Report for Ofcom

Cost of the BT UK local loop network

Non-confidential version

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Contents

Analysys

1 Introduction and aim

1.1 Context

Ofcom is engaged on a review of the costs associated with BT's local loop network (see the recent Ofcom consultation document "Valuing copper access - a consultation on principles"). The costs related to this network feed into the important wholesale products of WLR, LLU and some parts of PPCs.

One of the components of these costs is related to the current valuation of the network assets. Currently this valuation is undertaken by BT on a current cost accounting (CCA) basis. It is calculated by estimating the inventory of access network plant, based on a statistical sampling method, and then multiplying by appropriate unit costs to arrive at the valuation.

As part of this review, Ofcom have engaged Analysys to undertake a comparison between the valuation of the existing network and a hypothetical Modern Equivalent Asset (MEA). This report contains the results of this comparison.

1.2 Definition of MEA in this context

The MEA chosen will be the most cost efficient method, using modern technology, of providing the same services, to the same level of quality and to the same customer base as is provided by the existing copper access network.

Cost-efficiency: For an alternative technology/architecture to be considered more cost efficient it should be cheaper over the long run (in terms of total costs, including operating expenditure and maintenance) than the existing BT technology/architecture, for the defined service set.

Modern technology: The solution should be achievable with proven and currently available equipment.

Services: The MEA should support the existing main service set offered by BT over copper local loops:

- PSTN
- ISDN
- ADSL and SDSL
- Private circuits (including PPC terminating segments) over copper (e.g. Analogue/Kilostream/Megastream).

For the purposes of this study, the ability to support LLU was not a mandatory constraint. We note that Ofcom is currently consulting on a number of related issues (including “soft LLU”) in the NGN interconnection consultation.

There are a considerable number of other services currently provisioned over the copper loops in small quantities (e.g. “dry copper” for short range inter-building DSL or alarm circuits). We assume that another solution can be found for these “niche” requirements; whilst we acknowledge that these alternatives would carry some cost, we do not seek to cost them within this study.

Current customer premises equipment for the required service set should be able to be used in an unchanged manner, through an unchanged network terminating equipment (NTE). For the avoidance of doubt there should be no requirement for the end customer to provide power or to provide any more space than is required by the existing NTE.

Customer base: The MEA should be capable of serving the existing number of users.

1.2.1 Analysys comment

We note that the need to keep the current customer premises equipment is a particularly important constraint, and causes a several potential technologies to be rejected. Nevertheless, we consider this definition of MEA to be the right one, given the purpose to which the study results will be put in regulating prices of various wholesale services offered on the existing network.

1.3 Scope of analysis

The scope is limited to the wireline network (currently comprising twisted metallic pairs or their equivalent), and excludes all other local access network components (such as optical fibres used to support high bandwidth leased lines).

The “Drop wires” and the Main Distribution Frame (MDF) are excluded from the analysis within this study as the purpose of the study is to provide a comparator for BT’s existing valuation which also excludes these items.

We note that drop wires have significant value, but are not shared between users and they have historically been accounted for differently by BT.

1.3.1 Analysys comment

We consider this scope to be correct given the way in which BT’s costs are currently calculated.

1.4 Constraints

We are constrained to maintaining the locations of the MDF and the DPs. This is necessary since the purpose is to consider a modern equivalent to BT’s existing access network. Thus, it is assumed that the point of interconnection with the core, i.e. the MDF, and with the customer sites remain fixed. As we do not have information which identifies the locations of the individual customer sites, we are constrained to fix the locations of (and number of) the DPs.

Current construction standards are assumed for all installations. The network should be assumed to meet the applicable standard for any new construction; a similar rule is used to determine the valuation of BT's existing network under the CCA standard.

1.4.1 Analysys comment

We consider these constraints to be correct. We note that fixing the boundary of the access network at the MDF and excluding the costs of the MDF does mean that architectures that may require fewer exchange buildings cannot demonstrate this potential cost saving. The investigation of any cost savings which might be possible by removing this constraint would require a significant amount of geographic data on the location of DPs in adjacent exchanges, allowing optimisation of the architecture across existing exchange boundaries. This data is not available at the moment.

1.5 Data available

For this study we are constrained in the data which is available to us. We have:

- The exact geographical location of the distribution points (DP) in two BT exchanges (from a BT GIS called "PIPeR"). We do not have the geographical data for the ducts or cables, nor the network termination equipment (NTE) locations.
- The full line by line records from the BT local loop costing system (LLCS) for the duct and cable assets at eight exchanges, including the two for which we have PIPeR data. These eight include at least one from each of the six BT "geotypes" (a classification of BT exchange areas into 6 different sizes / demand densities). An individual LLCS record is for a single xx pair cable in a particular duct space of length yy m, with a footway box at the end: accordingly, these records are highly detailed but do not allow the user to trace the cable serving an individual primary cross-connect point (PCP) or DP as the interrelationship of the duct spaces and the interrelationship of the cables is not recorded.

- We have the LLCS costs for a set of individual asset types including various types of cable, duct and footway box/manhole. We do not have these for all asset types within the LLCS data set, as BT's procurement policy has changed over time; in these cases, we use the more modern equivalent asset.
- We have various extracts from BT's other asset databases, including the counts of installed lines, DPs and PCPs, and the geotype, for each BT main distribution frame (MDF) ("exchange area").
- We know the identity of the 176 exchanges for which BT gathers LLCS data.
- We have frequency charts of the average LLCS cost per DP for the LLCS exchanges
- We have BT's costs for PCPs, ducts per m (by number of bores), cables of various size per m, footway and roadway boxes and manholes, and cable jointing.

These limitations in the data constrain, in part, our ability to test whether BT's network layout is an efficient one and to put forward more efficient layouts (because it is very difficult to know whether they are feasible in practice given the data).

1.5.1 Analysys comment

Due to the small samples of data used in this study (e.g. based on 8 exchange areas for some items) it is not possible to be definitive about the likely error bound of the quantitative results. Nevertheless, we consider the data available to be sufficient to answer the main qualitative question faced by this study, i.e. whether the use of an alternative technology would reduce the costs of BT's UK local loop network.

We would prefer to have access to larger data sets and if these were available the robustness of the quantitative results of this study would be increased.

2 Selection of possible alternative architectures

2.1 Possible architectures

2.1.1 General discussion

There are a variety of methods which can be used to provide fixed telephony:

- Copper loops
- Copper loops with pair gain
- Fibre to the cabinet and copper elsewhere
- Fibre to the DP and copper elsewhere
- Fibre to the Premises (inc. TPON)
- Hybrid fibre coax - HFC
- Radio based systems

Copper loops. This is BT's current architecture. We consider this option in more detail below.

Copper loops with pair gain: In some circumstances where a shortage of loops was encountered in the past, a pair gain system is installed which allows two or more subscribers to share a single loop. We do not consider pair gain to be a solution which meets our constraints as it cannot provide DSL (so cannot meet the service set) and also because an efficient deployment would have built a better dimensioned copper loop network (rather than indulge in local solutions such as pair gain).

Fibre to the cabinet and copper elsewhere. We consider this option in more detail below.

Fibre to the DP and copper elsewhere. We consider this option in more detail below.

Fibre to the Premises. We consider this case in more detail below.

Hybrid fibre coax – (HFC). The HFC architecture is that of the UK's cable networks. It uses fibre to the cabinet followed by a "tree" network consisting of coaxial cable and a series of repeater amplifiers. These networks were built to support a different, more extensive service set than that considered for this study, as they were designed for the distribution of broadcast television signals. HFC networks are known to be more expensive to build than copper local loop networks. This can be seen, for example, in the lack of cable TV services in rural areas of the UK. In addition, different CPE would be required – for example existing DSL CPE would not be able to be used on an HFC network. Accordingly, we have not considered HFC as a candidate MEA.

Radio based architectures are conceivable as a means of providing voice services, but do not meet the constraints regarding CPE. Radio based solutions which offer the same interface to the installed base of existing customer premise equipment (CPE) do not currently exist for DSL in particular . Accordingly, we have not considered radio-based solutions as a candidate MEA.

