The FTTdp Technology Option for the Australian National Broadband Network[1]

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Fibre to the Distribution Point (FTTdp) is a broadband access network technology that encompasses fibre to the street lead-in pit at the front fence, with an average copper lead-in length of 30m. FTTdp promises very high VDSL2 capability, with easy upgrading to G.fast or individual FTTP (Fibre to the Premises) on an on-demand basis. The network capability of FTTdp is thus very close to the capability of a full FTTP deployment. Cost savings compared to FTTP promise to be substantial – a possible $12 billion in savings for the Australian National Broadband Network – due to the use of existing copper pair lead-ins, thus avoiding civil engineering works for each individual fibre lead-in. Indeed, there is reason to expect that the initial cost of FTTdp deployment will be comparable to that of FTTN (Fibre to the Node). FTTdp has additional benefits of reduced copper maintenance and limited ongoing upgrade costs compared to FTTN. Significantly deeper fibre network penetration is potentially cost-neutral (or better) with FTTdp when compared to the FTTN baseline due to elimination of time-consuming activities involved with FTTN deployment. The reduced street impact of FTTdp is also important.

Introduction

It is undeniable that bandwidth demands of all users are steadily increasing. Likewise there is broad agreement that current access networks, primarily ADSL, HFC (Hybrid Fibre Coax), and 3G and 4G wireless, need substantial augmentation or improvement to meet latent and evolving demand from the broad user base. The vision of the NBN is to supply access network capacity to meet this demand now, and well into the decades ahead. This includes various customer needs for symmetric and asymmetric services, one-way and two-way applications, support for multiple individual data and video channels from a multitude of world-wide sources, and various Qualities of Service.

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Naturally, the selection of technologies to provide bandwidth capability in the NBN context is highly dependent upon projections of demand growth. While we can easily agree that continued growth in bandwidth demand is effectively guaranteed, it is a much more complex task to find agreement on exactly where NBN Co design targets should be, even looking only as far as 2020. Extending this horizon to 2025 or 2030, results in extreme variance of opinion on future bandwidth demands (projections vary from 100 Mbps to 10 Gbps or more).

We can look to the emerging reality of 4K television, coupled with the present reality of multiple video streaming to a single premises, to determine a lower threshold of 100 Mbps as an absolute minimum network design capacity to be delivered on the 5-year time-frame. The 100 Mbps figure has received widespread support in recent years as a realistic – and yet somewhat aspirational – target, including from the FCC (US Federal Communications Commission). However, widespread rapid uptake of 4K TV may make even this figure seem low. If there is an economically feasible way to supply a significant increase in base-level capacity over this figure, then we must give it due consideration.

FTTP (Fibre to the Premises) supplies sufficient capacity to rise to the challenge of any future demand scenario. Single-mode optical fibre provides bandwidth capability, in conjunction with suitable selection of active electronic termination devices on either end, to meet any conceivable throughput demand. If costs were not a concern, FTTP is the obvious choice. The reality of the NBN Co deployment is that costs are an issue. The NBN Co Strategic Review report points to international costs of FTTP for countries 'most comparable' to Australia, being in the range of $1100 to $1300 per premises (NBN Co 2013: page 13 and 78). From page 61 of the same report, we can calculate an average FTTP cost in the NBN Co context of $4200. Limiting the focus to brownfields, the amount becomes $4970. Introducing the $12 billion savings from the 'Radically Redesigned FTTP' (from page 17), these amounts become $2880 per premises average, and $3260 for brownfields.

FTTN (Fibre to the Node) and FTTdp (Fibre to the Distribution Point) are options to reduce the NBN Co deployment cost. FTTN has been considered in some detail by NBN Co as part of the Strategic Review process. FTTdp has been introduced to readers of this journal in the recent paper by Mark Gregory (Gregory 2013). A worthwhile discussion on the use of copper technologies for the last customer access link is also contained in the recent paper by Robin Eckermann (Eckermann 2013). The papers by Gregory and Eckermann are well worth detailed study for those interested in obtaining a broad perspective on the NBN technology issue. We expand on the earlier FTTdp exposition provided in the Gregory paper, by focussing solely on very short-loop FTTdp (fibre to the street lead-in pit), and presenting further discussion on costs and benefits.

FTTN very clearly does not provide the level of network capability of FTTP. FTTN can provide a level of capability that satisfies low bandwidth demand increase scenarios (and a reduced need from high-demand premises). We observe a trend of downplaying bandwidth evolution scenarios in those contributions that suggest FTTN as a sensible approach for the nation (NBN Co 2013: page 79). For higher bandwidth demand growth projections, it is clear that the risk involved with mainstream FTTN deployment is very real (Watkins 2014).

Obviously, the difficulty with the FTTP approach is not the network capability provided, but the expense involved in deploying fibre all the way to premises. This in turn relates to costly tailored civil engineering works associated with each premises fibre lead-in. Clearly both costs and benefits must be carefully assessed when evaluating which technology to deploy. This complex task faces the NBN Cost Benefit analysis currently under way, with the expert panel having been recently appointed (Minister for Communications 2013).

