
Wireless Traffic Lights

UK Councils have the unique opportunity to create wireless communication systems that cover whole cities.

Fixed line costs can be reduced significantly by implementing a wireless network.

Applications complying with UTMC standards enable enhanced services across a city to both the general public and council employees.

802.11 b/g systems fail due to blocking and security concerns but a Mesh4G™ network based on military communication works.

Summary

Experience with Portsmouth City Council's network, operational since December 2003, has allowed NOW Wireless to implement traffic light communication systems in partnership with Peek and Siemens. These are currently being installed in Glasgow and Suffolk and other cities across the UK.

Capital costs are lower than those for civil engineering work of typical UTMC systems, and with no revenue costs.

Technology employed is a military Mesh Network technology called **Mesh4G™**.

Wi-Fi (802.11b/g) proved to be an unreliable solution due to interference and blocking issues.

RTI can be done with **Mesh4G™** as it operates on moving vehicles. Bus Priority and Clear-Down issues are solved.

Scope of the Mesh Network can encompass RTI, Car Park Counters, Variable Message Signs, Information Kiosks, Bus Stops, Ticket Machines, Council workers, Buses and CCTV.

Introduction – Why Wireless for Council?

In the present wireless digital world, it is now possible to provide integrated communications for Councils with no revenue component. With their physical infrastructure, Councils are in a very commanding position to install digital systems with a wireless infrastructure.

Traffic lights are not the only application to benefit from wireless; other areas are real-time passenger information, CCTV, parking ticket machines, variable message signs, Council workers, emergency services and schools.

With the advent of Urban Traffic Management and Control systems (UTMC), there is a need to provide information from the traffic light controller back to the Central Server. Either this is an existing system, based on serial communications which requires replacement, or a new communications connection. In most cases the use of a wireless system has an equal or lower capital cost than an equivalent cabled solution (taking into account the required civil engineering). In addition, the wireless solution does not incur a revenue cost.

For UTMC-connected traffic lights, a communications path must exist back to the control centre. This can be accomplished by the use of Mesh Network clusters.

Traffic lights are connected via Mesh Nodes to each other, and then via an Access Point back to the Network Control Centre.

Each Mesh Node provides an opportunity for other devices to route through it, either by direct connection or by a wireless connection from a nearby node. CCTV cameras for traffic monitoring can also be connected this way easily and cost-effectively. In fact, connections for multiple cameras can be put in place at one junction.

What can it do?

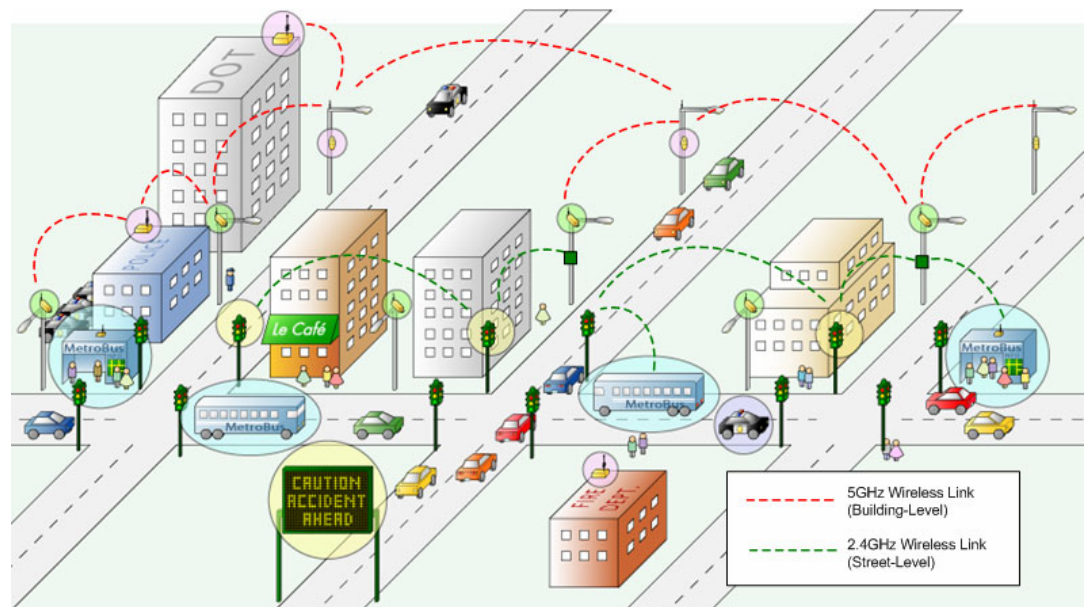
Mesh4G™, a street-level wireless Mesh Network, provides a low cost connection between traffic lights, buses, Council employees, bus stops, CCTV, ticket machines, variable message signs and the Council offices.