Accordingly we have focussed on four possible wireline architectures:

- the current architecture, copper to the NTE
- fibre to the PCP
- fibre to the DP
- fibre to the NTE.

For each of these options we look at the architecture, whether it meets the stated criteria for consideration in this project, the impact of this architecture on LLU, and any additional features gained (over the minimum criteria). The additional features are merely noted: for the avoidance of doubt, we have not reduced the cost of any option by allocating some of the cost to additional capabilities outside the minimum service set.

2.1.2 Existing architecture: copper to the NTE

Description

Each end user premise is connected via a "drop wire" to a distribution point. This is typically a small (book sized) plastic box in the basement, on a pole or on a wall. The drop wires are considered to be out of scope of this analysis as

1) this study aims to obtain a cost which can be directly compared with the results of BT's own study, LLCS which does not include costs of drop wires

2) drop wires have historically been accounted separately by BT (expensed in-year until 2000/2001, capitalised and depreciated since then).

Within this architecture, the distribution points (DP) are served either:

- directly from the exchange (so called "exchange only" DPs)
- or via an intermediate cross-connection point called a primary cross-connect point (PCP).
- It is feasible to have an additional layer of cross-connection (a "secondary cross connect point (SCP)"), but this is very rare within the BT network and we have therefore neglected this option in this study (which may result in a very small overestimation of the cost in some circumstances).

The cables serving the DP are most usually laid in duct (e.g. a plastic pipe buried under the pavement, with access points provided at manholes). If this duct is from a PCP to the DP it is called a "distribution side" (D-side) duct; if the duct contains cables serving DPs direct from the exchange (so called "Exchange only DPs"), that is with no PCP, is it an "exchange only" duct (and is sometimes treated as part of the D-side). Some EO cables share duct with the E-side cables serving PCPs (if any).

Each PCP is served from the exchange by large cables, typically 500 or 1000 or more copper pairs. These cables sometimes use pressurised air (supplied at the exchange) as a means of keeping the cables dry, though there are a variety of alternative technologies too (e.g. gel-filled cables); pressurised air cables are the option we have costed. These E-side cables are laid in the E-side duct.

This architecture is illustrated in Exhibit 2.1 below, which shows examples of the cable, joints, and duct provided.

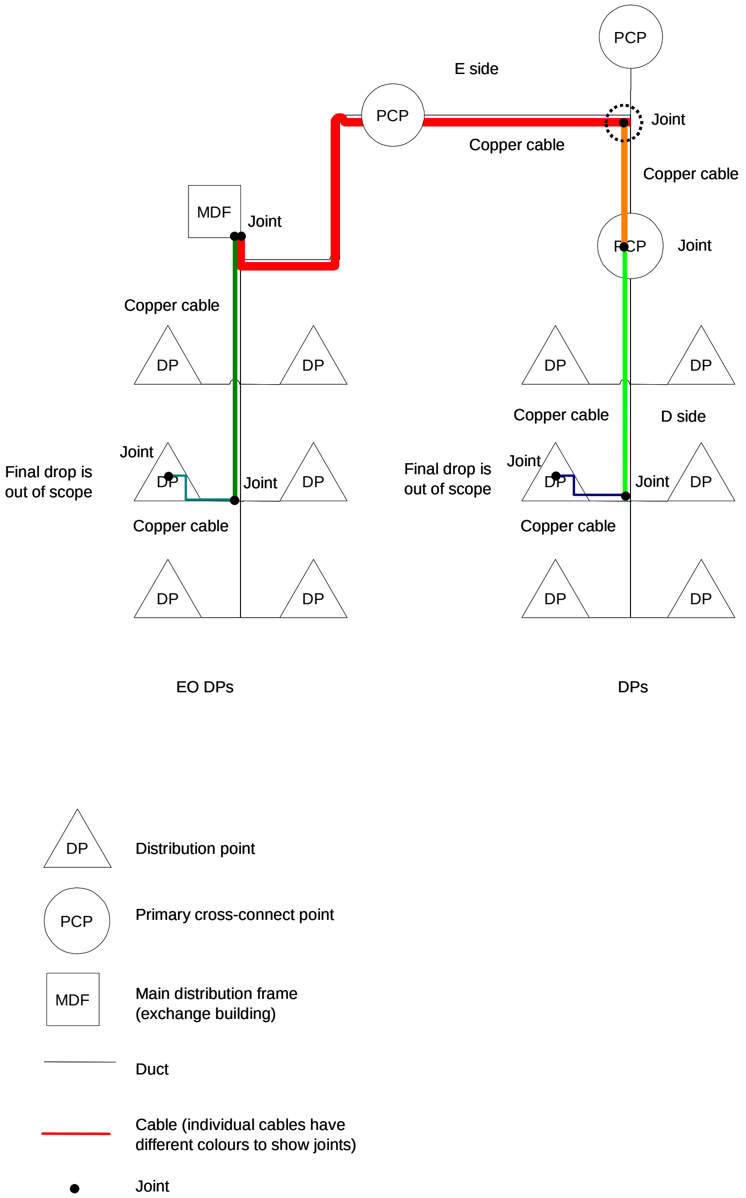

Exhibit 2.1: *Existing local loop architecture [Source: Analysys]*

It is important to note that within this architecture there are joints in the cables which are made at intermediate locations (i.e. joints are not just at the PCP or the DP). For example, there is a joint (circled) near the top right hand corner in the exhibit above that is at a location where there is a junction in the E-side ducts. These joints allow the total length of the cable to be reduced, and for higher capacity cables to be used (which both save money) at the cost of making the joint itself. There is therefore a trade-off possible between the cost of extra cable and the cost of extra jointing, which depends on the cost of cable and joints of a given size.

As this is the current network architecture, it necessarily meets all the constraints (and, in fact, also supports all the niche services such as “dry copper”).

It is an open question as to whether a new build would use exactly the same duct and cable layout as the existing BT network (which has grown incrementally to meet demand over time). This issue will not be examined in this study: we understand that Ofcom has undertaken a separate study of this issue with a different consulting company.

2.1.3 Fibre to the PCP

Description

Within this architecture the final drop, DPs and exchange-only distribution or D-side duct and cable is unchanged from the existing case. Again, there can be joints in the cable serving the DPs.

However, the PCP is replaced with active electronics, consisting of some form of multi-service access node in a small cabinet. This PCP is assumed to have its own battery back-up for providing service in the event of a short power failure (assumed to be 6 hours). The new “active” PCP might be at the current location (a “scorched node”), or (in principle) at a different set of locations.

If the PCPs are in different locations then the layout of the E-side and D-side would change slightly (e.g. less E-side cable, redesignation of some former E-side duct as D-side), and it is necessary to take account of this in the cost calculations (detailed below).

The E-side cable is replaced by a fibre optic cable serving the PCP. Again, there can be joints in this cable if necessary.

