Broadband Wireless CCTV Transmission

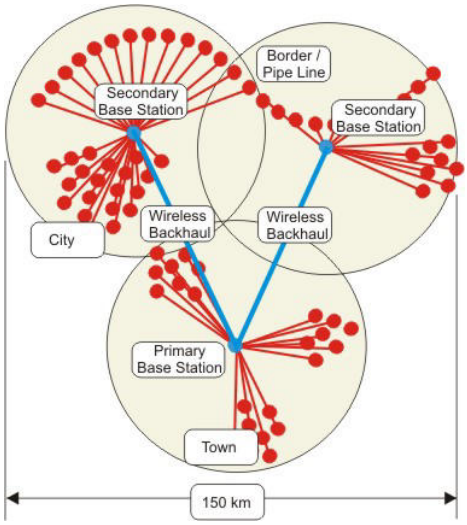
Ogier Electronics

1 Summary

This paper describes the advanced broadband wireless system that is capable of transmitting video and data over ranges of 40 km from many hundreds of CCTV cameras to a common Base Station.

The primary application is for CCTV cameras when they are installed over a wide area, such as in a town or city, but where they are not necessarily required to be viewed continuously, and the video quality requirements are lower than those for city centre CCTV networks. Such applications are for commercial premises such as banks, supermarkets and industrial sites when CCTV is generally only required in the event of a security problem.

A network of base stations using the wireless itself for the backhaul can provide the communications over very large areas of up to 20,000 square km. These applications include oil fields, pipe lines and large military bases.



Coverage with wireless backhaul

The core of the system is the high technology 10 GHz point to multipoint wireless equipment developed by Ogier Electronics; a system that is in commercial service in several countries around the world.

It complies with DOCSIS - the world standard for cable internet systems and uses the latest generation of hardware from Cisco Systems and other major manufacturers. A minimum of infrastructure is needed. This makes it easy to install and allows cameras to be commissioned and operational in hours.

The system incorporates a number of features that are essential for high security applications. High frequency directional antennas make the transmissions more difficult to detect or jam than low frequency, public band, wireless. The system encodes the video and data to ensure that only authorised users can interpret the information. It is also appreciably more resilient to attack than optical fibre or cable where complete networks can be disabled by cutting the fibre or cable in unprotected areas.

Because of this, the system is ideally suited to areas where on-going security operations demand an efficient, robust and easily installed CCTV transmission network.

2 Description

The system comprises four major elements:

The cameras and compression
The wireless units
The base station hardware
The system controller

Each of these elements is described below.

2.1 Cameras and Compression

Ogier CCTV transmission as used in Sharjah

The equipment comprises the camera and lens, the pan and tilt mount and the video compression unit.

The wireless system can transmit video from almost any camera, ranging from simple fixed internet units to professional low light devices with pan, tilt and zoom controls. Video can also be transmitted from IR or other night vision cameras.

This flexibility means that different types of camera can be used in a mix and match arrangement to suit the requirements at each location in the network.

The camera outputs are connected either to MPEG2/4, H261 or motion MJPEG video compression modules which are available from many manufacturers.

MPEG provides higher video quality than Motion JPEG for the same data rate, but has a longer latency of 50 to 200 mS. With fixed cameras this is clearly not a problem. Similarly it is not usually too serious a concern if the PTZ controls are merely required to pan to different areas rather than to track moving targets. Unless the absolute minimum latency is essential, the higher resolution MPEG solution is recommended.

Indigovision MPEG4 Compression

2.2 Wireless Units

The standard equipment comprises a wireless access module, a power supply and a cable modem. All the units are connected by a single low loss coax cable.

The dimensions of the wireless access module are only 22 x 21 x 5 cm. It is designed for all-weather operation on simple wall or pole installations. It requires a line of sight and alignment to the base station, but because the beam is relatively wide the alignment can be performed by eye in all but the most critical cases.

The wireless module provides access out to ranges of 10 km with availabilities of 99.99%. Standard 60 cm parabolic antennas can be used for longer ranges out to 40 km.

