NOMADICITY AND THE EVOLUTION OF APPLICATIONS, NETWORKS AND POLICY

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A number of behavioural observations point to a preference and willingness to pay for communications technologies that support mobile and nomadic use. This paper considers these observations and the implications for the evolution of mobile and fixed networks. It then considers whether there are wider external social benefits and the possible implications for public policy.

Mobile and fixed are both substitutes and complements. Consumers with low bandwidth and, in particular, low capacity (gigabytes per month) requirements may opt for mobile broadband only. Consumers with low bandwidth and high capacity requirements might choose to meet their need for capacity with copper, complemented by wireless. Demand for fibre may be more limited. To meet demand for mobile bandwidth and capacity, fibre can be run to mobile base stations, but this only requires a network of around 1/2000th the density in terms of points of connection of a fibre to the home network. Demand for fibre to the home is limited to those who are willing to pay for high bandwidth and capacity.

Some key questions addressed in this paper include whether external social benefits arise from mobile and fixed network access, whether the incremental external social gains from a move from current to next generation networks are material and whether they are likely to differ between mobile and fixed networks. We conclude that such gains are likely to be significantly larger for mobile than for fixed networks since wide area coverage and smart mobile devices can support applications that fixed cannot, mobile is likely to contribute more to getting the final third of the population online and spectrum reallocation would result in gains from trade that are not privately appropriable since spectrum utilised for broadcasting is generally non-tradable. These questions have a direct implication for policy decisions: priority should be given to spectrum reallocation for mobile use (including public expenditure as required) and removal of barriers to commercial investment in fibre, including possible regulatory barriers to copper network retirement and price differentiation for wholesale fibre access.

'Our nature consists in motion; complete rest is death.' (Pascal 1660)

CONSUMER BEHAVIOUR AND WILLINGNESS TO PAY FOR NOMADIC/MOBILE SERVICES

Studies show that humans have a natural propensity to be mobile/travel (Mokhtarian et al. 2001). This suggests that nomadic/mobile apps have a unique added value, and some of the services that mobile devices support uniquely require mobile/nomadic access and cannot be replicated using fixed broadband. For example, applications that rely on sensors and location derive most of their value from mobile use. The value of these attributes is not therefore necessarily separable from the value of mobile broadband access when revealed behaviour is considered.

The following lists some of the attributes of mobile devices and services that are both valuable to users and are not available or would not be nearly as valuable with fixed broadband access only:

- Location awareness. This enables maps to be used more effectively for navigation and facilitates location tagging of photos/video, location based search and social networking services.
- Sensors, currently including a camera, microphone and orientation/movement sensing via accelerometers and gyroscopes. These sensors enable new interfaces, sharing of experiences, obtaining information such as the identity of an object, barcode or song directly and for information to be overlaid on the environment through 'augmented reality'.
- Mobile devices enable consumers to interact with the device's content and applications, to share knowledge regarding functionality and to learn from and help others in social contexts. This aspect can be expected to impact on Internet adoption and digital literacy.

We now consider evidence that consumers have an incremental willingness to pay and demand for unique value added of nomadic and mobile applications and wide area connectivity.

DEMAND FOR NOMADIC/MOBILE DEVICES AND SERVICES

Consumer demand for devices that fit our social and nomadic tendencies is evidenced by the growth in mobile phones, netbooks, smartphones and tablets. These devices have shown far more rapid growth than earlier technologies such as fixed line voice telephony which took almost a century to reach high levels of penetration in wealthy countries (the slow diffusion of fixed line telephony may also in part be explained by monopoly and regulation) (Wallsten 2001).

Mobile phone ownership is high in many developed countries, for example, 96 per cent of those aged 15–74 in the Republic of Ireland say they personally own a mobile phone (ComReg 2010). Mobile ownership is also growing rapidly in developing countries. Aside from the advantages inherent to mobility, the emergence of mobile phones has facilitated more flexible tariff options including pre-pay. It has also to a large extent avoided *ex ante* regulation which has facilitated network rollout and innovation in technology, business models and pricing.