This is illustrated in Exhibit 2.2 below:

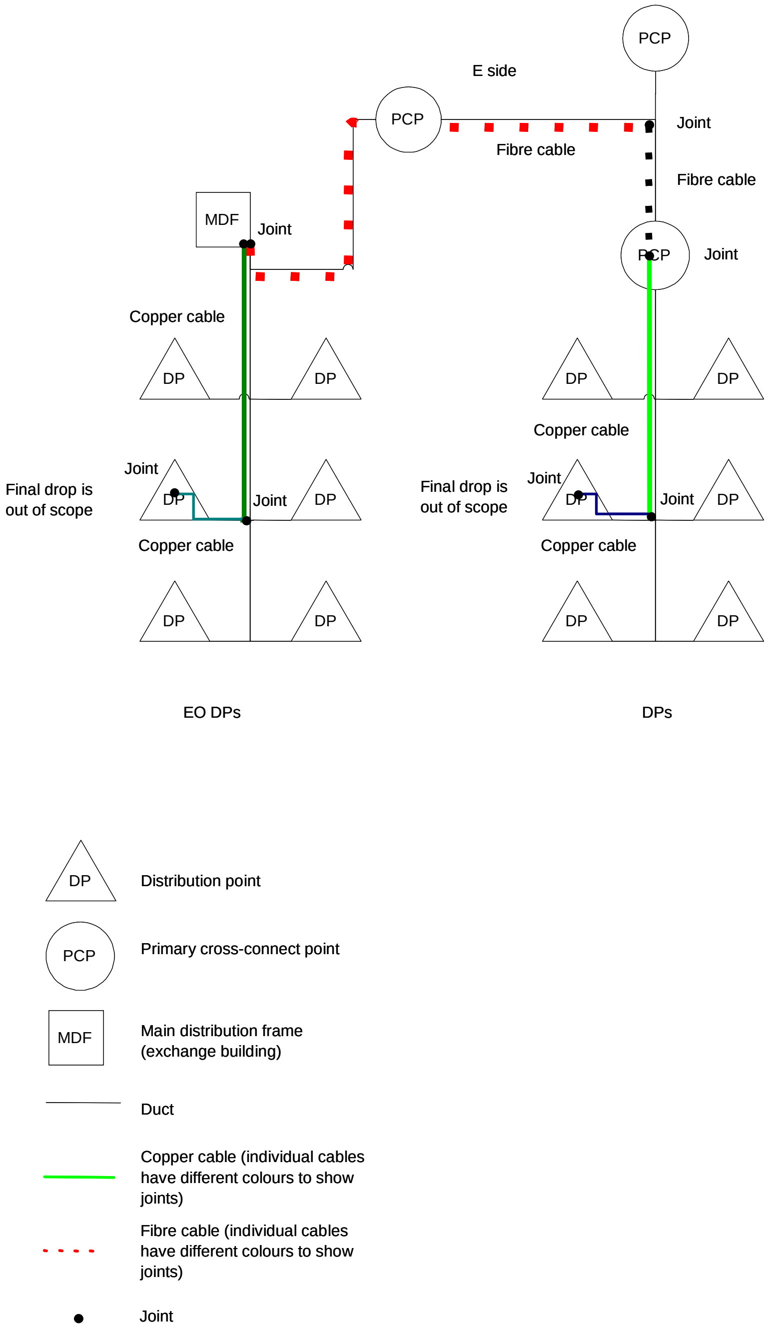

Exhibit 2.2: *Fibre to the PCP architecture [Source: Analysys]*

Fit with criteria

This architecture can support the existing retail service set as there are multi-service concentrators available which serve PSTN, ISDN, DSL and leased lines (as well as other services such as ATM and FR), which can be fitted within street cabinets. The cost-effectiveness of this option is considered later.

Impact of this architecture on LLU

Within such an architecture, full LLU is not available in its current form, though sub loop unbundling is available at the PCP.

We note that the economics of this unbundling are different to the economics of LLU at the exchange, due to:

- serving fewer customers at the PCP, reducing any economies of scale (different and smaller DSLAMs)
- the need to place additional street cabinets to house the unbundler's equipment, which is more difficult than in-exchange co-mingling or collocation and will probably not be popular with planning authorities
- the need for the unbundler to obtain a backhaul link to this more remote point, (e.g. by leased line, or by installing their own fibre or radio link); competitive networks are rarely available at PCPs

Additional features gained by the use of this architecture

The major additional features gained by the use of fibre to the PCP are:

- The shorter copper loop distances that result would allow BT and other network operators to immediately offer higher speed VDSL services or ADSL services (e.g. a reliable 6Mbit/s on ADSL), even within the existing frequency/power mask (the "Access Network Frequency Plan" (ANFP))
- It may increase the number of homes that can be reached by DSL services (by reducing the distance to the DSLAM)

- it might be possible to relax some parts of the power/frequency mask which may allow even higher speed services such as Ethernet over copper to be deployed
- there would be an option of adopting a fibre to the DP or fibre-to-the-home (FTTH) architecture at a future date, and the investment in fibre to the PCP would make this slightly cheaper (than would be the case were this investment not to have happened)
- the additional network build needed to offer services such as high bandwidth leased lines or Ethernet services such as BT LAN extension service (LES) would be reduced. This up-front "excess construction" cost is sometimes a deterrent to potential customers for high bandwidth services; accordingly, the market for such services might grow.

2.1.4 Fibre to the DP

Description/Fit with criteria

In this architecture the duct network remains unchanged, but all the D-side and E-side cables are replaced with fibre optics. The fibre reaches all the way to the distribution point. As previously, there can be joints (or "splices") at intermediate points as well as at the PCP and the DP.

The DP is replaced with active electronics, consisting of some form of multi-service access node in a small cabinet.

This architecture is illustrated in Exhibit 2.3 below:

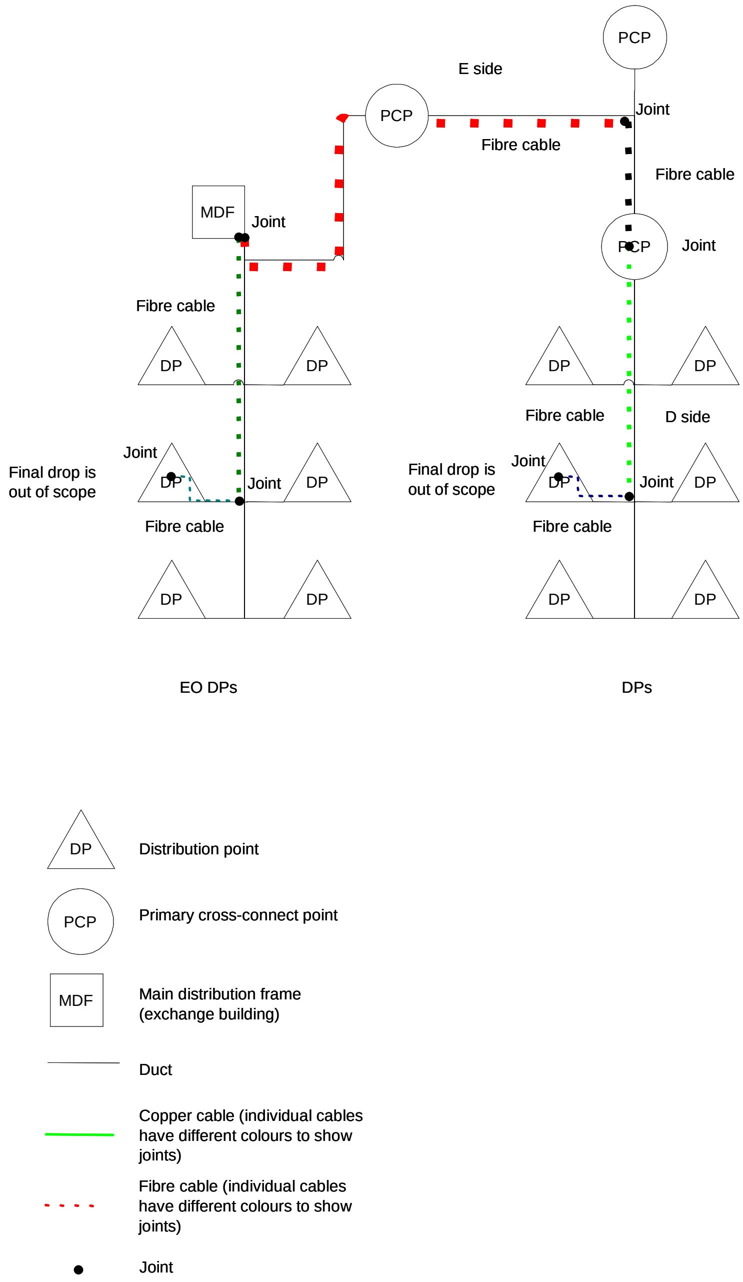

Exhibit 2.3: *Fibre to the DP architecture [Source: Analysys]*

There are as yet no commercial devices that would offer the entire existing service set (PSTN, ISDN, DSL, etc.) within DP-sized and hardened equipments. Providing power to these remote points would be hard: these are not locations where a large pack of lead-acid batteries will be feasible as the current DPs are in locations where size and weight matter (e.g. on a wall, or at the top of a pole), and accordingly these devices would have to be powered from the centre by means of copper cables laid with the fibre.

