Telzed Limited

Strategic issues for fixed and mobile broadband

A discussion paper

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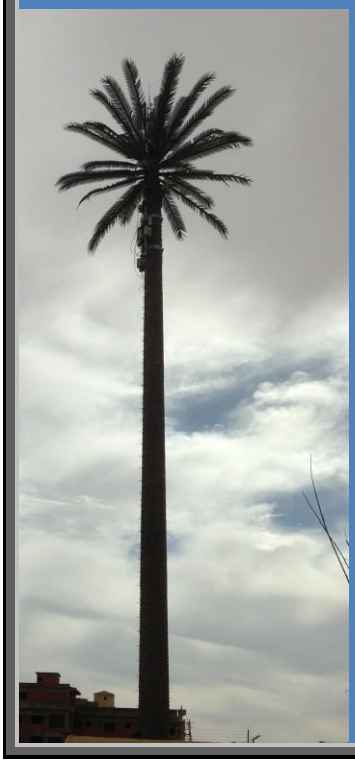

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Including: including where mobile and fixed should converge or compete

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1 Introduction

1.1 This report addresses key strategic questions

This report provides policy makers, managers, regulators, strategists, economic-modellers and decision makers with insights on broadband usage in fixed and mobile networks. Broadband is a vital part of the national economy in almost all countries, yet there seems to be multiple approaches to its development.

To assist with industry plans, this report highlights some key facts about fixed and mobile broadband and the potential for each to become the primary broadband platform for domestic and business users. This report points out that there is a convergence in the fixed and mobile technologies – so regulations and business plans also need to converge. This is not a novel observation. However, it is vital that it is understood properly in the context of the fundamental capabilities of fixed and mobile networks.

The current roll out of 4G and in particular the potentials of 5G networks to deliver greater broadband capabilities *could* provide a new approach for the telecommunications industry to address customers' demands. It is possible to argue that mobile (5G) based solutions could substitute for fixed line broadband. The key choice could then be:

- Fibre to the premises (or close to the premises) with copper of coaxial[1] for the final link (FTTx) as a "fixed" solution or
- A 5G based solution that *potentially* provides similar performance from more, smaller base stations than used today. This avoids the need for the final fibre, copper or coaxial cable link to the premises. 4G could also be used with many more smaller cells, but more usually 5G is proposed to be the future approach for this small-cell architecture. For many strategic discussions, the mobile technology chosen (4G/5G) is not significant.

The start point for this report is the Telzed paper "A guide to understanding broadband usage" April 2017[2]. This April Report provides the basic facts about the performances of fixed and mobile networks. The facts show that current mobile network broadband usage *per customer* is ~20-100 times smaller than that on fixed broadband, in most developed countries (UK example data was used but similar values will be seen in many other countries). This shows the magnitude of the problems, *if* a mobile type solution aspires to replace the fixed line approach.

The *mobile* solution terminates with a small base station to cover a small cell. This is effectively converging towards FTTPremises, but with fibre terminating close the premises and using radio for the last link. This is in contrast to a *truly all fixed* approach that uses the

[1] Coaxial cables are widely used instead of copper wires for cable TV and broadband service delivery. Depending on the local market and history of competition, the TV company may deliver in parallel to the traditional copper fixed line operator or instead of it. Some countries have very little Cable TV

[2] See Telzed web site

legacy copper wires for the final connection (or fibre or coaxial for that same final link. A point to point radio link would also be "fixed" in this sense). Copper cannot carry large capacities over long distances, but it can work reasonably well over shorter distances. Both use fibre to, or close the premises. The convergence is clear if the base station is looked at as a super "home WiFi router," but with a bit more power to cover more than one house or apartment and its neighbours – which some WiFi terminals can already achieve.

The key questions for strategic business, investor and regulatory plans include:

- Can a mobile based approach be the primary broadband delivery technology?
- Should mobile broadband remain an add-on service to "simply" supplement a fixed broadband delivery (based on FTTx), when users are peripatetic?
- Should the two approaches be converged to benefit consumers and both the fixed and mobile industries, and if so: how?

To assist with such answers, the key facts from the April Report are expanded on below with some insight and lessons from the past. These are a serious reminder that major mistakes can happen again, and just because a major company follows a certain path that seems at first to be solid, history shows it can still fail.

The facts and lessons from history are then considered together to give general insights on the strategic directions that may be followed. These directions will not be the same for every country or possibly every region within a country. The required approaches may be broadly split into three categories:

- Developed economies with existing fixed line broadband and mobile services
- City-states where the market is dominated by one or a very few urban centres, with a very small rural population
- Emerging economies which tend to have low fixed line penetration levels and rely mainly on mobile services for voice and data. They also tend to have low income per person and low national GDP.

Some countries have regions that cover more than one of these categories.

1.2 Key messages from the April 2017 Telzed report

Developed countries have significant fixed line broadband usage – over 100Gbyte per month downloads. Mobile downloads tend to be **much** lower – a few Gbyte per month[3]. The figures for both are rising by ~50% per year. This means the network capacity will have to grow by a factor of 10 in only about five and half years' time[4].

[3] As well as Ofcom market data, used in the earlier Telzed April report, this is shown in many other reports. See for example the Tefficient report: Industry analysis #5 2016 Mobile data 1H 2016 "Unlimited pushes data usage to new heights". This report has a number of interesting insights on mobile data usage

[4] There seems no significant chance of this growth levelling off as video, HD, TV, OTT, cloud computing, IoT etc carry on growing. The use of data compression technology will surely have negligible impact (though it is still a worthy technology). It might speed a download, but that just encourages *more* downloads

The Telzed April Report showed that this *download* demand causes a *traffic* demand in the busy period that drives the costs of the network. The busy hour average Mbit/s drives the cost of the key concentration points of a network[5]. This is not the download speed. Fixed line average busy hour traffic usage levels of 1-5Mbit/s per household already exist today. A mobile user is more likely to make ~0.05Mbit/s usage, except for a relatively few heavy users.

This is the *average* usage that is made over the physical download link – which might be at some 20 or even 100Mbit/s – whatever is available and paid for by the user. Average download physical link speeds are over 20Mbit/s in many countries even over mobile networks. The physical download speed is limited by the technology (fibre, 3G, 4G, distances from the base station, copper length). The service is rarely if ever used continuously for many hours at the maximum speed. It is the average usage that drives the network capacity at the concentration points, and so it is the critical driver of costs. This does not mean that the download speed does not matter – it clearly makes a huge difference to the consumer experience and what types of work or entertainment are possible. HD movies, large databases, video, rich graphics etc all require fast networks. A simple indication is that many PCs have ~1 terabyte of storage. Many consumers may now have 500Gbyte of information stored. This will periodically need to be downloaded or uploaded. The time involved is easy to calculate, but the average up or down stream speed may be well less than the headline speed. A 10Mbit/s USO[6] speed is being discussed again in the UK (August 2017) – this requires over 3 days to recover/copy the data, even assuming the 10Mbit/s rate was achieved 24/7. Your back-up or cloud service is rather less useful than you might have hoped.

The key concentration points that must expand to cope with the aggregated demand of many customers are the mobile base station and the core network routers in the fixed network. Mobile base stations have finite spectrum and limits to the amount of data that can be delivered over each MHz of spectrum – defined by the 3G/4G/5G technology. Too much mobile traffic requires more base stations, or new ones with more capacity and faster backhaul links to the core network. Without this, there are familiar slow-downs of the customers' traffic. More fixed traffic requires larger routers and transmission links in the core network to avoid slower downloads. Some fixed line technologies have some concentration within the access network – this is not considered here.

