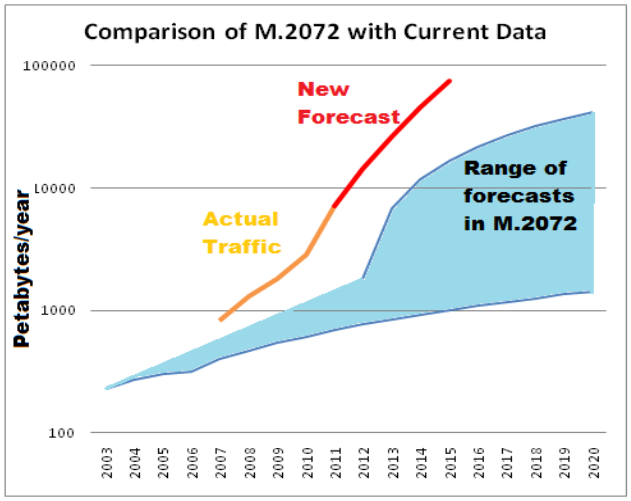
Mobile Backhaul – the Wireless Solution

Abstract: The explosion of mobile data is putting ever greater strains on backhaul at a time when operator's finances are being squeezed. To provide the necessary capacity in a cost effective manner a range of wireless technologies will be required. This White paper looks at the options, including use of point to point, point to multi-point and mesh style networks operating in the licence exempt, lightly licensed, site license or block licensing regulatory models.

The Mobile Data Explosion

Over the last few years the rapid growth in mobile data has exceeded some of the most optimistic forecasts. This can be seen in the graph below, taken from Report ITU-R M. 2243. The graph compares the data in petabytes/year as predicted by Recommendation ITU-R M.2072 against actual levels:



Data requirements keep on increasing. For example market studies in the UK undertaken by the regulator, Ofcom, show that time on YouTube increased by 42% between 2011 and 2012 while mobile data usage doubled over a period of 18 months.

The most recent ITU World Telecommunications/ICT Indicators Database shows that mobile broadband subscriptions have risen by 40% in the past year and went past 1 billion connections in 2011. The development of 4G worldwide can only drive this demand even higher.

This demand can be met in a number of ways. The operator could acquire more spectrum or upgrading to the latest technology such as LTE or using smaller cell sizes. Both these steps would require increases in CAPEX and/or OPEX. Meanwhile finances are under pressure, caught between increased competition and regulatory pressures.

While revenue from data is increasing, the Ofcom survey only showed increases of the order of 5% while voice traffic and revenue both fell. It is therefore crucial for mobile operators to be able to provide a cost effective yet high capacity data service.

One of the key components of any data service is the backhaul, routing traffic from cells sites into the core network.

The lowest OPEX route is to install fibre, but with costs of around $ 85,000 per km to install, the CAPEX, and resulting cash flow requirements, does not make it financially viable as the solution across an entire network. Furthermore it typically takes longer to install than wireless solutions, leading to delays in the rollout of new services.

Wireless, therefore, will continue to be central to backhaul – but what are the key requirements and what are the available technologies?

Wireless Backhaul

A number of technologies can be used to connect cell sites to the core network, in particular:

- **Point to point (PtP):** this has traditionally been used for locations away from cable infrastructure. Narrow pencil like beams connect two points, one of which is the cell site
- **Point to multi-point (PtMP)**: in this approach, at one end a broader beam is used. This beam covers a relatively wide area within which there could be several cell sites
- **Multi-point to multi-point or mesh**: here cells sites communicate to, potentially, multiple other cell sites with traffic routed between them

Wireless backhaul can operate in frequency division duplex (FDD) mode with a pair of frequencies, one for each direction, or time division duplex (TDD) mode, sharing capacity between uplink/downlink directions.

The most effective technological solution will depend on the specific requirements, which will include considerations such as:

- The number of sites to be connected
- Site location and accessibility
- Existing communication facilities at each site
- Traffic profiles (mean, peak, burstyness etc)

- Scalability over deployment lifetime
- Reliability and resilience

Furthermore there will of course be budgetary constraints and comparative equipment costs.

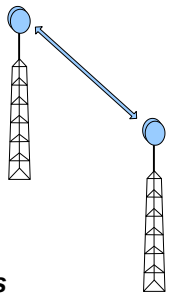
The solution is likely to evolve as requirements and technology changes and could include a combination of PtP, PtMP and mesh technologies.