It might be possible to build such an architecture if the service set was greatly simplified (e.g. use VoIP, IP, Ethernet, 100BaseT). Nevertheless, this is not the desired service set and as such does not meet the constraints for the purpose of setting an MEA price (because it is not equivalent for all services considered (including DSL and leased lines) and a new CPE would be required).

Additional features gained by the use of this architecture

The major additional features gained by the use of fibre to the DP are:

- BT would be immediately able to offer very high data rate services (e.g. 100Mbit/s Ethernet) over the shorter copper loop distances which would result
- FTTH would be a realistic future prospect as only the DP electronics, the drop wires and NTE would need to be replaced
- the additional network build needed to offer services such as high bandwidth leased lines or Ethernet services such as LES would be greatly reduced. This up-front “excess construction” cost is sometimes a deterrent to potential customers for high bandwidth services; accordingly, the market for such services might be expected to grow.

Impact of this architecture on LLU

LLU within the DP is highly unlikely to be economic due to the very close reach of DPs to the end customer (typically within 30m) and small number of customers per DP (typically 5–20). With a small number of customers per DP, and a small fraction of these buying service from the new entrant, a direct build to the customer is (in effect) almost equivalent in cost to taking LLU at the DP. For one customer per DP it would be exactly equivalent if the final drop sub-loop prices were “at cost”.

TPON

There have been within BT a number of small trial scale deployments (of order 30,000 lines – approximately 0.1% of all BT lines) of TPON systems. Whilst these trials have undoubtedly shown that such systems are feasible for either a fibre to the DP architecture (in the past) or a fibre to the premises solution (in a more recent trial), they have not yet demonstrated economic viability for the current service set. We understand that a new build of TPON would use a similar duct layout to the existing network (i.e. a “tree”), and that it would therefore face very similar costs to the existing network for duct and fibres. Unfortunately for the economic case for TPON however, there is an additional significant cost, the CPE (Optical Network Unit, ONU), currently costing several hundred pounds per line: accordingly significant additional service revenues would be needed to make it attractive compared to the existing architecture. It is therefore not a modern equivalent asset we will consider further in this study.

For the avoidance of doubt, there are no TPON lines in the exchanges used as sources of data for this study.

2.1.5 Fibre to the NTE

Description/Fit with criteria

Within this architecture, the duct network is unchanged, but all the cabling including the drop wire is replaced with fibre-optics. The fibre extends all the way to the end user premise NTE. This architecture, though extremely capable, would require replacement of the NTE and final drop wires.

A solution would be required which could ensure the provision of “lifeline voice” during power failures, e.g. by providing power to the NTE via copper cable laid with the fibre

An equivalent to the existing service set could be supported, but only by replacement of all the existing CPE. This is in itself enough to rule out this option, in a similar way to the rejection of radio based architectures.

As we do not have the data on the NTE locations or existing drop wire lengths, it is also not currently possible to cost this option accurately.

Accordingly, we have not considered it in more detail within this study.

Impact of this architecture on LLU

This architecture does not support LLU in its current form, because there is no copper loop to unbundle. We note that fibre loop unbundling could be offered, though this is not currently regulated in the UK.

2.1.6 Conclusion on technical architectures

In principle, we have found two possible architectures which meet the desired constraints:

- the existing copper loop architecture
- a fibre to the PCP architecture
- we note that a third option is to have a hybrid or mix of these two architectures (e.g. fibre fed PCPs only in situations where this is more cost effective; for instance, in those cases where the PCP is a long distance from the exchange, such as PCPs in rural areas, or in dense urban areas where the PCP can serve a very large number of end users in a small area). We have considered within this study as a sensitivity analysis a partial hybrid where whole exchanges are either served using fibre to the PCP or copper to the PCP. The more detailed alternative of choosing to serve an exchange with a mixture of technologies (some PCP served with fibre, some with copper) might be a lower cost but to determine this accurately would require a more detailed geographic data set

3 Cost modelling the two alternative architectures

3.1 Costs which are common to the two options

3.1.1 Duct

Introduction

The cost of duct is high (industry benchmarks range from US$50-US$150/m or higher according to circumstances), and although its lifetime is long (e.g. 60 years or more), it is still a very major contributor to the annualised cost of a wireline access network. Accordingly, minimising the duct costs will tend to keep the annualised costs low.

The next biggest cost item, cables, has a cost which also increases with the length of the ducts, but one may also choose to duplicate cables on certain segments of duct in order to save on jointing costs. Accordingly, the lowest cost solution will have a short duct but possibly a slightly longer than expected cable network.

Theoretical optimum

The shortest network linking a number of points (in our case, including a central point, the MDF site) is a tree network which allows for the use of intermediate points (so called "Steiner points") – a minimum Steiner tree. [1]

The minimum Steiner tree solution is up to a factor of sqrt(3)/2 of the length (i.e., a maximum of 13.4% shorter) of the so-called "minimum spanning tree" which does not admit the use of arbitrary intermediate points. In practice, the minimum spanning tree is often closer than this to an optimal solution, within a few percent of the optimum, and minimum spanning trees are often used as proxies given that finding such optimal minimum Steiner tree solutions is known to be difficult [2].

It is however clear from this discussion that a tree will be the optimal cost solution in the absence of additional constraints. BT's network is a tree: this is in principle an appropriate design (although BT's may still not be the best tree, this can only be determined by looking at the layout in great detail). We understand that this issue is being addressed by a separate study.

A "tree" architecture is also used by incumbent network operators in other countries.

Practical constraints

In the case of BT's access network, there are additional constraints which apply and which make the problem slightly more complex than the theoretical one discussed above:

- The copper loop network should be designed to minimise total cost including the cost of cables, joints, distribution points and primary cross-connections, as well as duct and

[1] One of many academic papers on this topic can be found in "Steiner tree problems" (Du, Lu, Ngo, Pardalos) in Encyclopedia of Optimization (C.A. Floudas and P.M. Pardalos, Eds.). Kluwer Academic Publishers (2001), Vol. 5, pp. 227-290.

[2] for mathematicians, the problems are of the class "NP-hard"

manholes; it should also take ongoing costs into account as well as capex and installation costs.

- There is a maximum length of copper wire for the PSTN to work without additional costly interventions (e.g. higher diameter copper wire or amplifiers) – a constraint which partly determines the size of BT's exchange areas. In principle the fibre to the PCP architecture could greatly reduce the space required to support the access network within BT exchanges (to a single cabinet serving the direct DPs,), and this might offer the possibility of a saving in the long run. However, this saving is not within the scope of this study, which stops at the MDF.
- The ducts in which the cables are laid are constrained to run along easily accessible routes; in practice, this means in almost all cases under or alongside existing roads. Accordingly, the actual layout may be less efficient than the theoretical simply as a result of the routes taken by the local road network. Barriers such as rivers, canals and railways are also constraints.

Advantages of non-tree architectures

Non-tree networks are sub-optimal and carry additional cost, but this cost could sometimes be justified if it provides additional benefits. One such architecture is a "ring" or a series of interconnected rings: in such an architecture, PCPs can have two independent routes for cables back to the exchange and hence there can be added resilience to failures in the "ring" parts of the access network (e.g. contractors accidentally digging up the cable). SDH technologies such as those used in metropolitan area fibre networks for large business customers are naturally suited to such "ring" topologies. A tree does not have this added level of resilience: if a branch is cut, all the leaves on that branch will suffer.

It is possible to calculate the length penalty of a "ring" over a Steiner tree for specified distributions of points (e.g. uniformly distributed) and specified constraints about resilience (e.g. failure in any one segment of duct should not lose connectivity at any network node) and lengths of cables (e.g. how much additional cable can be laid to provide the resilience, or what is the maximum length of the cables).