Traffic lights are converted from standalone operation by the installation of a wireless point in the control cabinet with a cable running to the nearest traffic pole. Just a small box with an aerial is installed, connecting to existing mountings on the pole, and installation is complete.

No major engineering is required and the traffic light can now communicate with devices such as other traffic lights or central servers.

The wireless device can communicate through up to five or more devices before reaching an Access Point, which then connects via a higher-level network to the Control Centre. The higher-level network can consist of ADSL, EPS9 circuits, 5GHz wireless or any other existing communications medium.

If a gap in reception is found then a Wireless Repeater can be used. Devices are then installed within range of any of these wireless points to provide services including access terminals for variable message signs, bus stops and iKiosks.



Buses with a **Mesh4G™** device installed can communicate with the city network, providing location information to a central server or communicating directly to bus stops and traffic lights. They in turn act as extra dynamic repeaters in the network, providing additional resilience. The more nodes that are deployed, the more traffic and resilience the system can deliver. Traffic does not all need to go to the centre; it may go from point to point as needed.

In out-of-town locations where a street-level Mesh Network is not required, connections using 5GHz can be made at a cost similar to or lower than the Mesh Nodes. If more equipment is needed at a later time then a **Mesh4G™** Access Point can be installed and a local cluster of devices managed.

CCTV traffic cameras can be installed on the network anywhere within range of a traffic light. There is no requirement to install special circuits. If detectors are required, these can also be connected back to the traffic lights via wireless.

Why Wireless for Traffic Lights?

The disruption and cost of civil engineering work, together with the delays involved waiting for communications cable installation, have resulted in headaches for traffic managers. Great hopes were generated by the introduction of wireless technology; however, to date it has not resulted in effective systems. In short, the wireless technologies were not sophisticated enough to provide the resilience needed.

In the wireless world there are two levels of sophistication: on the one hand, the world of GSM and 3G, which have billions invested in their respective technologies. On the other, the 802.11 world uses \$15 components and does not have the resilience needed for street-level deployments.

NOW Wireless has an extensive range of wireless products ranging from £60 value 802.11b/g access points to sophisticated 5GHz systems giving 20 mile coverage.

In 2003 NOW Wireless was brought in by Portsmouth City Council to deploy a street-level network. As the 2.4GHz band was licence free and capable of penetrating buildings, it provided the best solution. However, EC regulations limit the power of these networks to 100mW, whereas in the US and Far East power levels of 1 or 2W are commonplace. GSM handsets use 500mW–1W. Wi-Fi (802.11b/g) was

investigated but it was found that, with only three non-overlapping channels and a very primitive radio, it was very easy to block. A person with a notebook computer could easily stop a Wi-Fi transmission. This solution ignored the security issues of Wi-Fi, which can be solved, but no solution was found for the blocking.

In our review of available technology, we found a military system which had had some \$350 million invested in it. This technology was a Mesh Network which employed military-grade encryption and was designed to be resistant to all attempts to block it. This was one of the most complex wireless technologies we had seen, with four individual radios with multi-tapped receivers for dealing with reflections, as well as full Doppler correction to allow operation aboard moving vehicles (tested to 250mph). Each radio acted within the network to provide transmission of a signal from one point to another, selecting frequency and route according to available resources. Currently used by the US Military, a commercial lower cost version with a PCMCIA card in the sub-£500 category made this an obvious option.

Portsmouth has had this Mesh Network installed for over three years. Excellent service has been provided without disruption at the street level.

Brief Overview of Other Wireless Technology

Mesh4G™ is a system utilizing three pieces of technology to provide a network with multiple redundant paths. It is designed to utilise the 2.4GHz and 5GHz unlicensed wireless bands. The 2.4GHz network provides the street-level communications while the 5GHz provides longer distance communications.

Technology History

2G is a GSM network with dial up data with up to 14.4 Kbps

2.5G is a GPRS network with up to 44 Kbps

3G is a UTMS network with speeds up to 384 Kbps

Mesh4G™ is a mixture of 2.4GHz and 5GHz networks using hopping technology to make connections, with speeds of up to 54 Mbps.

Mesh4G™ networks also include a mixture of fixed-line communications to fill in areas where wireless communications are not

practical, especially on the links returning to the Network Control Centre.

2.4GHz wireless uses only 100mW but can penetrate two brick walls on average, with a free-air transmit distance of approximately 500m. 5GHz has a transmit power of 1W and has a transmit distance of about 18 miles, but cannot penetrate objects. GSM in contrast has a transmit power of 1W in a phone handset.

The NOW Wireless Mesh4G™ Solution – How does it work?

Infrastructure

To provide a city-wide communications network, two networks are required. The first is a street-level network which allows individual nodes to communicate with each other and with the Network Control Centre. The second is a backbone network that allows for secure and resilient high-capacity data transfers.

