Supercharging Super Fast Broadband

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Copper based broadband

- Digital Subscriber Line (DSL) technology enables high speed data communications to be sent over the existing phone lines.
- Significantly faster than dial-up through use of higher frequencies
- Separate frequency bands used for downstream and upstream transmission
    - Downstream transmission from exchange to customer
    - Upstream transmission from customer to exchange
- Downstream throughput typically higher than upstream, hence "asymmetric"
- A DSL system typically comprises the following :
    - Digital Subscriber Line Access Multiplexer (DSLAM) which terminates the line in the exchange or cabinet and provides backhaul connectivity
    - Splitter filters used to enable voice and data to be transmitted simultaneously over the same line and separated out at each end
    - Customer Premises Equipment (CPE) which terminates the line in the customers premise
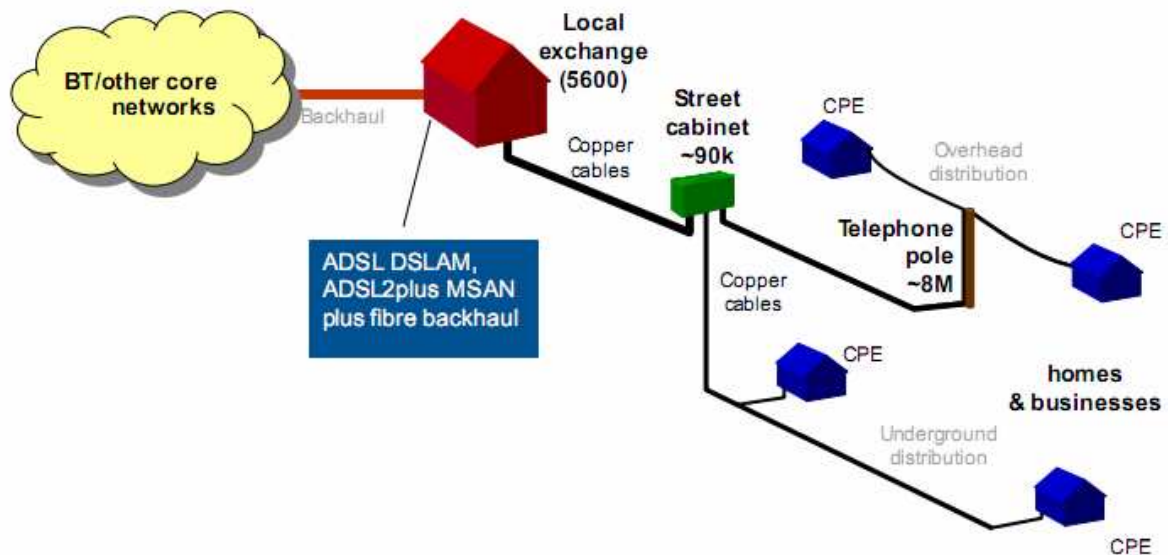
Common DSL technologies

- Asymmetric Digital Subscriber Line (ADSL)
  - Data rates of up to 8Mbit/s downstream and 448kbit/s upstream
  - Exchange based system
- ADSL with extended bandwidth (ADSL2plus)
  - Data rates of up to 24Mbit/s downstream and up to 1Mbit/s upstream
  - Exchange based system
- Very high-speed Digital Subscriber Line (VDSL)
  - Currently up to 40Mbit/s downstream, up to 15Mbit/s upstream
  - Cabinet based system
  - Key enabler for UK Next Generation Access (NGA) systems