The cost-benefit analysis is complicated enough if only two options of FTTP and FTTN existed. The need to fully consider HFC networks promises significant challenge to the expert telecommunications technology input able to be recruited for the task. A key consideration here is properly understanding the capabilities and limitations of the HFC technology, now and into the future. (HFC originated as a broadcast medium for selected video channels, and is now being applied to on-demand delivery of content from millions of channels world-wide, as well as two-way voice and video conferencing.) We must assess the impact of evolving bandwidth demand on the shared HFC network elements, and understand the expenses involved with infrastructure upgrades to maintain capability commensurate with the number of users and demand statistics. A detailed long-term technology road-map must be produced (in rough form at least) if any sensible determination of the cost-benefit equation is to be made for HFC. As HFC coverage is proposed to account for up to 30% of the premises in the nation, it is clear that these considerations must not be taken too lightly.

Ignoring the HFC question for the present, FTTdp can be seen to have network capability benefits closely aligned to that of FTTP, while (potentially) being cost-comparable to (or better than) FTTN. As such, proper consideration of the FTTdp option is likely to greatly simplify the overall cost-benefit analysis. The possibility is very strong that FTTdp may be found to provide a comprehensively robust and economic NBN technology solution. Making a sensible determination on this issue will again require expert telecommunications technology input supplied to the cost-benefit analysis team.

There is little argument that FTTP is the only sensible choice for greenfield deployment. FTTP is also the only sensible choice where it can be deployed economically (with aerial FTTP needing careful consideration in this regard), due to the robust and flexible nature of a

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full fibre solution. However, a significant majority of premises to be covered by the NBN are in brownfield development areas, and as such present more challenge to the physical deployment effort. In this paper we focus solely on the brownfield deployment scenario.

The paper aims to outline some of the key cost and benefit considerations for a FTTdp deployment. We do this by comparison to FTTP and to FTTN. Discussion of benefits is in the context of projected future bandwidth demand scenarios and a long-term focus. Cost consideration is necessarily crude, but we attempt to supply reasonable estimations in conjunction with cost data extracted from the NBN Co Strategic Review report (NBN Co 2013).

A Definition of FTTdp

Fibre to the Distribution Point (FTTdp) is a broadband access network technology, encompassing fibre to the street lead-in pit at the front fence. FTTdp is often deployed in conjunction with a wider FTTP deployment. In this setting we expect FTTdp to interoperate smoothly with the wider FTTP protocols such as GPON (Gigabit Passive Optical Network). In general we can define FTTdp as having copper lengths less than 200m. This is the sense in which Swisscom is deploying FTTdp (Swisscom 2013) in areas away from major urban centres. The NBN Co Strategic Review report introduces FTTdp as an augmentation approach for a FTTN deployment (copper length not stated, but assumed to be up to 200m). FTTdp in the present paper implies taking fibre to the street distribution pit, leading to an average copper loop length of around 30m.

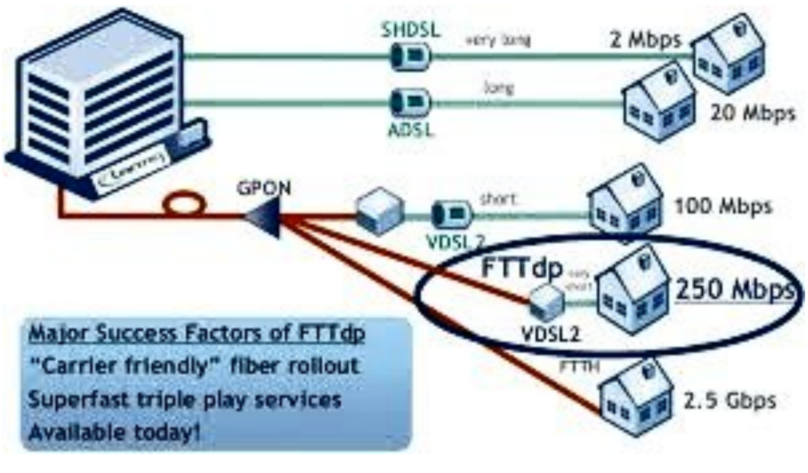

Figure 1 – The FTTdp Option (Image Credit: Lantiq)

Generally the public has a solid understanding of what FTTN represents, but there is less universal understanding of FTTdp. A Telstra pillar or major connection point is clearly identifiable as a node in the FTTN context, although more generally the term 'node' applies to any network connection point. For FTTN we are dealing with upwards of 50,000 nodes across the country, with an average of more than 200 premises per node.

