

APPLICATION OF A CONVERGED INTERNET PROTOCOL BASED INTER-URBAN COMMUNICATIONS INFRASTRUCTURE

James Gibson¹, Simon Jones²

1. Traffic Wales, M4 Junction 32, Coryton, Cardiff, CF14 7EF,

Tel: +44 29 2062 9420, Fax: +44 29 2062 9423, email: james.gibson@traffic-wales.com

2. Traffic Wales (Address and telephone as above), email simon.jones@traffic-wales.com.

ABSTRACT

In 2003 the Welsh Assembly Government adopted industry standard Internet Protocol (IP) as a common transmission technique for all trunk and roadside communications. Historically, transmission of communications signals (including data, video and voice) across roadside communications infrastructure has been carried out on a system by system basis. The prospective benefits of a common infrastructure based around IP led to the Welsh Assembly Government's decision, enabling all communications signals, within transmission buildings and control offices, on trunk routes and out to roadside equipment to be delivered in this manner. Immediate and measurable benefits were attained through allowing industry standard hardware and software to seamlessly integrate into the motorway infrastructure without the need for specialist engineering support and therefore lowering costs in both capital and maintenance.

INTRODUCTION

SYNOPSIS

The paper will discuss the benefits that have been accrued by the implementation of a converged Internet Protocol (IP) infrastructure for voice, video and data in Wales. The improved infrastructure is now being utilised for providing traditional network management ITS services, such as CCTV and emergency telephony, but is also capable of supporting emerging telematics' requirements, such as vehicle to infrastructure communications.

BACKGROUND

Whilst researching and investigating a modern alternative for transmission of data during the early part of this decade, the worldwide acceptance of Ethernet and IP products and their consequent availability, pricing, reliability and ubiquity made a compelling case for their utilisation in the area of trunk communications. In fact, many large telephony and communications organisations have been investigating and trialling packet based methods of communication as a viable alternative to existing multiplexing techniques (Pulse Coded Modulation and Time Division Multiplexing). To this end, the Welsh Assembly Government's chosen communication network became Gigabit Ethernet. This was applied to the servicing of all major nodes on the motorway network and in the latter phases extended to serve individual roadside devices. The network has been augmented by the provision of an IP telephony (IPT) system, and the trunk transmission of CCTV video streams from around 250 cameras over the network using a number of standards based encoding techniques.

IP NETWORK

CONVERGED NETWORK INFRASTRUCTURE

A converged infrastructure was designed and implemented across the network. Using this infrastructure, solutions have been delivered to various roadside systems, including:

- Emergency Telephones (Combining IPT with existing roadside equipment)
- Closed Circuit Television (CCTV)
- Buried Inductive Loops (MIDAS)
- Matrix Signals and Message Signs (NMCS2)

The core network comprises Cisco 3500 and 4500 series Ethernet switches, carrying out layer 3 (IP) routing. The switches are connected in a series of interlinked rings. At layer 2 the network supports in excess of 50 Virtual Local Area Networks (VLANs). At layer 3, a range of subnets have been declared, approximating to the VLANs at layer 2. Interconnections between switches operate at Gigabit Ethernet speed over the Welsh Assembly Government's ("The Assembly's") own fibre optic infrastructure. This runs parallel with over 300Km (18%) of The Assembly's road network and 100% of the Trans European Road Network (TERN) which travels through both North and South Wales.

AWAY FROM THE INFRASTRUCTURE

The geography and social landscape of Wales does not lend itself to cable infrastructure that traverses the entire country. In those cases where roadside cable is not available, the core network has been augmented and extended by the use of a third party telecoms provider's Multi Protocol Label Switching (MPLS) network. This allows data, including CCTV images, to be transferred to and from remotes sites, at relatively low cost, based on ADSL uplinks.

Multiprotocol Label Switching (MPLS) is a data-carrying mechanism which emulates some properties of a circuit-switched network over a packet-switched network. MPLS operates at an OSI Model layer that is generally considered to lie between traditional definitions of Layer 2 (data link layer) and Layer 3 (network layer), and thus is often referred to as a "Layer 2.5" protocol. It was designed to provide a unified data-carrying service for both circuit-based clients and packet-switching clients which provide a datagram service model. It can be used to carry many different kinds of traffic. Adopting MPLS in conjunction with the converged networks has allowed many of the point to point circuits that were used for communicating away from the core infrastructure to be removed. This provides cost savings and improved network integrity, many times better than previous systems. Failure of a leased line would previously have resulted in complete failure of the node. The MPLS approach (in common with TCP/IP) allows data to be dynamically re-routed, with only minor end user disruption.