In the street-level network, individual nodes connect to each other before jumping to the high-level network to access the central system. These points where the two networks join are called Access Points. The backbone network consists of a number of different technologies to allow for maximum utilisation of the existing infrastructure; fixed links such as ADSL, fibre, etc., in addition to wireless.

The street-level network operates at 2.4GHz using a QCMR (Quad Channel Military Radio) transmission over four independent 20MHz channels, with dynamic channel selection on a node-by-node and packet-by-packet basis.

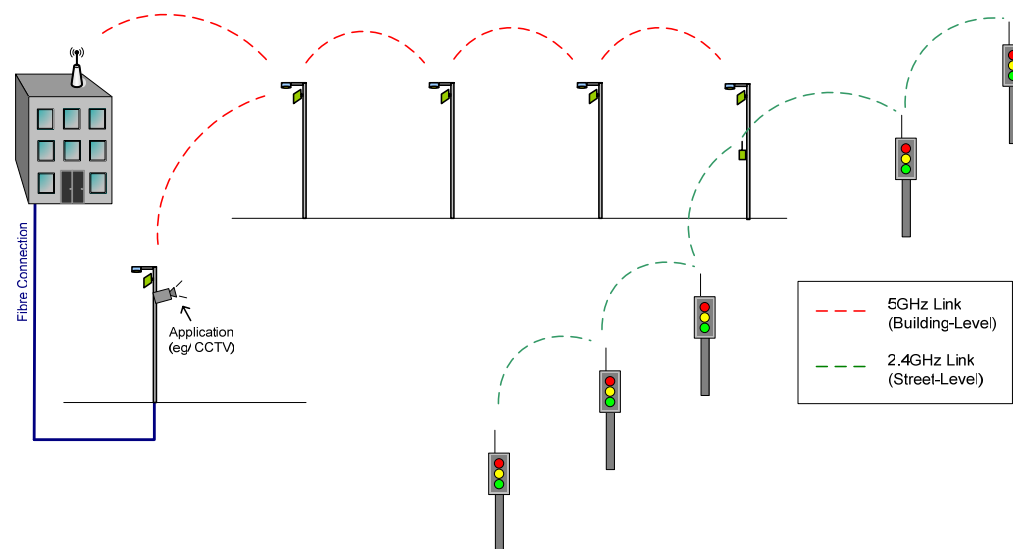
Each packet is routed by the optimal route at every transmission. This communication is designed to allow information to be carried over any available spectrum and route around congested areas.

Each node within the network acts as a Wireless Repeater, so the more nodes there are in the system, the more traffic it can handle. Each link is unique and capable of handling 6Mbps burst and 2Mbps sustained. All wireless traffic is encrypted and designed to be non-blocking. It would require a city-wide attempt to stop communications by using transmissions from other radio equipment.

Each Mesh Node finds a communications path to the Access Point which then uses a directional wireless system in the 5GHz band to transmit the signal to the nearest physical connection to the Council

Building. This can be situated on the Council Building itself or to other points where high speed access is available, such as CCTV camera poles.

It is recommended that a traffic light be no more than five hops from an Access Point, though more hops are possible. Multiple paths back to the Council Building can be created by the use of more than five hops so that redundancy can be built in. This gives a 2.5km radius on each access point dependent on geography of the city with the potential of 100+ nodes per access point.



System Components

Following is an overview of Mesh4G™ products:

