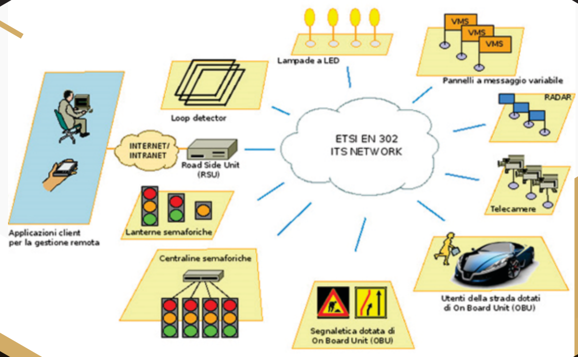
JK TECHNOLOGIES

ITS Communication & Networks



Communication infrastructure: Communication has a crucial importance for Intelligent Transport System applications. Fiber optic cable infrastructure is the most suitable one for ITS operation in the sense of high rate data transferring. It is also aimed to establish an efficient communication infrastructure which will allow those systems built in the scope of ITS to provide communication with each other and with other transport modes. Wireless communication will also be used when necessary. To this end, fiber optic cables will be installed on road network.

Telecommunications networks resemble the nervous system in a human body. Specifically, the communications networks tie the different components of ITS together, allowing for a truly integrated system. For example, they provide a data link from the field devices (detection technologies, Dynamic Message Signs, signal controllers) to traffic operations centres - where the collected data is fused, analysed and acted upon. Telecommunications are also needed to carry instructions and commands from control centres back to field devices for traffic control purposes. They are also the means for infrastructure operators (controllers) relaying information to travellers and stakeholders.

An ITS system will not function without an appropriately designed communications network that has adequate bandwidth and is capable of delivering an adequate level of service (in terms of message delivery, latency and drop-out rates). Decisions on the appropriate communication technology, the appropriate network topology and other communications design issues have to be made carefully. This is because the cost of the communication network typically constitutes a major component of the cost of a specific ITS system. In some cases, where a cable and transmission equipment infrastructure needs to be installed, it can be up to 50%.

Telecommunications Architecture

The telecommunications network to support ITS needs to be carefully designed. A common architecture for such networks is known as a hierarchical or layered architecture, which exhibits many similarities to the hierarchical system of road networks themselves. Specifically, telecommunications networks may be regarded as consisting of four layers:

- Backbone Layer
- Backhaul Layer
- Distribution Layer
- Access Layer

Backbone Layer – Using highways as an analogy for telecommunications, the backbone layer is similar to the inter-state / inter-urban strategic roads. It enables moving (hauling) large amounts of data between a limited numbers of fixed distribution points. As with road networks, the different layers of a communication network are interconnected. Fiber optics cables are commonly used for this layer.

Backhaul Layer – The function of the backhaul layer is to move (haul) large amounts of data (which still requires large bandwidth) from the backbone network to the Traffic Control Centre. It is often off the highway/road network - and can be provided by a service provider.

Distribution Layer – The distribution layer resembles the system of arterial roads in a road network. This layer typically does not handle large volumes of data. Its main purpose is to provide multiple points of presence to enhance accessibility.

Access Layer – Finally, the access layer resembles a residential or local street network or the lead/cable which connects the TV to the aerial socket - that provides local cabling to access the different devices on the network.

The various communications technologies are used in ITS applications. This includes wired technologies, such as fiber-optic and Ethernet cables, and leased telephone lines and cables. This also includes wireless technologies, such as spread-spectrum radio, Wi-Fi/ Worldwide Interoperability of Microwave Access (WiMAX), and cellular data.

The majority of ITS applications and services require one or two way communication. Currently the communication relies on following network:

- Wired communication
- Fiber optic Cable
- Twisted pair wires
- Ethernet Cable
- Wireless communication
- Point To Point Microwave
- Wi-Fi
- Dedicated Short-Range Communications (Dsrc)
- Bluetooth and Wi-Fi Sensor Networks
- Wide-Area Telecommunications

Fibre Optics Cable – A fibre optics cable is a communications medium for light waves to carry a signal that transfers information from one point to another. The cable itself is very thin (slightly thicker than a human hair). For operations, an optical transmitter is needed at one end of the cable, and a receiver at the other - to convert electrical signals into light signals and back again at the receiving end.

Current fiber optics technology is capable of transmitting about 10 Gbps, 40 Gbps, and even 100 Gbps of information per second.