The required cost increases are often worse in mobiles – an additional cell and mast is a major investment. As spectrum is finite, large increases require significantly more cells. This is why mobile call plans usually have limited downloads per month (typically a few Gbyte/month or up to ~30Gbyte for heavy users willing to pay possibly significant fees). There are sometimes punitive additional fees for exceeding the limit. This demonstrates the strong cost-driver effect of usage on mobile networks. There is a significant marginal cost for additional data capacity. There *are* some mobile limits approaching fixed line usage levels (100Gbyte/month) without huge prices (check the retail offers globally). This is probably due to 4G capacity increases, that were not accompanied by large increases in base station numbers. Fixed line services more often have unlimited downloads, or very high limits or simply "fair use" clauses. Such monthly Gbyte limits, where they exist, are typically well over 10 times a mobile service's limit. This demonstrates the lower marginal costs – more data

[5] Downloads done overnight are not going to cause most network planners and the CFO any concern

[6] Universal Service Obligation. This obliges service providers (usually just the fixed incumbent) to deliver a minimum service. Sometimes a USO may be offered "voluntarily"

capacity requires a larger core network, but this is normally large and there are economies of scale, but the mobile capacity increases have to be in the radio access network – the capacity and number of base stations – where the cost increases are significant.

The access speed and its costs are not directly altered by the monthly downloads. 20, 100 or 500Mbit/s services are available and the access network costs of each are constant – the fibre or copper remains the same, even if the monthly download increases. Certainly a faster service costs more (it needs FTTP and/or faster termination equipment) but the costs remain independent of the usage (in Gbyte/month or busy hour Mbit/s). It should also be noted that 100Mbit/s or 500Mbit/s over fibre have similar costs as the cable installation costs dominate – the termination equipment costs are less of a factor. So the fixed access network costs do have an increase with download speed, but the cost is then constant with usage. Access core costs rise with busy hour usage (the aggregated Mbit/s usage in busy hour of all customers), but there are major economies of scale.

Mobile technologies have the radio access (base station) costs driven directly by the average usage per customer (busy hour Mbit/s). The mobile base station backhaul costs are also driven by aggregated busy hour usage (Mbit/s) of each customer.

Mobile networks also have a core network whose cost drivers are similar to that of fixed networks, but this is dominated by the incremental costs in the radio access network. 10x more traffic might need very small investments in the core, but will need possibly many new base stations in the radio access network, if the current cells are close to capacity limits – are new cells really so much cheaper to compensate for this demand cost-driver?

2 Lessons from history

2.1 Ever increasing data demands and telecom failures

Telecoms is a fast moving industry and few can predict the outcomes more than a few years' hence. It is currently strongly driven by the Internet and broadband usage. The huge changes in the Internet world "simply" cause more data to be downloaded (and uploaded). What that data is, does not matter much to the telco access provider.

This paper is not concerned whether the Internet service has similarity to traditional telecoms services such as voice or messaging. Most regulators and governments do not see any need to regulate the Internet services in the same way as the telecoms services – though some regulations on performance, consumer rights, advertising standards, security etc. are rightfully relevant. The truth or otherwise of Internet content and for what purposes they are used are also major issues. These are not telecoms issues *per se* and are generally covered separately to the regulation of the "lower layers" that provide the underlying downloads of broadband content in the first place. We consider here only the lower telecom service layers[7].

Huge investments in these lower layers are both required and planned. With rapidly increasing demand for more capacity, this places pressures on all network providers, investors and decision makers. There is a significant risk that every plan will not succeed.

Some general lessons from history include:

- The demand for more traffic and more downloads is unlikely to fall off. History shows that traffic has continued to grow exponentially. Even emerging economies see the same trends, but simply have less demand today
- Major telecoms ventures can and do fail. International cable companies around Y2000 such as Global Crossing did fail. Others may have been taken over in "market consolidation." This consolidation continues today, in particular within the mobile arena where the number of operators in some countries has fallen (UK for example)
- Equipment suppliers have also suffered (Nortel, Nokia etc)
- The available revenue for telecoms markets is finite and there is a linkage between the expenditures made by the end users. The growth of mobile (and over the top – OTT services) has been accompanied by reductions in fixed line calls. Mobile data and Internet usage is accompanied by falling mobile voice and SMS traffic. Total household monthly spends on telecoms might increase for broadband, but might reduce for calls. TV and entertainment budgets are also often linked to the telecoms spends. Business IT spends are usually tightly controlled and the telecom budgets

[7] The OSI seven layer model remains a valid conceptual framework or model of telecoms, that is easy to understand. Infrastructure and bit-transport layers are at the bottom. The top application layer could be subsequently used for anything (YouTube, Wikipedia, education, hand-bag sales or even voice and text messages). However this should normally be considered to be in an unregulated market, that is beyond the telecoms framework

are part of this – increased telecom spends have significant hurdles to cross before they are approved.

Other telco failures include: LEO/GEO satellite systems; UK cable TV franchises; Ionica in the UK; Yorkshire broadband; etc. Failures of fixed wireless access (FWA) businesses are also worth noting - although there are successful ventures using this technology. Most countries do not have significant FWA providers and many such ventures failed.

There is a collective message: good and bad ideas may get investment. Even with good intent, huge amounts have been lost in the past. Telco failures have been common. There is no logic to believe that more huge failures cannot happen again. It is a risky business.

2.2 No huge growth in telecoms spends

The ARPU levels today for many countries' fixed line and mobile subscribers show small growth (few percent) and are sometimes even in decline. As customer numbers are mostly in saturation levels in developed economies, consumers simply consume more data/traffic for about the same price. This is demonstrated by:

- The data in the Tefficient report see: footnote 3. This shows that internationally the mobile data APRU is ~20€ per month both for leading countries like Finland with ~7Gbyte per month downloaded *and* for countries with less than one Gbyte per month per SIM. The greater downloads per month are significantly due to price reductions but **do not** create significant revenue increases. Most countries have downloads of a few Gbyte per month or less – but this is growing rapidly, most likely without proportional revenue increases
- Recent advertisements in the UK show the mobiles offering monthly increases to the monthly data limit without additional data fees
- Revenue information in market reports such as from Ofcom or RTR in Austria – both show small changes to total mobile revenues, falling voice and message volumes and rising data volumes. **Significantly more data does not create significantly more revenues**.
- Fixed network revenue information shows similar trends – no significant revenue or ARPU increases[8]
- The RTR market report shows fixed line broadband numbers increasing slightly. This is relevant as RTR Austria had fixed and mobile broadband in the same regulatory market – demonstrating that it was a leader in mobile broadband. A huge "switch to mobile" is clearly not continuing. It is reasonable to assume that the reasons for this include the fact that both the speed and high download per month limits of fixed broadband are now required. The prices of mobile broadband often rise rapidly for download volumes approaching that of fixed. Mobile broadband is not currently able to be the primary broadband method for most consumers.

[8] The RTR report 2015 showed fixed revenue growth of 4.7% but this was due to subscriber numbers rising. This could be a mix of population changes or more households taking up fixed broadband

The overall telecoms market revenues (mobile, fixed, calls, data and business services), are relatively static (see above regulator's market reports). Of course there is growth in some areas, but this may be accompanied by reductions elsewhere. Revenue growth or ARPU growth is far removed from the data-volume growth.

This is not a new phenomenon. The exponential rises in traffic were real long ago, but did not translate to equivalent revenue increases – surely this was part of the past business failures: revenue-reality did not match volume-expectations and volume-reality. Of course some areas *did* grow – mobile in particular when it started out but partly at the expense of fixed line revenues. In developed markets that phenomenal mobile growth has slowed.

The industry success and huge traffic growth without pro-rata revenue growth is significantly down to technology. The cost of equipment has fallen and/or the performance has increased so much that it was able to carry the vastly increased traffic, at similar total costs. This trend has been seen for well over 20 years in mobile and fixed networks as well as in international/sub-sea cables. It underpins the industry. Fibre communications is also a central part of this. Long distance terrestrial or sub-sea cables provide the huge capacities needed. Fibre is also capable of huge capacity to the premises (or close to the premises), the costs of which continue to fall, leaving the cost of digging, pulling cables and civil works to dominate. Even these fall with new digging methods such directional drilling.