However, whilst there are leased line services offered by BT that do have this kind of diverse routing for additional resilience (e.g. Megastream Genus, Cellstream Secure+), we think that this is relatively rare and we expect that it is provided for separately by BT. In other words, we expect that BT has added to its duct network to provide for it, rather than designing it to be so in the first place. As this is not an intrinsic feature of the copper loop network, it is therefore difficult to argue that such added cost and added resilience should be included within the modern equivalent asset. Such additional diversity would only become important if the fibre to the cabinet architecture was seeking a higher reliability than that currently provided in the E-side cabling.

It is not known whether any of the LLCS sample exchanges (i.e., the LLCS data set used by BT to estimate the costs of the duct and cable in the network) have ducts that were built purely to provide the ability to offer separate or diverse routing. If they do, then it is arguable that these ducts and cables ought to be excluded from the LLCS calculations as regards the cost of the copper loops: such costs ought to be allocated instead to the relevant leased line services which caused them to be incurred.

Conclusion

An efficient tree network should be costed.

3.2 Costs which differ

Our cost assumptions for the fibre-fed PCP are summarised in the table below:

Certain costs of the PCP are in principle common, if not exactly the same:

- planning
- cabinet installation (though noting that a cabinet with power, batteries and active electronics may need to be slightly bigger, costs may need to be increased slightly and planning issues may need to be made more significant)
- jumpering the copper wires to/from the DPs.

Certain costs offer a saving in the fibre-fed case:

- cost per m of copper cable serving a typical PCP
- cost per m of fibre cable serving a typical PCP
- (possibly) fewer metres of cable per PCP if the PCPs were laid out differently (e.g. if there were fewer PCPs)
- fewer bores in ducts in the fibre-fed case.

Cost per m

We have assumed that fibre can be pulled for the same as BT's cost of installing typical E-side copper cables. We have made this assumption because the BT value for E-side cable pull cost is below our fibre benchmark. Accordingly, the remaining cost difference comes from the lower cost per m of a few fibre pairs compared to hundreds of pairs of copper wire.

Cable length

If the PCPs were laid out differently (e.g. if there were fewer PCPs), then there would be a potential saving in the length of the E-side cables: in essence, each remaining PCP is slightly closer to the exchange.

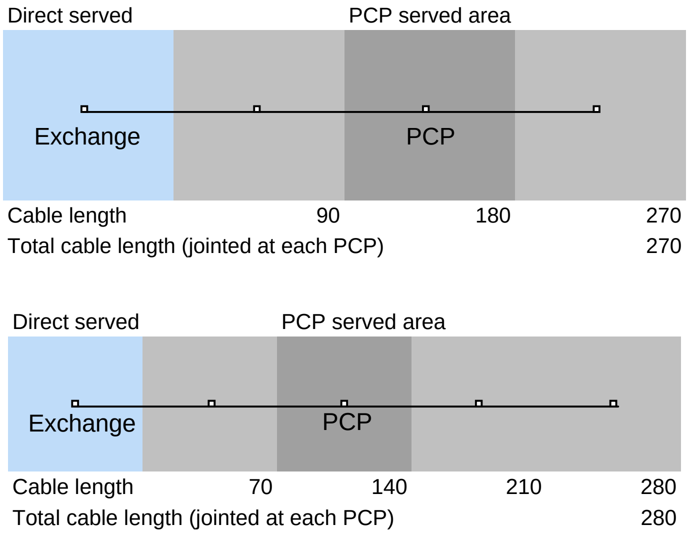

Exhibit 3.1: *Illustration that fewer PCPs may bring the furthest PCP closer to the exchange [Source: Analysys]*

Fewer bores in ducts in the fibre fed case

The fibre cables are considerably smaller than the E-side copper cables and, accordingly, fewer bores would be needed in the ducts. The overall savings are relatively small because there are strong economies of scale in duct bores as illustrated in exhibit 3.2 below.

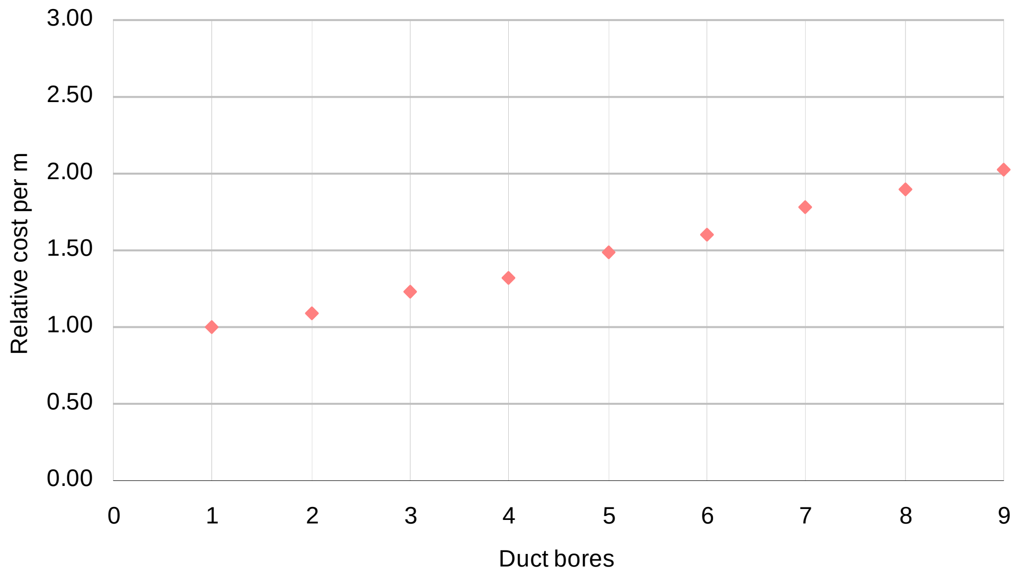

Exhibit 3.2: *Relative costs of ducts with larger numbers of bores, showing strong economies of scale [Source: Analysys/BT]*

Elsewhere, the fibre-fed PCP carries additional costs, as follows:

- power and back-up power
- active electronics capex
- test/ installation/ commissioning costs associated with the active electronics (install, configure, test).

For power and back-up power there are difficult trade-offs to be made:

- Is it necessary to provide battery backed-up power at the PCP? If batteries are used, how many hours of capacity are needed? Is it better to centrally supply the power from the exchange site where a generator-backed battery is a feasible option?
- We have assumed six hours of battery-backed power is provided at the PCP with no generator back-up. This might be insufficient time to prevent a loss of lifeline telephony, depending on the reliability guaranteed by the main electricity system: certainly, there have been outages of >6 hours in a number of areas in the last year or two. We understand that

the BT TPON deployments with fibre to the cabinet have of order 8hrs of battery backup power.

For the active electronics, we have assumed that we should not include the cost of the PSTN/ISDN line cards as these are not costed as part of BT's LLCS, although these would be part of BT's costs of offering PSTN line rental for either architecture (either at the MDF site in the traditional architecture, or within the PCP in the fibre to the PCP architecture). The cost of the frame and a small capacity backhaul card is estimated at GBP3000(Source: Supplier discussions).

If line cards for an MSAN suitable for deployment in a PCP would be more expensive than those for an existing concentrator, then it would be justifiable to include these additional costs within this calculation. However, we believe that MSAN line card costs are lower than the costs of line cards used by existing BT equipment and equal to the costs of line cards for an MSAN located in the exchange. Therefore, the cost of copper does not need to reflect any additional element to reflect this.

Lifetime and operating and maintenance costs

Some of the active PCP elements will have a shorter lifetime, typical of electronics, and a higher operation and maintenance cost than a traditional PCP (which is in effect just a series of copper joints).

Other elements in the fibre-fed architecture will result in maintenance cost savings (especially the fibre cable, which has a lower maintenance cost per sheath metre per annum than copper cable). We include this effect in our cost model.