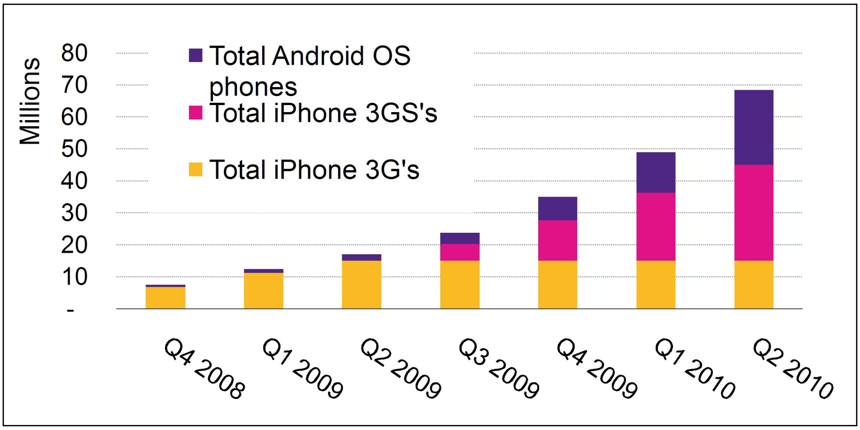

Figure 1 Global number of iPhones & Android phones sold
Source: Plum Consulting, Apple quarterly financial results, Gartner

A more profound change is now underway with the development of advanced smartphones and tablets with easy to use multi-touch interfaces, downloadable third-party applications ('apps') and 3G/WiFi access. This has allowed Internet enabled devices to be carried at all times and for applications to be developed that exploit the location aware and sensor rich characteristics of smartphones and which optimise the user experience over relatively slow and variable wireless connections.

The take-off of this class of device can be dated to 2008 with the launch of the iPhone 3G, the Apple apps store in July 2008, and Android in October 2008. Figure 1 shows estimated cumulative iPhone (Apple 2010a) and Android phone sales since then (Gartner 2010).

On the basis of current sales, over half of consumers in high-income countries may have advanced smartphones within five years.[1]

MOBILE DATA TRAFFIC GROWTH

Adoption of mobile devices and use of the mobile Internet have driven growth in mobile traffic volumes, over-taxing networks in a number of locations. Figure 2 shows projected mobile traffic in Asia Pacific, North America and Europe where projected mobile data growth rates are over 100 per cent pa (Cisco 2010).

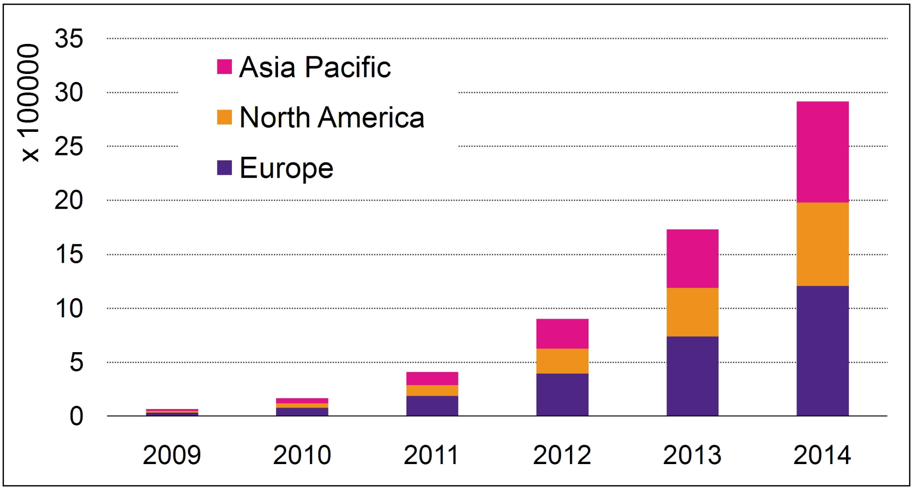

Figure 2 Mobile data traffic forecast (TB/month)
Source: Plum Consulting, Cisco

WILLINGNESS TO PAY AND CONSUMER SURPLUS

The adoption of smartphones indicates that consumers have an incremental willingness to pay both for devices and for the associated mobile data plans. For example, a contract-free 16 GB iPhone 4G costs £499 in the UK (significantly higher than the cost of a basic mobile phone which can be as low as £10), and a 12 month SIM-only contract including 500 MB of data costs £15 per month, while an identical contract excluding a data allowance costs £10 per month.[2] The handset cost difference compared to a basic phone is almost £500 and the data premium is £5 per month for 500 MB (with the option to buy additional data at the same per 500 MB price).

