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Intelligent transportation systems

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Abstract
Transportation systems play a crucial role in almost all areas of modern life. Intelligent transportation systems (ITS) are basically transportation technologies that support the operations of a state highway system through advanced wireless communication technologies. ITS are being used to improve the safety, comfort, efficiency, productivity, dependability, and cost-effectiveness of our surface transportation systems. They can potentially revolutionize mobility, changing everything from the way we move to how we design vehicles. This paper provides an introduction to ITS.

Keywords: transportation, intelligent transportation systems

Introduction

Transportation is the movement of people and goods across geographical distances. Transportation systems are an indispensable part of human activities. They remain the life blood of the US economy. Moving people and products demands smart freeways, bridges, marine ports, mass transit routes, rail lines, tunnels, etc. However, transportation has some notable problems which include traffic congestion, accidents and safety, energy consumption, and environmental impacts. To meet these and other related problems, intelligent transportation systems (ITS) offer a host of technologies.

Intelligent transportation systems (ITS) integrates advanced communications technologies into vehicles and transportation infrastructure. It is a system that applies ICT to road transportation including infrastructure, vehicles and users. ITS is an indispensable component of the notion of a smart city transforming cities into digital societies. The smart city concept promotes the growth of social capital through the development of telecommunication, education and research infrastructure. The goal of ITS is to advance transportation safety, mobility, efficiency, and environmental sustainability through electronic and information technology applications. The range of impacts of ITS may be local, regional, or national.

ITS may be regarded as part of the Internet of things (IoT). An increasing number of devices are being connected to the Internet and becoming smart and Internet friendly. ITS data flows from a variety of locations and devices such as in-vehicle sensors, police dispatch centers, and infrastructure sensors. The vast amounts of data collected by ITS for real-time operations holds the potential to significantly improve a wide range of transportation analyses [1].

Concept of ITS

Intelligent transportation systems are innovative solutions that address modern transportation problems. ITS systems may involve surveillance of the roadways (which is a priority of homeland security) and automation that allow people and goods to move efficiently. ITS can play a role in the rapid mass evacuation of people in urban centers after a natural disaster. ITS is supported by various forms of wireless communications technologies including wireless radio, bluetooth and Wi-Fi, microwave systems, fiber optics, and automated technologies with a goal to improve surface transportation safety, efficiency, and convenience. A typical ITS is shown in Figure 1 [2].

The objectives of ITS include [3]:

- To improve traffic safety
- To relieve traffic congestion
- To improve transportation efficiency
- To reduce air pollution
- To increase the energy efficiency
- To promote the development of related industries

The eight groups of ITS user services are described as follows [4]

1. Travel and traffic management
2. Public transportation operations
3. Electronic payment
4. Commercial vehicle operations
5. Advance vehicle control and safety systems
6. Emergency management
7. Information management
8. Maintenance and construction management

Components of ITS

ITS typically consists of the following components [5]

- *Active Traffic Management (ATM):* This allows for improved safety and mobility during incidents, roadwork, and peak commute times,
- *Traffic Cameras (CCTV)*: This is a network of closed-circuit television across the state to detect and quickly respond to congestion, incidents, and other problems on the roads.
- *Highway Advisory Radios (HAR)*: These are licensed low-power AM radio stations installed along the roadway, which provide alerts and general information regarding traffic and travel.
- *Road/Weather Information Systems (RWIS)*: These stations are installed along the roadway to provide

weather and road conditions such as road surface temperature, barometric pressure, humidity, wind speed and direction, precipitation, and visibility.
- *Ramp Meters:* These are traffic signals on freeway on-ramps that alternate between red and green to control the flow of vehicles entering the freeway mainline.
- *Traffic Management Centers (TMC)*: These are the nerve centers for our operations activities gathering real-time information 24/7. This information is used to respond to incidents, deal with other problems that occur, and notify the public and the media of what is happening on the roads.

Some of these components of ITS are shown in Figure 2 [6].

ITS Technologies

The concept of intelligent transport systems was born in the 1980s when a group of transportation professionals conceived the impact that communication technologies could have on surface transportation. In the US, Electronic Route Guidance System was the initial stage of ITS in 1970s. ITS facilitates better public transport services by enhancing safety and mobility while reducing traffic congestion and environmental impact of transportation. ITS is being supported by US Department of Transportation (USDOT) through research, development, adoption, and deployment. The major technological constituents of ITS are [7]: (1) Various forms of wireless communication for both short-range and long-range data exchange (UHF, VHF, WiMAX, GSM, etc.); (2) Sensing technology – employing sensors to feed control systems with both vehicle-based data (from devices such as radar, RFID readers, infrared- and visible-band cameras), (3) Software to implement and optimize the desired behaviors in these systems.

