Novel Fibre Infrastructure Solutions for Fibre-to-the-Premises in the UK

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Why Consider Fibre Infrastructure?

- Costs of access infrastructure range between 50-80% capital investment (access component) depending upon
  - Capitalisation of infrastructure build (normal in BT)
  - Choice of system topology
  - Availability of existing duct or overhead poles
  - Terrain (if new digging is required)
- 1500 premises B-PON trial being constructed
  - New blown-fibre solutions to be tested
    - Tubing pre-provisioned (easier than fibre handling)
    - Fibre units blown-in later
  - Green-field deployment or targeted upgrade are possible outcomes
What are the Problems We are Trying to Solve?

• How to reduce fibre installation and management costs in central offices, distribution network and customer connections?
  – simplify the network construction
  – ensure that intervention faults are minimised
  – record and identify fibre routes
  – reduce the number of fibre connections/splices
  – maintain flexibility for growth or upgrade
Cabling Overview

- **Primary Node**: BF 1f unit in 8 tube bundle 3.5/5mm

- **Secondary Node**: BF 1f unit in 1 tube OH drop - 2.5/6mm

- **O/H Tube manifold**: BF 1f unit in 1 tube OH drop - 2.5/6mm – ducted

- **Exchange/CO**: jumper cables

- **Equipment rack**: Flexibility racks

- **Cable Chamber Joint**: Spur Joint

- **Joint box**: Blown cable up to 276 fibres

- **Single dwelling**: jumper cables

- **Spur Joint**: BF 4f unit in 7 or 4 tube bundle 3.5/5mm

- **BF 1f unit in 1 tube U/G drop**: 2.5/6mm

- **U/G Tube manifold In joint box**: BF 1f unit in 8 tube bundle 2.5/4mm

- **Single dwelling**: Blown cable up to 276 fibres

- **Single dwelling**: BF 1f unit in 8 tube bundle 2.5/4mm
How Significant are Infrastructure Cost Savings in the Central Office (CO)?

- Current systems are mostly point-to-point
  - CO cost contribution is on a per-customer basis

- Future systems allow fibre sharing
  - Reduces cost of CO contribution
    - PON Sharing factors are typically 8, 16 and 32
Potential Fibre Management problems in a CO

• Cables not well supported  
  – bend losses are incurred
• Cables incorrectly routed
• Poor route records
• Splice losses
Solution Choices

• Present system
  – Pairs of flexibility racks on each floor with splice trays for fibre patch cord connection
  – Manual record keeping

• Optical switching
  – Allows pre-provision
    • Higher upfront cost
  – Costs tend to be too high
    • May be justified where sharing factor is high and rapid restoration is needed

• Blown fibre technology; the solution proposed here
  – A single-splice route can be provided from the Cable Chamber Joint to the Equipment Rack
    • Simple push-fit connections for blown tubes
  – Flexible
    • The network inside the CO can be easily reconfigured
  – Risk of damage to neighbouring fibres is minimised
Re-routing in a CO, today’s method

Needed to upgrade CO equipment

- New fibre route installed (black)
- 5 new splices needed (S6-S10)
  - 4 new fibre lengths
- Changeover when S5 is broken and S10 is made

Obsolete route in red

New route in black

ER – Equipment Rack
OFR – Optical Flexibility Rack
CCJ – Cable Chamber Joint
E – E-side (Exchange Side)
L – L-side (Line Side)

Splice
Single Fibre Patch Cable
S1 - Splice No.
Proposed Service Upgrade Procedure

- Tubes in black are pre-provisioned
- Single fibre unit blown from ER2 to S4
- New splice needed, S4
  - Number of splices reduced from 5 to 1

Obsolete route in red

New route in black

ER – Equipment Rack
OFR – Optical Flexibility Rack
BFTFM – Blown Fibre Tube Flexibility Module
E – E-side (Exchange Side)
L – L-side (Line Side)
S1 - Splice No.
Prototype ‘BFX’ Flexibility Rack

BF Patching Rack

Input tube

output tube

Patching Tubes

Detail
Cost Savings in the Central Office

• Capital
  – 80% on material costs
    • The new flexibility racks use cheaper technology
  – 40% Adding the tubes and fibres, labour cost saving
    – Reduced time to construct
    • Simple tube connections
    • One rather than five splices

• Current
  40% savings on improved reliability and time-to-repair
  • Fewer repairs
  • Faster route identification
  • Less damage
  • Less time to repair
  • Avoidance of compensation payments
Trial Network Design

