Vehicle tracking methods

I have investigated the vehicle tracking methods available in our country. I found three methods which are suitable for the requirements of the company.

Firstly, I would like to explain about the nature of the vehicle tracking devices available in the market. Basically, they can be classified as “ Passive” and “ Active”.

“ Passive” devices store GPS location, speed, heading, vehicle details, direction and sometimes a trigger event such as key on/off, door open/closed. When the vehicle arrives to a predetermined point back, the device is removed and the data is downloaded to the computer for evaluation. Usually, automatic download system is available which downloads the data wirelessly. “ Passive” devices can store a certain amount of data that does not expire.

“ Active” devices also store the same information. But it immediately sends the data via cellular or satellite networks to the base station or to a computer of the data centre for evaluation. “ Active” devices can store unlimited data for a certain amount of time. With this device, we can know the exact location of a vehicle as it is there.

Some hybrid devices have both active and passive function. With hybrid device, the data is sent to a base station if the network is available and if the network is unavailable, the device stores data and send it later when the network is available.

Secondly, I will explain about the three tracking methods. They all use active devices. They are:

- Automatic Vehicle Location (AVL) system
- Assisted Global Positioning System (AGPS)
- Radio Frequency Identification (RFID)

Automatic Vehicle Location (AVL)

AVL system is an advanced method to track and monitor any remote vehicle with the device that receives and sends signals through GPS satellites. AVL comprises of Global Positioning System (GPS) and Geographic Information System (GIS) in order to provide the real geographic location of the vehicle. AVL system consists of PC-based tracking software to dispatch, a radio system, GPS receiver on the vehicle and GPS satellites. Among the two types of AVL, GPS-based and Signpost-based, GPS-based system is widely used.

1. The tracking method
2. GPS satellite is used to locate the vehicle equipped with GPS modem by sending satellite signals.
3. The accuracy of the tracking method
4. AVL system provides the vehicle location with the accuracy of about 5m to 10m.
5. The information delivered by the tracking system
6. The information transmitted to the base station is location, speed, direction, mileage, start and stop information, status of vehicle and asset in the vehicle.

7. How often the information is transmitted from the vehicle to the central control system
8. The information of the vehicle is often transmitted to the base station every 60 seconds. If the base station receives the data, it displays it on a computerized map.
9. The method of data transmission from vehicle to centre
10. GPS receiver on the vehicle receives the signals of its geographic location. Then the receiver sends that data plus speed, direction, etc. to the base station via a radio system.
11. The cost per vehicle per day of using the system
12. As the active vehicle tracking device is used, the subscription is needed. Average cost per vehicle per day is $1 to $2.
13. Additional services that the system can provide
14. The system can provide further more services: vehicle route replay facility, external sensor data, speed alerts.
15. Limitations of the system
16. AVL system cannot get accurate, complete and sufficient satellite data in dense urban areas or indoors and when transmission is blocked by natural obstructions (heavy tree cover) or many buildings. It can also occur in RF-shadowed environments and under unfriendly RF conditions. Sometimes, a position fix can be impossible.

Assisted GPS (AGPS)

In AGPS system, a terrestrial RF network is used to improve the performance of GPS receivers as it provides information about the satellite constellation

directly to the GPS receivers. AGPS uses both mobiles and cellular networks to locate the accurate positioning information.

AGPS is used to overcome some limitations of GPS. With unassisted GPS, locating the satellites, receiving the data and confirming the exact position may take several minutes.

1. The tracking method
2. AGPS uses GPS satellites to track the vehicles. A GPS receiver in vehicle is always in contact with 4 satellites (3 satellites determine latitude, longitude and elevation ad the fourth provides element of time). And so it never fails to detect the location of a vehicle.
3. The accuracy of the tracking method
4. Location of the vehicle is provided with accuracy of between 3m and 8m, and speed of 1km.
5. The information delivered by the tracking system
6. Vehicle location, average speed, direction, path traversed in a selected period and alerts (Engaged/Unengaged, speed limit, vehicle breakdown and traffic jam).
7. How often the information is transmitted from the vehicle to the central control system
8. The system provides continuous 10 second updates while the vehicle is in motion. It also provides data storage for up to 1 year.
9. The method of data transmission from vehicle to centre
10. The location is retrieved from the GPS device and relayed as an SMS using the cell phone by the Client Node to the Base station.