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The FTTdp option is associated with the 'final' copper network distribution point, and the deployment of weather-protected micro-node devices reverse-powered from the premises. Such micro-node devices may serve up to 16 premises in medium density urbanised environments, or 4 premises in a standard suburban environment. We can visualise a FTTdp deployment as placing micro-node devices everywhere the FTTP NBN model would have positioned a 12-port fibre multi-port connector (NBN Co 2012). From these Telstra lead-in pits or overhead poles, the final twisted pair copper lead-in is used. The average copper length in this FTTdp network approach is thus seen to be very short, perhaps 30m, allowing full exploitation of VDSL capabilities such as profile 30a (providing 100Mbps symmetric service over a single pair).

VDSL2 obtains maximum performance with shorter copper lengths, and the very short length of this type of FTTdp deployment enables network capacity to meet the needs of most users for many years, even under scenarios of continued rapid bandwidth demand increases. FTTdp in association with lead-in pit micro-node deployment, allows maximisation of the possibility for bonding pair use and minimisation of crosstalk influences.

G.fast and individual FTTP on-demand upgrades, enable the network to readily cater for those users with even higher levels of connectivity demand. VDSL2 profile 30a is able to provide symmetric 100Mbps down/100Mbps up over short copper lengths (the 30 MHz bandwidth provides limited benefit in the FTTN application, and is generally not used in that setting). Bonding and phantom mode promise significant benefit, and 250 Mbps downstream is commonly associated with short-loop FTTdp.

Some Misconceptions

A common misconception is that FTTdp technology is not ready for deployment. This misunderstanding is most likely related to the subconscious association of G.fast with FTTdp. For maximum benefit G.fast requires very short lengths of copper (less than 80m). The higher frequencies used in G.fast also make it extremely susceptible to crosstalk. New vectoring approaches promise to provide significant improvements here, but it is far from clear how practical G.fast will be in situations where there is a large component of crosstalk (Spruyt 2013). This consequently suggests that G.fast (without vectoring) is ideally deployed in the FTTdp setting where there is limited crosstalk due to reduced prevalence of shared lead-in (Brown, L 2012; Brown, T 2013; TechWeek 2013).

G.fast is not yet ready for widespread FTTdp deployment, although it will soon be, with ratification of the first release of the standard expected any day, and hardware implementations to be available by the end of 2014. By contrast, VDSL2 is most certainly ready for FTTdp deployment. Both Lantiq (Lantiq 2013) and Alcatel-Lucent have weather-

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protected micro-node equipment using VDSL, reverse powered from premises. Huawei, Adtran, and other major suppliers, either have current product offerings, or are likely to soon have product offerings available in quantity. More recent market entrants such as Sckipio (G.fast) are likely to contribute to a highly competitive market in the near future.

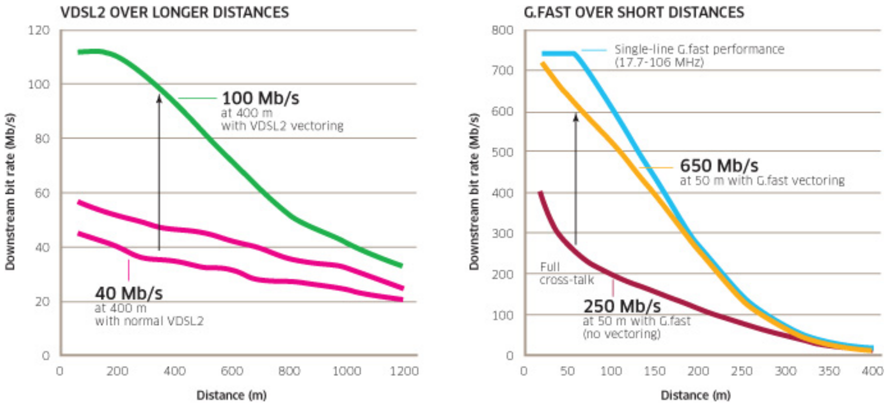

Figure 2 – VDSL2 and G.fast Throughput (Image Credit: Alcatel-Lucent)

The high bandwidth capability of VDSL2 (up to 250 Mbps) for short copper loop lengths translates to throughput capability that will serve the vast bulk of premises for many years into the future, even with scenarios of rapid bandwidth demand increases. For higher-demand premises, individual G.fast upgrade or FTTP upgrade are real options and can be provided for moderate cost due to the simplicity of the plug-and-play equipment upgrade for the G.fast option, and the short fibre deployment length in the FTTP case.

FTTdp thus provides robust and flexible capability, and can be deployed now. A determination of whether it is the most sensible deployment option compared to the other options of FTTN and FTTP must be made on the basis of weighing comparative benefits with costs. Crucially, network benefit can only be properly assessed with a sensible appreciation of network demand projections. FTTdp provides overall network capability very close to that of FTTP, for all but the most severely extreme projections of bandwidth demand. Even here, the fact that the core fibre FTTdp network is readily adaptable to widespread FTTP deployment, means there is very little chance of wasted deployment effort in the scenario where mass upgrade to FTTP occurs in a very short period (the extreme growth projection scenario). The worst case would appear to be scrapping a few hundred dollars' worth of CPE (Customer Premises Equipment) and micro-node equipment per premises, after they have already served the bulk of their anticipated deployment lifetime.