2.3 3G licence lessons show the dangers for the mobile industry

Key historical lessons should be taken from the issue of 3G licences. The UK famously had very high bids – which, with hindsight, were possibly a mistake. More significant for strategic insights were the industry beliefs at that time. There were still proponents of web portals – where the telco controlled the internet services and access, using a "walled garden" approach so that music downloads for example could have revenue sharing. Many younger readers might find this hard to believe. Search engines like Google, helped to finish such ideas and fixed operators became "suppliers of bit pipes to the Internet," and little value added income was possible from policing what type of service was being passed over the Internet access service – net neutrality became the *de facto* approach. This was mostly not a regulated outcome – the technical and market reality led telcos to provide data with only data volume and speed restrictions from the technology. It is generally rare for additional fees to access particular web sites[9]. This paper does not cover this net neutrality subject further as there *is* a more complex story on this including: zero rating, additional fees from some internet sites and blocking of some Internet services. Some telcos also decided to create their own Internet content and neutrality then can become a hotter competition/discrimination issue. The dominant outcome is that all (or almost all) Internet services are treated equally by the telco and content comes mainly from other *non-telecom* businesses[10].

The mobiles took longer to drop the idea for controls on the Internet access, but 3G rapidly developed as "simply" a voice/SMS network with vanilla-flavoured basic data access. At the time of the UK license bids there were ideas for 100+ services that could be network-

[9] It certainly does exist, but is not widespread in developed/competitive markets

[10] Some telcos do have TV or film content, but these are really separate business ventures in a different market

controlled (e.g. revenue for a music download would controlled and collected by a mobile network service).

The 3G saga and fixed & mobile ideas to have content management provide profound lessons:

- Major telcos with huge resources were proven to be almost totally wrong
- A "simple" best endeavours[11] service (Internet access) proved adequate for almost all services. Guaranteed or prioritised data or special/exclusive information services from the telcos were mostly unsuccessful, but these, of course did develop for business users
- Value moved to the customer application (in PC, laptop, or handset) and the end *Internet based* service provider – using over the top service provision (OTT)
- The demand for data, faster internet access and more broadband was hugely successful for the telcos. Mobile customers grew and the broadband was even able to be considered as a substitute for early fixed broadband (see the Austrian example). The telco's "cried all the way to the bank[12]" over the loss of the OTT revenue as they gained "just" the broadband revenue
- This broadband growth was not without pain as networks were overloaded and many tariff plans were unprepared for the data growth – "voice inclusive of unlimited data use" in a contract was soon seen to be a mistake for some telcos. Customers now really want data (and lots of it) and might have some free minutes or SMS includes on top.

The second point has wider significance than just mobile networks. To give a better service to some packets it often really requires other services to be slowed down or degraded. Ironically the money is spent on controls to reduce packet throughput (for which the customer pays less, despite more money being spent on these services). The high priority services are simply allowed to go through as fast as possible. Whilst this is a simplification, it shows how better service supply is not as simple as special equipment for the better quality of service packets. If the network simply has enough capacity then all services get "the best" throughput possible.

The last bullet point above is worth emphasising. The demand for data tends to exceed expectations (at least those of many telco managers). Engineers have long known that traffic "always seems to rise to exceed the capacity available." Current/recent growth implies this this remain a problem – how to increase capacity 10 fold every six years, *without* increasing costs significantly?

[11] Packets are all treated equally but there is no guarantee a packet will get through, so it may need to be re-sent
[12] Some "cried for loans" where they had not got the price and strategy right. Others deposited cash and bought more assets

2.4 TV and OTT

Another key phenomenon of the telecoms industry was the growth of cable TV. This was able to add telephony and broadband onto the TV services. This was a key step towards increased broadband delivery and the bundling of telecoms services with content (TV). The traditional telcos naturally coveted the TV revenues (and vice versa) and so it led to combined TV/telco businesses. However it remains hard to see TV content (in contrast to TV delivery to the home) and telecom broadband access as in the same *market*, but bundling does appeal and the access link to the premises is shared by the TV and broadband service – so there are synergies. Some TV centred businesses were able to take parts of the broadband and telephony market. Traditional telcos have also tried to move into the TV arena – a more radical business change than moves in the reverse direction.

The significance of cable TV is very country dependent – the history of licenses, the cost to serve (that depends on geography/demographics) etc. means that some countries have significant cable TV *with* fixed line broadband, but others have almost none.

The most recent major phenomenon is the growth of OTT content and video. This is driving demand for more network capacity and impinges on the TV markets as video content moves to be OTT, and less is watched by broadcast and cable. Although most video is still watched by traditional methods (cable, satellite and broadcast), this is changing rapidly. The telcos "simply" get even more traffic and the TV content businesses have to move to on-line Internet based delivery, in addition to the traditional delivery methods.

Perhaps the real lesson from TV/video on the Internet comes from how rapid the changes are, and perhaps seven years ago very few could have correctly predicted such an outcome. The impacts of Google, Facebook, messaging apps, cloud services, Netflix and YouTube etc. have been enormous. In the next seven years there will be other major changes – this paper does not attempt to predict them other than to identify that they will occur and will add yet more capacity demands onto the networks.

One should not forget the *many* failures in the Internet world as well as the successes. It is proof (if any is needed) that seven years is a long time – we should expect the unexpected. The "Internet bubble" cY2000+ and the many telco and Internet failures are strong reminders to everyone that picking the winners remains very difficult. This leads to the key questions:

- Whether telcos should venture into such areas as content, or
- Remain as "just" providers of broadband access and bit streams (of everything including TV and OTT).

The last point may not be as appealing as Netflix or Skype, but the revenues are stable (probably!).

Those that kept to core telecoms service provision, still had a significant number of failures but arguably fewer than in the Internet world. Lessons from history are always worth revisiting.

It is worth noting that there are at least two classes of failures – those that had a business plan and good ideas that stood up to scrutiny, but despite the best endeavours, the market, or technology etc., did not work out. Such entrepreneurs must be applauded as "heroic failures." These may be contrasted to those with totally unrealistic plans without proper scrutiny - for example a belief that a huge increase in the volume of traffic gives proportional revenues. These are best referred to as "Chapter 11 idiots." Anyone who does not properly understand the trends, demands, technologies and capabilities of networks should not be making

decisions. The insights of the Telzed April report *should* be basic knowledge. Why might there be suspicions that some decision makers do *not* understand such things?

3 Strategic options

3.1 Strategic aims

In this section, the above discourse and the facts in the Telzed April report are used to outline some strategic ideas that should be considered. This ought to be basic knowledge for the policy planners and decision makers in government, industry and the regulatory authorities.

Any strategy requires a statement of what are we trying to achieve? A simple definition is:

- Ultrafast (aka superfast) broadband to be affordable and available to almost every citizen (very high 90s%)
- This should be available at home, office or when peripatetic
- The *current* broadband should cope with busy hour average usage of about 3Mbit/s or more without significant slowing down of the user's service. This value is country dependent
- The capacity should rise to cope with 10x growth in about six years' time.

This is reasonable for most developed countries and most city states. Developing/emerging countries should still aspire to the same (if not, the GDP and welfare will never reach the desired levels). In the short term, their requirements should be broadband of some basic speed, to almost everyone. This might assume some sharing across communities and households. Social inclusion is a key step forward. This is demonstrated by the number of government initiatives for backbone communications to act as an enabler for other telecom networks (see Mexico and South Africa or example).

The strategic aims do not specify any technology. A customer uses broadband: no one really one cares if that is via VDSL, fibre to the home/cabinet/street, microwave, fixed wireless access or mobile. Some just cannot meet the speed/demand as economically as others.

Policy makers and governments must take a wider view than just the broadband speed and coverage. The real benefits come from using broadband. So a focus is needed on *using* the Internet (trade, education, medicine, bio-technology, nano-technology, AI, materials science etc., that all need almost universally-available cheap fast communications). These benefits are surely more than the (still significant) Internet economy (content, servers, CDNs, applications) and the supporting telecoms economy (the broadband networks and voice/data services). This is well known – see for example the Telzed paper for the ITU and a Telzed analysis of Internet economy versus broadband[13]. The focus of this paper is the lower telecoms industry layers.

