data use compared with the average download speed"

As there are less downloads due to an overly-slow speed, a 30Mbit/s specification might be considered adequate. This is of course wrong for several reasons:

- New services and new ways of working always arise. No one (?) predicts telecoms and internet with any certainty more than a few years into the future
- The "*demand always seems to rise to exceed the capacity available to carry it*"
- 40%+ per year growth in downloads needs 10x network capacity in just 7 years. A point of debate is whether the speed increase could be much less or should be more
- Nielsen's law suggests the speed specification could even rise faster than the download demand
- The amount downloaded rises by ~30%-50% per year. This impacts the *average download speed* roughly in proportion. The physical speed of course must be much more than the average download speed. The UK data implies that this factor is perhaps[2] ~4 times. If average busy period speed were to rise from 7 to 20Mbit/s then

[2] 200Gbyte/month implies an average speed of 7Mbit/s in busy period (using Telzed rule of thumb), and minimum acceptable speed is ~30Mbit/s, hence factor of ~4x. Note: 4x is the minimum acceptable. It is much less on slower speed services as they have to drive the broadband to the limit more of the time. At the slowest speeds the physical speed is not much more than the average usage speed. A 3Mbit/s service is less than 2x the average use – and this is clearly inadequate for today. The customer is almost continuously downloading (and waiting)

the physical speed possibly needs to rise by *less* – maybe from 30Mbit/s to "only" 50 or 60Mbit/s, and not to 90Mbit/s. There could be (author's speculation) some "economy of scale speed effects" and the physical speed increase need not always be >4 times the average, *once the physical speed is "high enough."* So, when the required speed to be useful becomes 50Mbit/s ("knee point" in the figure), then 10 times more downloads per month probably does not require 500Mbit/s. The *speed needed is then set by the fastest service, not by the downloads* – this is discussed further below.

The fact that the Nielsen's law speed increase is greater than the download increase, in some countries, is significant. The average speed growth probably reflects the fact that so many consumers have a grossly insufficient speed. Telcos have to work hard to overcome this huge backlog of poorly serviced customers. If this backlog were suddenly addressed, then speed changes might then reflect the slightly lower increase in download totals. But should speed increase "only" at 30-50% per year, as per the download change? The last point above identified a possible economy of scale effect that could mean slower speed increases might be tolerable. But, it seems foolish to rely on the economy effect or to use this as an excuse for not upgrading the services. Clearly there *is* a current issue with inadequate speed and the economy of scale effect is likely to be seen only if the speed is adequately high (if it exists at all). Many countries probably do not have most customers on a speed that is "adequately high enough" for current needs.

A key point from the data, is that slow speed customers have average usage ~50% of the physical speed, and faster lines perhaps use only 25% or much less of the physical speed, on average. This **does not** mean that the access line is underutilised and 2-3 times more traffic for the same service speed is the solution. The access link is always 100% used when downloading. The customer waits, or may be able to view buffered video. Then nothing is downloaded until the next data download batch. It is this delay, stopping of video, or slow large-file downloads that makes a user not use the broadband (hence lower downloads for slow speed users). Alternatively, they only download low resolution video. Slow speed users have to use it closer to the physical speed, more of the time. 50-75% capacity is not unused in the sense that it is spare and can be easily used without pain – it is needed to reflect the reality of traffic demands and statistics. Running a broadband link close to 100% means the customer is probably suffering. All slow speed broadband users know this – they are constantly waiting for downloads. This follows from basic traffic theory which also shows how two users in one premises cause so much more pain than having one. The data implies an average usage of ~25% is deemed to be about acceptable in practice.

The data shows that high speed services do not cause much more downloads. This is to be expected, once past the "knee point" on Figure 1. The download volume is based on customer behaviour – what web sites, ways of working and videos are watched. This depends on the country of course. So 100Mbit/s fibre users might download less than 20Mbit/s users in another country. They key point is that, if the speeds are high enough, speed is not the driver (nor the limiter) of behaviour. "*Speed does not increase traffic (if above the knee point), but a <u>lack of speed</u> does <u>decrease</u> the traffic*."

The implications of the above suggest:

- Almost everyone should have access to **at least** ~30Mbit/s now, or in the *near* future
- Any deployment ought to be able to cope with a demand for ~100Mbit/s in a few years' time. This follows from the known data growth and likely new services. Unless the technology were able to be incrementally upgraded at low cost, it is likely to be false economy to build a network *today* with much less than this performance – the systems

will have to be replaced, which is often more costly than fitting better systems in the first place[3].