11. The cost per vehicle per day of using the system
12. The subscription for this system is $1. 33 per day per vehicle (10 second updates) and $1. 67 per day per vehicle (5 second updates).
13. Additional services that the system can provide
14. The system can provide atomic time (Accurate Time Assistance). There is a “ panic” button. When pressed, you can contact an operator and he or she will help you out or keep you safe from accidents or hijacks.
15. Limitations of the system
16. As GSM network is used to transmit data from the vehicle to the base station, the cost of sending SMS can be a major concern to be considered.

RFID system

RFID is an automatic identification method using devices called tags to store and remotely retrieve data. RFID uses radio waves to capture data from tags.

1. The tracking method
2. RFID comprises of three components: tag (passive, semi passive and active), reader (antenna or integrator) and software (middleware). RFID tag which contains micro electronic circuits sends the vehicle information to a remote RFID reader.
3. The accuracy of the tracking method
4. This system provides the location of the vehicle with the accuracy of 4m to 6m.
5. The information delivered by the tracking system

6. Location of the vehicle, mileage and speed are delivered to the centre.
7. d) How often the information is transmitted from the vehicle to the central control system
8. The information is updated every one minute.
9. The method of data transmission from vehicle to centre
10. The information is sent to and received from RFID tags by a reader using radio waves. RFID reader, basically a radio frequency (RF) transmitter and receiver, is controlled by a microprocessor or digital signal processor (DSP). RFID reader with an attached antenna reads data from RFID tags. Then, it forwards the data to the computer for further processing.
11. The cost per vehicle per day of using the system
12. Vehicle operation cost of this system approximately between $2 and $5.
13. g) Additional services that the system can provide
14. Additional services are external sensor providing status and equipment of vehicle and alert systems.
15. Limitations of the system
16. T he limitation of the RFID system is short range. The system is only available in short distances.

Recommendation

I recommend using Assisted GPS system. AGPS system has many advantages over any other vehicle tracking system.

- AGPS information includes identification of the visible satellites.

- Because the receiver is now searching only for specific signals, the amount of time it takes for a GPS receiver to obtain its first location of time-to-first-fix (TTFF) is reduced from minutes to seconds. This makes the system performance better.
- AGPS effectively increase the sensitivity of the receiver so that it is able to obtain and demodulate the satellite signals in areas where unassisted GPS could not.
- It is important to note that these advantages will be seen primarily under circumstances present when the device is in an unfriendly RF environment.
- In this circumstance, the Assistance information enables the receiver to obtain a fix more quickly than an unassisted device and in some cases, obtain a position fix where an unassisted device could not obtain one at all.

Task 2

Professional Mobile Radio (PMR) is radio communications system used to provide facilities of voice communication between base station and remote mobile users. The currently used standards of PMR are Terrestrial Trunked Radio Access (TETRA), APCO Project 25 and MPT-1327. Among them, I would like to explain about TETRA and APCO Project 25.

TETRA

TETRA is a modern standard of PMR and Public Access Mobile Radio (PAMR). Within a local area, a transmitter at a single site provides service for customers usually up to 45 km from the transmitter. Or sometimes, up to three transmitters at different sites. These transmitters are often called as

Common Base Station (CBS). If more than three transmitters are linked to provide a wider (national or regional) area, this is called PAMR. There are three categories (generic, open and proprietary), for equipment standards. TETRA is an open digital trunked mobile radio standard.

1. How method works?
2. The base station sends and receives from various mobiles continuously and TETRA uses Frequency Division Duplex. It also uses Time Division Multiple Access (TDMA). To protect eavesdropping, it has end-to-end encryption and over the air encryption.

Usually, 30 up to 1000 MHz spectrum bands have been identified to operate TETRA. But most TETRA system is operated in 380 to 400 MHz range. TETRA is implemented only in the spectrum bands reserved for its use. It doesn’t share with other radio system with other standards. The bandwidth for the TETRA network is 25 kHz/12. 5 kHz. TETRA provides 7. 2 kbps data rate. But an enhanced version of TETRA, TETRA release 2, can provide 130 kbps data rate.

TETRA has a facility called trunking that links the channels. The user doesn’t have to wait for a specific to be free. The users can share all available channels. The users can take up another free channel. It provides full duplex quality voice communications.

3. Details of the legal requirements for operating the system
4. For the allocation of frequencies, frequency bands within the identified range (380 to 400 MHz) are allocated general commercial mobile radio systems. The band plan uses 25 kHz spacing between carriers. To be

able to use frequency bands or telecommunications bands, a frequency license need to be applied. It is required to operate the system.