- Blown-fibre throughout
- Single fibre working,
- Single mode fibre
- Fusion spliced
- Overlay on copper
- Pre-provisioned to customer connection
- External or Internal customer equipment
- No “standby” protection circuits,
  - but 2nd Input fibre available to primary node
- Dimensioned for 100% customer take-up
Trial Infrastructure-blown fibre tubing

- Primary Node
- Secondary Node
- Exchange/Central Office
- Primary Spine – blown cable in sub-duct (20 mm ID x 15 mm OD)
- Secondary Spine – Blown Fibre (4-fibre bundle in 3.5/5 mm, 7-tube)
- Splice
- Cable intercept loops
- Intercept and drop 1 tube to each Secondary Node
- Overhead tube manifold
- Alternative underground tube manifold
- Up to 6 off 4-way Splitter Assemblies (SASAs)
- Trial Infrastructure-blown fibre tubing
Primary Node (PN)

- Contains Splice and Splitter-Array Sub-Assemblies (SASAs)
  - 2 input splice trays, 1 splitter tray and 4 output splice trays
- Distributes to secondary nodes

Unbroken Tube loops

6th SASA is only fitted as growth or repair contingency.

1x4 splitters may be fitted actively or reactively.

Water block connectors

7 or 4 tube (3.5/5mm), 4f unit to SNs
to next PN
Tube intercept joint (TIJ) and Secondary node (32 Customer)

- 1x8 splitters may be pre-provisioned or reactively fitted
- 4x8 unit in 1 tube
- 8 tube bundles to manifolds
- 1 fibre / customer
- Electrical continuity connection
- Water block connectors
- 2.5/4 mm
- 3.5/5 mm
- 4f unit in 1 tube

4th SASA is only fitted as growth or repair contingency.
FTTP Secondary Network Components

Secondary Node

Up to four 8 way splitter assemblies (SASAs)

Secondary Spine – Blown fibre 4f bundle in 3.5/5 mm 7 tube

U/G Tube Manifold

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Distribution Network Cost Savings

• Point-to-point rather than to point-to-multi-point
  – Fewer fibres in the primary distribution network
    • Fibre bottleneck near CO is reduced
  – Fewer splices

• Blown fibres to reduce splice numbers
  – Fewer splices
    • only four splices are used between CO and customer premises
  – Sliding trays allow access to splices for pre-provision or reactive deployment
  – Simpler repairs
Customer Premises Connections

• Costs are ‘per-line’ for both point-to-point and shared fibre systems

• Existing metallic systems
  – Overhead steel reinforced unscreened twisted pair (UTP)
  – Ducted UTP
  – Direct buried UTP
    • familiar techniques
    • easy handling

• Fibre systems
  – Fibres require delicate handling
    • Risk of being costly
  – New techniques needed
    • E.g. blown fibre and splicing equipment
Cost Savings Near the Customer Premises

- All three metallic techniques can be used for fibre
  - but the cost of fibre jointing is higher
- The number of fibre joints (splices) must be minimised
  - Blown-fibre allows simple joints in plastic tubing
    - longer runs of fibre with fewer joints are added afterwards
  - single rather than two-fibre systems (UTP has 2 wires)
Manifolds

- Low cost protection for unsheathed tubes and tube connectors
- Fibre unit passes through
  - Spliced at SN

8 tube bundle
U/G or O/H
1f unit per
tube

1 tube (2.5/4mm)
Over-sheathed to
6mm
1f unit per tube
Customer Termination (External ONU)

- **Pole top manifold**
- **OH or UG drop option**
- **Secondary Node**
- **Underground manifold**
- **8 micro-tube bundle**
- **1 tube/1 fibre**
- **Power, Coax, CAT5 and Telephony cables**
- **PSU**
Other Customer Connection Cost Savings

• Minimise the need for home visits
  – on Installation
  – or in fault situations
    • reliable aerial cable needed
    • easy access at customer premises (outdoor unit)
• Ensure all splicing is at ground level
  – ideally a single splice at the splitter location
• Choice of deployment strategy
  – neighbourhood deployment
    • green-field
    • ‘change-out’ if copper plant needs replacing
  – ‘on demand’ fibre provision
    • to pick up residual customers later
    • minimises ‘stranded’ or unused assets
Conclusions

• New technologies have been presented to reduce costs in
  – Central office
  – Distribution network
  – Customer connection
• The major contribution is through blown-fibre
  – Simplifies handling
  – Fewer splices
  – Better protection
  – Easily reconfigured
• Shared access systems for new developments or mass roll-out e.g. B-PON or G-PON
• Estimated cost savings in the central office are 40%
• More work is required to refine the technology and estimate the cost savings for distribution and customer connection