Another misconception is to rely too heavily on looking at overseas deployments of FTTdp to provide a reliable indication of where FTTdp might add value in the Australian NBN context. Recent NBN history clearly points to the fact that the local cost equation is quite different from that in many overseas environments. In particular, widespread deployment of FTTdp is

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not expected in those nations where construction of fibre premises lead-in drops is economic. In the Australian context the $2100 currently quoted (NBN Co 2013: page 61) for the average brownfield premises lead-in drop connection (mainly due to the tailored civil engineering works required for each individual lead-in and a need to professionally install CPE) is both a large financial outlay, and prevents skilled resources from undertaking other network construction activities, ultimately causing a substantial NBN deployment timetable impost. The reduced cost and time for FTTdp connection translates to large overall NBN Co cost and time benefits. The differences are substantial enough to turn what appears to be a weak option (full fibre FTTP) into a very strong option (FTTdp).

The Evolution of Bandwidth Demand

Direct extrapolation of past consumer access technology bandwidth increases can lead to some astounding projections for future bandwidth demand, including the suggestion that average consumers will require 10 Gbps connectivity within the next decade. These varied projections come from application of Nielsen's Law with small variations of input data (Nielsen 1998). If this proves to be the reality of bandwidth demand evolution, then it is immediately clear that FTTN would be a misstep for the nation at this point in time. However, it is far from clear whether the trends of past consumer access bandwidth supply, extrapolated into the future, give us any reliable estimate of access bandwidth demand in even 5 years (never mind 10 years).

We must delve deeper into the issue of bandwidth demand evolution in order to produce forward estimates that can be relied upon for access network capacity provisioning considerations.

Communications network convergence has been an expectation for a long time, and may now be showing signs of becoming a reality. Consideration of bandwidth demand for Ultra HD 4K video provides a worthwhile proxy for anticipation of broader network bandwidth demand over the next few years. Netflix has recently announced 4K streaming at 15.6 Mbps (CBS News 2014), but we must conservatively estimate the bandwidth demand for 4K video to be between 20 and 25 Mbps. The future impact of 3D 4K TV or 8K TV is difficult to predict with certainty. However, the reality of 4K screen price reductions will see multiple 4K devices in what may be considered average premises within a very short number of years. The NBN must be able to deliver multiple 4K streams to a single premises, as well as facilitate conference video scenarios for multiple simultaneous users. Simultaneous video streaming, from multiple video sources world-wide, is already a reality for many.

Consideration of multiple 4K video streams is a suitable proxy for broad downstream data bandwidth demand, but upload data rate requirements are likely to vary dramatically from

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premises to premises. Some small enterprises will require more symmetrical upload versus download capacity. With VDSL deployment there is restriction to a single fixed ratio between upload and download due to the necessity of minimising crosstalk implications from the frequency bands employed for the different data directions. The variation in distance from the node, in the FTTN case, creates the situation where this limitation is likely to cause difficulty for some premises. The situation is quite different for FTTdp, with maximum VDSL upload and download capacity effectively supplied to all premises.

The Cost of FTTdp Deployment

Naturally FTTdp involves a significantly deeper deployment of fibre into the access network than does FTTN. However, the cost of this greater fibre deployment is balanced against the higher capital expenditure for FTTN of copper remediation, time-consuming copper patching installation work at the node, the provision of large street cabinets (and associated risk of damage from errant vehicles), the provision of 240 volt power and battery banks to all nodes, the need for cabinet cooling, and more involved deployment cut-over practices. We perhaps do not even need to take the operational expenditure differences into account for working with a greater proportion of the legacy copper network for a cost comparison to become decisive. Distribution of fibres from the node to the distribution point lead-in pits is a non-trivial task, but offers substantial work flow advantages that a centralised FTTN deployment activity schedule does not.

Ultimately, detailed analysis is required to determine which is the cheaper option, when directly comparing FTTdp to FTTN (of the type requiring access to unpublished NBN Co costs). A direct comparison between FTTdp and FTTP is perhaps a simpler undertaking due to the similarity of work effort required in both cases. This allows an indirect comparison of costs between FTTN and FTTdp.