Camera Wireless Unit

2.3 Base Station Hardware

The base station requires only two types of unit

A Router and Upconverter
A Transceiver, Antenna & Power Supply

A Transceiver is usually required for each azimuth sector. However, in low density applications, a single Transceiver can feed two back-to-back 90 degree sectors. In this way, only two Transceivers are required for 360 degree coverage, but additional units can be added at any time should the capacity requirements increase.

Base Station Transceiver

The Transceivers are interfaced to the Router through an Upconverter in the downstream direction. The connections are direct in the upstream direction.

A powerful router like the Cisco Systems uBR7246VXR has a modular design that enables it to be expanded in service by adding cards to provide the data processing for up to 8 Transceivers.

At the opposite end of the spectrum, low cost "pizza box" solutions may be more appropriate for smaller systems.

2.4 System Controller

The system can display each video in any number of ways from full screen, to quad or 16 videos per screen, using analogue or digital monitors.

Typical quad format

In most systems quad formats of the type shown above are used for general surveillance with full screen displays of any operator selected video. Map overlays and touch screen controls can be incorporated.

Video motion detectors are recommended in high capacity systems with hundreds of cameras, especially if many are located in sparsely populated areas. In this way, the videos need only be viewed when the pictures change. The motion detection can be local to the cameras, or at the control centre.

Recording can also be local or central. The fact that the system is entirely digital from the camera onwards, means that there is considerable flexibility in where these functions are implemented.

3 Capacity

The simplest base station provides a usable data rate of 32 Mbps in both the downstream and the upstream directions. This is sufficient to operate 32 cameras, all transmitting simultaneously at 1 Mbps. In practice only 1 in 5 cameras usually operate at the full rate at any time, with the others using much lower rates. This means that 100 cameras can be supported in a typical small system.

The capacity can be increased by the addition of modules and units. Plug in cards can be fitted in the Routers and additional Transceivers can increase the angular coverage or the capacity in any sector.

The system uses up to 90 MHz in each direction. It employs spectrally efficient modulation to achieve a useable data rate of almost 150 Mbps in each sector - 600 Mbps from a single station. This corresponds to 600 cameras all transmitting simultaneously, or more than 2,000 in a real multiplexed system. In practice the capacity is even greater because several base stations can be co-located within the coverage area.

4 Options

The configuration of the system is particularly flexible. Cameras can be added at any time. To activate a new camera, the operator simply allocates it an address and a channel number.

The capacity can be increased and the coverage can be extended by the use of repeaters or by adding Base Stations. Other services and remote monitoring can also be provided.

4.1 Repeaters

The range of the system can be extended and blind sectors “filled in” by Repeaters which relay the signals between the Base Station and the cameras.

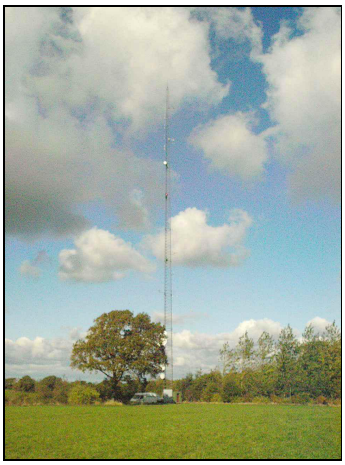
Simple Repeater

The most sophisticated Repeater comprises a unit that provides the communication to the Base Station, and has one or more Transceivers to provide coverage to the local cameras.

At the other extreme, very compact Relays as shown in the photograph can be used to cover localised blind spots.

4.2 Secondary Base Stations

The complexity of the backhaul to the outside world can be reduced by aggregating the data requirements of several base stations using the wireless network itself to provide the communications between the stations.



Secondary Base Station

The secondary Base Stations can be located up to 30 km from the master without the need for any additional equipment. However if a dedicated directional antenna is used at the master, the separation to the Secondary stations can be up to 80 km.