Another advantage of fiber optics communication is that it is not susceptible to magnetic interference or electrical resistance, since it uses light waves. On the downside, fiber optics communications are relatively expensive, although their widespread use nowadays has made them more affordable. A large portion of the cost of fiber optics technology relates to purchase of the right-of-way, the termination equipment (converting electrical pulses to light and back again) - and the trenching needed.

A number of highway/motorway transport agencies have entered into an agreement with a telecommunications company:

- Allowing the telecommunications company to use the transport agency's right of way to install fiber optic cables;
- In return the transport agency is granted the use (at no, or reduced, cost) a portion of the telecommunications companies' bandwidth capacity.

Fiber optic cable is commonly used in ITS for applications where there large amounts of data transmitted. A good example is the connection between a Traffic Control Centre (TCC) and field devices such as video cameras. There is emerging interest in taking fiber cables direct to the end-devices - leading to roadside equipment now being specified with an optical fiber input or connector-socket. Fiber optic cables are expensive and challenging to fix when damaged.

Copper Cable – Copper cabling is good for voice and data transmission - but increasingly cable systems need to transport high bandwidth signals associated with CCTV images and other video. Fiber optics are rapidly replacing copper for 'main line' telecommunications - but distribution within buildings and over the last mile often relies on copper coaxial cable. Copper cabling requires the use of line amplifiers to cover distance - with an increased risk of noise on the high bandwidth signals. With the spread of digital signaling and ADSL existing copper cables are having a new lease of life to provide the distribution and access layers.

Twisted Wire Pair (TWP) – Twisted wire pair (TWP) is amongst the most common communications media for ITS applications. It is made of two insulated copper conductors twisted together to cancel out electromagnetic interference. Recent advances have allowed the use of Ethernet over TWP in a number of ITS applications.

Twisted wire pairs are the most commonly used option for ITS communications for the access and distribution layers - especially since recent advancements in ADSL technology allows the use of Ethernet over TWP. This has also opened opportunities for the utilization of legacy TWP infrastructure. ADSL is now widely used - following the practice of Telecommunications Companies - to make best use of their extensive existing copper cable networks.

Ethernet Cable – Ethernet cable is used to create Local Area Networks (LAN) providing a physical data network - connecting devices together within a control centre. It carries data using the Ethernet protocol which is almost exclusively used for ICT applications in buildings/offices. The current most commonly used industry standard is Category 6 (CAT6). Category 6 is an Ethernet cable standard defined by the Electronic Industries Association (EIA) and Telecommunications Industry Association (TIA). Cat 6 is the sixth generation of twisted pair Ethernet cabling that is used in home and business networks. Cat 6 cabling is backward compatible with the Cat 5 and Cat 5e standards that preceded it. Category 6 cables support Gigabit Ethernet data rates of 1 gigabit per second. They can accommodate 10 Gigabit Ethernet connections over a limited distance - 164 feet for a single cable. Cat 6 cable contains four pairs of copper wire and uses all the pairs for signaling in order to obtain its high level of performance.

An interesting development for ITS in recent years is the concept of Power over Ethernet (PoE), which allows a single cable to provide both the data connection as well as electrical power to ITS field devices. PoE allows for longer cable lengths.

Apart from the need for an Ethernet network within the TMC, Ethernet cables are commonly used in ITS to form the access layer to connect a field device (such as a CCTV camera) to a network or to an Internet access point. In this case the cables are there primarily as local device interconnects.

Power over Ethernet (PoE) – Power over Ethernet (PoE) describes a standardized system to pass electrical power along with data on Ethernet cabling. This allows a single cable to provide both data connection and electrical power to such devices as vehicle detectors and video cameras. Unlike standards such as Universal Serial Bus, which also power devices over data cables, PoE allows long cable lengths. Extra pairs of wire, not used for data transmission, are used for power. Up to 25 watts is available for a device, depending on the version of the standard in use. CAT5 (or higher) cable is required for PoE applications.

Wireless Communications

Point to Point Microwave – Point-to-point microwave communication uses ground-based transmitters and receivers resembling satellite dishes to provided dedicated backhaul links where land-lines would impractical or prohibitively expenses to connect roadside networks to a control center. They are usually in the low-gigahertz range and limited to line of sight. Repeater stations can be spaced at approximately 48 km intervals to cover greater distances.