This does not mean that even faster speeds are not needed. High end users and home workers need more. The same deployment will inevitably cover businesses. Any deployed technology should not be "one size for all." Some need more and can pay a bit more.

Costs and speed

Faster services need new technology or better versions of the same technology. This could cost more, but the following factors need consideration:

- Fibre based services (especially FTTH or close to premises) are dominated by the fibre civil works. The end electronics has relatively little impact. So, for the customer link, the costs of 1Gbit/s are not much more than 50Mbit/s[4]
- All technologies that have concentration systems which aggregate average traffic from several customers, can have significant costs, *when* the system's limits are exceeded (sum of customer average traffic exceeds the aggregate limit). This is one reason why PONs and electronics in the street have some risks. Upgrades could require every premise on the one system to be upgraded, if the aggregate threshold is passed
- Copper wire systems, no matter how splendidly the copper-link electronics improve, will always struggle. There is inevitably a significant percentage of customers who cannot get the required speed, and this rises over time as the "minimum adequate speed" rises. Even the current need for 20-30Mbit/s is not possible on many fibre-copper wires (see Figure 1's Ofcom data fig 16). Ultimately yet more street cabinets/systems are needed for higher speeds – expensive investments. This is a technical blind alleyway that was always going to have boundaries – this was long foreseen. The key benefit of copper wires is low cost (sunk investment) – so the appeal is obvious, plus "it works" and many can live with the speed limitations. Copper/fibre is "just about good enough" for many. There remains a problem of dealing with the few high-speed customers' demands and the significant number of customers who still cannot get decent speeds. Yet deeper deployment of fibre *in parallel* to the copper wires can deal with high-demand customers, but the economics of parallel network investments is questionable: perhaps these customers have to be disappointed (this is the implied outcome chosen with a FTTC approach and long-ish copper wires). This

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[3] This should be self-evident. Sending a technician to the premises or street is far more expensive than software configured networks. All networks are ultimately restricted by the technology choice. A fixed network solution without migration to 30-100Mbit/s for most and a Gbit/s options for some, in the *near future*, is surely a wrong choice

[4] Many fibre solutions use PONs - passive optical networks - where perhaps 32 customers share the signals from one network optical transmitter. Each customer might get 20-100Mbit/s, yet the customer site electronics/optics has to run at the aggregate speed of all customers in order to select the individual customer's data. So the incremental cost of high speed optics (multi-Gbit/s) is clearly small – it is already in place. Assuming the customers aggregate speed (sum of all 32 services) is less than the physical speed of the optical system, the marginal cost of a faster service is close to zero. The incremental cost is in the core – but even this can be small (see footnote 1). Note that core costs are *not* significantly driven by access speed – they are driven by the average download. The low cost-increment of access broadband speed is also shown by alternative broadband providers, who can often offer 100Mbit+ services as, once they make the FTTx investment, the prices of slow and high speed services may be similar

links to a key point: just because customers want faster speed does not mean they must get it at a low price. Wrong technology choices are however not the fault of the customer

- Copper coaxial systems (typical for cable TV) can have fibre like performance (100+Mbit/s). This can lead to street electronics for the coaxial section to interface via fibre back to the head end. The cost to install a coaxial cable is not much less than fibre. Of course, this is now often a sunk cost, and coax is much less limited than copper wires; so it is sensible to upgrade the speed. Also, a cable TV play adds to the business merits. Coaxial cables fundamentally have significant speed potential, but fibre is probably more likely for many greenfield sites

- FWA (fixed wireless access) could deliver fast services, but the limitations are obvious. These include: possible speed limitations; possible line of site limitations ("*who put that school/house/tree there?*"); mast costs; adequate spectrum that works inside premises etc. Cheap backhaul depends on sharing the cable with fixed access lines. Maybe the time for FWA can rise again, but many past failures provide warnings. The convergence of FTTP, FTTx, FWA and small-cell mobile is clear. 5G and converged networks might be "the way" - please contact Telzed to discuss further, as this moves beyond this paper's scope.