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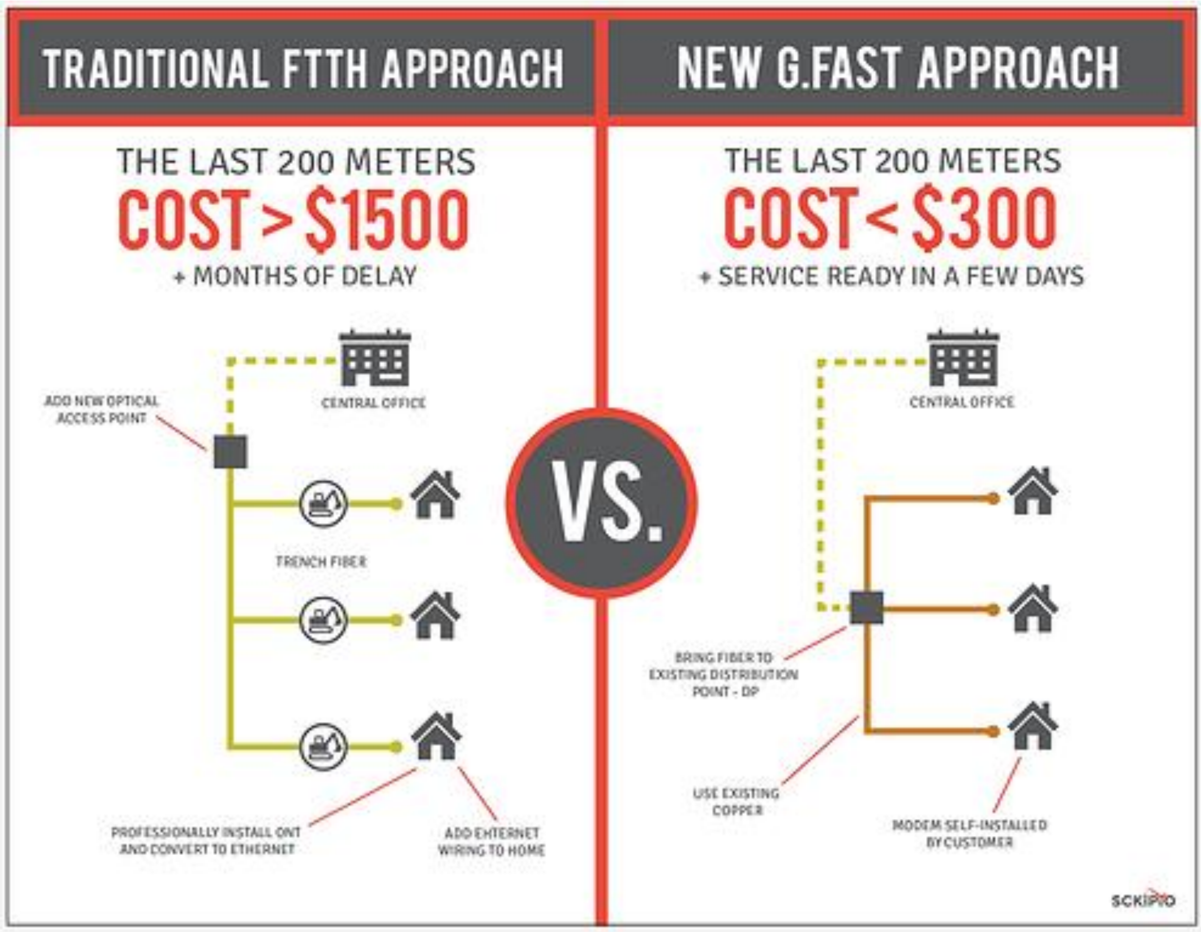

Figure 3 – FTTdp compared with FTTP (Image Credit: Sckipio)

Figure 3 from Sckipio, presents a cost comparison for the FTTdp situation. We have mentioned above how the Australian NBN costs differ markedly from the international experience. However, Sckipio seem to be suggesting that even with the emerging G.fast option for FTTdp (still not a fully mature technology option), the cost of FTTdp is a substantial reduction on the cost of FTTP. We need to ask what corresponding costs should be assumed for the parts of the access network not included in Sckipio's final 200m calculations, but it is likely that the cost of FTTdp even in their estimation is not far above that of the $350 to $700 international FTTN range given at page 78 of the NBN Co Strategic Review report.

The larger cost of the civil work network components in the Australian setting make any cost comparison vastly different to that presented by Sckipio. However, the cost of the FTTdp customer connection in the Australian NBN setting involves only a portion of the work performed for the $300 cost suggested by Sckipio above (being supply and installation in the pit of the micro-node device). This Figure therefore provides a crude, but nonetheless useful, reference point for FTTdp connection costs (exclusive of the fibre network construction cost).

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The NBN Co Strategic Review document (page 61) indicates an average customer connect (lead-in drop plus CPE installation) cost per premises for FTTP of $2100 for approximately 7 million brownfields premises (under the 93% FTTP model). This figure is a significant portion of the $4970 cost for brownfield FTTP extracted from the NBN Co Strategic Review report as outlined in the introduction section. While practically no detail is provided in the NBN Co Strategic Review related to the 'Radically Redesigned FTTP' Scenario 2, there is little expectation of any impact on the customer connection cost in this scenario. The exception is the cost of CPE, quoted to be $80 to $110, likely passed to the RSP (NBN Co 2013: page 82). Subtracting this, the approximately $2000 customer connection cost is then seen as a significant portion of the average $3260 FTTP brownfields cost under Scenario 2.

FTTdp effectively eliminates this $2000 cost of individual tailored civil engineering works at each premises, replacing it with the FTTdp connection cost at the street pit. A device must be installed in the pit and connected to the copper pairs coming from the premises which share the pit (for the NBN Co suburban layout this is an average of 4 premises).