The documents required for applying TETRA license are:

- A copy of valid Business Registration Certificate
- A copy of relevant document to prove the valid owner
- Moreover, for the grant of the license by Ministry of Post and Telegraph, the licensee:
- Should ensure that any radio communications stations and equipment are designed in the way that doesn’t cause any interference.
- Should not suffer the person who uses the equipment involved in any of radio communications stations.
- Should ensure that any person comprising in operation of the system are aware of this license and other applicable license.
- Should permit any authorized person to inspect or test any equipment or to access the stations whenever emergency case happens.

5. Costs
6. The costs for operating the TETRA standard are as following:

The license can be renewable on an annual basis.

7. Limitations
8. TETRA handsets are more expensive than cellular phones ($1, 200). Although data transfer rate is efficient, it can only provide 7. 2 kbps

data rate per timeslot (3. 5 kbps per slot). But by combining 4 timeslots can turn into a single data channel and can provide higher rates. Also, TETRA requires higher cost as it requires sophisticated trunking equipment.

APCO Project 25

Project 25 (P25) trunked radio system is digital radio communications standard developed by Association of Public Safety Communications Officials International (APCO). It is standardized under Telecommunications Industry Association (TIA).

1. How method works?
2. P25 system uses APCO-25 Common Air Interface (CAI) standard. CAI standard enables to communicate with another CAI radio, regardless of manufacturer. It identifies the type, layout and content of signals transmitted. CAI uses Improved Multi-Band Excitation (IMBE). IMBE voice encoder-decoder transforms audio input into digital stream. The digital stream is then transmitted to the vocoder in the radio. It produces an equivalent of input sound.

P25 system can be either conventional or trunked. If conventional, specific frequencies are used for a specific group of radio users. If trunked, 9600-baud control channel (pure P25) or 3600-baud control channel (proprietary Motorola protocol) can be used. Currently, P25 system uses 12. 5 kHz wide channels. Usually, 300 to 800 MHz frequency range is available.

3. Details of the legal requirements for operating the system

4. To operate the system, license for APCO Project 25 need to be applied. When apply for the license, the following documents should be included with the application form.

For limited company,

- A copy of valid Business Registration Certificate and
- A copy of Certificate of Incorporation.
- For sole proprietorship or partnership,
- A copy of valid Business Registration Certificate and
- A current Certified Extracts of Information on the Business Register issued by particular Business Registration Office.

A copy of relevant document showing the applicant is the valid owner.

5. Costs
6. The costs for operating APCO Project 25 are as following:
7. Limitations
8. One disadvantage of APCO Project 25 is cost. It is costly than less specialized technology. Whether digital or analog, the radio may face interference as colliding transmission. Sometimes, losing signals occurs. However, interference can’t be heard and only noise occurs. Moreover, call setup delay and background noise can occur.

Recommendation

I would recommend using TETRA for the following reasons:

- It can provide large coverage area by linking three transmitters situated at different sites.

- It can also cut down infrastructure setting up cost as it uses lower frequency which gives longer range with few transmitters.
- For the security, over-the-air encryption and end-to-end encryption are available.
- Call setup rate is very fast.
- Equipment required for the system is available from a variety of suppliers.
- It can work at high speed (400 km per hour).
- If disaster occurs, fast recovery solutions and temporary capacity provision are available.

Task 3

To create an in-house network (LAN), I have investigated three topologies and three media.

Topologies

Star

In star topology, all computers are connected to a central device (switch, hub or computer) to transmit data. The central device, all computers and transmission links between them form a graph of star. The access method used is Carrier Sense Multiple Access / Collision Detection (CSMA/CD).

For the central device, switch is preferred to hub. Hub retransmits all data received from any computer to all computers on the network. But switch retransmits the specific message to the specific node only.

Although a transmission line is broken down, the rest of the network with the remaining computers will not be affected. But the failure of the central device will make the whole network unavailable.

Bus

In bus topology, all computers is connected to a single cable which is called “ backbone” having two end points. These end points should be ended with a device called “ terminator”. The terminator absorbs signal preventing it from being reflected back on the backbone in the opposite direction which can cause interference and degradation of the signals.

In bus topology, two or more computers cannot send data at the same time. If sent, collision results. To handle or avoid collision, CSMA/CD method is used. It allows a computer to transmit data only when the backbone cable is free.

Ring

In Ring topology, each computer is connected to exactly two other nodes and the first and the last computer are also connected to form a single pathway a ring. The access method used is Token Passing. The data is transmitted using a Token.

In the network, a token passes from one computer to another in a single circular direction. A token becomes busy when a computer puts data in it. Busy token passes through computers to destination. After destination computer has taken the data, the token has to travel to its originating computer to make a full circle. The transmission in the network is, therefore, slower.