The initial points on fibre need further emphasis. Fibre termination-electronics with faster speed, has a small cost impact and the fibre itself is a fixed cost. So why are faster broadband services priced so much higher? The reasons for this include:

- Fibre *does* cost more. Contrast: copper wires *already exist*. The analysis is complicated by short and long terms costs, operational costs, upgrade costs etc. This paper does not analyse the costs

- Customers will pay more. Sometimes this is true if they need the speed or not. Any business will charge what it can get. There is a fibre and speed premium[5]

- Competition at the high speeds is limited

- There are some more costs in the core from greater *usage* (total downloaded and higher busy hour average speed). Higher speed *does* encourage more download, even above the knee point (though effect is then lower). So pricing by speed is an indirect way to control the total download and average usage speed

- If many customers demand >100Mbit/s or if average usage rises, then some systems require a major technical upgrade. If such a threshold must be crossed soon, it arguably implies a wrong technical strategy choice was made (the trends have been clear for many years). To avoid the major upgrade, prices may be set accordingly to delay the network upgrade that results if more than a few migrate to high speed[6]

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[5] There is the "well known" story of the customer asking for the new fibre to the home. "But you only take a fixed phone line and no broadband or TV." "I want fibre because it is better"

[6] Perhaps this shows an incorrect mind set in some telcos. How can we slow down customer behaviour and make them stop using the broadband too much? Rather than: why did we choose the wrong technology in the first place? Was the technical choice influenced by regulatory strategies to avoid unbundling or flexible wholesale access?

- Volume based tariffs are not liked by fixed network customers. Indirect discouragement of volume downloads by speed-pricing can be more attractive. This keeps customers mostly at or below the knee point of Figure 1

- Telcos know there are unknowns. "*Data always rises to exceed the capacity (or speed) available*" is an old maxim used by telco engineers and others. Some new applications will surely arise to make large volume use of 100M-1Gbit/s sooner or later – but whether everyone *really needs* them, is open to debate. This high download (and related usage cost) is pre-empted by higher prices. It is the high total download (many Gbyte per month and high *average* Mbit/s) that is often the cost problem; delivering 1Gbit/s often is not much more expensive than 100Mbit/s over FTTx.

Home site needs

The customer needs must be properly understood. Many will be familiar with the problem of performance degradation on slow broadband: "*Turn the PC off and stop downloading, I need to work/get Netflix/have a Skype call*." In practice this does not mean there is a real need to sum up every possible service used at home by every person who might be in the premise. One person can rarely do many things at the same time. When that happens, then one may well be a background task (and hence not critical to speed). TV might need 15Mbit/s, Skype 3Mbit/s, voice calls 0.5Mbit/s, gaming perhaps 10Mbit/s, but who cares when watching TV? They rarely need 28.5Mbit/s. It is a statistical service. Note: values are for illustration only. A user needs at least the speed of the fastest service, plus a mark-up to make it work reliably.

The earlier analysis suggests the speeds should be ~4x the average usage. It is **not** 4x the TV speed. The TV needs 15Mbit/s, and this is easy over a 30Mbit/s service (only 2x). It runs at 30Mbits then stops, then more is downloaded. The average of all services may be about 7Mbit/s (~1/4 of 30Mbit/s), to deliver 200Gbyte/month downloaded (rule of thumb). One might think just over 15Mbit/s would be enough (the fastest service), but the UK data shows this is not seen as adequate. Customers quite reasonably like the download to be completed quickly, plus there are other users in most households. Two 15Mbit/s TV/video viewers in a house will struggle on a 30Mbit/s service but the 30Mbit/s service probably does not need to double in speed.

Meeting the total premise's needs must appreciate that the statistical demands of 2 or 3 users in one premise has a far worse variance than 300 customers. The total traffic of 300 customers tends closely to 300x the average of each. This is elementary traffic theory, and so mobile masts and telco core networks should not often have major overloads. This means that a broadband speed needs to be much more than the average usage (hence the >4x value) and also significantly more than the fastest service used (perhaps by a factor of[7] 1.2-2x). If two or three

[7] This is a value that needs more consideration than is possible here. Lower values of this "Telzed speed overhead" leaves little headroom, including that for growth, but potentially a lower value may be more tolerable for very high speed. 10Mbit/s video might need at least 15Mbit/s to work reliably (factor 1.5), but 40bit/s video might not need more than 50Mbit/s (x1.25). Current speeds required for streaming video services probably support such figures and a 25Mbit/s broadband should be enough for current HD video (which probably explains the knee point in the figure). This implies 50-100Mbit/s should be adequate perhaps out to 2025+ for many premises, unless video/TV *service speeds* grow very fast (total monthly downloads [Gbyte] *will* grow, but this is a different problem). "Even-better-HD" may become available but that is likely to be accompanied by additional compression. 100Mbit/s+ video streaming seems doubtful as a *major* demand-driver in the *near* term if ultra-HD only needs only 25Mbit/s today

users frequently need the same top-speed service, then the premise's speed must be 1.2-2x this aggregate speed.