Willingness to pay is not observed directly and will, for all but the marginal consumer, exceed what they actually pay (consumer surplus is the difference between willingness to pay and what consumers pay). What we know is that a growing number of consumers are prepared to pay a premium for access to mobile Internet.[3]

PRODUCER SURPLUS

Whilst consumers have benefited from mobile services, some producers have also earned high returns providing mobile services and devices. For example, Apple has seen high revenue growth from their mobile products; it earned a gross margin of 39 per cent in the June 2010 quarter (Apple 2010b) and had an overall market capitalisation which exceeded that of Microsoft on 26 May 2010. Verizon in the US, which offers both wireless and fixed (copper and fibre) access to services, has seen growth in wireless connections and a decline in total fixed connections, an EBITDA of 47.5 per cent for wireless versus 22.7 per cent for fixed, and has an investment focus on LTE wireless going forward (Verizon 2010). Commercial incentives are therefore strongly aligned with ongoing innovation and investment in relation to mobile devices and networks.

CONSUMER PREFERENCES, NETWORK COSTS AND MARKET OUTCOMES

Consumer behaviour, devices, applications and both fixed and wireless networks should be thought of as a system that is co-evolving. Consumer preferences, available devices and supply side network characteristics and cost functions will shape outcomes. The following sets out some of the key interactions:

- Growth in the number of mobile devices, apps and cloud computing may lower the bandwidth requirement for a given service level, since smaller screen sizes require less bandwidth for a given resolution and apps and the cloud allows data transfer to be optimised for slower, less reliable connections.[4] An increase in mobile data usage will also promote the search for more effective compression.[5] These developments will tend to reduce incremental willingness to pay for bandwidth and advantage wireless and copper relative to fibre.
- Fixed and mobile will be complements in some ways since:
    - The gap in the cost of adding incremental capacity to wireless versus fixed networks will drive mobile networks and consumers (via tiered pricing and other incentives) to offload traffic onto WiFi-fixed rather than carrying all traffic on the wide area mobile network.
    - Growth of mobile device use may promote content creation and sharing which will create demand for higher upload speeds and capacity. Whilst LTE offers a significant upgrade in upload speed, the combination of upload speed and capacity may be expensive to meet via wireless given the need to minimise device transmit power and therefore to have a dense cellular network.
    - Reallocation of spectrum from terrestrial broadcasting to mobile broadband will reduce capacity on terrestrial broadcast platforms (particularly for HDTV), which will increase demand for fibre and satellite distribution. In this sense, mobile and fibre are indirect complements.
- Fixed and mobile will be substitutes for some since:

- Growth of mobile-only voice households will raise the effective price of fixed DSL broadband for such households since the opportunity cost of maintaining or adopting fixed broadband then includes the line rental.
- Mobile will offer low monthly tariffs for low traffic volumes as LTE lowers the cost per gigabyte (GB).[6] Additional spectrum would also lower the cost per GB and increase average speed.
- If fibre investment involves price increases it will encourage wireless substitution for fixed for those with relatively low monthly data requirements (particularly if regulation constrains opportunities for price differentiation, thereby limiting the scope for both higher and lower prices for fibre service differentiated by, say, bandwidth).

The way in which these considerations play out will depend on the preferences and behaviours of individuals and households and on the specific wireless and fixed costs functions for current and next generation access. Whilst our understanding of behaviour is poor (since there is no revealed preference information available for a next generation fixed and wireless environment), our understanding of supply side costs functions is reasonably good.

Figure 3 shows estimated supply side costs (not necessarily market prices) of current and next generation fixed and mobile access as a function of traffic volume.[7]