Other ITS technologies are many including car navigation, traffic signal control systems, electronic toll collection, video automatic number plate recognition, ramp meters, traffic light cameras, traffic-signal coordination, transit signal priority and traveler-information systems, vehicle magnetic signature detection, automatic incident detection, parking guidance and information systems, automatic road enforcement, weather information, etc. Some of these technologies are already deployed across the nation include the following [8]:

- *Electronic Toll Collection (ETC):* This enables identification of registered vehicles and supports the collection of payment at toll plazas using automated systems. It directly debits accounts of registered users and alerts law enforcers in case of violations. It increases the operational efficiency, mobility, and convenience of toll collection.
- *Ramp Meter (RM):* This meter is installed on freeway ramps. It sends alternate red and green signals to control the flow of vehicles entering the freeway.
- *Red Light Camera (RLC):* RLC detects a motor vehicle that passes over sensors after a traffic signal has turned red. The sensors connect to computers with cameras, which take two photographs (front and rear) of the violation. Traffic police officers review the photographs and mail a citation to the registered owner of the vehicle.
- *Transit Signal Priority (TSP):* TSP gives special treatment to transit vehicles at signalized intersections. TSP may extend the duration of green signals for public transportation vehicles if necessary.
- *Traveler Information Systems (TIS):* TIS supports many categories of drivers and travelers. Traveler information applications use a variety of technologies, including Internet websites, telephone hotlines, radio, and TV to allow users to make informed decisions regarding trip departures, routes, and mode of travel.
- *Global Positioning System (GPS):* An increasing number of vehicles are equipped with GPS (or satellite navigation systems) that have two-way communication with a traffic data provider. Position readings from these vehicles are used to compute vehicle speeds.

Examples of ITS

Some examples of the applications of ITS include [9]

- Real time information, both for public transport and private road transport, which can improve safety.
- The use of geographical information systems (GIS) and relational databases to keep inventories of transport infrastructure in an area.
- Detailed route planning information (often in real time) for both public transport and car users.
- Parking guidance systems, to reduce parking search time.
- Public transport information in various formats (e.g. audible) for disabled people.
- High-occupancy vehicle lane cameras that identify vehicles violating HOV requirements.

Some of these examples of ITS applications are illustrated in Figure 3 [10].

Benefits and challenges

The purpose of ITS technology is to share information that can prevent potential accidents, keep traffic moving, and decrease the negative environmental impacts of the transportation on our society. Government leaders favor ITS because of its promise to significantly improve the efficiency of existing transportation systems. ITS enhances safety, reduces risk, increases comfort, improves mobility, optimizes traffic efficiency, promotes sustainability, and minimizes traffic problems in a number of situations. The key beneficiaries of ITS safety improvements are travelers, businesses, and transportation agencies. Leveraging citizens with an ITS can save their time and make their city smarter. The homeland security can use the data available from ITS. ITS will decrease accidents by way of safe driving support and reduce traffic congestion by providing ongoing congestion information. ITS plays a major role in reducing the negative environmental impact of transportation and achieving sustainable development requirements. It can also contribute to poverty reduction by improving the travel costs.

The proliferation of ITS projects has inevitably led to problems of compatibility and interoperability within and across nations. Developing ITS standards at national and international levels is important. The deployment of ITS also raises significant issues with respect to personal privacy. It seems likely that some form of privacy regulation is on the way [11].