A generous allowance of $800 in equipment costs and $800 for multiple installer visits to the street pit, translates to $1600 in total, for an average of $400 per premises. This represents a saving of $1600 per premises over the quoted costs for FTTP, amounting to $11.2 billion in capital expenditure savings for both Scenario 1 and 2 as presented in the NBN Co Strategic Review report.

These savings come with little impact on revenue or operating costs. Should service adoption rates exceed the 70% used as a conservative estimate, the FTTdp business case improves even further. The marginal cost of connecting additional customers to a FTTdp network is very small (involving no additional network equipment and a few additional minutes of work time if performed as part of the primary connection process, and a single-person-crew attention to a task taking minutes only if performed at a later stage).

Widespread FTTdp deployment based on Scenario 2 must be analysed in more detail on the promise of this simplistic cost analysis. However, the more sensible approach is to consider the adoption of HFC and FTTB (Fibre to the Building/Basement) such as starting from Scenario 4 as a baseline. Here the lower number of FTTP premises in Scenario 4 translates to a reduced saving from the FTTdp approach, amounting to $6.2 billion.

This modified Scenario 4 then looks very favourable in terms of costs compared to all the other technology mix scenarios presented in the Strategic Review document. The network capability benefit, including the vital benefit of network flexibility to handle higher rate CIR (Committed Information Rate) services, high demand users, and higher traffic demand profile increases, is significantly improved compared to other scenarios involving substantial FTTN deployment.

Note the capital expenditure shown on page 17 of the NBN Co Strategic Review report does not show a significant decrease from Scenario 2 to Scenario 4, which it presumably should if the substantial savings from the FTTP radical redesign have been carried across to Scenario 4. Assuming 50% of the Scenario 2 (FTTP radical redesign) savings are applicable to Scenario 4, the capital savings would amount to $6 billion. The total FTTdp savings of just over $12 billion brings the total FY11-24 cumulative capital expenditure for FTTdp to $28 billion. The figures NBN Co use and supply have significant uncertainties, and this number has even poorer accuracy, due primarily to a lack of published cost information from NBN Co. However, the potential saving is enticing enough to warrant closer analysis by NBN Co.

Additional FTTdp Benefits

In addition to obtaining extremely high VDSL performance, the FTTdp approach eliminates upwards of 90% more of the copper network compared to FTTN (on a lineal pair measure basis). The elimination of the vast majority of copper pair connections is a major advantage, even if we assume that there is no major network-wide corrosion problem with poorly sealed joints or a major issue with faulty gel sealant material.

Passing the cost of CPE more directly to end users, most logically through RSPs (Retail Service Providers), is unlikely to meet with significant objection under the FTTdp model. VDSL modem equipment is expected to be readily available at reasonable prices from a large number of suppliers, as is clearly the case today for ADSL modems. (The same claim can be made with FTTN, but CPE equipment costs for FTTP presents some concern with how these are likely to be passed to customers and not act to slow service uptake, especially if this cost also includes the necessary professional installation of the FTTP CPE.)

Cut-over from a telephony/ADSL connection to an NBN FTTdp connection can easily be accommodated by a single person mobile unit needing to work only at the lead-in street pit location. Workloads in any one area can be balanced by scheduling, with new CPE posted or delivered to end-user premises ahead of the scheduled time of disconnecting the old CPE and connecting the new equipment.

Micro-node devices, certified by NBN Co for use on the NBN, can be installed and tested as part of the FTTdp fibre deployment or on an as-needed basis for connections. Both approaches have pros and cons, and an optimised approach may involve a mixture. (Presumably equipment can be installed in lead-in pits as part of the fibre deployment where there is a high likelihood of services being ordered, determined from data on existing ADSL and phone connections and other sources.) In either case, the skill set required for premises connection is modest and mobilisation of a large workforce of individual contractors, certified by NBN Co to work on the customer end of the NBN, is a realistic expectation.

The FTTdp approach encompasses reduced LFN (Local Fibre Network) fibre counts and substantially reduces the size of splitter cabinets required (FDH, Fibre Distribution Hub, enclosures). This opens the prospect of splitter infrastructure being retracted into pits, away from vandals, errant vehicles, and falling branches. The reduction in impact of street furniture is a major positive consideration compared to the FTTN approach. Large cabinets for FTTN present a very real site location problem that altered legislation does not 'solve'. NBN Co and the government cannot expect to win the hearts and minds of the masses by ignoring genuine public concerns.

The benefit of reduced LFN fibre counts is unclear in terms of impact on deployment costs. Presumably smaller and lighter cables are somewhat easier to pull or blow through conduits, in addition to general handling and transport benefits. Small incremental differences in costs can translate to large savings over the size of the NBN project. The complexity of the task of accurately patching LFN fibres at the FDH is reduced dramatically when there are only 50 or so fibres to contend with compared to 600 in the NBN Co FTTP approach.