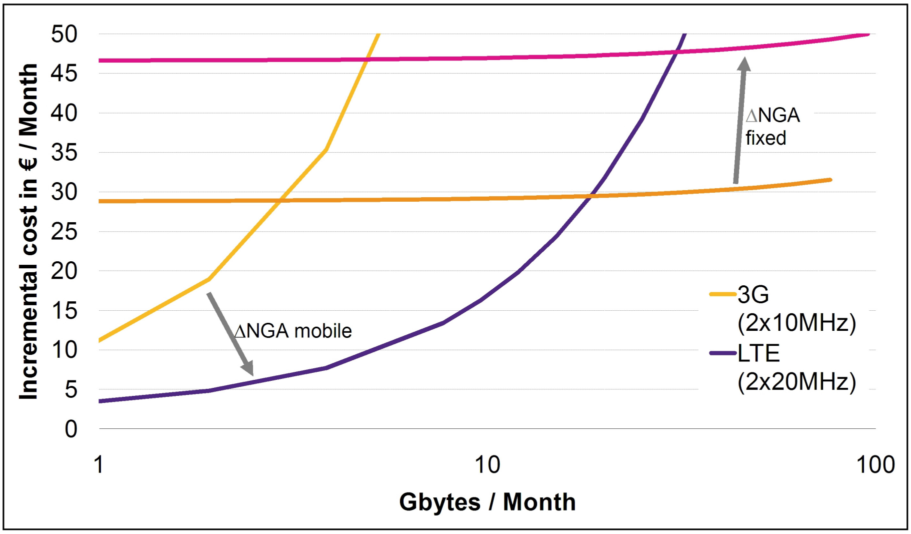

Figure 3 Incremental costs of broadband
Source: Plum cost modelling, Analysys Mason, European Commission

Two observations flow from Figure 3:

- Investment in NGA fixed access (fibre) raises costs, whilst investment in NGA mobile (LTE) lowers costs and will make very low tariffs feasible for low users. The investment case for fibre is therefore dependent on incremental willingness to pay (and potentially price differentiation in order to convert willingness to pay into incremental revenue) whilst the investment case for LTE is not.

- The incremental cost of traffic over fixed lines is very low whilst the incremental costs of traffic over mobile remains relatively high. Tiered pricing per GB and potentially other approaches to managing traffic levels will be necessary for mobile but not fixed. This is a relevant consideration in relation to the debate over the open Internet and 'net neutrality.'

As mobile traffic volumes grow, mobile network operators will have an incentive to lay fibre to mobile base stations. Mobile network operators will also have an incentive to offload traffic onto WiFi hotspots and picocells supported by copper or fibre connections. With the end of 'unlimited' mobile data plans, consumers will also face incentives to offload traffic either at home or elsewhere.

As LTE is anticipated to increase download speeds to around 8–12 Mbps (McAdam 2010) and upload speeds to around half that or 4–6 Mbps, and as mobile devices and applications improve the consumer experience with lower speed connections, the primary difference between fixed and mobile for many consumers may be capacity rather than speed. For modest bandwidth high monthly capacity consumers, copper may be perfectly adequate – delivering around 5 Mbps and almost unlimited capacity. Upload speed and capacity may also be an important differentiator between copper, LTE and fibre. Figure 4 illustrates 3G, LTE, copper and fibre according to their capacity and speed characteristics and reflecting the cost functions illustrated in Figure 3. Upload speed (not shown) and capacity may also be an important differentiator between copper, LTE and fibre.