Part Name	Description	Technology
M4.1010	Layer 2 Wireless Backhaul Link	A pair of devices which creates a layer 2 tunnel across ADSL, a Corporate Network, MetroFlex and other IP networks. It uses ICSA certified Firewall/VPN.
M4.1400	Fibre to IP Switch	Layer 2 meshing device supporting a mixture of copper, fibre, and wireless connections. Has failover routing and supports ring meshing.
M4.4000	Mesh Access Point (IAP)	Allows up to 100 devices to connect to the central system as well as managing the client devices. It enables dynamic cell switching as in a GSM network. The unit requires access to the Wireless Network Infrastructure.
M4.4030	Mesh Node (PCMCIA)	Allows the connection of Windows-based equipment to the Mesh network. It works in mobile computers and in conjunction with the Wireless Network Infrastructure.
M4.4100	Mesh Node (VMA)	Allows for the secure connection of devices to the Mesh network. The VMA supports encrypted communications. It works with either the M4.4000 or the M4.4140 and the Wireless Network Infrastructure.
M4.4110	Mesh Node (VMA GPRS/3G)	Provides a GPRS or 3G connection and gives a subnet on the IP side allowing a mixture of 3G and Mesh nodes in same address space.
M4.4110-N	Mesh Node with N-Type Connector (VMA GPRS/3G)	Provides a GPRS or 3G connection and gives a subnet on the IP side allowing a mixture of 3G and Mesh nodes in same address space. It can be upgraded to Mesh by replacement of the interface card and aerial.
M4.4120	Mesh Node (VMA 11g)	A low cost meshing network providing a hotspot or a low cost mesh cluster.
M4.4140	Mesh Access Point (MAP)	Allows up to 100 devices to connect to the central system as well as managing the client devices. It enables dynamic cell switching as in a GSM network. The unit requires access to a Wireless Network Infrastructure. Street mounted for increased range.
M4.4150	Mesh Cluster Access Point (VMAP)	Will connect up to 10 devices as a cluster to the Central Cluster Manager.
M4.4151	Mesh Cluster Controller	Provides termination of VMAP tunnels to control up to 50 nodes.
M4.4152	Mesh Lite Node (VMA Lite)	Allows for the secure connection of devices to the Mesh network. The VMA Lite works with the VMAP Access Point (M4.4150) and the Cluster Controller (M4.4151).
M4.4200	Mesh Node (VMC)	Vehicle mounted XP/Linux Based Node
M4.4710	Mesh Manager Software (50 Nodes Max)	Software for the Wireless Network Infrastructure. Manages up to 50 nodes.
M4.4720	Mesh Manager Software Full (Up to 100,000 Nodes)	Software for the Wireless Network Infrastructure – basic licence. Licences required for nodes.

M4.4750	Wireless Network Infrastructure for M4.4710	All hardware required for a wireless network with up to 50 nodes. Comprises of servers, routers, switches and other peripherals. Requires Mesh Manager Software 50 Nodes (M4.4710).
M4.4760	Wireless Network Infrastructure for M4.4720	All hardware required for a wireless network with up to 100,000 nodes. Comprises of servers, routers, switches and other peripherals. Requires Mesh Manager Software Full (M4.4720).
M4.5512	5GHz Wireless Node with 1 Ethernet	Provides backbone for M4.4000 series. It enables a throughput of 15Mbps* at 5.8GHz and 30Mbps* at 5.4GHz. It provides a transmission distance of up to 8km.
M4.5522	5GHz Dual-Wireless Node with 2 Ethernet	Contains two radios. Provides backbone for M4.4000 series. It enables a throughput of 15Mbps* at 5.8GHz and 30Mbps* at 5.4GHz. It provides a transmission distance of up to 8km.
M4.5530	5GHz 45Mbps* Wireless Link	A pair of 5GHz 45Mbps* wireless devices that use OFDM & ARQ, providing a transmission distance of up to 20km.
M4.5600	5GHz Outdoor Modular Radio System Cabinet	A modular outdoor radio system capable of supporting multiple radios. Suitable for the central site in a multi-zone network. Supports between 1 and 3 M4.5622 modules to provide 2 to 6 independent radios.
M4.5622	5GHz Dual Radio Module (for M4.5600)	Installs in the M4.5600 to provide 2 radios.
M4.7010	Mesh Module	7000 Series Mesh Module
M4.7020	20Mbps** Link	A pair of 20Mbps** 5GHz devices that provide a wireless link that can change frequency 500 times per second, providing a transmission distance of up to 100km.
M4.7040	40Mbps** Link	A pair of 40Mbps** 5GHz devices that provide a wireless link that can change frequency 500 times per second, providing a transmission distance of up to 100km.
M4.7150	150Mbps** Link	A pair of 150Mbps** 5GHz devices that provide a wireless link that can change frequency 500 times per second, providing a transmission distance of up to 100km.
M4.7300	300Mbps** Link	A pair of 300Mbps** 5GHz devices that provide a wireless link that can change frequency 500 times per second, providing a transmission distance of up to 100km.
MK.4000 Series	Mounting Kit M4.4000	Kit to mount M4.4000 series to traffic lights and lamp columns. Includes power supply and PoE injector. Includes antenna.
MK.5500 Series	Mounting Kit M4.5500	Kit to mount M4.5500 series to traffic lights and lamp columns. Includes power supply and PoE injector. Excludes antenna.
MK.A5000 Series	5GHz Antenna with Mounting Kit	5GHz antenna and antenna mounting kit.

* True data throughput. Physical throughput 54Mbps/108Mbps.

** True data throughput.

Company History

NOW Wireless Limited has been involved in many wireless projects over recent years.

These include the wireless gateways for the police's new Tetra system, the implementation of the data element of the 3G network on the Isle of Man, and many other projects. NOW Wireless has, in the past three years, worked with Portsmouth City Council to implement a wireless strategy for their RTI, traffic light and CCTV systems, as well as extensions for car park signs, variable message signs and ticket machines.

We are also currently providing wireless systems to councils in Glasgow, Suffolk, Kent, Coventry and Edinburgh.

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