[13] See ITU paper on broadband strategies and broadband analysis

3.2 Fixed or mobile centred strategies?

This is a continuing area for policy/strategic debate. This is in part because they were very clearly quite separate markets, using different technologies and with significantly different costs (and prices). This difference is now much less, and mobile *could* deliver a fixed line quality service (~10Mbit/s-100Mbit/s speeds and many Gbyte per month of downloads). It also has the mobility that most users need at some time. The F&M services converge, as fibre to the smaller base stations that move closer to customer (needed for high capacity and high speed mobile) is increasingly similar to FTTH or FTTX. The same fibre could be used, with small differences to the termination equipment chosen, for the transport of bits from home or from the base station. Why not use the same fibre for mobile *and* fixed access using copper/fibre/point-to-point radio?

There is convergence and some substitution, but no compelling evidence that mobile is currently a major substitute for fixed broadband. The countries with the largest mobile data also have high fixed broadband usage and usually significant fibre deployment (see footnote 3 and April report). Major fixed line usage needs large mobile usage, in addition.

Fixed lines generally have higher speeds and also significantly more Gbyte/month capabilities for roughly similar or less prices. Mobile broadband is far from a substitute for fixed broadband – the usage levels are 20 to 100 times less than in fixed networks; so, for it to be a substitute, it would have to deliver this capacity increase without significant cost (price) increases – and that only brings mobile up to today's fixed line usage. There will surely be some countries where mobile can be a major substitute for fixed, and some may already be going that way (possibly Finland, see footnote 3). Developing countries are already mobile centric. Clearly some countries therefore must have mobile & fixed as roughly equal providers. It remains doubtful that many will *significantly* reduce fixed line capacity usage to mainly use mobile instead, especially if they are developed economies. City states have greater potential for mobile substitution (see Section 3.7).

It may be noted that "fixed" broadband can also have mobile features and converges to mobile from a different direction – roaming onto other home WiFi networks or hot spots in shopping malls or in offices. This is not truly "mobile network" type roaming, but as most serious data usage is done when "sitting down," the need for broadband while actually travelling is not so huge.

Whilst there is convergence, most customers need and desire a truly mobile solution, either instead of the fixed line (why have both if one will suffice?) or in addition to the fixed solution.

Most countries will need both types of network. The convergence is most clear as the underlying technology of both is usually fibre. The fibre to small mobile cells and the fibre to premises (or close to premises) are essentially similar. To keep with normal terminology mobile, and fixed are discussed below as separate networks even though they can/should converge technically.

Some mobile networks make significant use of microwave to the base station rather than fibre. It still has a major role to play. This paper does not discuss further the relative merits other than to note that 100Gbit/s over 50km over fibre is not a significant target. Microwave at greater than 1Gbit/s over long distances is still a challenge – excluding issues such as weather or local geography.

3.3 A mobile centred approach

A mobile centred strategy to deliver **most of** a country's broadband probably requires one of two general scenarios:

1. A development of the existing mobile networks based on 3/4G/5G. These tend to have base stations with about 1000 subscribers[14].
2. A more radical approach where the cell sizes are much smaller with perhaps 50-100 subscribers each, or even less. This is the "5G" type approach mentioned in the UK Government 5G strategy.

The first approach could require a small increase of base station numbers (currently ~50,000 in the UK) and the latter might need 500,000 or much more.

New technology usually costs less, and provides more performance. 5G will surely be no different. Some reports suggest a 5G station could cost about 10% of the current price.

The April Telzed report showed that fixed line average usage demands are often at least 2 or 3Mbit/s in the busy hour today. Ideally this must be over physical speeds of ~50Mbit/s or more to cope with most near-term future demands[15] and to give adequate response/delay times. This is reasonable as the average access speeds are already over 20Mbit/s in many countries.

As demand is rising so fast, a five-year horizon implies ~20Mbit/s[16] average busy hour usage[17] per premises – which of course has to be delivered over a service that has a physical download speed limit well in excess of that. Therefore in scenario 1, a base station cell will need to cope with about 20Gbit/s[18]. This is perhaps unlikely even with the best of 5G developments. So the number of cells must increase – a tenfold increase implies ~1Gbit/s cell capacity. This is more plausible, but it moves the mobile solution into a totally different position from today – *at least* 10 times more cell sites. The total capacity of these cells sites has to be over *100 times* greater than today[19]. This capacity and cell number increases have huge impacts on costs and backhaul costs.

The current mobile usage is as low as ~0.05Mbit/s per data user. So current networks have to grow by 20-100 just to deliver today's typical fixed broadband usage, and this requires about 1000 fold increase to cope with predicable near-term future fixed-line demands. A factor of 10 reduction in each cell's cost is insufficient.

To avoid total costs per subscriber rising excessively, it requires at least 10x reduction in capital costs per cell site, and backhaul costs to be much lower than today (perhaps to be

[14] Of course this will vary a lot but this is typical of UK and EU
[15] Many households and SoHo require more than that already today. Solutions should allow exceptional service provision. Why should these customers be held back by the average customer's requirements? High end users are likely to also be contributors to technology/business/education advances and so make larger GDP contributions
[16] Ten times the current 2-3Mbit/s busy hour average usage
[17] This seems extraordinary, but simply is an extension of the current facts from UK usage and known typical growth. There will be other countries with higher usage than the UK's figures.
[18] This is a simple analysis, and so the effect of variances on traffic have not been considered. This could require more than 20Gbit/s capacities
[19] This is because the current mobile usage (Mbit/s or Gbyte/month) is so far behind fixed line usage

similar to domestic FTTx costs). Also the operational costs of so many cells cannot be much higher than the total for all cells today. This follows from the basic conclusion that the likely total revenues will surely be similar to current revenues[20].

An optimistic mobile centred future might assume that the existing fixed line services are terminated – and this implies that fixed network revenue is addressable. This could happen if the mobile service had the capacity, quality, coverage, speed, and in-premises ability of fixed line services, and if this were at about the same price as fixed line services (or a little more assuming the revenue is transferred from fixed to mobile). They key word is: **if.** It also assumes that fixed line operators and technologies have no counter to the mobile-only proposition.

It is reasonable to conclude that the mobile centred solution (where mobile is the primary broadband solution) is unlikely to work in large developed countries like the UK. Additional problems also have to be tackled. For example, the UK had many premises with no mobile broadband indoors. This is a poor outcome, so basic coverage is far behind universal coverage, even today. The mobile solution would require significant investment just to make up this gap.

The likely approaches will be between:

- Using new spectrum with better spectral efficiency (Mbits/s per Mbit of spectrum) to give more capacity using roughly the same number of cell sites. This increases the capacity at relatively low cost. This is surely a basis of the recent 4G investments in many countries - shown by significant increases in monthly allowances with similar prices to 3G data prices
- The more radical approach of more small sites that gives much more capacity, but with significant additional costs. This approach is converges with fixed wireless access (FWA).

The former has obvious business benefits – is that not what most CEOs would really like to get away with? The latter is a risker and more expensive approach. Clearly spectrum with good coverage and building penetration is required – this may make some very high frequencies of limited use except for the second approach

The strategies are also affected by the spectrum and its costs. Existing/established mobile operators will surely have no option but to get a 5G licence, no matter the bid price. Despite 3G lessons. This might force strategies more towards the first option – no money left for huge infrastructure investment. A new entrant 5G bidder is unlikely to win head-to head with established players, especially in developed economies. So this forces strategies more towards the second approach.

Mobile networks would also require huge increases in the core network capacity, but this is not the major bottleneck. Core network capacity cost increases are low due economies of

[20] ARPUs often do not rise more than a few percent per year or even fall. This has been true in both F & M in developed countries. Without incremental revenue, the new network should not add to the existing costs. Optimistically the current network and costs are written off and so we only have the new network's costs. Else: the cost is incremental without incremental revenue, ignoring here the possibility of totally new services/revenues, IoT and gaining money from OTT services – this is a major topic of debate

scale. If mobile was to substitute for the fixed services, then of course the total mobile core network capacity would need to exceed that of fixed networks.

The danger of getting these sums and business plans wrong have long been clear[21]. There are dangers with 5G (and also with fixed solutions). A business plan (and company) may fail from getting costs, revenues or demand wrong by "just" 50% - yet the mobile requirements show *orders of magnitude* increases in cell number, downloads and customers numbers using ultrafast. The lessons of history should not be forgotten. Risks of disaster are real.