A number of tasks will have to be undertaken:

- Selection of suitable architectures and topologies
- Selection of frequency bands
- Access to suitable spectrum
- Frequency planning and interference analysis

Selecting the Architecture

Each of the wireless backhaul types has strengths and weaknesses.



PtP Links

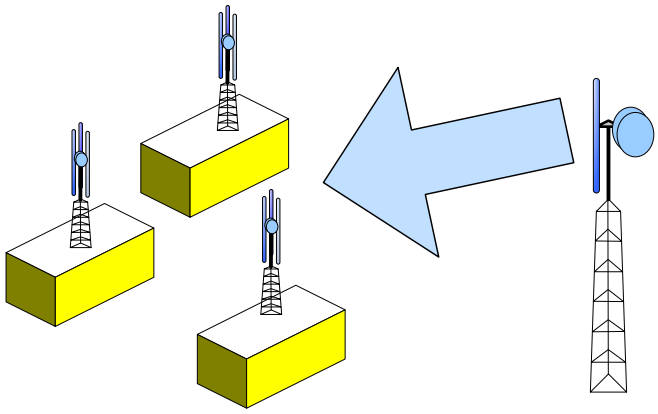
These use highly directional antenna to provide capacity between two fixed locations. They are very spectrally efficient and can provide very high data rates (up to a Gbps) and QoS (such as 99.999% availability).

Equipment is readily available from multiple manufacturers providing a range of features to improve link stability and performance (e.g. low noise, higher modulations, adaptive modulation, and adaptive power control).

Spectrum is also readily available in a number of frequency bands and links can be deployed quickly with low CAPEX.

A disadvantage is that every cell site will require at least one antenna and there can be difficulties in installing PtP equipment on pico-cells and cells using street-furniture such as lamp-posts.

To get to the core network it might be necessary to daisy chain links together, in particular as in urban areas there is less likely to be line of sight between sites.



PtMP Links

One problem with PtP links is that every time a new cell site is installed it needs a dedicated antenna at some other site to connect with. In addition the capacity of the link is sized by the need to service the cell's peak data rate which will result in unused capacity for most of the time.

A PtMP system gets round this by having a sectorial antenna at a central point that can cover a wide area within which there could be many cell sites. As more cells are introduced there is no need to modify the hub station as the existing antenna can be re-used.

Furthermore capacity is shared between all sites so that the bandwidth required can be sized by the peak demand over all cells, which for bursty traffic such as web browsing is significantly less than the aggregate of the peak demand of each cell.

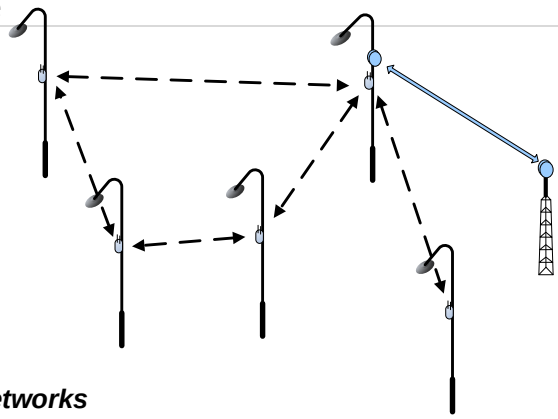
One problem with PtMP systems is that the central station's antenna's wide beam is less spectrum efficient than using multiple highly directional antennas.

Some radio planning tools can have problems managing both PtP and PtMP operating co-frequency, though as we will see, Transfinite's planning tools have no problems.

For this reason not all regulators make available spectrum licence product that permit site by site licensing, which therefore requires purchase of a spectrum block in an auction.

When cells get very small it becomes important to have compact equipment boxes – for example those attached to street furniture such as street lights. These might have little space for a directional antenna and can have difficulties maintaining the tight pointing accuracy required for parabolic dish antennas and often in urban areas having line of sight to the central station.

For these scenarios some organisations have considered looking at mesh style backhaul.



Mesh Networks

Where there are many small cells located below roof tops, for example on street lights, it can be difficult to get the line of sight needed for backhaul links.

Also as there are so many sites to deploy it becomes important to keep the cost of installation as low as possible.

One solution is for each site to talk to another as nodes in a mesh, preferably auto-configuring the radio component.

Traffic aggregates through the mesh until reaching an access node which could be fibre or a point to point link.

Each site operates as a node within a network, routing traffic from other sites in a way that brings resilience and also permits new sites to be introduced automatically.

One problem with mesh networks is that the traffic builds up and the links nearest the access node can become congested.