On the downstream side of the splitter (LFN) there is the potential to use loose tube fibre bundles from 6 to 24 fibres (corresponding to the 72 to 288 fibres in the initial FTTP approach). A single fibre goes to each micro-node device. In reality some additional fibre capacity would be included in the bundles. For FTTP upgrade the micro-node device is replaced by a small splitter (a dual-stage optical splitter FTTP implementation thus results). Micro-node devices with integrated splitters are clearly not difficult to envisage.

The small size of a connector for a single fibre compared to a 12-port multi-port enables some flexibility in terms of the LFN deployment. Presumably a major component of the cost in the LFN deployment is not pulling the fibre itself, but ensuring that multi-ports present at the right locations in the pits.

Suggestions of major potential LFN deployment cost savings from FTTdp are speculative, but warrant close examination. NBN Co is able to supply the detailed cost information required to properly delve into such matters and should undertake a comprehensive analysis. Some of these cost savings may already be exploited by the radically redesigned FTTP Scenario 2, presented in the NBN Co Strategic Review report.

FTTdp Upgrade Options

A FTTdp deployment involves deep fibre penetration into the network. Any network upgrade is largely a premises-by-premises decision. There is no need for another additional major

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nation-wide network construction process with the FTTdp approach. Upgrades to G.fast or FTTP can occur on an individual premises basis in accordance with demand, facilitated by a thriving ecosystem of small contractor specialist installers. The very high capability of short-loop VDSL in the FTTdp setting (including use of bonding and phantom mode), implies a small initial demand for individual capability upgrade. (This is important as it does not withdraw resources from the ongoing main network build.) Over time, with increasing network demand growth, we would expect a steady stream of premises wishing to upgrade their connectivity. The volume of upgrade activity will obviously be dependent upon actual bandwidth demand growth. High capability of the initial VDSL FTTdp deployment ensures that a large number of premises will continue to be well served by the initial technology deployment for the longest possible time.

The coming G.fast option ensures that the gap between VDSL performance and the investment involved with individual FTTP upgrade is bridged. However, it remains to be seen whether G.fast will be practically viable enough to warrant implementation in more than a small number of situations. Again, the robust capability provided by VDSL in the FTTdp context ensures that there are a number of years ahead, prior to G.fast implementation needing to be considered for more widespread deployment. By then G.fast implementations will be mature, and cost and performance considerations of the technology will be more readily understood. Any potential G.fast FTTdp deployment must be balanced against the relatively modest cost of individual FTTP fibre deployment (note that this premises fibre lead-in drop is largely through property controlled by individual premises owners, and distributing control of this fibre connection to premises owners is likely to result in optimised cost outcomes).

It should be noted that G.fast is capable of interoperation with VDSL by choosing to limit the G.fast deployment bandwidth to commence above the 17 MHz or 30 MHz VDSL profile band. In the FTTdp scenario it is also conceivable that all users connected to a micro-node would be upgraded to G.fast at a single time, thus not requiring interoperability and using the full bandwidth for G.fast. However, it is pointless to speculate on what is likely to be the most sensible approach to an upgrade problem not likely to emerge for a few years, if at all.

We need to contrast this flexible upgrade capability of FTTdp with the prospect for FTTN. Due to the large copper lengths and shared lead-in of FTTN, G.fast has little scope for provision of significant benefit. Likewise, VDSL profile 30a, bonding, and phantom mode offer little potential gain in the FTTN setting. The high cost of individual FTTP upgrades from a FTTN node is likely to suppress latent demand for such upgrades. As dissatisfaction with FTTN capabilities grows, we can expect to see ad hoc deployment of fibre past the node.

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Whether an ultimate decision is made to deploy FTTdp or FTTP, it is not clear whether the ad hoc fibre deployment investment can be fully exploited.

Additional Cost-Benefit Considerations

Crucially, the requirements of high-demand users are met by the FTTdp build, effectively to the same level they are met with FTTP. We must not be tempted to think that high-demand users represent only a small percentage of the total user base of the NBN and that their requirements should only be weighted in proportion to their number. The NBN represents important national infrastructure. Communications networks are inextricably linked to the modern global, and rapidly evolving, economy. A significant proportion of high-demand users are likely to be involved with ventures that represent a growing component of the national economy. High technology web companies are part of this equation, but greater use of networks is implicit in almost every sector of our modern economy.

Business investment in smaller organisations can be expected to be predicated on reliable network connectivity that promises to grow with the business. A fibre-on-demand model for individual FTTP connection in a FTTN deployment meets some of the generic requirements of business customers, but it presents uncertainties related to high cost and installation time (being dependent on arranging a tailored major fibre installation by NBN Co). While these issues do not pose a major threat to many businesses, they are likely to be significant concerns for others. The FTTdp model provides baseline capability that will suffice for the majority of customers, adding simple upgrade options. As such, it instils communications capability confidence for businesses, providing a communications technology roadmap that can be relied upon.