4.3 Data and Voice transmission

In addition to video, the equipment can transmit voice, or data at rates of 4 kbps, both upstream and downstream, to any user. The interface is 10baseT Ethernet.

A performance equivalent to dedicated leased lines can be made available, but it tends to be wasteful in spectrum. To overcome this the transmission system uses the DOCSIS protocol, which is the world standard for cable networks. It is a packet switched protocol that enables many users to share the available capacity in the most efficient way possible. Typical contention ratios up to 20:1 are used

4.4 Internet Connectivity

The system operates in a stand alone mode as a totally self contained network. However, it can also be connected to the internet so that the video and the data can be made available to authorised users anywhere in the world. In these circumstances the system becomes a virtual private network.

The Cisco Systems Routers are specifically designed for internet compatibility and form the basis of the majority of the world's cable modem networks.

No changes or modifications to any of the elements of the network are required to enable internet connectivity. The interface can be Ethernet, ATM or virtually any international protocol. The physical connection can be either cable, fibre or satellite VSAT.

5 Specifications

The top-level outline specifications are provided below. More details on any part of the system can be provided if required.

Camera interface	PAL or NTSC
Camera control	Fixed or proportional PTZ
Digital compression	MPEG2/4, H261 or JPEG
Data rate per camera	0.5 to 2 Mbps
Camera capacity	2,000 per base station
Video quality	Equivalent to VHS
Transmission Frequency	10.2 GHz downstream 10.5 GHz Upstream
Bandwidth	30 to 90 MHz
Transmission protocol	DOCSIS
Camera to base station	10 km as standard 40 km with 60 cm ants
Base station capacity	24 to 600 Mbps
Base station separation	Up to 80 km
Videos per display	Full screen, quad or 16

6 Case Study

6.1 Requirement

There is a requirement in a city in the Arabian Gulf for a broadband wireless CCTV system to supplement the roadside cameras planned for the city. A broadcast quality analogue system will be used for the roadside cameras because the highest possible video quality is required with no latency.

However the quality requirements of the broadband wireless network are less demanding. Their application is for shops and other commercial premises. In the event of a security problem or emergency, the police controllers will use the system to assess the situation, to make an initial appraisal of the resources needed and to monitor the effectiveness of the response.

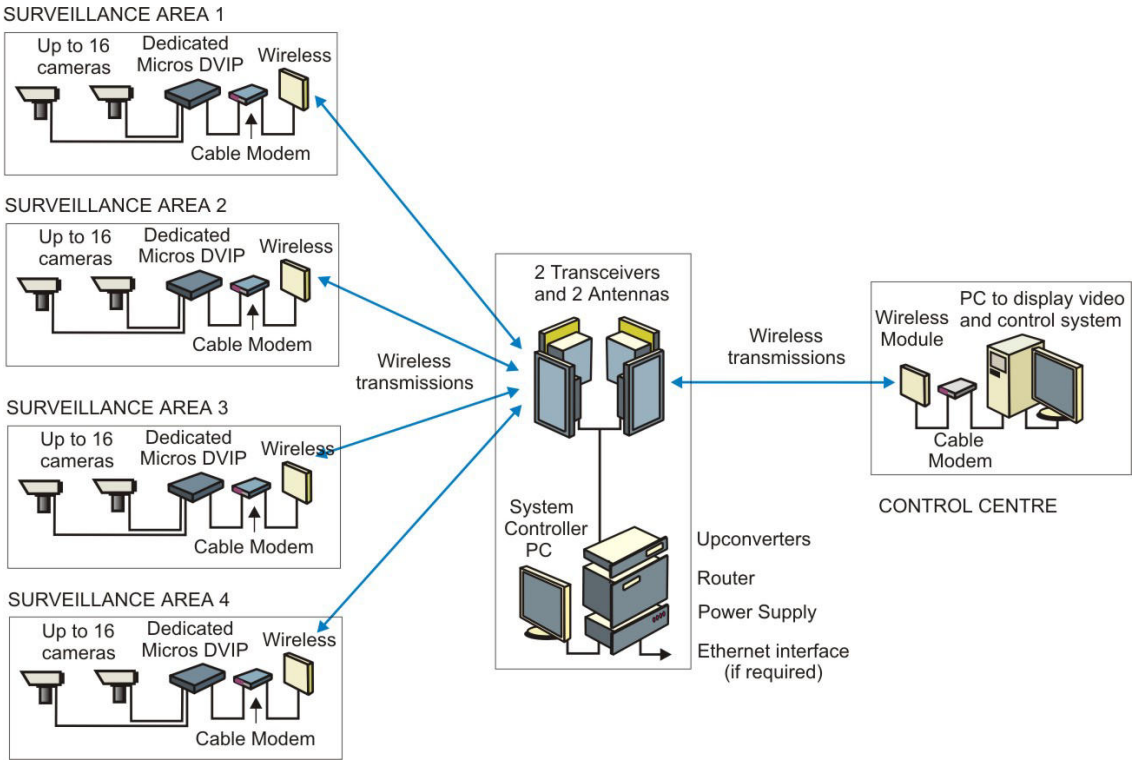
The use of the public, licence exempt bands was not acceptable because of fears regarding interference, whereas the broadband wireless system operating in the licensed 10 GHz band provided an ideal solution.