3.4 A fixed centred approach

This scenario would be based on FTTx and so it can supply the 20-100Mbit/s or more physical speeds required. **This paper specifically avoids defining a target speed, but clearly the future is "Gbit/s" type speeds.** The faster speeds cost little more and global leaders[22] are already there, or going there (and it is a global market that matters, at least to the developed countries). The current average busy hour usage demands of ~2Mbit/s or more (UK) can be delivered and 20Mbit/s demands in five + years can also be met, but this obviously requires the physical download speed to be circa 100Mbit/s or more – you cannot expect a 20Mbit/s download service to average that speed continuously. This 100M-1Gbit/s (to carry 20Mbit/s usage with adequate download times) is easily achieved using fibre. Increases in the core network capacity are needed, but the 10x capacity increase does not require pro rata cost increases.

The fixed line approach cannot provide mobility. So an *additional* mobile solution is needed. But this is only a "fill-in" while being mobile, under this fixed centred approach. So the average mobile usage will not be like the fixed line demands because it is not a full substitute except for a minority of the population. Perhaps of the order of 1Mbit/s average mobile usage, will be required. This can fit into cells with ~1Gbit/s capacity – something that is surely quite possible using 5G and some (not too large) increase in the cell numbers.

A fixed line approach therefore needs to focus on:

- FTTx to give 50-100Mbit/s or more physical speed. Some customers already need far more
    - With all-fibre to the premises solutions, the cost of 50Mbit/s or 500Mbit/s are not hugely different
    - How to ensure FTTx delivery at over 50Mbit/s physical speeds, if the costs of "the last 100meters of fibre" is high?

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[21] See for example Telzed paper from 2012 or the later South Yorkshire case where ~£100M of public money seems to have been lost on fibre - e.g. http://www.telegraph.co.uk/news/politics/council-spending/9927708/Disastrous-100m-public-fundedbroadband-project-faces-shutdown.html

[22] Recent examples include Vodafone (the "mobile" operator!) building fibre in Germany https://www.mobileworldlive.com/featured-content/home-banner/vodafone-details-e2b-investment-in-germany/?ID=00Qw000000kHnorEAC&BU=
or Singapore terminating copper https://www.telecompaper.com/news/singtel-to-close-copper-based-adsl-network-by-2018--1211412?utm_source=headlines_-_english&utm_medium=email&utm_campaign=12-09-2017&utm_content=textlink

- Increases of the core capacity to cope with the demand of ever rising traffic.

100Mbit/s+ access speeds and 20Mbit/s average usage obviously works if the costs are similar to the current PSTN+broadband delivery. Where there is also a cable TV play, then the economics becomes more attractive, as the access link to the premises is shared by another service (TV).

It is emphasised that the fixed line strategies have their own revenue problems. The monthly revenues for fixed line access (PSTN and broadband) are not likely to change much. Therefore the fibre deployment has major cost hurdles. It works *if* the costs are similar to today. If efficient fibre operating costs are lower than today's copper-centred access then then FTTPremises is more viable. This is a point of debate. In any event, it is clear that the FTTx costs rise as the fibre gets closer to the premises, and as the subscriber density becomes less. Rural/sub-urban costs are higher. Less clear is how, FTTstreet or cabinet solutions to enable a hybrid copper/fibre approach, compare to FTTP. 100% fibre might even be cheaper – this can follow from:

- Removal of copper (one less fault-prone technology in the network surely reduces costs)
- Lower opex for fibre[23]
- Termination systems for fibre become remotely configurable
- Removal of cabinets and distribution systems that require on-site service
- Fibres that go far further into the network, so removing the need for systems in local exchanges. The only reason local exchanges exist is the legacy of copper. An all fibre approach reduces the need for so many sites and systems
- The lifetime of fibre is long[24]. Just as copper still works when its accounting lifetime has been exceeded, fibre can be upgraded. There is no foreseeable technical obsolescence.

The key to lower costs is reduced opex and avoidance of field repairs and the "man in a van." Efficient fibre OSS is essential. Radical/bold plans to almost eliminate copper and move to best fibre solutions, are probably viable. Half way approaches are likely to cost more in the long run. Choices of technology are also influenced by regulations (unbundling, passive optical networks, FTTCabinet, point to point fibre) – for obvious reasons.

This is a strategy paper and does not attempt to define the actual fibre (or mobile) costs per subscriber. In any event this varies by country and local geography. Can local ducts for copper be re-used? – this is just one of many factors.

The business case for fibre is not always so clear cut (else fibre would be there already). But perhaps some incumbents failed see the future and/or preferred more revenues from old copper assets. Clearly some countries and telcos have justified the investment. So the

[23] The author of this report asked an engineer if the opex had been reduced after the telco's fibre investment. The answer was: "I will tell you if we ever get rid of the copper"

[24] It is however not recommended that a business plans on huge time lengths for an NPV positive result, but in theory this possible. Contact Telzed for a discussion on this, if required

business case is not failing by huge amounts. In many countries it is easy to justify, at least in urban areas.

The lack of clear financial business case in some areas has led to the now-accepted idea of government subsidies or assistance. Tax payer money for hugely rich fixed or mobile corporations would have been thought unacceptable just a few years ago. Any government intervention has obvious dangers (as well as benefits). For example, there are already many commercial fibre investments – their plans can be undermined by later subsidy monies to other operators[25]. Money is nice to get, but it is not always good for everyone.

3.5 Fixed/mobile synergies

This report above shows the key factors affecting fixed and mobile centred solutions. Surely no one think that mobile centred solutions will *not* play a big role for most people. There are some who believe that fixed centred solutions could be mostly replaced by mobile – this requires some of the very major "if" concerns raised above to be solved. In contrast to the mobile-centred supporters are those who interpret the evidence and trends to show that mobile is a supplement, not a replacement for fixed-network type solutions. A "third way" is perhaps not to consider one or the other, but to consider both as essential and to consider the synergies. This joined up thinking is probably more beneficial for both the industry and consumers – something that policy makers and regulator must address by considering the notionally separate F & M markets *together*.

In many countries, it looks unlikely that the barriers to a mostly-mobile outcome can be met. The basic figures on speeds, average download speeds or monthly downloads, indoor mobile coverage, retail prices etc. show that mobile is so far from fixed line broadband, it is hard to believe that a catch up is possible, never mind a takeover[26]. This means that a fixed centred solution will be the primary medium used by most people for large volumes (as per today). The natural question then is how much of the market can be taken by mobile? This is perhaps the wrong question as it first has to consider how mobile and fixed can combine. There are synergies and too often planners and policies consider them as separate. This is not helped by some regulatory economic thinking that can define F&M as separate markets, as this reduces the ability to have joined up plans that consider the two together. Separate discussions on: 5G spectrum; FTTx subsidies; mobile coverage (or rather the lack of it); maintaining technology-agnostic fixed regulation; access to ducts for mass market broadband/business broadband/mobile backhaul; dark fibre access etc are sometimes not seeing the wider national needs. Not only are networks converging but regulatory thinking must also converge and think of solutions that are not "simply" fixed or mobile.