Wi-Fi – Wi-Fi has become a very popular technology for the exchange of data wirelessly using radio waves over a computer network. Wi-Fi can support non-critical ITS applications because it avoids delay - but does not have bandwidth guarantees. Wi-Fi operates using unlicensed frequencies - so are more susceptible to interference. The technology has potential for use in ITS as a means for connecting field devices to a Traffic Control Centre - for example, where a wired communications solution would be too expensive. In this case, a secure Wi-Fi connection, such as the wifi-mesh network shown in the figure below would need to be provided. This shows a multipoint to multipoint WiFi Mesh network suitable for VMS, car park counters, traffic signals, remote monitoring and non-enforcement CCTV.

Wi-Fi is based on the Institute of Electrical and Electronics Engineers' (IEEE) (IEEE) Standard 802.11. It is designed to provide local network access over relatively short distances (between 50 - 100 meters) with speeds of up to 54 Mbits/second.

Dedicated Short-Range Communications (DSRC) – Another group of communications technologies widely used in ITS is dedicated short-range communications (DSRC). DSRC was developed specifically for vehicular communications and is likely to witness a dramatic increase in use with the introduction of Connected Vehicle technologies. The technologies are used in a number of ITS applications including:

- electronic payment for parking and tolls;
- commercial vehicle pre clearance;
- bus and emergency vehicle signal priority;
- in-vehicle signage;
- probe vehicle data collection;
- highway/motorway intersection warning;
- intersection collision avoidance.

Passive Microwave (Tag & Beacon) – Passive tags do not have an internal power supply. Instead, they use the very small electrical current induced in the antenna by the incoming radio frequency signal, to transmit a response. For this reason, the antenna has to be designed not only to collect power from the incoming signal, but also to transmit the outbound backscatter signal. The main advantage of passive microwave tags is that they can be quite small and have an unlimited life. Passive microwave was used in ITS for early types of electronic toll collection systems. Innovations in their use continue.

Active Microwave (IEEE 802.11/WAVE) – Active tags have their own internal power source which can generate the outgoing signal. Compared to passive tags, they may have a longer range and can store additional information sent by the transceiver. Active microwave is employed in many electronic toll collection systems. More expensive on-board units have batteries which need replacing.

Infra-Red (DSRC) – uses infra-red technology, as opposed to radio spectrum or microwave, for short-range communications. Infra-red DSRC can be used in ITS where it is difficult to secure a frequency spectrum license. The technology is also appropriate when the weather is generally rainy - but not foggy. Infra-red DSRC is less susceptible to security intercepts.

Bluetooth & Wi-Fi Sensor Networks – Bluetooth is a wireless technology designed to allow data exchange over short distances (a maximum of about 10 meters). Most cell phones on the market today have Bluetooth technology. They also have Wi-Fi wireless technology, which uses radio waves for connections for distances to a Wi-Fi base station of up to 90 meters. In recent years, several automotive manufacturers have been embedding Bluetooth technology into their vehicles to allow drivers to connect their phones or music devices to in-vehicle audio systems.

When activated, Bluetooth and Wi-Fi transceivers continuously broadcast "discovery" messages to allow other devices to find and connect with them. The discovery messages include a unique identifier that can be used for vehicle detection and tracking. Essentially, all that is needed is a Bluetooth or Wi-Fi sensor installed close to the roadway. These sensors record the time at which a vehicle equipped with an on-board Bluetooth or Wi-Fi device drives past them. By utilising the unique identifiers recorded at successive monitoring points, information on travel times along a road segment - or the pattern of Origin-Destination flows through a network - can be derived.

The use of Bluetooth or Wi-Fi is ideal for crowd sourcing but the results have to be calibrated as:

- Not all vehicles report an identifier - since some will not be equipped with the technology or the equipment may be turned off - leading, in both cases, to no count being registered
- Or a single vehicle may have several active devices - leading to multiple counts.
- When using this vehicle sampling technique a key challenge is to ensure that a sufficiently high proportion of vehicles are equipped with Bluetooth and Wi-Fi devices. In urban areas, this may not be a major concern, but in other regions low market penetration may limit the application of these detection technologies.

Wide-Area Telecommunications – Communications over a wide area are often required in Network Operations - particularly in rural areas where the options for voice and data communications and the transmission of CCTV images are more limited.

WIMAX – WiMax stands for Worldwide Interoperability for Microwave Access. WiMax is designed to provide much higher bandwidth, compared to Wi-Fi, and at a much extended range. Recent years have seen increased interest from the ITS industry in integrating WiMax and Wi-Fi as an alternative communications medium to wired communications.

Under ideal conditions, WiMax could have a range of more than 40 kilometres, and offer speeds of up to 70 Mbits/seconds. It implements the IEEE 802.16 Standard, with newer standards designed for speeds of up to 1 Gbits/second. A typical WiMax network would consist of a base station connected to several client radios (Customer Premise Equipment or CPE).