3.2.1 Summary of cost assumptions

Cost item	*Traditional*			*Source*		
	Capex (GBP)	*Lifetime (yrs)*	*Opex (% of capex)*	*Capex*	*Lifetime (yrs)*	*Opex (% of capex)*
Planning	1500	15	Nil	Analysys days, BT man hour cost	Match to BT D side lifetime	N/a
Cabinet and installation	3000	15	2%	Analysys	Match to BT D side lifetime	Analysys
Jumpering the Copper wires (based on 500 pairs in and out)	450	15	Nil	Analysys days, BT man hour cost	Match to BT D side lifetime	N/a
Cost per sheath m of E side cable	confidential	15	confidential		BT	
Power and back-up power	Nil	N/A	Nil	N/a	N/a	N/a
Active electronics capex.	Nil	N/A	Nil	N/a	N/a	N/a
Electronics test and installation costs	Nil (install of cabinet and wires is above)	N/A	Nil	N/a	N/a	N/a

Exhibit 3.3: *Base case assumptions for traditional PCP [Source: Analysys]*

Cost item	*Active fibre-fed PCP*			*Source*		
	Capex (GBP)	*Lifetime (yrs)*	*Opex (% of capex)*	*Capex (GBP)*	*Lifetime (yrs)*	*Opex (% of capex)*
Planning	1500	15	Nil	Analysys days, BT man hour cost	Match to BT D side lifetime	N/a
Cabinet and installation	3000	15	5%	Analysys	Match to BT D side lifetime	Analysys
Jumpering the Copper wires (based on 500 pairs in and out)	450	15	Nil	Analysys days, BT man hour cost	Match to BT D side lifetime	N/a
Cost per sheath m of E side cable	5/m	30	confidential	Analysys	BT	
Power and back-up power	450	10	5%	Analysys	Analysys	Analysys
Active electronics capex.	3000 (excluding line cards)	10	5%	Analysys based on supplier discussions	Analysys	Analysys
Electronics test and installation costs	2000	10	Nil	Analysys	Match to actives	N/a

Exhibit 3.4: *Base case assumptions for fibre fed PCP [Source: Analysys]*

4 Results of investigations

The key question within the cost modelling is how much an alternative technology would save compared to the existing BT architecture for the UK, assuming either:

- "scorched node", keeping the network nodes in their current positions
- "scorched earth", an optimised alternative architecture which allows nodes to be moved.

In this section we examine this question for the six geotypes used in BT's own network cost analyses in order to discover whether the results vary with geography.

4.1 Constructing the cost of the entire copper network

In order to calculate the cost per line, additional assumptions are required over and above those discussed in Section 3. These concentrate on the PCP and the cost elements that differ between the two architectures (fibre or copper to the PCP).

- We have calculated capex based on unit volumes and unit costs, and have calculated annual opex based on metrics (either as an annual percentage of capex, or as a per-unit-per-annum figure).

- Opex is assumed to be constant in real terms (as most opex is in manpower, this is equivalent to assuming that "inflation plus efficiency gains" based pay rises occur).

- Capex is annualised to be constant in real terms using a flat annuity over the economic life of each asset in turn. This is a simple and straightforward means of annualisation which assumes that replacement equipment will cost the same as current equipment in real terms.

- A cost of capital of 13% in nominal terms is used (assumed to be 10.5% in real terms).

- Costs are calculated in 2002/3 terms as these are the basis of the input unit costs supplied by BT.

- We have calculated the duct capex costs based on BT's total duct volumes and costs (for a suitably weighted average number of duct bores) from LLCS. We have this data by geotype for E-side and D-side (we assume the D-side figure includes EO duct). Whilst a fibre to the PCP architecture would use fewer bores, the saving in bores is a very small fraction of the total cost of duct

- Similarly, we have calculated the manhole/footway box capex costs based on BT's total volumes and costs from LLCS. We have this data by geotype.

- We have BT's actual data (from AMIS) on the number of PCPs, EO DPs, and PCP-connected DPs by geotype. We have used the PCP cost assumptions shown in the previous section.

- We have calculated cable costs based on the data we have on BT's cable costs per m, for cables of the average size used by BT in the E-side and D-side. Cable sizes (pairs) are estimated based on the eight LLCS exchanges for which we have detailed data (a minimum of one of each geotype). Cable lengths are estimated based on the eight LLCS exchanges for which we have detailed data (a minimum of one of each geotype), and converted to average cables per duct (total cable length/total duct length). In essence, we are assuming that these eight exchange areas are a good representation of the cable layout of their geotypes: this is a potential source of inaccuracy that could be improved in future by the use of PIPeR data. While the LLCS survey is only partial within each exchange (only covering approximately one-quarter of the D-side) this approach allows us to estimate the cable length for all exchanges directly as we already have data on the total ducts by geotype.

- For jointing costs, we use a BT-derived cost function for the cost of cable joints and an Analysys estimate of the cost of fibre joints per fibre pair. We again use the eight LLCS exchanges for which we have data to get information on the number and type of joints. We have applied correction factors, based on the number of PCPs and DPs sampled by the LLCS, because only approximately one-quarter of the D-side is sampled within LLCS. Accordingly, the D-side joint costs need to be increased by a factor of approximately four (dependent on the actual LLCS exchange and the fraction of AMIS assets sampled in LLCS: we have used the actual factors in the calculation). Again, the use of a small sample from LLCS is a potential source of inaccuracy that could be improved in future by the use of PIPeR data.

- By summing the annualised cost for D-side, EO and E-side ducts, cable, joints, boxes, PCPs and DPs, we can therefore estimate a total cost for an average exchange for each geotype.

Dividing by the average number of lines in service per exchange by geotype gives us an overall annualised cost per line. The number of lines in service is a particularly important variable and we note that the data that we have used for this parameter is over 4 years old.

4.2 Result of cost comparison for scorched node

The cost difference arising from the fibre-fed PCP architecture compared to the existing BT architecture can be calculated from the cost assumptions above.

All costs are in 2002/3 terms.

Geotype	*BT architecture, scorched node Cost per in-service pair (GBP)*	*Fibre to PCP architecture, scorched node Cost per in-service pair (GBP)*	*Difference (%) per line in cost terms compared to BT architecture*	*Number of pairs*
1	confidential	confidential	+4.8%	confidential
2	confidential	confidential	+4.3%	confidential
3	confidential	confidential	+5.3%	confidential
4	confidential	confidential	+3.4%	confidential
5	confidential	confidential	+6.1%	confidential
6	confidential	confidential	+4.8%	confidential
weighted average	confidential	confidential	**5.1%**	confidential

Exhibit 4.1: *Scorched node costs for the two architectures [Source: Analysys]*

This table shows that, for example, a scorched node fibre to the PCP architecture is approximately 5% more expensive per line per annum than the existing copper to the PCP architecture for the service set specified.

4.3 Scorched earth: improved layout of network

It is possible that the existing copper-fed PCP architecture may not be the most efficient layout for a different technical architecture involving fibre-fed PCPs. For example, fewer, larger PCPs might be used, perhaps at the cost of additional resources elsewhere in the network (e.g. D-side cable).

Accordingly, it is necessary to consider laying out parts of the network slightly differently.

We caution that it is difficult to be sure whether this trade-off is feasible in practice without real geographical data. For example, it is possible that the number of DPs served by a PCP is given by the number of houses connected in a village, and that it is impractical to suppose that a second (perhaps 1km distant) village could also be served from the same PCP. This issue is likely to be particularly important in the most rural geotype, geotype 6.

Nevertheless, we can do cost trade-offs on the basis of simple models, provided we are aware that the models may not sufficiently reflect the typical geography of the UK.

4.3.1 Changing the number of PCPs

Changing the number or location of the PCPs has a number of effects:

- fewer larger PCPs would slightly increase the length of D-side cable, and increase the average size of the cables and joints used within the D-side
- fewer PCPs would perhaps slightly decrease the amount of E-side duct (the furthest PCPs would be slightly closer to the exchange), but there would be a corresponding equal increase in D-side duct (i.e. the duct "tree" would be unchanged, but the labels attached to some parts of it would be different)
- fewer larger PCPs would decrease the length of E-side cable but it would be in larger numbers of pairs/cable (and the joints would be correspondingly larger for copper cables where there is a joint for each copper wire).