Upload speed

This is a Cinderella of the broadband discussion. In part we have slow uploads due to the historic xDSL copper wire technology. Coaxial or fibre-based solutions do not have this limit. TV/video is mostly a one-way service, but many other things need bi-directional flow (video calls, voice, interactive working, back-ups, file transfer, virtual reality, gaming etc). So why the restrictions on upload speed? A number of factors may be at play:

- Legacy technology is still in place (copper or poor optical systems that did not have upload speed migration paths)
- Some other technical limits may exist
- Telcos can charge for upload speed. "*Never sell anything cheap if someone will pay more*" – this is possible because we *expect* a slow service due to historical experience
- The upload amount is certainly less than the download, but more uploads have little effect on the access-link cost. Low upload speed limits restrict many applications. This *suggests* telcos deliberately keep upload speed down to restrict how broadband is used – it stops some applications, and stops unknown new applications that might arise, that create major new volumes of traffic (a cost driver in the core network)
- Protection of other telco services.

The latter is needs further study. Telcos often sell IT services, internet site hosting and IP transit services. They get revenue from the "other end of the internet business" as well as from domestic consumers. If customers have their own server and web site at home then this could cause service cannibalisation[8].

A 100Mbit/s broadband upload could be used for: a small web site host; for your own private internet service; data back-up for friends and family; video sharing etc. Telcos generally do not like re-sale (or re-use) of any service due to the lost revenue potential.

Fast uplinks could open up a number of new ways of working, that are not currently possible. What might users do with 100Mbit/s+ two-way communications? Telcos might prefer to play safe and simply restrict such options from arising as they might give no more revenue and uploads increase the total average traffic, which of course *has* a cost increment and this could be significant with some new interactive ways of working.

The upstream service speeds and prices need to be examined further from technical, competition and regulatory viewpoints.

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[8] Large OTT TV *down*loads also cannibalise cable TV or other TV services, which may cause some telcos to be reluctant to deliver high speed downloads. But this is surely a pointless task as OTT will grow enormously over the next few years; it cannot be stopped

Mobile speed

There are limits to what a telco can do about this. It is essentially limited by the GSM technology. Also, users run into the contended capacity of the base station (see footnote 1). Upload speeds are also limited by technology and power concerns: "microwaving your head!"

Speed based prices can be hard to implement in mobile networks, as speed is rarely under the operator's full control[9]. A move to 5G could increase the speed, but that is unlikely to enable a speed price premium. Furthermore, the chief cost driver in mobile networks is the download and average usage, so pricing by #Gbyte/month is more usual.

The technical standards set limits when linked to the spectrum available. GSM technical standards allow up to *about* 1bit/s/Hz of spectrum but this can rise with good signals and 4G (5G should do much better). With technical advances to ~5bit/s/Hz[10], maybe 250Mbit/s is possible from 50MHz (a large block of continuous spectrum, not often issued). This is far from the fabled 1-10Gbit/s of 5G. Of course the same spectrum can be split up and re-used so that one mast might have 50 MHz in many sectors (we assume here 10 sectors using directional antennae – the current norm is three). So this gives 250Mbit/s in each sector and total mast capacity of 2.5Gbit/s. Note how any one user cannot get this. The Telzed paper (footnote 1) shows how this capacity is still a very attractive business case. "Just" 100Mbit/s download speed is also excellent and adequate for many[11] applications, but as it is shared with other devices in your neighbourhood, it will be less on average. This is only a problem when the aggregate usage exceeds the sector limit. If the mobile users average 1Mbit/s then many customers can share the 250Mbit/s; again, basic traffic statistics should be understood.

Mobile could (?) provide 1Gbit/s but this needs a lot of spectrum and technologies to give high bit/s/Hz. Large continuous spectrum allocations are rarely awarded to one operator at <3GHz. Aggregating separate spectrum blocks might be a solution. Microwave bands allow more spectrum to be made available. Line of site (or close to) enables high signal to noise levels to allow high multi-bit/s/Hz. But this has problems: it is really a type of FWA solution and may need many smaller cell (mast) sites. The business case for small cells and FWA is beyond this short paper.