Furthermore there can be difficulties in some planning tools in introducing low gain mesh networks into the spectrum planning.

For this reason again some regulators restrict the use of this sort of technology to the lightly licensed bands. These bands can become congested which leads to reduced QoS.

Licensing Models

A wide range of frequency bands is available for use by wireless backhaul, often depending upon the architecture used.

A number of different regulatory models can be used to provide access to spectrum including:

Licence exempt: examples would be the 2.4 GHz wifi band and the 5.1 GHz RLAN bands where equipment can be purchased and switched on without requiring a licence

Lightly licensed bands: in some countries there is a simple registration process for bands such as upper 5 GHz, 60 GHz and 70 / 80 GHz. The regulator does not undertake any compatibility or planning tasks but the list of registered systems can be used by users to self-manage the band. For example there is often an assumption that in the case of interference the priority goes to the organisation that registered the earliest.

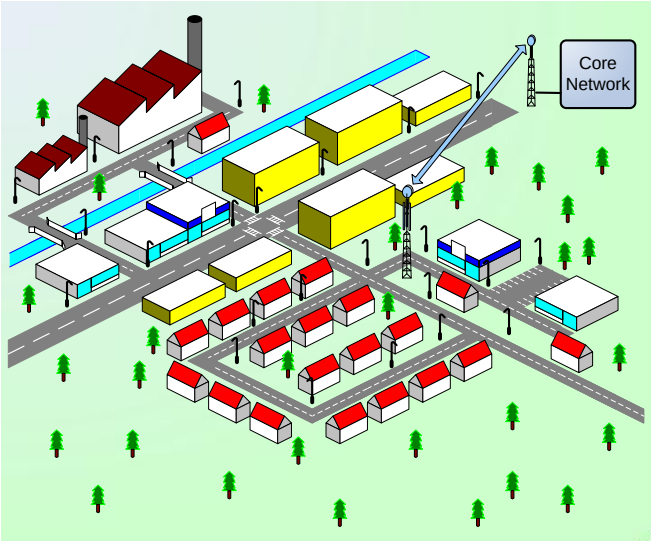
Site licensing: this is the traditional way to provide PtP backhaul and involves the regulator or approved third party undertaking spectrum management tasks including planning and interference analysis. There are a wide range of bands available including but not limited to 1.4, 6, 7, 12, 14, 18, 23, 25, 28, 32, 36 and 42 GHz.

Block licensing: in this case the regulator makes available, usually via auction, entire blocks of spectrum which the user (e.g. operator) can manage themselves. In this case there are generic constraints (frequency, geography, maximum eirp, block edge masks etc) that must be met but apart from that there is flexibility in its usage. The frequency bands available will depend upon the national regulator but in the UK they are the 10, 28, 32 and 40 GHz bands.

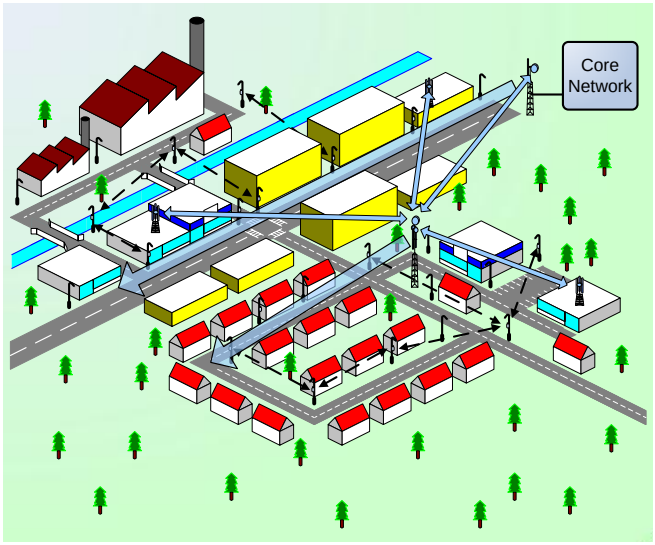
Example Scenario

It can be necessary to combine all of these technologies and licensing models to provide an integrated cost effective backhaul solution.