Cellular Data – Cellular networks were established primarily for voice communications, but there is steadily growing increased interest in their use for data communications as well. Two voice communication cellular technologies have evolved in this way:

- Global System for Mobiles (GSM)
- Code Division Multiple Access (CDMA)

They differ in the way they transfer data. GSM divides the frequency band into multiple channels for use by different users. CDMA digitises calls and unpacks them at the back end. Both GSM and CDMA have been refined and enhanced over the years to allow for increased speed. For example GPRS (for packet data communications) uses the GSM cellular network at speeds suitable for transmitting commands to VMS and car park counters.

The latest cellular data technology is Long Term Evolution (LTE) (also known as 4G LTE). Unlike GSM and CDMA, LTE is designed primarily for data communications, with voice as an override. It offers high bandwidth, low latency, and supports full data rates while travelling at high speeds (a feature which is important in the ITS environment with fast-moving vehicles). Cellular data communications can be used in ITS where wire line communications are not available or are cost-prohibitive.

Digital Radio Data – Digital Radio Data (DRT) refers to the practice of transmitting digitised and compressed data over FM radio. This allows small amounts of digital information to be embedded in conventional FM radio broadcasts. A good example of a DRT application in ITS is the Radio Data System-Traffic Message Channel (RDS-TMC), where digitally encoded traffic information is made available for in-vehicle navigation devices. RDS-TMC is an early form of digital data transmission. It was developed in Europe to exploit the Radio Data System used by some broadcasting authorities. Travel information is transmitted digitally over FM radio frequencies - and a decoder, built into the car radio or navigation device, interprets the digital code for text or graphic display.

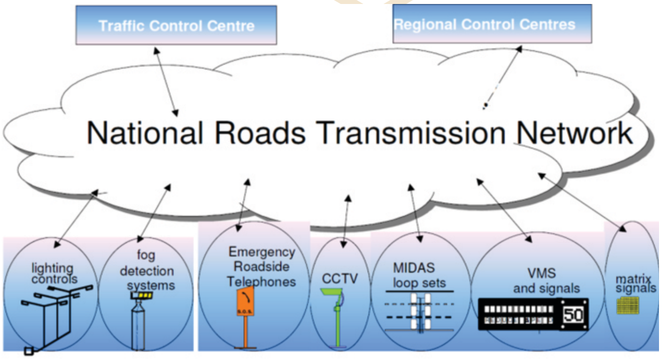
Spread Spectrum Radio – is a radio network that has a "line-of-sight" requirement (unobstructed line of path between a subject and an object). In this network, one radio serves as the master and the other as slave. An example of the use of spread spectrum radio in ITS is the connection between a set of traffic controllers at signalised intersections and the Traffic Management Centre (TMC) needed for monitoring and signal timing purposes.

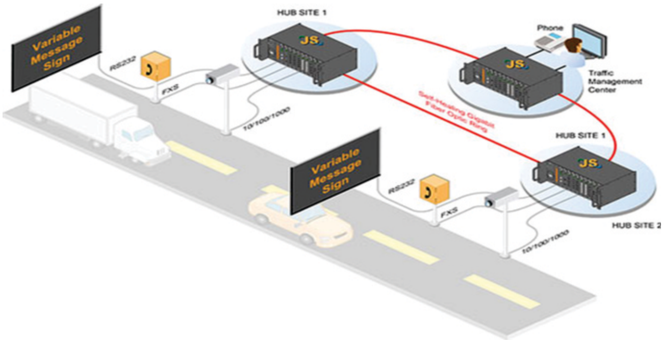
In some cases, it might not be possible to directly link the two radios because of distance or interference - in which case another radio (called a repeater) would need to be installed in-between the two radios. These networks are most commonly used to allow a number of traffic controllers to communicate with one another, or to communicate with a traffic operations centre. They can broadcast over the unlicensed frequencies of 900MHz, 2.4 GHz and 5.8 GHz. The 5.8 GHz frequency provides the highest bandwidth at about 54 Mbits/second, but is very susceptible to line-of-sight problems.

Whilst theoretically, spread spectrum radio can provide a communication range of up to 60 miles, in practice the range is much shorter because of line of sight attenuation or obstructions.

ITS Communication Equipment

- Router
- Firewall
- Access Points
- Fiber to Ethernet Media Convertor
- Point to Point Microwave Radios
- Network switches
- POE Switches
- Uninterrupted power supply and Solar System for Power Supply.





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