Cable*free* Solutions Limited

Leaders in Optical Wireless Technology

Broadband Point-to-Multipoint - Technology Comparisons

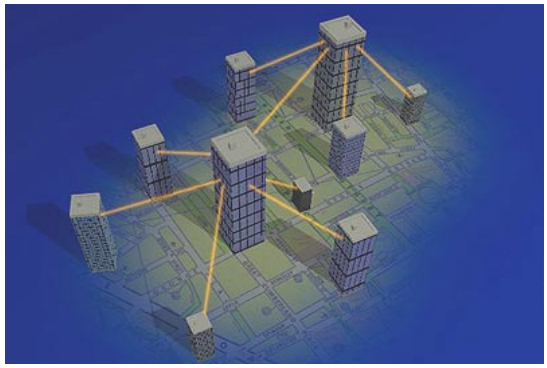
Broadband Multipoint Technologies

In this comparison we investigate broadband wireless technologies for multipoint connection of subscribers to a network. Note that narrowband systems (Wireless Local Loop, for example) are not compared. All cases here assume a cellular deployment, where a central 'hub site' in each area connects subscribers within the coverage radius.

ISM-band systems typically use frequency-hopping or direct sequence spread-spectrum technology to overcome interference in the unlicensed frequencies around 2.4GHz. A central base station communicates to the subscribers either in an omnidirectional or sectored coverage area. In dense urban areas, actual delivered bandwidth depends on the density of deployment of such systems and any other sources of interference. In some countries, similar systems are deployed using licensed frequencies, such as around 3.5GHz, or the 2.5-2.7GHz MMDS frequencies to avoid interference and offer better quality of service. The data rates are modest, typically 3-8Mbps per frequency per sector.

Similar in cellular deployment model, LMDS systems use licensed microwave frequencies in the 24 - 40GHz bands to offer higher capacity connectivity, typically up to 155Mbps per sector.

Typically, Optical Wireless systems cannot offer 'true' multipoint due to power budgets limiting possible beam widths – however, extremely high bandwidths in a license-free band can be delivered. By using 'virtual' multipoint, with individual beams between the cell-site and each subscriber, non-shared bandwidths up to 1.5Gbps (using today's technology) to each subscriber can be used.



Licensing

The ISM (Industrial, Scientific and Medical) band of 2.4GHz is deemed license-exempt in most countries. In Europe, ETSI rules govern the maximum permissible output powers. Other than data communication, this band is also used by other applications, such as video transmission and microwave ovens.

LMDS licenses are awarded to operators typically on a country-by-country basis. The precise frequencies allocated vary. Frequency planning to avoid interference is used both for adjacent sectors, neighbouring cells and other operator's frequencies.

Optical Wireless systems use the infrared portion of the electro-magnetic spectrum, which is not subject to frequency licensing. Generally, the only restriction on deployment is holding a telecommunication network operator's license. Very rarely, deployment can be restricted where a state monopoly exists.

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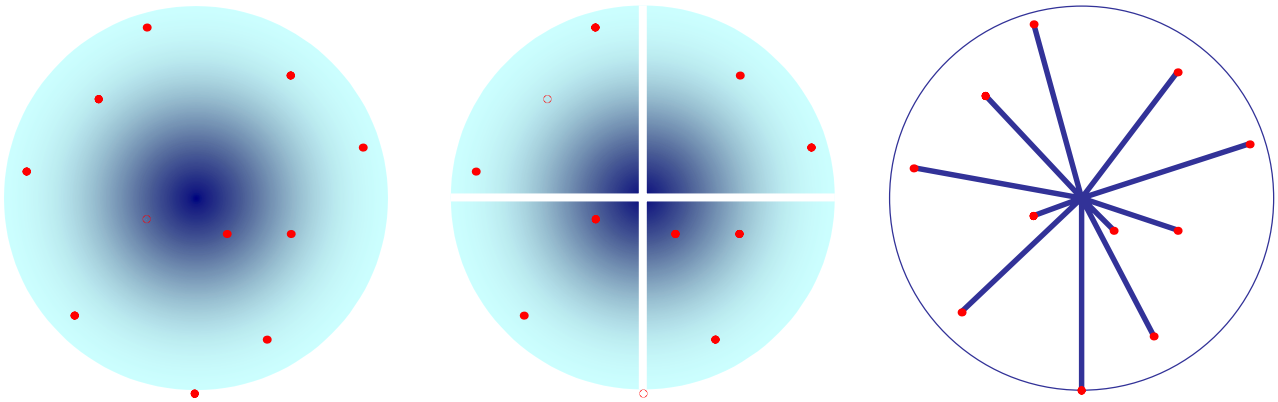
Omnidirectional, Sectored and Virtual Multipoint

Omnidirectional Multipoint Sectored Multipoint Virtual Multipoint



Cell Size and Fade Mechanisms

In all three technologies here, cell size is influenced by weather conditions and terrain/clutter morphology. For microwave LMDS, this is limited by the amount of local rainfall – microwave signals are attenuated by water and unavailability increases. To correct this, LMDS operators can either increase the power of their transmissions during heavy rainfall to try and ensure an adequate signal reaches its destination (with a possible increase in interference levels), or to deploy networks with reduced cell size.

ISM-band systems operate at much lower frequencies than LMDS, and are less susceptible to rainfall. Weather outages only occur in extreme conditions, such monsoon season in tropical climates.

Optical wireless systems, by contrast, do not suffer significant rain fade, even in severe tropical rainfall at distances under 2 - 4km. The serious fade mechanisms are thick fog, snow and dust storms, which limit practical distances to 1 - 2km for reliability. This is almost an exact opposite to microwave, for which heavy rain causes outages.