The adoption of MPLS would not have been possible using the communications systems used prior to the adoption of IP for ITS in Wales. The use of MPLS provides significant financial benefits when compared with the multiplicity of point to point links that preceded it.

PROVEN BENEFITS OF THE CONVERGED INFRASTRUCTURE

GENERAL

The Assembly adopted a converged infrastructure approach for a number of reasons, outlined below, each of which has now realized tangible benefits for The Assembly:

- Common infrastructure for all services
- High bandwidth achievable
- Will provide support for next generation roadside services
- Industry standard, widely available, cost effective (IP and associated protocols are not licensed so equipment from many vendors can inter-operate successfully)
- In-built fault tolerance
- Disaster recovery
- Fibre economy
- Improved services
- Allows commercial off-the-shelf systems (eg automatic number plate recognition cameras) to be added easily
- Integration with MPLS networks to provide a network wide data collection system

It is not within the scope of this paper to describe each of the above in detail, but when considered as a whole, the benefits formed a compelling case for The Assembly to adopt this approach for all inter-urban ITS communications.

EXPERIENCE OF INSTALLED INFRASTRUCTURE

General

The Assembly has now been operating a converged infrastructure since Spring 2003. Since that time, CCTV, telephony and data services have been operating over the network. The primary services that are delivered over the converged infrastructure are discussed in the following sections.

Flexibility

The flexibility of the converged network approach is notable. In early 2005 a need was established for a standby control office facility. Had the ITS road management systems been deployed in the traditional way, this would have taken many months of planning, reorganising and implementing, and would have attracted significant costs. The facility was made operational within a month of a suitable site being made available, however because of the free access from any point, which is a feature of IP. The site has full access to all CCTV pictures, emergency telephone and signal/sign setting equipment.

Digital CCTV

In order to capitalise on the network benefits outlined above, The Assembly has adopted a digital CCTV approach, with video data transported over the converged infrastructure. This effectively leverages all of the network's benefits to the CCTV system. It also allows pictures to be delivered, viewed or controlled from any network connected location, including the internet or an external network such as a service provider's MPLS infrastructure.

IP Telephony

An IP telephony system has been installed that provides a fault tolerant internal phone network wherever the core IP Ethernet infrastructure extends. In south Wales the system features dual redundant Call Managers (PC based private branch exchange - PBX), dual redundant public telephone network gateways, messaging servers, call recording, automated attendant and a billing/reporting service, the core functions are mirrored in north Wales.

Further Developments

The model adopted has also allowed other technologies to be put in place, to provide additional services, for example:

- Real-time vehicle-by-vehicle data can be collected from each of the existing 500m spaced inductive loops, rather than the amortised data currently collected, to enable more accurate travel time and congestion estimation.
- Roadside message signs can be interrogated, upgraded and maintained more easily (with fewer visits to site).
- Automatic Number Plate Recognition cameras have been installed across the network, without the need for a dedicated communications infrastructure.
- Wireless Access Points have been installed to communicate with IT systems in vehicles at the roadside.

CONCLUSION

Experience with IP Telephony and CCTV illustrates the proven benefits of adopting the wider IT and telecoms industry principles of a converged network running over a flexible cable infrastructure. It also demonstrates the benefits now being derived from this approach, notably;

- Reduced dependence on specific suppliers;
- Access to a wider market for equipment and skills
- Fault tolerance;
- The ability to make better use of the installed asset base.

Also, it is notable that the development of MPLS networks has created significant opportunities for monitoring and information gathering from the entire road network.

The Welsh Assembly Government has a policy of making best use of their installed assets, this includes the communications infrastructure of both fibre cables and IP infrastructure. As such, services have been developed, and are currently being rolled out, to deliver on this commitment. For instance, freeing up fibre cores for other uses by use of a converged core network or delivering services to the public or stakeholders via the converged network/internet.

The expanded infrastructure has now been made available as a telematics' test track, covering approximately 100km of road, which is now being used for a variety of academic and commercial research projects.