It remains quite possible for mobile/small cells to deliver a 50-100Mbit/s service in the near future with 500+Gbyte/month. But, by the time that is offered many countries will have a fixed line FTTx service already in place that has no performance limits set by other customer numbers in the same neighbourhood. Problems arise if more than a minority of customers actually make use of this 500Gbyte limit – the capacity per sector or per mast is exceeded by the total average usage. This is *unrelated to* the speed. This leads to the small-cell solution to reduce the traffic per mast. See Telzed rule of thumb and footnote 1.

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[9] A mobile operator cannot offer 30Mbit/s service as it has no ability to say when this might be achieved. It can only offer "what might be possible" with 3G, 4G or 5G technology. History has shown that the new technology has shown limited ability to charge additional premiums for the new GSM generation

[10] Example used for illustration only. Some radio technology & 5G can do far higher than this, but it gets hard if the user is further from the mast and/or line of site is lost. Real world situations include sitting down "not near the window facing the mast"

[11] Probably most. Almost certainly it is adequate for the majority of bytes that are likely to be sent today. This short paper does not attempt to cover the mobile situations requiring Gbit/s+ speeds. There are some demand-claims for >1Gbit/s mobile using 5G

The key challenges are: can (or should) mobile ever deliver 1Gbit/s on a useable widespread basis? Is 50-100Mbit/s adequate (it *is* for home broadband, at least for the near term)? Could mobile provide 500Gbyte per month download to most users and replace all (or most) fixed lines? Such claims are made. The answers should be obvious.

Summary of possible speed "solutions"

One answer will never fit all situations. A few pointers to the future may be given that bring together the earlier points and set some numbers in place that can be argued over:

- A jump to 30-50Mbit/s should cover most consumer needs of today, but deployment plans should aim higher. Higher speed needs will arise, but the pressure for >>50Mbit/s might not be large, as it is "good enough" for most
- Some users should have access to much higher speeds. One limit for the many should not hold back the needs of a few
- If moving to fibre-based services, then the fibre is the major cost and the speed is not a concern. It is false economy to build a network than cannot migrate to faster speeds other than at low incremental costs. A fibre 100Mbit/s solution can be a 1Gbit/s solution with small additional cost. Is this not the approach used by new fibre entrants (altnets)? They do not deploy 20Mbit/s solutions and enhance later, it is capable of much faster service and slower services are offered for commercial reasons, not because their FTTx deployment is incapable. Deploy and forget it is surely cheaper than sending a man in a van out every 1-3 years to the street or house. Avoid technical blind alleys that need major re-investment
- There is no one "must have" speed – any target will rise over time and will vary by country and individual
- Mobile speeds of 30 to 100Mbit/s should be adequate for many applications (it seems to be for fixed lines). The main mobile costs factors are the total download and average usage, not physical speed. Large spectrum allocations with high bit/s/Hz techniques, are needed for high speed
- Speed is vital for real-time streaming (TV/video). The required speed for these real-time services needs the greatest focus, and the physical speed must be "a reasonable amount more" – see the "Telzed speed overhead" and consider also the user statistics in each premise. Real time ultra HD TV or virtual reality at 20Mbit/s needs perhaps 30Mbit/s broadband to be reliable, or 50Mbit/s if two users are in one premise
- Large-download and upload applications need completion in a convenient period. Although relatively specialised, these may be the main home or SOHO driver for Gbit/s, not TV. *This should be a key focus area because streaming is not an obvious driver for Gbit/s services (though it is obviously a driver for up to 100Mbit/s services)*
- Video speeds will rise, but how rapidly, once perhaps a 25Mbit/s HD service were available (itself a significant speed)? This can be (just) delivered over 30Mbit/s+ broadband. The amount downloaded of course will rise as we make more use of video but this has a different cost driver to that of the fastest real time service. Download totals indirectly impact the required speed, but have little impact once broadband speed is over the demand "knee point" in the above figure. If we need "just a bit more" speed than the fastest real time service, then only a *very few* home broadband premises will need >1Gbit/s as it seems unlikely that real time video applications of 500Mbit/s are

going to be common in the next 10 years. This is the crux of the need and demand discussion. A 1Gbit/s home or business is probably driven by fast large file transfer requirements (previous bullet)

- *Most premises can be satisfied with 50-100Mbit/s,* perhaps for a number of years - HD video, gaming or virtual reality *are* never-ending demand drivers, but will surely **not** need “2Gbit/s” in the next few years. Compression works. Users need a bit more than the single highest speed service – currently video, and that only needs ~30Mbit/s today – this implies the 50-100Mbit/s figure