Key synergies and areas where mobile and fixed are linked include:

- Backhaul. Fibre to base stations and fibre the premises fulfil similar aims and face similar problems – putting fibre in the ground from a few central sites to a point close the customer

[25] See for example some of the submissions from alternative operators to the Ofcom Digital Strategy Review
[26] The numbers in this report, the April report, information of numbers of base stations, and other data on fixed and mobile usage show the situation. This should already be familiar to all policy planners and strategists

- Existing fixed-network duct and fibre. This provides a common platform for FTTx and mobile backhaul
- Core networks (this includes Internet access in international connectivity) – the same core is equally applicable to fixed or mobile broadband
- Universal service obligations. If a broadband USO is used then in many situations mobile ("wireless") will have a role where fibre in the ground is too expensive. The converse is also true – if the local base station is blocked[27] or in-building penetration is poor, then a copper/fibre delivery may be the only economic solution.
- Shared WiFi and FWA. Having one fibre shared by neighbours' WiFi converges with FWA that has the one fibre being shared by perhaps 10 or more premises. The technical solution clearly converges. FWA may be deemed a mobile solution or a fixed solution – this nomenclature is not too important for the end user. Most current thinking seems to have small cell 5G as the basis for FWA broadband, so this is considered here as notionally a mobile solution
- Fixed network "Wireless drop" to premises. The last 50-100meters to premises, is where FTTP costs can be highest. Small/cheap systems can do some of the delivery. This is a parallel to 5G and FWA
- Copper legacy drop to premises. Fibre to the street may not meet the ultimate performance and benefits of FTTP, but short copper can deliver decent performance. So a FTTx solution and FWA/wireless/mobile delivery to premises can both make use of legacy copper to do the same delivery. This naturally leads to the many small cell 5G approach, which surely will mostly use fibre to the cell site that also enables fibre or hybrid fibre/copper to the premises – the last link can be over legacy copper or over new fibre. For this *not* to happen implies fibre to the cell site is done in a way that excludes the same fibre cable being also used for all-fibre or fibre-copper delivery to premises. Could any investor or regulator conceive of forbidding this option? Fibre for 5G helps FTTx and vice versa.

The cost of mobile backhaul could be reduced if the same fibre used for FTTx is used. Strategies should surely combine the two. This is a significant change as different business minds historically tended to lead each plan. Regulations of both networks also tended to be very different. Also regulators encouraged new separate infrastructure investment and competition at the lowest levels (Ofcom for example) but this policy has been significantly changed in recent years with dark fibre and duct access. Mobile networks are *now* also allowed to share masts etc. The past approaches did not work sufficiently, or else they had fulfilled their role (depending on your view).

Government policy, regulations and business plans now need to be positively linked so that the same fibre/duct/digging investments are able to be used by both F & M players. The civil works have the largest costs, not the fibre. Customers do not buy infrastructure – they buy active services. Encouraging duplicate infrastructure has a logic, but the counter arguments

[27] Although wireless is likely to be cheaper in the expensive-to-serve rural USO areas, these might only work almost line of site. The author of this report experienced this with a FWA business, and its simple evaluation for whether service could be provided was to check if the local mast was visible from the customer premises. If not, then the customer would have to consider fixed cable alternatives

are obvious – dual ducts in a street are nice, but it almost doubles the investment and either is only likely to have 50% of subscribers – all other factors being equal. Duplications in the core network however are clearly much more logical and economically viable. In emerging economies where there is a lack of any infrastructure, the idea of encouraging duplicate competitive investments is often a wrong approach, except in a few areas. Developed economies countries still encourage duplicate infrastructure, but now do not force the idea so hard (there are now passive access remedies) so that more shared networks can now emerge, which is subtly different from emerging economies that probably should not try to get duplicate investments in the first place as this can discourage investment – and *any* investment is the primary aim.

It is worth repeating the April paper's point that a key reason that mobile fibre backhaul to small sites can be cheap is because the cable, duct, digging etc are shared with FTTx or shared with legacy copper services. *Replacing* FTTx/copper solutions increases the mobile backhaul costs – making major fixed line substitution less likely. There is a self-limiting factor in the economics. Related to this is a typical regulatory thinking that a new service might be priced at the marginal cost. The marginal cost of spare space in a duct is almost zero, so new FTTx/5G can be cheap. This assumes the existing costs are covered by existing broadband and PSTN. If the aim of the 5G the solution is to substitute the existing service then what pays for the civil works/duct? This is not a new problem. Copper broadband often assumed the copper costs were covered by PSTN line rental so broadband had only the additional signal-splitters and broadband equipment. But if customers wanted to terminate the PSTN line and use VoIP (and take just "naked DSL" broadband) then the broadband service prices had to rise. As a result, it is hardly worth a customer not taking PSTN line rental as the shared copper costs are an unavoidable part of access. This has led to fixed line PSTN remaining around longer than expected in some countries – and contributed to the inability of mobile voice to substitute for fixed voice. Broadband and PSTN over copper are not totally separate services. This has probably led to fibre-based supply having fixed line voice as a service that is also hard to avoid in the pricing schemes – it is another revenue (cost) that is hard to avoid. Many consumers *could* use mobile[28] or VoIP type services, but as they pay a monthly line rental anyway, the fixed line call marginal costs are low. The outcomes of course depend on the national situation (existence of fixed line PSTN, quality, how aggressive mobiles were to win fixed-line traffic, PSTN/broadband pricing bundles, existence of integrated fixed-mobile operators etc.).

3.6 Developed country strategic solutions

The report so far has concentrated on developed countries. In the following a "check list" of items to address and points to bear in mind, is provided to help define the strategic ways forward and to assist with the delivery of broadband. The order is not prioritised.

- Mobile broadband is an essential add on to fixed broadband
- Fixed line broadband has to move to FTTx or FTTP to provide the speeds required

[28] Here we ignore the fact that mobile voice has still surprising quality problems in many areas. How often do we still use the fixed line for important calls? Even today, mobile voice is often not a full substitute for fixed. Quality has increased in recent years and mobile prices have fallen so mobile call substitution has happened and in some countries it has significantly overtaken the fixed line traffic

- Leading countries in mobile broadband are usually also leading countries in FTTx (Korea, Japan, Sweden etc). No significant (or any?) sign exists of a mobile replacing fixed fibre and legacy copper in developed countries[29]
- The average busy usage per customer will rise from a few Mbit/s to ~20Mbit's in ~6 years
- Mobile usage will be smaller on average than on fixed (as per today) except for a few consumers who will be mobile-only and be willing to pay for the large downloads per month
- Many mobile only consumers probably gain frequent access to "fixed" or WiF broadband at times, yet may not need a subscription. These might appear as mobile-only customers, but clearly they are not. This may explain some of the usage and subscriber statistics
- The demand for traffic growth will not stop rising. Video, HD, cloud working etc will surely increase. Some unexpected new Internet based services and demand for more capacity can be expected
- F&M converge in many ways – WiFi, public hot spots etc are "fixed" but give roaming to notionally fixed ways of working
- Fibre backhaul for 5G, FWA and small cell mobile has strong synergies to FTTx. Policies and plans should be combined
- Simplify mobile base station (or FWA) planning rules. 10-100 times more masts will(?) be required. This cannot be economic unless the rules, timelines and costs are reduced. Having local municipalities each with their own unique controls, rules and processes is a major cost. Local and national governments must be aligned
- Fibre backhaul for small cell mobile requires power for the terminal unit. Fixed line FTTstreet for legacy copper or radio drop has an almost identical requirement. Combine the approaches and technologies
- Ducts and existing fibres from the incumbent probably link to the local exchange. Other operators, mobile and fixed, would benefit from fibres that linked to their locations. Incumbents and alternative operators can both benefit from fibres that link to fewer/better central sites to remove the legacy of site numbers and locations that were defined by inherent copper limitations. Use different architectures than "straight to local exchange site"
- Small mast sites are likely to make use of lamp posts or similar (cheap, pre-existing, has power and are located high up). Ensure cheap access. Ownership and planning rules must make such solutions easy
- Solve the existing mobile coverage problems. The UK had low in-premises mobile broadband penetration levels. Mobile coverage while traveling (UK) is poor. This is a major failure as it shows that peripatetic broadband users cannot rely on having

[29] There may be exceptions but generally this does not seem to be happening to a major extent

mobile – so there cannot be a solid plan to use mobile solutions. They have to plan on using fixed-type solutions. A number of issues relate to this:

- This outcome helps stop mobile substitution – no coverage means no ability to "cut the wire" of fixed services if the customer is peripatetic
- Mobile strategies to only cover the most lucrative areas only, has led to longer term problems of mobile not being credible to consumers (it does not even work when travelling, which is the primary benefit of a mobile service). A mobile centred way of working did not emerge for many consumers. Of course, some countries are far more mobile-centred
- Sometimes regulators (arguably) did not force strongly enough the coverage as a requirement – to the detriment of consumers
- Alternatively, coverage was perhaps never economical so the mobiles did the correct thing by not building masts to cover the country with in-premises data signal strengths. The truth of business-economics or lack of strong regulatory direction can remain a debate for others to consider
- The poor existing mobile broadband coverage makes it even harder to expect IoT ideas to work in the future – unless they are only to work in some/most urban areas. If this is the case then the service is hardly vital as it is not reliably available or close to universally available. So why would there be any price premium? Why pay for something that just *might* work?
- Regulators and policy makers need to reflect on the UK outcome. How bad are other countries/regions?
- Note that broadband is almost always used seriously when in premises – indoor coverage matters
- Note that consumers have only one network supplier – regulators/governments must not "big up" the figures by noting the coverage by at least one network supplier. It there is no national roaming, this is irrelevant. Coverage maps of mobile signal availability are also almost useless – are consumers really expected to plan mobile usage based on likely locations on the day/week ahead or choose the network provider based on some future prediction of their locations?
- It has been 16 years since the UK 3G licenses were issued. The broadband coverage was still poor in 2016. Reasons and responsibility for this lie where?