Bandwidth and Scalability

In both ISM-band and LMDS deployments, a downstream bandwidth limit exists for a given omnidirectional cell, or sector within the cell. The available bandwidth is shared between the subscribers within this area. In the upstream direction, limits also exist based on the frequencies and modulation schemes involved. Typically these are asymmetric paths, the upstream data rate being lower than the downstream. As more subscribers are added to the area, a 'saturation' point is reached where either the number of sectors or frequencies must be increased, limited by the specific systems in use.

A typical Optical wireless deployment utilises separate point-to-point links between the base site and subscribers, and enjoys symmetric bandwidth limited by only by the technology in use – typically 1.5Gbps in both downstream and upstream directions. The addition of more subscribers does not affect existing ones, as no bandwidth sharing is in use. The ultimate limits are the minimum angular separation of beams (typically 0.1 - 0.5 deg) and frequencies (or wavelengths), both determined by the type of system in use. In practice, these are unlikely to constrain deployment.

Architecture and Deployment Issues

Line-of-sight

All of the technologies considered here rely on line-of-sight connection between the base station and the subscriber. Objects such as buildings or cranes will block transmission. For LMDS and ISM-band microwave signals, scaffolding, leaves, trees and branches can also cause signal loss, but overlapping cells and roof-mounted antennas generally overcome this problem. Optical wireless systems require totally clear line-of-sight.

Ring & Mesh architectures and Black-spot in-fill

In dense urban areas, line-of-sight from the base site to potential subscribers may be blocked by tall buildings causing areas of so-called 'shadow' or 'black-spots' in coverage. Solutions are to use repeaters on strategic locations to provide coverage from a different angle, or to use overlapping cells, so that a given point is within the coverage range of more than one base site.

Optical Wireless deployments can be made using so-called 'Mesh' architectures where a subscriber is connected simultaneously to two or more base sites, increasing network resilience and flexibility.

Alternatively, 'Ring' topologies allow customer premises become ring nodes or, at least, one hop away from the ring. In this way an alternate route is always available in case of link unavailability.

Security

Multipoint ISM-band and LMDS microwave technologies potentially suffer risk of unintended 'eavesdropping' on data transmitted from the base sites, as the beam widths are large. Conversely, Optical Wireless uses narrow beams (typically 0.1 – 0.5deg), with no side-lobes or antenna-rear-emission – this technology is inherently hard to intercept. For all systems, system security can be increased by the use of DES-grade encryption systems, either software or hardware based.

Protocol independence

Both ISM-band and LMDS microwave deployments use switching hardware to convert between the user data protocols and the shared wireless channel. By contrast, Optical Wireless 'virtual' multipoint allows each subscriber able to connect to the base site using any protocol or data rate (up to 1.5Gbps today) independently of others in the cell.

Complementary Deployment of Technologies

For ISM-band deployments, Optical Wireless can be used to provide higher-bandwidth connections to key customers, or to alleviate bandwidth saturation within an overloaded cell. Both technologies are unlicensed.

LMDS operators, utilising licensed frequencies, can use optical wireless to provide additional capacity to customers in congested areas, or to provide resilience in high rainfall areas.

It is a fact that networking a medium to fully loaded LMDS hub (3 to 6 sectors, 2x28 MHz to 2x112 MHz bandwidth per sector) in a dense urban environment requires optical fibre or Optical Wireless connectivity solutions.

Conversely, networks using Optical Wireless Virtual-Multipoint can utilise ISM-band coverage for low-speed Internet access or coverage for mobile users. Licensed point-to-point microwave can also be used for longer-distance connections.

Cost models

Multipoint technologies such as ISM-band and LMDS deployments tend to incur high capital cost of start-up. The initial implementation costs are in creating hubs and cell sites. Once they are on-line, new costs are incurred only as additional customers are connected. The largest fixed cost associated with building out ISM-band and LMDS cells will probably be the cost of subscriber equipment, rather than the transmission infrastructure equipment. Additionally, LMDS customers requiring high bandwidths up to 155Mbps may cause saturation of available bandwidth for a given sector, requiring significant expenditure in base site hardware to provide more capacity.

By comparison, Optical Wireless deployments have low capital cost of start-up. Apart from base site acquisition and switchgear, the cost of transmission links between the base site and each customer are added only as and when the customers require connection. These costs depend typically on the range and bandwidth required. There is no saturation penalty in cases where many subscribers require high bandwidth connections, as links from the base site to customers are independent, not sharing bandwidth.

Summary

Optical Wireless is a complimentary technology to ISM-band radio and LMDS microwave for broadband multipoint connectivity. The limitations of distance are balanced by the high data rates, license-free operation, and future-proof scalability of virtual-multipoint architecture.

System	ISM Band	LMDS	Optical Wireless
Frequency	2.4GHz	24-40GHz	30-60THz
Licensed	No	Yes	No
Multipoint Topology	Omni or Sectored	Omni or Sectored	Virtual Multipoint
Cell Radius	8-15km	2-3km	1-2km
Downstream Bandwidth	3-8Mbps per sector (per frequency)	155Mbps per sector	1.5Gbps per user
Upstream Bandwidth	3Mbps peak per user	3-10Mbps per user	1.5Gbps per user
Symmetric	No	No	Yes
Protocol Independence	No	No	Yes
Fade Mechanism	Heavy Rain	Rain	Thick Fog, Snow
Initial Investment for few subscribers	High	High	Low
Investment for 50-100 subscribers per cell	Medium	Medium	Medium

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