6.2 Installation

A mast in the centre of the city was identified as the ideal location for the Base Station. The control centre, located at the Police Headquarters is 5 km from the mast and the shops at which the cameras are to be installed are at ranges of up to 10 km.

The diagram below shows the general configuration of the system which is based on the use of Dedicated Micros DVIP units. There are several DVIP units in the network, one for each surveillance area. Up to 16 analogue cameras in each area (commercial building or terrace of shops) are hardwired to a DVIP unit which in turn is connected to a wireless transceiver through a standard cable modem.

The wireless units communicate with the Base Station and then to the Police Headquarters. In the simple illustration shown below, a single work station allows an operator to call up any camera in the network or any combination of cameras in the selected surveillance area using a split screen or montage form of presentation.



6.3 Configuration

The actual configuration of the system is illustrated in the diagram below. Sixteen DVIP units are used, each with up to 16 cameras. This gives an initial capacity of 256 cameras.

In addition, 10 PC terminals will be used throughout the city, each with 4 Mbps of data in the downstream and upstream directions. The initial assessment is that they will require access with a 10:1 contention ratio. Four work stations will be provided at the Police Headquarters.

6.4 Data Rates

The system is scalable. The basic configuration has just one line card in the Cisco router, leaving 3 blanks for future growth.

The capacity of this configuration is 40 Mbps in the downstream direction and 32 Mbps in the upstream. These are the usable rates (some 70% of the total) and exclude that used for error correction and other overheads.

The data rates actually required are indicated on the diagram. From this it can be seen that the network uses only 40% of the system capacity in the downstream and 44% in the upstream.

6.5 Growth Potential

If three additional line cards are inserted in the Router and the number of Transceivers is increased to match, then the capacity of the system can be quadrupled. In addition, further Transceivers can be installed together with another router to re-use the frequencies transmitted and received in opposite directions.

Taken together, this gives a total capacity of 320 Mbps in the downstream and 256 Mbps in the upstream.

Translating this into hardware, the capacity with the 4 work stations at the Police Headquarters is more than 20 times greater than that shown in the diagram, i.e. 40 DVIPs, each with 16 cameras and simultaneously, 200 other PC users at a 10:1 contention.

In reality the total capacity is even higher. Only 30 MHz of spectrum is necessary to run the system with 640 cameras and 200 PCs. In practice there is at least 3 to 5 times this spectrum available in the 10 GHz band, which means a capacity of 2,000 to 3,000 cameras.

Even this is not the limit because several base stations can be installed within a city. In London for example NTL, the largest cable company in the UK, installed 6 Base Stations over a 500 sq km area.