- Business plans will mostly need to be based on almost constant ARPU. It is optimistic to expect significant new consumer spends in the telecoms markets
- Critical questions exist over new markets such as automotive communications. Can a F or M telco business address them? Does the value move to the OTT service provider and 5G simply repeats what happened with 3G? This is the central business proposition – is there a new business and revenue stream for the telco? This paper concentrates only on the known telecoms and TV services
- Ensure the broadband and Internet based economy develops. Having fast speeds and large volumes of TV are good outcomes, but if content and services are developed nationally then clearly the wider economy is growing. This requires

strategies that are beyond telecoms, but the they need to be aligned with the telecom plans[30]

- Encourage the appropriate technology. Non-blocking (little or no contention) of traffic is best and this is easy with P2P fibre or some FTTx solutions. It is very annoying to have slow-downs caused by "pesky neighbours who have 3 teenage Netflix addicts." It is also unnecessary
- PON technology has a number of long term concerns on scalability and ease of use by competitive service providers, so the cost-benefit analysis is not quite as obvious as some might think. The inherent barriers to unbundled service or bespoke delivery to one customer reduce the options for competitors' access. Was this a contributory reason behind the choice?
- Note that it might cost a bit more to deploy 100Mbit/s or more and many might not use this fully today. But some do need this now. Upgrades often involve field or customer visits – this additional cost can be avoided by a bit of future-proofing. Long run costs of multiple upgrades versus a slightly higher capex is not a complex analysis. The rate of demand growth is high – plan accordingly. Only a "Chapter 11 idiot" would build a network with only enough capacity for current demand
- Develop a clear approach to competition led investment, infrastructure based competition, service level competition, citizens' welfare and national economic gains. This may change but confusing and continuous modifications of regulatory approaches are not helpful
- Past regulatory thinking supported multiple mobile base stations/masts. Such infrastructure competition is easy to justify when there are several 1000 customers per mast. Operators are able to distinguish themselves by their coverage and performance data, which encourages competition led investment. If masts are covering only ~100 subscribers then duplicated masts from multiple network providers may have questionable net benefits. Three operators implies ~30 subscribers might need to be the break-even target. To reduce the obvious business risks, the tendency of an investor will then be to have more subscribers per cell site and this pushes back towards the existing roughly 1000 subscribers per site. This may negate some of the proposed 5G benefits as existing 3G/4G subscriber densities may be the result
- Note how competition is often partial. Two access network providers in one street is good (but could be bad!) but it is not full competition. Three or four mobile operators is not full competition. Even full competition may not address some rural areas. Many regulations/policies need to consider other factors and not leave it entirely to competitive forces, which certainly is the best direction/solution. Even competitive areas like PSTN line rental and fixed market calls can show unexpected outcomes (rising prices yet falling costs and wholesale prices in the UK). Regulators still need

[30] Most developed countries have such plans – see https://www.gov.uk/government/publications/uk-digital-strategy/uk-digital-strategy in the UK. How good are these plans and will they achieve the business developments anticipated – outside of the telecoms markets?

to watch for sub-optimum outcomes. Mobile coverage is an example where leaving it entirely to even five competing mobiles might still result in low coverage

- An integrated mobile and fixed operator may be more of a concern as the technologies and services converge further. Some regulations might need modifications if they consider them to be totally separate markets. They are separate, but not *totally* separate
- Develop sound USO approaches. Do not define sub-standard targets, as this perpetuates a digital divide. *Some* divide might be acceptable - could inner city broadband ever be economic in every location? – but this harms a significant minority. A one-off investment in the right infrastructure that can be easily upgraded over time is probably more sensible than delivering broadband that is a "backstop" service for today, knowing that it will be inadequate in ~ six years' time
- Funding the USO, FTTx and broadband is an ongoing issue for the digital divide. Individual households or communities can work together on this. The investment could be through household mortgages (500Mbit/s FTTP surely increases a house value). This has been done in some places. This (and other funding) of an incumbent needs some consideration as it helps it to build its capital base. If the prices then paid by the individual or community are the same as the national average, it gives the telco a possible over-recovery of the investment as it is paid for twice
- Consider regulations on neutrality and service prioritisation. There could well be services (especially over 5G) that are viable that make use of low delay or guarantees of reliable delivery. But if the final service is on the Internet, then net neutrality rules might be encountered. This might create some interesting outcomes with non-discrimination rules applied to network service 1 and applied differently to a better network service 2. Or will such plans default to one best endeavours service?
- Competition led investment is generally "the way" but it can work in slightly unexpected ways. Alternative FTTP network providers (including cable TV/broadband providers) are likely to face fibre investment to the premises or close to, from the incumbent. Yet existing *incumbent* FTTP investments defines area that alternative providers probably would *not* seek to address as priority areas (unless they were in the best areas – central business areas and residential areas with the right demographics). This follows from basic business thinking and shows an asymmetry in business plans. Whether this needs any regulatory action is open to question, but clearly funding for the incumbent to help coverage or USO could encourage them to enter areas that the alternative was able to just make a business case for, based on the assumption it would be not economic for the incumbent to enter for many years. Funding or enforced deployment targets for incumbents could undermine competing infrastructure investments.

There are many papers available on 5G and broadband. Many national plans and strategies exist. Almost none of that work is replaced by this list. The issues in the April paper remain valid and the basic technical and economic factors must be understood by decision makers. The benefits from the wider broadband based economy have still to be obtained but this moves beyond the telecoms layers in the supply chain.

3.7 City state solutions

Many of the developed-country issues remain equally valid, so these are not repeated. Key differences in these smaller markets with high urbanisation and often homogeneous markets are considered in the following.

- Small states cannot rely "simply" on promotion of competition to deliver the desired outcomes. It is very unlikely there will be 10 fixed operators and 4 mobiles. A more subtle regulatory approach based on encouraging good outcomes, investment and new services, is needed
- The core network costs are likely to be relatively low (short distances etc.) and further benefits from integrating the F & M cores may be possible – with obvious balances on effects on investment, competition and possible collusion. A city state lacks overall economies of scale (as exist in most large developed countries discussed above), so areas where there are inherent advantages (like a small core) should be accentuated
- The cost of international links and possible bottleneck suppliers are likely to be significant. Even more so if it is an island economy. Working with neighbours and making collective deals should help. The costs of cables falls and their capacities rise with time, so incremental investments and leases may be better than 20 year IRU deals. IP transit price data is widely available and negotiations should aim to get the prices available to the developed/large economies
- City states should have smaller distances and so lower mobile backhaul costs. Higher urbanisation should also lead to lower mobile costs. Cheap planning rules and low cost build out opportunities are still needed for the mobile networks
- **City states, especially those with high GDP, are arguably the most likely places where mobile broadband could dominate over fixed.** It is more likely that they will have relatively greater use of mobile (than large countries), but the use of ultrafast fibre-based fixed broadband will still be the primary medium for major users/most traffic. Almost-exclusive-mobile broadband use should be possible for well more than perhaps 20%+ of customers, even if it is not possible for the majority
- Integration of backhaul and FTTx has possibly even greater gains than in the developed countries as it should be possible for a many cell sites
- As there is a small market, it might not be viable to have 4+ mobile networks as seen in larger countries. Maximising sharing of infrastructure and backhaul etc can reduce the costs – a trend now also seen in the larger developed countries
- If 5G has a radical change in cell site numbers then network sharing has an increased logic – why duplicate so many small mast sites and backhaul? Sharing schemes may work
- Local developments of business parks or housing schemes may account for a significant percentage of customers. Rules for new builds, such as duct access or to allow mast deployments are sensible. Retro digging should be avoided. Ownership, rights of way, premises access and rentals of infrastructure not built by the teclo are issues that need to be addressed. This is true in any market, but city states often have significant numbers of developments.