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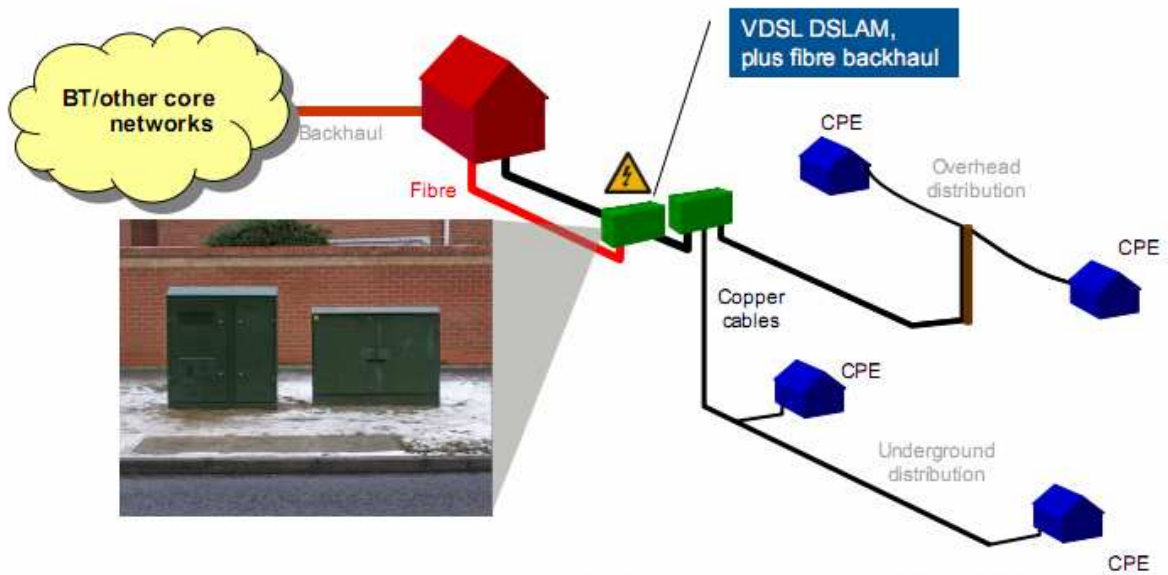## SFBB - Setting the scene: Broadband from the exchange

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SFBB: Fibre-to-the-Cabinet (FTTC)

VDSL DSLAM, plus fibre backhaul

BT/other core networks

Backhaul

Fibre

CPE

Overhead distribution

CPE

Copper cables

CPE

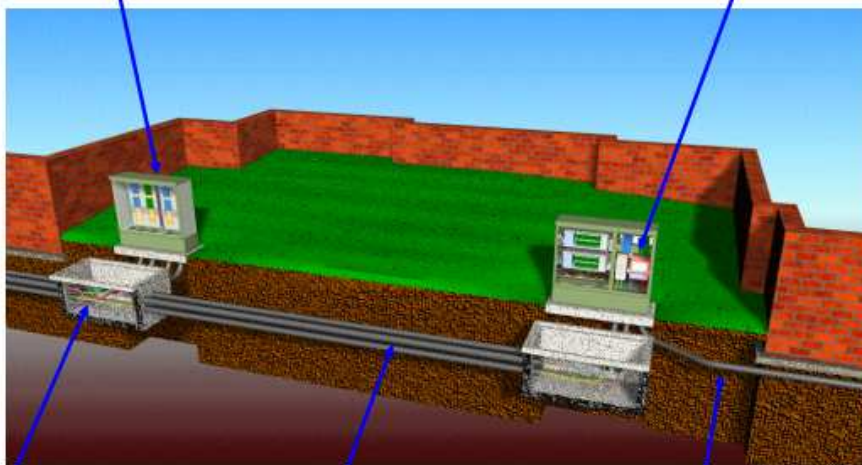Underground distribution

CPE

Distance from cabinet to customer still varies so speed achieved still varies from customer to customer

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Fibre To The Cabinet (FTTC)

Existing Narrowband Street Cabinet

New Broadband Cabinet

Copper Connection to Customer Premises

Copper 'Tie-Cables'

Fibre From the Exchange

Strategy for achieving 100Mbit/s FTTC

- Change the VDSL band plan ✓
  - Change to a proven increased band plan to boost line rates
  - Industry wide agreement completed on 4th September 2011
  - Implementable on BT's NGA systems via remote software upgrade
- and potentially in the future …
  - Vectoring
    - Remove signal interference (crosstalk) between copper pairs that reduces VDSL line rates
    - Requires next generation of DSLAM hardware which is now becoming available
  - Bonding
    - Use 2 or more copper pairs to customer to double VDSL line rates
    - Needs new modem and spare copper pairs

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What is the "Band Plan" change?