Modelling these effects

On this basis we have built the overall cost model to look at the optimum number of PCPs by extending the model so it is possible to vary the number of PCPs:

- E-side duct is reduced pro-rata with the number of PCPs
- the length of the E-side cable is assumed to be reduced by the same factor (i.e. cable per duct is unchanged)
- the costs per m of E-side copper cable is calculated as a function of the number of pairs based on typical numbers from BT. With reduced PCPs, the pairs per cable increases pro-rata. E-side fibre is assumed to have a different cost, as given in Section 3
- the cost of E-side jointing is assumed to be unchanged for copper fed PCPs (e.g. reduced pro-rata with the smaller number of PCPs but increased pro-rata for average pairs per joint) but reduced pro-rata for fibre fed PCPs.
- the cost of current and larger (fibre-fed) PCPs are based on our assumptions, as defined above

- costs of manholes and joint boxes are assumed to be unchanged
- D-side duct is assumed to increase in length by an amount exactly equal to the reduction in E-side duct
- D-side cable is assumed to maintain the same number of cables per duct
- average size of cables increases in proportion to the number of DPs per PCP. This is an implicit assumption about the cable layout. One layout that would scale in this way is a single cable from the PCP to a group of DPs, with a joint at each DP, although there are also many others with the same properties. We emphasise that there is not an explicit assumption about the actual cable layout
- the costs per m of D-side cable are calculated as a function of the number of pairs based on typical numbers from BT
- the length of D-side cable is assumed to increase as a result of the duct reallocation from the E-side and a constant figure for cables/duct
- D-side jointing is assumed to be more costly in proportion to the greater length of cable and a higher number of pairs served per PCP (increasing the average size of the jointed cables, which increases the cost of the typical joint linearly)
- EO duct is not affected
- EO cable is not affected
- EO jointing is not affected.

4.4 Results of scorched earth model

Results from this model are shown in Exhibit 4.2 below.

Geotype	*BT architecture, scorched node Cost per in-service pair (GBP)*	*Fibre to PCP architecture, scorched earth Cost per in-service pair (GBP)*	*PCP factor*	*Difference (%)per line in cost terms compared to BT architecture*	*Number of pairs*
1	confidential	confidential	0.55	+1.3%	confidential
2	confidential	confidential	0.40	-3.0%	confidential
3	confidential	confidential	0.35	-1.6%	confidential
4	confidential	confidential	0.40	-2.2%	confidential
5	confidential	confidential	0.40	+0.0%	confidential
6	confidential	confidential	0.20	-1.4%	confidential
weighted average	confidential	confidential		**-1.5%**	confidential

Exhibit 4.2: *Comparison of existing architecture to optimised fibre architecture [Source: Analysys]*

The "PCP factor" is the fraction of the original number of PCPs deployed in this case. For example, a PCP factor of .65 indicates a 35% reduction in the number of PCPs.

This shows that the fibre to the PCP architecture could result in small savings (of order 1.5%). However, this saving is contingent on the ability to reduce the number of PCPs. If we assume that in Geotype 6 exchanges we are not able to reduce the number of PCPs, the fibre to the PCP architecture is marginally (0.5%) more expensive, as shown below.

Geotype	*BT architecture, scorched node Cost per in-service pair (GBP)*	*Fibre to PCP architecture, scorched earth Cost per in-service pair (GBP)*	*PCP factor*	*Difference (%)per line in cost terms compared to BT architecture*	*Number of pairs*
1	confidential	confidential	0.55	+1.3%	confidential
2	confidential	confidential	0.40	-3.0%	confidential
3	confidential	confidential	0.35	-1.6%	confidential
4	confidential	confidential	0.40	-2.2%	confidential
5	confidential	confidential	0.40	+0.0%	confidential
6	confidential	confidential	1.00	+4.8%	confidential
weighted average	confidential	confidential		**0.5%**	confidential

Exhibit 4.3: *Comparison of existing architecture to optimised fibre architecture, except Geotype 6 [Source: Analysys]*

We note that, in certain cases, the assumptions used can significantly change the optimum number of PCPs without greatly affecting the optimum cost. For example, this applies to the jointing costs; however, without a physical layout (e.g. from a model using the PIPeR data) it is very difficult to be sure of the implications of a reduced number of PCPs for the required jointing as the joints have a multitude of purposes:

- splitting cables to go in different directions, e.g. at "Steiner points"
- splitting long duct sections which would be infeasible for a single piece of cable
- minimising cost by keeping the total length of cable down.

In these circumstances it is difficult to tell whether or not the jointing cost is a linear function of the length and average size of cables, and if it is not linear, the form of the best function to use. More data (e.g. from additional LLCS exchanges and from PIPeR) would help here.

Existing architecture

This model can also investigate whether BT's existing copper architecture could be improved by changing the number of PCPs.

Geotype	*BT architecture, scorched node, Cost per in-service pair (GBP)*	*Copper architecture, scorched earth Cost per in-service pair (GBP)*	*PCP factor*	*Difference (%)per line in cost terms compared to BT architecture*	*Number of pairs*
1	confidential	confidential	1.00	0.0%	confidential
2	confidential	confidential	0.70	-0.7%	confidential
3	confidential	confidential	0.65	-0.7%	confidential
4	confidential	confidential	0.65	-0.5%	confidential
5	confidential	confidential	0.70	-0.5%	confidential
6	confidential	confidential	0.30	-1.7%	confidential
weighted average	confidential	confidential		**-0.9%**	confidential

Exhibit 4.4: *Comparison of existing architecture to optimised copper architecture [Source: Analysys]*

The cost resulting is slightly higher (around 0.6%) than that offered by the optimised fibre to the PCP solution if the number of geotype 6 PCPs can be reduced.

4.5 Sensitivity

We have examined a number of sensitivities with the base case modelling.

Pairs in service

One significant point of difference may be the assumed number of pairs in service over which the entire cost needs to be recovered. A 10% reduction in the number of pairs in service increases the cost per pair by 10% (assuming that there is no corresponding reduction in the recoverable asset base, e.g. by arguing that the number of spare pairs is now unjustifiably high).

Spares

We have also examined the impact of changing the number of spare pairs built into the network. The costs used are based on BT's actual cable statistics (this is because estimating the number of cable pairs required in terms of the end user capacity needed would require a geographical model of the actual cable layout, e.g. based on the PIPeR data). However, we can model the impact of reducing the spare pairs in the following way:

- reduce the cable cost pro-rata
- reduce the copper jointing cost by a fraction of the reduction in pairs (about 60% of the pro-rata reduction in pairs).

We have examined 4 cases, reducing the number of copper pairs by 10%, 25%, 40%, and 50%. These figures correspond to spares of 80% of the installed base, 50%, 20%, and zero spares.

Geotype	*BT architecture, scorched node, Cost per in-service pair (GBP)*	*Copper architecture, scorched node Cost per in-service pair (GBP)*	*Copper architecture, scorched node Cost per in-service pair (GBP)*	*Copper architecture, scorched node Cost per in-service pair (GBP)*	*Copper architecture, scorched node Cost per in-service pair (GBP)*
	Existing spares (100% spare)	*10% fewer (80% spare)*	*25% fewer (50% spare)*	*40% fewer (20% spare)*	*50% fewer (no spare)*
% Difference per line in cost terms compared to BT architecture	0.00%	-0.65%	-1.64%	-2.62%	-3.27%

Exhibit 4.5: *Modelled cost reductions with fewer spare pairs deployed [Source: Analysys]*

A 10% reduction in the amount of capacity built results in a much smaller reduction in overall costs (0.65%), showing that the cost is dominated by the cost of duct (which in effect does not scale significantly with the number of pairs installed).

It is a matter of judgement what the correct spares allowance is. As can be seen from the above calculations, quite large changes in the amount of spare capacity have a relatively small impact (of order 1.6-3.2%) on the cost per line per annum.

Allowing for no spares would be an extreme position and would cause significantly higher costs to install new capacity as a result of, for example, additional lines per business site, or new fill-in housing built between existing served sites.

Hybrid architecture

An additional sensitivity is the possibility of a hybrid architecture. The simplest hybrid can be modelled by assuming that the cheaper of the two options will be used on a geotype by geotype basis. That is, for geotypes where the fibre to the PCP option is cheaper, we use this; elsewhere we retain the existing architecture.