3.8 Emerging economic markets

Large parts of the world are under-served by telecoms and ICT in general. Most of these areas have limited fixed line networks as these were never built in the 1970/80s, except in some city or affluent areas. Mobile phones are the main communication medium. This follows because mobile networks are cheaper over large areas (no digging) and the one cell can be shared by many customers. As most customers have low income, the voice and now more critically the data usage levels per subscriber, are low. So widespread sharing of a single mast is the natural outcome. In contrast city states have mobile cells numbers that are driven by traffic capacity – the total usage by the customers in the cells, not by the need to cover as much area and population as possible.

A number of specific areas to consider are discussed below. See also the Telzed/ITU paper on broadband strategies for emerging markets.

- The mobile dominance (over fixed) is a not a proof that mobile is naturally better for broadband – it is simply the outcome caused by telecoms history and low GDP. If the broadband usage were remotely similar to developed economies then the mobile networks' capacities would have been strained and more fixed investments would have followed to take up the demand
- The citizens' needs are really no different to those of developed markets – aims should always be to bring up the speeds and capacities as fast as possible
- The GDP gains from good broadband are likely to be very significant. Better roads, power, water have obvious benefits. Telecoms benefits almost all industries: healthcare, education, government services
- Government intervention to help with telecoms investment is now accepted in developed economies so there should be no hesitation (if it ever existed) to consider this as part of national infrastructure plans. The primary differences are that the money available is smaller, and the telecoms coverage issues are bigger (not just to address a small percentage of the population which is the main gap in developed economies)
- Create an integrated approach to infrastructure build. Digging and civil works is always a major cost. All digging, road constructions, power, water etc should be aligned to give opportunities for other amenities to benefit from the same digging. Simply installing a cheap plastic duct in all trenches ready for other future cables is a basic/simple step
- Large rural areas require backbone network developments. Economies of scale are helped by sharing. Competition can build these in developed economies but a shared platform with possibly some government involvement (monies or management) may assist. As the market grows, in parts of the country this network can be sold off and competing networks will emerge
- Handsets and devices are crucial. Imports and approvals can be smoothed.
- Method for micropayments and money transfers already exist. Can this be developed further for the poorest areas?
- The backbone will probably be fibre based – nothing else really has the capacity, reliability distance capability and long-term benefits

- Consider cultural and language issues - developing countries often have many languages and cultures. Social inclusion and benefits should be for all
- Competition led solutions should not be ignored, just because it is currently hard to see multiple service providers investing. Competition led investment remains the best approach, so intervention should be removed were possible. Of course a larger percentage of the population or geographical area will probably require some financial assistance than in more-developed high GDP markets
- National plans correctly define targets for availability of services. It is easy to then avoid the harder questions of *how* to achieve the targets. A set of target figures is not a national plan
- Encouraging in-country IT and services reduces the pressures on international capacity links and leads to a virtuous circle of benefits (see ITU paper)
- Governments should be wary of taxes. Taxing mobile (or even fixed networks) is easy, and emerging economy governments often need such revenues. There are obvious balancing factors regarding how this affects citizens welfare, retail prices and investments[31]
- Even low income countries do have areas that have localised higher incomes. There are political pressures not to allow these wealthier consumers to have good/fast broadband while others have none. This has an obvious political basis. Arguably it is better that at least *some* homes and businesses gain broadband (and they are likely to be those who contribute most to GDP and inward investment) rather than no one gets anything. A balanced approach is surely required
- Governments should ensure key services are available and are moved "on line." Examples include government services, education, healthcare, taxation, agriculture information etc. If citizens have to queue up and fill in paper forms, then there is probably something wrong or could be improved
- Be wary about banning arbitrage. Retail service re-sale has been common in the past and continues in many forms such as international call by-pass, SIM boxes or simply sharing a broadband service with neighbours. Many of these are very hard to stop, even if a regulator or operator wants to stop the service. Often they exist because there are other problems in the market, such as excessive prices for international calls or broadband retail prices that are high and charges for downloads that are not related to cost. Retail re-sale is unlikely to cause significant harm unless a telco is foolish enough to not offer cost based prices. This has obvious benefits and give good signals regarding liberalisation
- As a general guide, many countries could benefit from a start point of considering: not regulating anything. Then authorities can apply regulations where needed, rather than a start point of controlling everything and then lifting restrictions in a few areas. This reversed thinking probably has most application in emerging economies but even some thinking in the EU seems to suggest there are some who support more regulation of the end applications, because these happen to simulate lower level telco

[31] See for example ITU paper on Taxing telecommunications.

services. A more logical step might be to lift regulation from the lower layers because there are competing services

- Mobile subscriber numbers are still growing fast in less developed economies. The growth potential for broadband is huge and as there is almost no fixed broadband this will be the primary medium. The usage per subscriber is held back by low income and poor networks
- Beware of controls. Network controls are notably absent in most developed economies (of course there are some blocks or rules such as for child protection etc). For example, stopping VoIP, OTT services or overseas video may have some political logic but it has far wider implications for the messages it gives for external investment and for (not) attracting competition into the market. The messages surely go far beyond the telecom market.

4 Summary

This paper used as its start point the current status of fixed and mobile usage. This shows how costs are driven as fixed and mobile usage develop. These basic facts are critical to any business or government strategy. A strategy has to know where the economy is at present and what the cost drivers are.

Strategies also have to consider what they are trying to achieve. From this, plans to achieve those goals can be defined. This paper suggests that broadband (with good coverage, reasonable prices, high speeds – tending to Gbit/s, and certainly more than 50Mbit/s, large downloads, reliable etc) is the requirement, and the technology is not the fundamental issue. Nearly all devices work wirelessly (WiFi or mobile) so it does not matter if the broadband is over a fixed or a mobile network.

There is no point aiming for fibre to the premises in *developing* countries, just because it has almost unlimited potential for speed and capacity – it may be better but it is not economically viable for the majority, at least in the near future. Mobile is surely the better (most appropriate solution) at least in the near term. Neither F or M is fundamentally better, *if* the service works well.

The technology factors are still relevant to city states and large developed economies. Strategies do have to understand the benefits and limitations of mobile and fixed centred solutions and how these converge/overlap. This last point is probably not fully appreciated.

The strategies have to be able to meet not only today's demand but the inevitable future demand for faster services and larger downloads. This means well in excess of 100Mbit/s speeds and busy hour average usage levels of 20Mbit/s. The data demand growth means networks have to have ~10x the capacity every 6 years. Technological advances have been able to delivery this (3G-4G, smart phones versus basic phones, low cost router switches, core fibre transmission, sub-sea cables, FTTx compared to all copper etc), but it still places huge pressures on all investment plans. **History shows that many plans fail and just because multi-billion $ investments are made, they can still fail if the basics are not understood.**

Some emerging 5G plans show plans for a more radical change than seen 3G to 4G. Much of the plans are based on a 10x or more increase in base station numbers. This radically alters the investment in backhaul and mast infrastructure. The approach converges with FTTx. Warnings are obvious: this has to provide well over 100x the current mobile capacity if the plan is to be a *major* substitute for fixed line type solutions. Yet there will probably be limited new revenue.

Many countries and plans should not be based on a purely mobile or fixed centric solution. Both are needed.

This paper provides a check list of strategic points and ideas. This is not an exhaustive study. Other options exist and other issues need to be considered. Also every country will probably have its own solution – even within Europe, counties have significant differences. Developed countries, city states and emerging markets are three categories that show how solutions are unlikely to be the same everywhere. More tailored strategies and more in-depth investigations of trends can be considered for any country, regulator or service provider – please contact Telzed.