Media

Basically, there are two types of media:

Bounded media

- Copper wire
- Coaxial cable
- Twisted pair cable
- Fiber optic
- Unbounded media
- Radio transmission lines

From the aspect of security, bounded media is better. So, I will explain about only bounded media further.

Coaxial Cable

Mostly, Ring and Bus topologies use coaxial cable. In the center of the cable is a copper conductor. Around the conductor is a flexible insulator which is covered with a metallic foil or copper braid acting as a shield.

Coaxial covers longer distance than any other cable. It offers higher bandwidth and higher data rate of 10 to 100 Mbps. Coaxial comprises of thick coaxial (10Base5) and thin coaxial (10Base2). 10Base5 provides 500 meters and 10Base2 around 200 meters.

Twisted Pair Cable

Star topology uses twisted pair cable. The cable has four pairs of wires inside the jacket. Each pair is twisted to prevent crosstalk (the noise produced by contiguous pairs). Two types of twisted pair cable are unshielded twisted pair

(UTP) and shielded twisted pair (STP). Both cables provide 100 meters segment length.

UTP is immune to electromagnetic interference (EMI) and radio frequency interference (RFI). The wires are wrapped with insulating material and are twisted. UTP supports 10Mbps to 1Gbps data rate.

STP has each pair of wire covered with a metallic foil. STP is immune to interference both within (crosstalk) and from outside the cable (EMI and RFI). STP supports 10 to 100 Mbps. STP is rarely used due to difficult installation.

Fiber Optic Cable

In the center is a glass (WAN) or plastic (LAN) core covered with many layers of protection materials. Light waves are used to transmit data rather than electronic signals removing EMI.

Fiber optic cable can be of two types: multimode and monomode. Multimode breaks down light waves into a number of paths along the fiber and are reflected off the fiber wall. Multimode supports 2km and data rate of 100 Mbps to 100 Gbps. In monomode, only a single stream of light flowed down each fiber strand. Monomode supports 1km and 100 Mbps to 9. 92 Gbps.

Main disadvantages are expensive special tools, handling and precision required to attach the connector and two cables required to send and receive data which double the costs.

Recommendation

I recommend using star topology and unshielded twisted pair (UTP). Star topology provides many advantages:

- Better performance: it prevents passing data to unnecessary computers. Every transmission needs only 3 devices and 2 links.
- Isolation of devices: each computer is connected to the central device with its own link eliminating breakdown of the whole network due to any non-centralized failure.
- Simplicity: it is easy to implement and understand removing complicated routing or message passing protocols.
- Future growth: expanding network is easily done by adding another concentrator.
- Star topology mostly uses UTP and UTP has many advantages:
- Most buildings are wired with UTP and, therefore, many transmission standards can be adapted to use UTP eliminating costly rewiring for an alternative cable type.
- UTP is the least expensive media for data transmission.

Task 4

Transmission of vehicle location data

In a network, any wireless device equipped can be an open invitation for threats to the entire network if there is no protection. The data transmitted over the network can be partially or totally observed by eavesdroppers or unintended persons.

While the data is transmitted over the network, there are two possible security risks. They are monitoring and access of data by unauthorized user and modification of data by unauthorized user. The former one can’t be known easily when the data transmitted is listened, read or copied. For the

latter one, it must ensure that the data passes the network without any modification. Whatever risk occurs, the network becomes insecure.

The consequences can be:

- Gaining access to the pathway of important customers
- Car kidnapping
- Reduced customers' trust

Voice communications transmission

For the voice communication network, voice conversation must be secure enough to prevent from eavesdropping and tampering. If an eavesdropper or a hacker gets access to voice conversation, he or she could rearrange the voice packets to provide new conversation. Also, a call between base station and vehicle can be redirected to different destination.

As the result of eavesdropping and tampering, the following can occur:

- Crimes
- Terrorizing customers
- Kidnapping customers
- Reduced customers' reliability

Recommendation

Whether voice or data communications transmission, integrity and confidentiality are important things and, therefore, a good security measure should be established. For any viable information security strategy, a robust encryption technology is required. The best way to protect security risks is encryption (data and voice).

Privacy and authentication are the two most fundamental facts of data encryption. Among two types of data encryption: traditional encryption algorithms and key-based encryption algorithms, key-based ones are better and more effective. Key-based one need to define a key to encrypt data and it produces another encrypted output. That output uses the key to decrypt.