Such a "whole geotype" hybrid architecture generates no significant improvement (£0.01) over the fibre to the PCP results.

This is not the full flexibility of a true hybrid option, which could for example use different solutions in exchanges of the same geotype, or indeed to serve different PCPs within the same exchange. The data we have available does not allow us to model the costs of such architectures.

Sensitivity to costs of providing power backup at the PCP

One possible cost saving available to the fibre to the PCP option would be to provide power to the PCPs by cables laid in the duct alongside the E side fibre cables. This would enable the PCPs to be slightly cheaper as they would not require batteries.

To illustrate the effect of removing the batteries we have reduced the cost of the fibre fed PCP and assumed no increase in the cost of cabling.

This shows that a small additional saving (around 0.2% per line) can be made by removing the batteries, if the cost of the additional cabling is neglected. This is a very small effect.

Sensitivity to costs of electronics

To illustrate the influence of developments in the MSAN market, we have investigated the sensitivity to a halving in the cost of the MSAN (excluding line cards).

Halving the costs of the MSAN without the line cards reduces the cost per line by approximately 0.6%. This shows that the electronics are not the dominant cost item, and implies that even substantial reductions in the cost of electronics will not significantly change the cost of the local loop provided using wireline technologies.

5 Conclusions

The aim of this study has been to examine the cost of a modern equivalent asset (MEA) to BT's UK copper wire local loop network.

There are a number of constraints to the study, in terms of the requirements to be met by the alternative architecture and the boundary of the costing. These constraints are in our view appropriate given the intended use of the study results.

We have considered a wide variety of possible architectures. Other than the current architecture, only one met all the study constraints: "fibre to the PCP". The costs of a fibre to the PCP architecture are very similar to those of the current copper architecture, but are slightly higher than the current architecture, for the current layout of the PCPs (street cabinets). They are very slightly lower than the current architecture, if the number of PCPs can be significantly reduced for the fibre architecture (including in Geotype 6 – rural exchanges), but this advantage is removed and the costs are higher than the current architecture if Geotype 6 cannot in practice be optimised in such a manner.

Accordingly, this is a mixed picture: fibre to the PCP is not unambiguously cheaper than the current architecture. Its costs are very similar because much of the cost arises from the duct and D side cabling which is in essence unchanged from the existing architecture.

As noted above, a small saving could potentially be achieved by a "scorched earth" approach. In this approach, a saving can be made by moving to a smaller number of larger PCPs, for either the current architecture or for fibre to the PCP. Unfortunately it is very difficult to know whether such a reduction in the number of PCPs is feasible in practice, given the data available. Given the small size of the saving available from moving to fewer PCPs, and the level of uncertainty involved in this model , we do not think that the result merits a change to the assumed architecture for the purposes of costing the MEA of the existing copper local loop.

Accordingly, we have concluded that an alternative technology is not a cheaper MEA to the existing BT architecture, and that Ofcom should base its costing on the current architecture.

Sensitivities

We have examined a number of sensitivities using the model. The most important of these is the total number of pairs in service, where a 10% reduction in the pairs in service increases the unit costs by approximately 10%. Accordingly, BT's unit costs are strongly affected by loss of market share in access lines to cable companies and mobile telephony.

Changing the number of spare pairs has by comparison a relatively small effect because the costs of cable are only weakly dependent on the number of pairs, and because cabling and joints represent a small fraction of the overall costs.

Suggestions for future work

We are confident that the qualitative conclusion of the study is robust, i.e. that alternative architectures meeting the study constraints would not be significantly cheaper than the existing architecture.

Nevertheless, the study results are dependent on BT's LLCS sample data, and in some cases on small samples from within LLCS data (a mere eight exchanges). Significant areas of the modelling could be improved if better data on the actual cabling layout were available for a statistically useful set of exchanges (e.g. via PIPeR)..

We believe it would be useful for Ofcom to compare these results to the outputs from BT's LLCS in both absolute and relative terms (e.g. the cost breakdown by geotype and by asset type).

6 Glossary

Term	Definition
100 Base T	An Ethernet interface specification, commonly used in office local area networks
ADSL	Asymmetric digital subscriber line – a communications technology which allows an ordinary telephone to be used for high-speed (broadband) communications. The fact that it is asymmetric makes it particularly useful for Internet access
AMIS	A BT management information system which holds data about various local loop assets
ANFP	Access network frequency plan: a specification of the way in which DSL technologies may use the copper loop (in terms of power and frequency)
ATM	Asynchronous transfer mode – a high-speed data switching technology which switches data in small cells (53 bytes) at very high speeds
CCA	Current cost accounting
DP	Distribution point
D-side	Distribution side: the part of the access network between the PCP and the NTE
DSLAM	Digital subscriber line access multiplexer
Duct	A tube (nowadays made of PVC) buried in the ground, in which cables can be laid (e.g. by pulling or blowing through). The duct can be accessed via joint boxes covered by concrete or steel lids. Not all cables are laid in ducts; some have been directly buried.
E-side	Exchange side: the part of the access network between the MDF and the PCP
Exchange only DP	A DP served directly from the exchange, with no intermediate PCP
FR	Frame relay. A data switching technology.
FTTC	Fibre to the cabinet
FTTH	Fibre to the home
FTTP	Fibre to the premises
GBP	Pound Sterling
Geotype	A classification of BT exchange areas by number of lines and line density
HFC	Hybrid fibre/coaxial. A cable TV network technology, used by UK cable networks
ISDN	Integrated Services Digital Network. A standard used for digital telephones.
LES	LAN extension service. A high bandwidth BT service used to link Ethernet networks.
LLCS	Local loop costing study. A BT study based on a sample of the paper records of the ducts and cables in the access network, across a sample of exchange areas.
LLU	Local loop unbundling. A wholesale service whereby a competitor to BT can lease access to an individual copper loop in order to provide, for example, DLS services.
Local loop	The pair of copper wires linking an end customer to a BT exchange building. Also known as the "last mile", though often longer than a mile.

MDF	Main distribution frame. A part of the local exchange building, where all of the local loops are brought and individually joined (on a "frame") to other wires linked to the electronics (such as a concentrator).
MEA	Modern equivalent asset
Minimum spanning tree	The shortest tree of links, linking a set of points, where each link is directly between a pair of the points in the set
MSAN	Multi service access node. An electronic device combining the functionality of multiple services access devices (eg voice concentrator and DSLAM)
NTE	Network terminating equipment
PCP	Primary Cross-connect point. A cabinet at the roadside, containing a small frame on which joints are made between the individual copper wires to the MDF and copper wires to the DP (qv)
PIPeR	A BT geographic information system, currently being deployed, which will record the location of BT's access network cables and ducts.
PPC	Partial Private Circuit. A wholesale variant of a BT private circuit, currently used by operators other than BT.
PSTN	Public Switched Telephony Network. In essence, the fixed telephone network.
SCP	Secondary cross-connect point. An uncommon feature of the BT network; an intermediate cross-connect between the PCP and the DP
SDH	Synchronous Digital Hierarchy. A current technology used to provide leased line services.
SDSL	Symmetric DSL. A DSL technology suitable for services with equal needs for transmission both to (downstream) and from (upstream) the end customer
Steiner point	An intermediate point introduced in a tree network so as to minimise the total length of the tree.
TPON	Telecommunications passive optical network. A technology using fibre optics which has "branches" in which a single fibre from the exchange is progressively split into multiple fibres; accordingly multiple end users share the capacity of a single fibre.
VDSL	Very high speed DSL. A next generation asymmetric DSL technology offering speeds up to 26Mbit/s.
VoIP	Voice over IP. A technology using a set of standards built on IP, the Internet Protocol. It can use the Internet, but need not do so.
WLR	Wholesale line rental. A wholesale product offered by BT, which allows providers of carrier pre-select to bill the end user for the line rental as well as for the calls.

Exhibit 6.1: *Glossary of selected terms [Source: Analysys]*