- UK NGA is currently constrained to using a band plan with an upper frequency of 7MHz

U0	D1	U1	D2

0.025   0.138   3   5.1   7.05   f (MHz)

Current Plan (truncated to 7MHz)
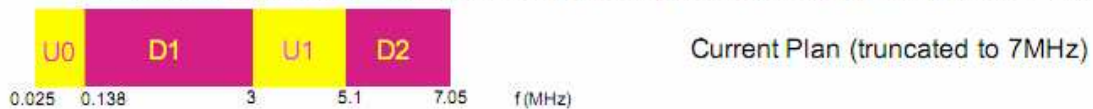
- U0, U1, D1 and D2 represent the frequency bands used for upstream and downstream transmission
- BT assessed the available options for changing this and what they would offer UK NGA
- BT convinced UK Industry to get the regulations changed to enable NGA to be deployed up to 17MHz.
  - Extending the frequency enables higher data rates
  - Access Network Frequency Plan (ANFP) revised to include new band plan
  - All UK NGA lines must be configured to use the new band plan by 1st July 2012

U0	D1	U1	D2	U2	D3

0.025   0.138   3.75   5.2   8.5   12   14   17.664   f (MHz)

Newly Agreed Plan (17MHz)

D=Downstream, U=Upstream
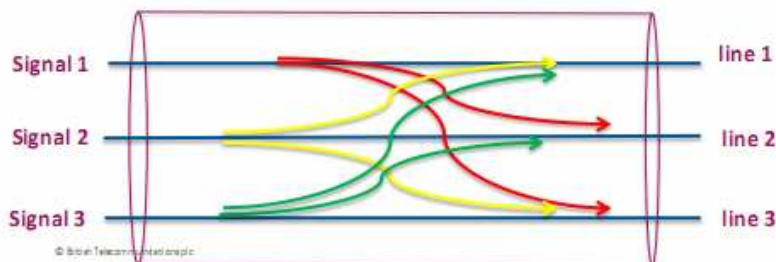
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Band plan impact

- Lines with short D-sides
  - New Band plan allows approx doubling of maximum speed compared with previous plan (i.e. download of up to 80Mbps from up to 40Mbps)

- Lines with long D-sides…
  - Little change from previous plan (i.e. band plan benefit fades with distance)

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What is "vectoring"?

- The challenge:
  - Crosstalk is due to signal interference between pairs in a multi-pair copper cable and limits VDSL2 performance (speed and reach)
  - Increasing the number of active broadband pairs in a cable increases crosstalk and reduces line-rates
  - Crosstalk also increases with frequency
- The solution:
  - Reducing crosstalk results in improved performance.
  - The technique for doing this in real-time is called "Vectoring"
  - Vectoring estimates the crosstalk on each line and cancels it dynamically
  - Vectoring is an international standardised technology with global suppliers
  - BT currently evaluating the network performance of a prototype vectoring system

Signal 1 ————————— line 1

Signal 2 ————————— line 2

Signal 3 ————————— line 3

The unwanted coupling from line to line is called "Crosstalk".

Another term you will hear is **FEXT** or Far End Crosstalk.
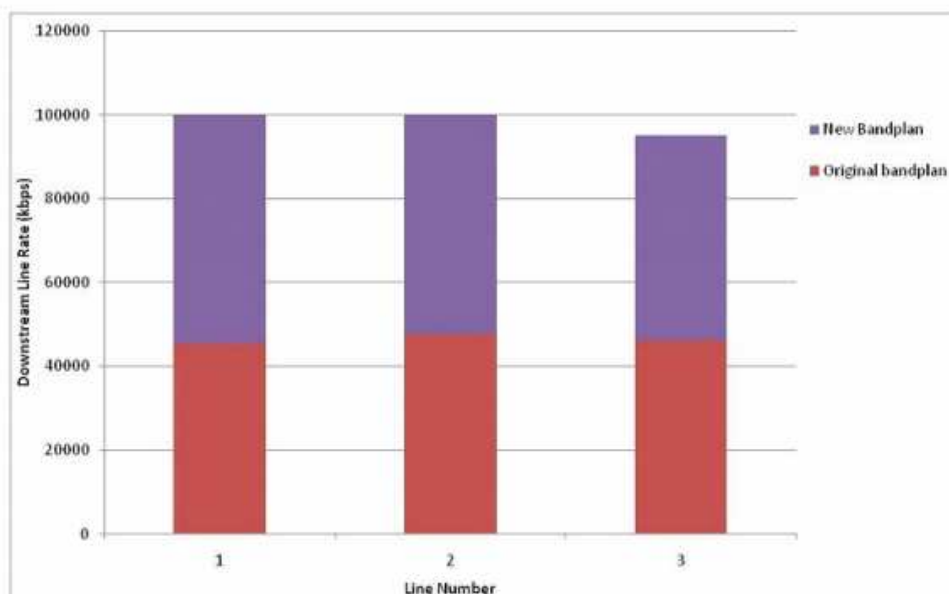
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Band plan and vectoring impact