The prospect for uniform retail product offerings across the breadth of the NBN is significantly greater with FTTdp than with FTTN. The extra complexity of not being able to supply a largely uniform retail product set with FTTN has business cost implications for RSPs.

Deployment of new overhead or underground HFC infrastructure is not likely to be materially different in cost and time compared to provision of FTTdp. With the latter option there is a significant simplification in the premises connection as this can be implemented from the lead-in pit. FTTdp must thus be properly considered for use in HFC black spot areas. Neither FTTN nor FTTP offers the strong cost-benefit equation of FTTdp for such use.

For very small gaps in HFC coverage (hardly describable in terms of a black spot), running new HFC infrastructure is likely to be the only sensible option.

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Conclusion

The 2013 Australian federal election campaign presented an FTTP option against FTTN. The former has been criticised as too costly, while the latter may not provide a sufficient 'future-proof' capability. Following the lead of Gregory (2013), this paper presents the third option of FTTdp. It is suggested that FTTdp may provide network capability close to that of full FTTP, with cost similar to FTTN. FTTdp may provide optimal ability to meet the unknown, yet high, anticipated bandwidth demand of the future, with comparatively low initial capital outlay.

Widespread deployment of FTTN runs a very real risk of supplying inadequate network capability, and provides limited flexibility in meeting large premises-to-premises demand variation. FTTP on the other hand appears to have failed to meet most promises of deployment cost and timetable (in the Australian NBN context).

FTTdp can be viewed as a middle-ground solution for brownfield NBN deployment. (For greenfields there is strong reason to suggest that FTTP is the only sensible choice.) The very short copper lengths of FTTdp imply that VDSL rates will be high enough to meet the needs of all but the most demanding users for the immediate future. G.fast also promises a convenient upgrade path. An on-demand, user-pays fibre lead-in drop model completes the equation in terms of flexibility and network longevity. The small FTTdp node devices are powered from the premises over the copper, and there is no need for large (and unpopular) street cabinets. The likely availability of multiple lead-in pairs for many premises allows pair bonding and phantom mode for maximal VDSL2 (or G.fast) performance. Splitter fan-out is significantly reduced compared to FTTP, allowing the possibility of street furniture greatly reduced in scale, including solutions where the splitter frame is retracted into a pit. Greatly reduced LFN fibre counts compared to the default FTTP model used by NBN Co to date, introduces the prospect of substantial network deployment cost savings on the LFN side in addition to major savings on the customer connection.

Mainstream FTTdp NBN deployment must be thoroughly analysed. In contrast to FTTN it promises a single network build, long-term solution. The fibre drop portion of FTTP is eliminated due to the use of existing copper pair lead-ins, translating to a substantial deployment cost saving. FTTdp has the advantage of eliminating somewhere up to 90% of the legacy copper network compared to FTTN. Importantly, the majority of the copper joints are eliminated.

If we start from a baseline assuming the use of HFC, similar to Scenario 4 in the Strategic Review, the saving from FTTdp (based on little more than back-of-the-envelope analysis) is approximately \$6.2 billion (with a potential further \$6 billion saving in already-identified

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NBN Co fibre deployment initiatives). While the cost equation is appealing at this simplistic level, a decision to pursue a FTTdp trajectory versus a FTTN one must clearly be made on the basis of a consideration of both costs and benefits. Here the network utility provided by FTTdp is a large improvement over that provided by FTTN.

The cost savings of the FTTdp approach correspond to a workforce saving that translates to more skilled resources being available to accelerate the network deployment timetable.

Primary use of FTTdp is likely to lead to some revenue upside compared to the FTTN case, due to the higher connection throughput and the greater ability to offer high CIR products. The revenue upside could be substantial in FTTdp should subscriber numbers be driven upward. For FTTP, similar revenue increases come at additional large customer connection costs that simply do not apply in the FTTdp case.

A more sophisticated analysis such as that performed for the other technology options in the NBN Co Strategic Review report may indeed determine that widespread FTTdp is the obvious technology choice from all angles: chiefly cost, time, revenue, and capability (benefit).

Polarised views will continue to plague the NBN initiative while FTTN is selected as the primary deployment technology. We can expect that within as little as three years, one side of this debate will be able to point to enough external developments to quieten objection from the other side. The risk in FTTN is that we may be on the wrong side of the equation, with migration to FTTdp or FTTP required on such a short time-scale that in hindsight, FTTN becomes a clear misstep. FTTdp holds the promise of eliminating the vast majority of any polarised debate from square one (and may do so with no additional cost implications). The nation must honestly investigate this option.

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Endnotes

1. The authors contributed a substantial document to the Senate Select Committee on the National Broadband Network on the 31st of January 2014 (Watkins 2014). The most significant recommendation of that contribution was the need to properly investigate the option of Fibre-to-the-Distribution-Point (FTTdp) as a major NBN deployment alternative. This short paper aims to focus solely on the FTTdp option and highlight key considerations of the technology.

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