- Users want speed, but it has to be economically viable. Even a small cost increase to deliver XMbit/s, is a big number when multiplied by tens of millions of premises. So commercial reality must be part of any strategy and policy

- A more visionary approach would “just deploy it” and use deep fibre (FTTX/FTTP/FTTstreet & FWA with FTTstreet & small-cell mobile) and expect the additional investment is paid for by lower opex and wider economic gains. Note that these gains are in other industries, not accessible to the telco. This may be a tax issue for governments to consider (profits from content and services). Lower opex requires a more radical approach to remove parallel copper and change network architectures, that are currently based on switch sites with ~3km radius caused by copper, to a fibre-centred solution

- Many sources indicate monthly revenues (fixed and mobile) are almost constant, so there is clear reluctance to take superfast broadband, if it costs more. Customer nature is always to take the lowest possible speed (and price) that is “just about acceptable.” Therefore, take up rates for superfast can be low: demand will be centred around the “acceptable speed knee point”

- The many low-income households will bear a bit of degradation to save money. They remain on slow speed, even if faster is available. Copper-wire based solutions therefore can have a continuing role to play as it may be a “bit cheaper” than fibre centred solutions (debatable point) and, though often a just bit too slow, are not slow enough to force the upgrade

- The incremental cost of faster speed is low, with fibre to or close to the premises. This also enables mobile & FWA. There are still commercial, technical-speed and volume cost factors that discourage universal Gbit/s deployment. This should not hold back deployment of 100Mbit/s migration options or Gbit/s availability for a *few* customers

- Technical strategies must be long term and factor in the known changes and possible unexpected new demands

- Special mobile applications that need 1Gbit/s speeds are a key platform for 5G claims. Technically this speed can be achieved (claim 5G advocates), but surely this is more likely in just a few locations. If the speed is accompanied by large volume usage, then these sites will have capacity problems unless sites are small - which leads to cost concerns

- Mobile is a complement to fixed broadband for the majority, *not a replacement*. This is due to the capacity and cost limits of mobile networks. But there will be countries and regional exceptions to this, where mobile can, and should, dominate

- A mast site with 2Gbit/s total capacity could deliver about 50Gbyte/month to about 1000 subscribers. This could be delivered at 1Gbit/s or 100Mbit/s. The speed is set by radio technology, amount of spectrum and signal levels. Such 50Gbyte usage is well above most mobile users today, but below fixed line usage. The physical speed is also statistical[12] – it might slow down depending on other users, so it cannot be absolutely critical. This is significant for potentially charging a price premium for speed and for what applications can be used. What applications need 1Gbit/s, but can accept that this speed may sometimes slow down and will not be used for huge volumes?

- More study is needed on the applications that need large volume/fast downloads or uploads. These drive some customers to Gbit/s. What needs a fast download but is not done very often, so the average usage is still reasonably low? Fast downloads that *also* need huge volumes (streaming) may be required, but these are surely specialised business situations – and they should rightly pay for the core capacity increases that follow. Such high volume and high speed mobile applications are even more specialised – what are they? This is in contrast to fast mobile application demands that are *not* also causing huge volumes (which is far more likely), but again the demand and willingness to pay for the services needs further study

- Finally it is worth noting the rarely discussed "application" that possibly drives the desire for high definition or real time interactive features. This is not often seen in 5G "use case" discussions. Adult material has been a major factor in driving broadband traffic, and it might well be one of the leading drivers for higher broadband speed, in the future. It is certainly responsible for a significant volume of internet traffic (Telzed suggests: Google for information on the *statistics*, not on the content). Many other "normal" applications might need very high speed, but might well have much less impact overall due to the relative popularity and lower traffic volumes.

Anyone today on FTTx or >50Mbit/s with unlimited downloads probably never thinks about the speed. Other things in life are more important. 40 or 100Mbit/s makes little difference: ***if*** it is more than the threshold not to care (currently ~20-30Mbit/s and rising). Conclusion: deploy 50-100Mbits minimum as soon as possible, with a 1Gbit/s option for some high-end users and as possible wider market migration option over next X years (number to be debated). The demand for mass market Gbit/s services seems elusive, especially if accompanied by large average usage (download volumes). In contrast: the demand for ~50-100Mbit/s for many, with large downloads, is much more obvious in the near term.

Discussions are welcomed – please contact the author at Telzed.

[12] There cannot be five simultaneous downloads at 1Gbit/s as that exceeds the total mast site capacity – some traffic must slow down


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