- Lines with short D-sides
  - New Band plan allows approx doubling of maximum speed compared with previous plan (i.e. download of up to 80Mbps from up to 40Mbps)
  - Vectoring further improves those speeds to 100mbps+

- Lines with long D-sides…
  - Little change from previous plan (i.e. band plan benefit fades with distance)
  - Vectoring continues to deliver improvement, though at a reduced rate (i.e. there is a reach benefit)

Downstream rate improvement from 7MHz to 17MHz
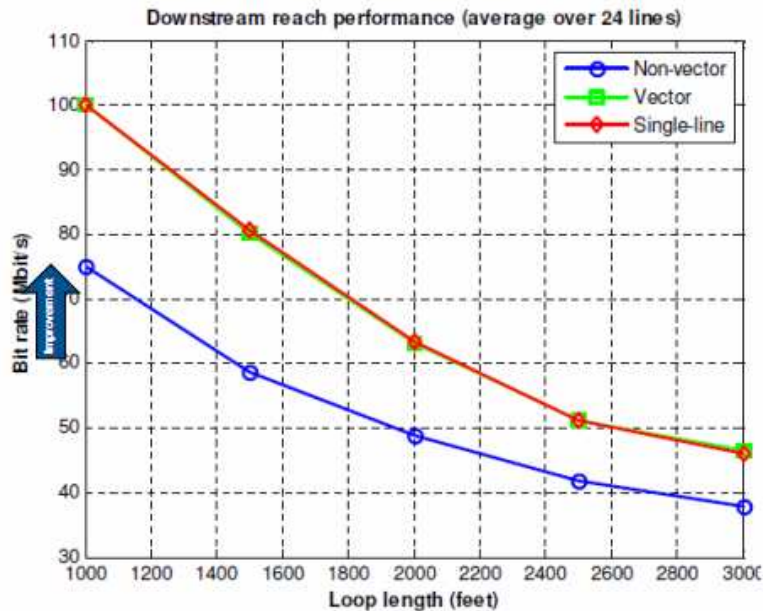
# With vectoring and bandplan change, VDSL can reach 100Mbps downstream....

Downstream reach performance (average over 24 lines)

Legend:
- Non-vector
- Vector
- Single-line

(Y-axis: Bit rate (Mbit/s), X-axis: Loop length (feet))

http://cms.comsoc.org/SiteGen/Uploads/Public/Docs_Globecom_2009/Vector_globecom2009_final_v2.pdf

What is "Bonding"?

- Bonding is a technique to use multiple copper pairs to increase the total line rate
  - The data carried on two pairs is combined together to give an aggregate rate of ~double the individual rates carried on each pair.
- This technique is already widely used by BT for Ethernet in the First Mile (EFM) services using symmetric DSL technology (G.SHDSL)
- Bonding can be applied to VDSL to achieve either:
  - Increase bit rate – i.e. doubling line rates to 160Mbit/s
  - Increase reach – i.e. making 80Mbit/s available on longer loops
- Bonding requires dedicated equipment in customers premise

- VDSL modem
- Aggregator
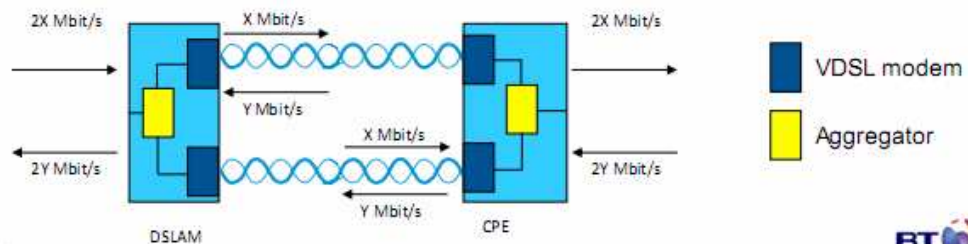
Summary

- Technical developments are driving FTTC line rates up
- BT gained industry approval to double FTTC line rates to the benefit of the UK
- Data rate could rise from up to 40Mbit/s to up to 80Mbit/s
- BT is trialling vectoring technology and has seen real world lines achieve 100Mbit/s
- Bonding offers additional benefits to further increase the rate and reach of FTTC
- Copper pairs still have a strong broadband evolution path and BT is actively pursuing technical and regulatory developments

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