Consider the example scenario below. Initially when the network is driven by voice traffic or low data rate messaging it could be sufficient to have a single base station using a PtP link for backhaul:



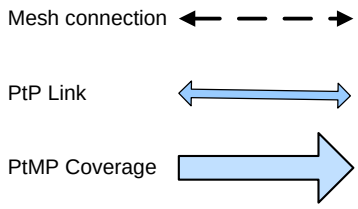
As traffic levels increase a more comprehensive solution is needed:



Coverage is now provided by:

- 3 base stations mounted on roof tops
- 15 pico cells attached to street lights

This example shows how a combination of PtP, PtMP and mesh links can be used to provide backhaul, as identified in the figure using the key below:



How Transfinite can help

If you are looking at developing strategies for backhaul in a mobile network, you should be thinking about wireless as a part of your solution.

A number of unique features (described in a paper you can download here) mean that wireless is key to ensuring cost effective capacity is delivered to the widest possible coverage areas.

At Transfinite we have 20 years' experience in the study of wireless systems of all types. We have a particular expertise in the development of a strategy based on sound technical analysis – we are currently applying this expertise to backhaul.

We can help during all phases of backhaul implementation from:

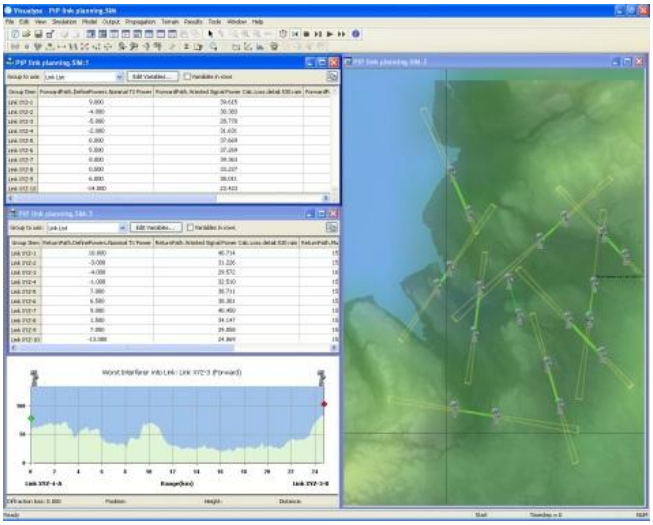
- Consultancy work and studies
- Link design and radio spectrum planning
- Deployment
- Network optimisation
- Operations
- Regulatory support
- Auction support

Some of the examples of our capability are described below.

Radio System Analysis

We can use our desktop study tool Visualyse Professional to analyse radio systems including link planning, coverage and interference analysis.

Visualyse Professional can analyse all types of radio system including PtP, PtMP and mesh networks. It can also model other services that might have to share spectrum - satellite earth stations for example.



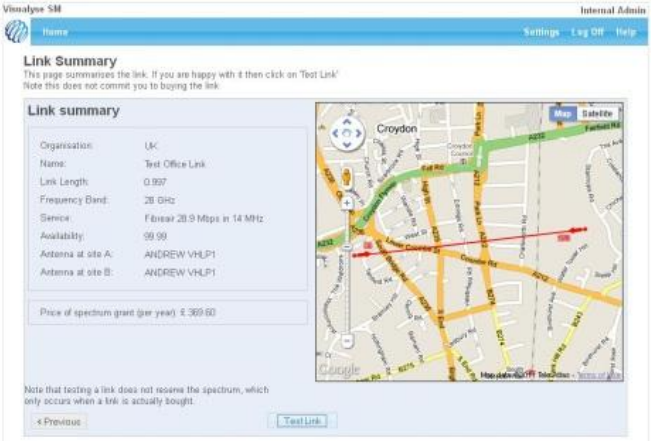
We can use Visualyse Professional to undertake all types of study, including optimisation.

Radio Spectrum Management

We can use our web based Visualyse Spectrum Manager to manage blocks of spectrum, undertaking planning and interference analysis of all types of radio system including PtP, PtMP and mesh networks.

We use a powerful generic interference analysis engine, developed under an R&D project for Ofcom, that allows us to plan bands in which there are, simultaneously, all types of radio system

The solution runs over the web and provides a simple interface that makes it easy to quickly and accurately define radio systems. The interface uses many familiar tools including Google Maps to display and select locations:



Regulatory Support

We can provide a range of regulatory support consultancy services including licensing and representation at international and regional meetings (e.g. ITU and CEPT).

We have experience in spectrum auctions and trading, together with operating as a spectrum management organisation (SMO).

Training

We can also provide training services in our products and radio engineering.

Contact us

If you have any questions or comments or would like more information please contact us at:

Email: info@transfinite.com

Phone: +44 (0) 20 8240 6648We can also provide demonstration version of the Visualyse Professional study tool and trial log-ins to Visualyse Spectrum Manager.