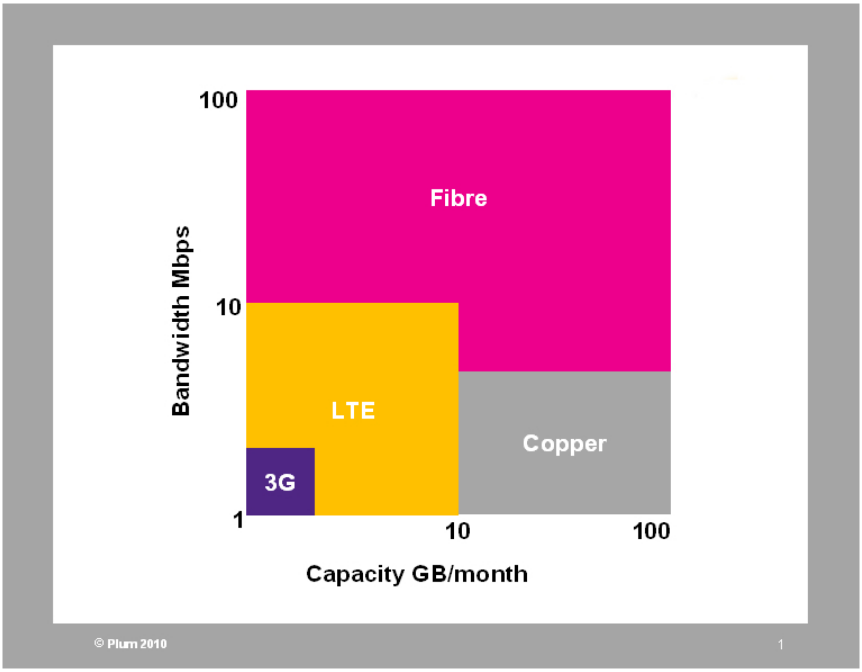

Figure 4 Comparison of capacity and speed characteristics

What we do not know is how customers will be distributed in this space now and in the future given changes in devices and applications and a cost premium for fibre over copper of around 50 per cent.[8]

Across all these segments, WiFi will complement mobile as a means of offloading traffic to fixed (copper or fibre) at home and in public places such as cafes and high traffic density locations. Fibre will also complement wireless as a means of offloading traffic from base stations. However, we note that the density of the fibre network in terms of points of connection required for this is three orders of magnitude lower than a fibre to the home network since there is a ratio of around 2,000 households per base station in developed countries.

Having considered consumer preferences, network costs and the possible evolution of fixed and mobile current and next generation access we now consider whether there are wider external/social benefits which suggest a role for policy intervention to achieve outcomes that would differ from market outcomes.

WIDER EXTERNAL SOCIAL BENEFITS

From a policy perspective material difference between private costs and benefits and wider social costs and benefits are an important consideration. For services and applications where all, or part, of the value is social rather than private one can think of this value as attributed to citizens rather than consumers. An externality may also arise in relation to spectrum reallocation since, even though the value for mobile use may exceed that for say broadcast use, the gains from trade may not be privately appropriable if spectrum rights are not privately held and/or tradable.

The question we are interested in here is whether external benefits are material and how they relate to technology and service choices. If external benefits are material, and particularly if they differ between current and next generation access and fixed versus wireless, then they might justify public policy intervention, for example, to promote Internet use or network enhancement.

SOCIAL BENEFITS FROM INTERNET ADOPTION AND USE

There is a growing view that wider Internet adoption and use is socially desirable on grounds that: the Internet is now so important that non-adoption may result in economic and social exclusion; wider Internet adoption will promote productivity growth; and near universal adoption might allow more costly means of government service delivery to be shut down. An important question is therefore why some people do not use the Internet and what might be done to promote wider Internet use and broadband adoption.

Available evidence points to supply-side issues playing a small part in explaining differences in Internet adoption in developed countries (Lewin 2010). Key considerations in explaining within-country and cross-country differences appear to be education by age segment and workforce participation. Both factors are linked to complexity barriers and perceived relevance in adoption and use decisions.

We note that mobile devices including, in particular, smartphones and tablets may significantly reduce these barriers for three reasons. First, the user interface and experience is simpler and more intuitive. Second, the user can interact directly with applications and services rather than accessing these via a browser. Third, the device can be carried into social settings where users can learn from one another and where non-users are exposed to Internet based applications that may be relevant to them. Public policy interventions designed to promote Internet adoption might therefore be re-focussed on mobile devices and mobile broadband rather than on PCs and fixed broadband.

EXTERNAL BENEFITS OF APPLICATIONS OVER FIBRE AND MOBILE BROADBAND NETWORKS

A number of studies have claimed significant external benefits from the transition from copper to fibre. However, such studies may fail to distinguish the incremental costs and benefits of fibre from the benefits of fixed copper and mobile broadband (including LTE in the near term).

They may also include categories of benefit which do not constitute genuine externalities (Marks and Williamson 2008), including changes in GDP and productivity, which may mostly reflect private benefits, and reductions in greenhouse gas emissions which may only come about if other policies such as a carbon price are in place (particularly given that communications and transport may be complements rather than substitutes) (Choo et al. 2007).

Mobile broadband and devices have two distinguishing features which may open up much greater scope for external benefits in excess of private benefits:

- First, mobile broadband coverage can be expected to be high once sub 1 GHz spectrum is made available for UMTS (Moral et al. 2010) and is not restricted to premises. This makes applications such as emergency response services (FCC 2010a), social networking, and location-based services possible. Furthermore, health monitoring and assistance applications, such as 'Glucose buddy' for those with diabetes, always need to be tailored to the individual to be effective. Applications such as these are not always possible over fibre.
- Second, mobile devices incorporate sensors and are location aware, a combination that may lend itself to social applications and greatly lower the costs for individuals performing civic functions. For example, apps exist for reporting litter or potholes by photographing the problem and sending the photo, plus location, automatically to a publicly accessible local government database which allows tasks to be prioritised and progress tracked.