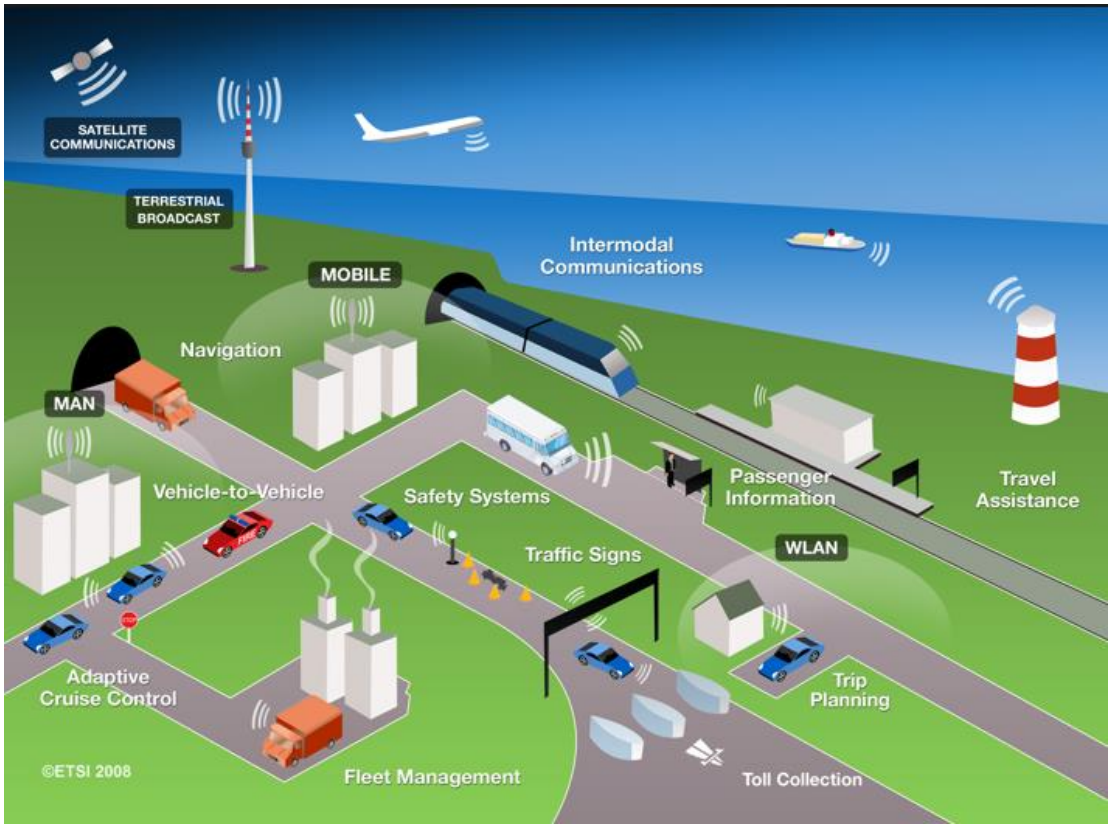

Fig 1: A typical ITS [2].

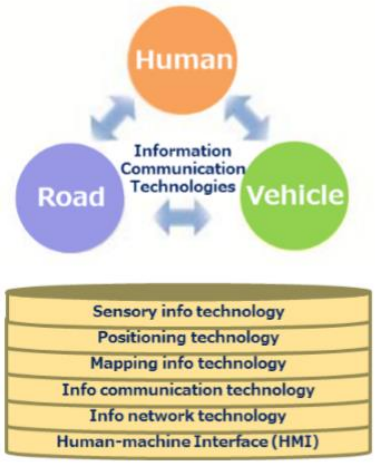

Fig 2: Components of ITS [6].

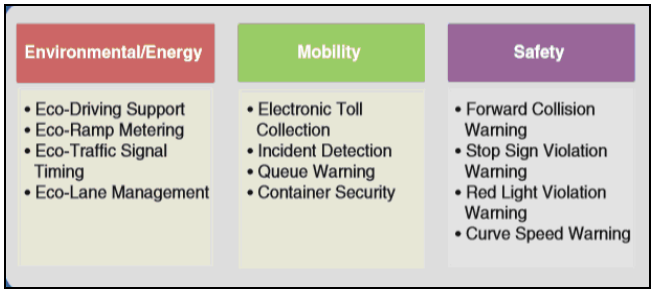

Fig 3: Examples of ITS applications [10].

Conclusion

ITS applies ICT technologies to the transport sector and integrates people, roads and vehicles and significantly contributes to improve road safety, efficiency and comfort, as well as environmental conservation. Although ITS is often associated with road traffic, other transport modes (such as s and air traffic) are becoming ITS. ITS is widely accepted and used worldwide. It is increasingly being used by developing nations to improve traffic in rapidly growing cities. It is paving the way for automation in the transport sector. New smart transportation models and technologies are emerging globally.

ITS World Congress is an annual trade show to promote ITS technologies. In the US, each state has its own ITS chapter that holds a yearly conference to promote ITS technologies. The days of adding more lanes to ease congestion is gone. New technologies such as ITS are designed to improve surface transportation.

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