In the encryption process, the plaintext (original message) is transformed by an encryption method into ciphertext (disguised message). In the decryption process, the ciphertext is retransformed into the plaintext. Among the various kinds of data encryption methods, the most popular one is DES (Data Encryption Standard), which is key-based.

Among the various kinds of data encryption methods, the most popular one is DES (Data Encryption Standard), which is key-based. In DES, block cipher is used. A block cipher is that a block of data all is encrypted at once and then, next block. It is claimed that the ciphertext encrypted with DES are completely secure. The sender and the receiver of the message should use the same private key.

For the security of voice communication, scrambling or encryption method can be used. The concept of voice scrambling (or voice inversion) is that it makes the signal reversed around a pre-set frequency. Encryption can be divided into two: hardware-based and software-based. Hardware-based can provide more secure and more useful encryption though they are expensive and rare. Although software currently available is free, a computer has to be used and it is not preferable. A hardware-based encryption method, DVP (Digital Voice Protection), is the most popular one.

In spite of the fact that voice encryption may add costs and complexity to the network, voice encryption is needed for safety and efficiency of the network as it ensures that the network is accessible by authorized persons only.

Therefore, voice and data encryption process is important for the network operation. It is more important then purchase of radio equipment and setting up of the network.

Task 5

This report is written for a taxi company, A2B Cars. The company provides transport services for individual clients, commercial organizations and other bodies.

In this report, I have carried out required investigation to implement a vehicle tracking system and two-way voice communication that the company requires. There are altogether four main subjects I have investigated for the company:

- Vehicle tracking system
- Two-way voice communication
- Network topologies and media for LAN network
- Security issues

Vehicle tracking system

The company wants to track its vehicle in order to provide route information, to provide information for security purposes and to dispatch the vehicle nearby to the customers. The company currently has 20 taxis and plan to

expand further. I found 3 systems to track vehicle: Automatic Vehicle Location (AVL), Assisted GPS and RFID.

All three systems can provide the required information such as vehicle location, average speed, status (engaged / unengaged), direction. AVL and Assisted GPS use GPS satellites to track vehicle while RFID use radio waves. All methods give satisfactory result for the requirements of the company. But some have limitations. AVL doesn't work properly under unfriendly RF conditions. RFID covers only short range. Although Assisted GPS is costly than others, it is preferable as it can provide:

- Better system performance
- Increased receiver's sensitivity working well under unfriendly RF conditions
- A fixed position
- Wider area coverage (easier to expand)

As the company is providing taxi service, it is important to track vehicles even in RF-shadowed areas. Therefore, Assisted GPS is the most suitable method.

Two-way voice communication

The company has five controllers for planning customers' journeys, routes for vehicles and dealing with customer telephone enquiries. Every controller will have his own workstation. For two-way voice communication between taxi drivers and the controllers, I found two systems: TETRA (Terrestrial Trunked Radio Access) and P-25 (APCO Project 25).

Whatever system is operated, you need to apply for the license. It is important to prove that your business is valid and registered. Two systems operate in different frequencies and bandwidth. P-25 is more expensive than TETRA. In P-25, signal loss can sometimes occur. TETRA is more secure with encryption, can offer fast call setup rate and less infrastructure setting up cost with few transmitters.

Network topologies and media for LAN network

For use by five controllers at base station, an in-house LAN network is to be established. The most popular network topologies are Star, Bus and Ring. Star network is more robust and Bus and Ring. In Bus, main cable breakdown results in network failure. In Ring, cable or a computer failure makes the whole network unavailable. In Star, even a transmission link or a computer fails, the remaining network can work well. This is one major advantage over other networks.

For media, Coaxial, Twisted Pair and Fiber Optic cables are investigated. Coaxial and Fiber Optic are very expensive although they can immune to interference than Twisted Pair. Unshielded twisted pair (UTP) is more suitable than Shielded twisted pair (STP) as UTP can be easily implemented on traditional phone wiring.

Security Issues

When implementing a secure network, the following characteristics should be considered.

- Performance

- After security solution is established, network performance should be measured to ensure that the network can function effectively. The security solution must not affect network performance.
- Transparency
- Security solution should be implemented in an easy and simple ways without adding any complexity to the network.
- Easy management
- Security solution should be easily managed by the network administrator.

To achieve a secure network, the best way is to encrypt data and voice. For data encryption, DES (Data Encryption Standard) is the most widely used method. It can provide very safe encrypted data block. For voice encryption, DVP (Digital Voice Protection) is used. DVP is considered to be very secure.

I hope this report can outline some guidelines for the network requirements for the company. In recommending th