EXTERNAL BENEFITS OF SPECTRUM REALLOCATION

Potential sources of additional spectrum for mobile broadband use include UHF spectrum currently utilised for broadcasting and spectrum utilised by governments, including that currently set aside for military use. However, potential gains from trade may not be privately appropriable since the spectrum rights are not privately held and/or tradable. In the absence of rights and trade, government intervention and/or expenditure is required to reallocate spectrum. In the US, the FCC (FCC 2010c) has identified the need for measures to ensure the timely reallocation of spectrum, including the possibility of forward auctions (FCC 2010b) which would allow broadcasters to profit from voluntarily relinquishing spectrum and then sharing auction proceeds (which amounts to the creation of de-facto property rights and government expenditure via potential revenue foregone to expedite spectrum transfer). (FCC 2010c and FCC 2010b).

CONCLUSION AND POLICY IMPLICATIONS

Human preferences and revealed behaviour point to a premium on mobile and nomadic applications. In the communications sector, technology has only recently made many of these applications feasible. As Risto Linturi was quoted in Wired magazine as saying, pervasive mobile will (Wired 1999):

> ...bring us back to behaviour patterns that were natural to us and destroy behaviour patterns that were brought about by the limitations of technology

Demand for mobility and mobile applications is driving demand for mobile broadband and, in turn, additional spectrum for mobile broadband use. Alongside mobile broadband, fibre will provide high capacity and speed to offload traffic from base stations and to businesses and households where willingness to pay is sufficient to justify investment. Obstacles to private fibre investment should where possible be removed. In particular, a framework for copper network retirement (to avoid dual running costs) is required and may require a reassessment of the approach to universal service. In addition, a regulatory approach which allows price differentiation to support timely investment and the possibility of low user fibre tariffs should be adopted.

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ENDNOTES

1 Utilising the World Bank definition of high-income countries as those with incomes over $12,196 in 2009 – a total population of a little over 1 billion (World Bank 2010).

2 We have utilised UK pricing as this enables the various components to be separated; iPhones can be purchased contract-free and SIM-only plans are available with and without data allowances. Prior to the launch of the iPhone4 some tariffs had included ‘unlimited’ data.

3 Some data and measures may not attribute revenues correctly, particularly if monthly connectivity charges are not separately identifiable for data. In other words, data revenues may be understated relative to overall revenues.

4 For example, the bandwidth requirements for a two-way video call using Apple FaceTime (initially only available on the iPhone4) are relatively modest at around 0.2-0.4 Mbps, whilst watching on-demand video on an iPad (which could substitute for 2nd and 3rd TV sets) over broadband will require significantly less bandwidth than on a large screen TV.

5 For example, Verizon have noted that they are working with partners to get the bandwidth requirement for HD video down from 10 Mbps to 2 – 3 Mbps over LTE (McAdam 2010).

6 There is perhaps more uncertainty regarding consumers' demand for and willingness to pay for capacity than bandwidth since the total quantity of data consumed in the home including TV and computer games is very large compared to existing levels of data carried over broadband connections (Bohn and Short 2010).

7 Costs for copper DSL include both the fixed line charge and the additional broadband charge (on the grounds that the fixed line is retained primarily for broadband) and are based on estimates for Europe. Fibre costs are estimated based on US pricing by Verizon for fibre to the home (broadband only packages). The traffic-dependent element of fixed line costs is based on incremental cost estimates for 2012. (Analysys Mason 2008).

The cost estimates for 3G and LTE were made by Plum, based on assumptions regarding equipment costs and spectral efficiency. We assume 372 kbit/s per MHz per site for 3G HSPA and 1125 kbit/s per MHz per site for LTE long-term, and that additional spectrum is available per network for LTE (2 x 20 MHz) compared to 3G (2 x 10MHz).

8 Note that satellite and local storage for HDTV and LTE for Internet applications could be complements for some customers if the combination is cheaper than fibre.

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