Transit Surveillance System Design

Surveillance Systems designed for the transport industry bring out inherent challenges in product design and architecture.

eInfochips, with strong experience in building comprehensive, critical, complex and connected solutions, brings together expertise on multiple tools and technologies to meet these product design challenges.

This whitepaper elaborates on the design approach and technology exposure for Bus Surveillance Systems.

Contents

In London, there were 38,298 offences in 2010, or 105 per day. Some 12,000 CCTV cameras across the Tube network are vital in helping us identify offenders and reduce crime.

- ***BBC News, 21 Feb 2011***

A total of 43 charges have been laid in just 2 days across public transit networks in Sydney, for offences including assault, malicious damage, possession of drugs and knives and offensive behavior.

- ***ABC News, 13 May 2012***

“Installation of CCTVs will not only help in crime detection but crime prevention as well. The 'you are being watched' factor acts as a major deterrent.” (Police commissioner, Chennai, India)

– Times of India, 26 Dec 2012

This (Video surveillance) will reduce crime rate and traffic nuisance. The project shall allow tight control over any suspicious activities in the city. Disaster Management can also be assisted

– Economic Times, 18 Oct 2012

Preface

In the imperfect world we live in, crimes on public transport systems cover various offences committed on buses, railways, trams, cabs, subways etc. These offences could be against the fleet operator (system damages, vandalism etc.), employees (ticket checker, driver etc.) or the fleet users (pickpocketing, assault, eve-teasing etc.).

For emerging economies, law-and-order implementation is a major impediment to the safety of people. Public transport has been a soft target over the years, with zero traceability, negligible deterrents or forensic records admissible in courts.

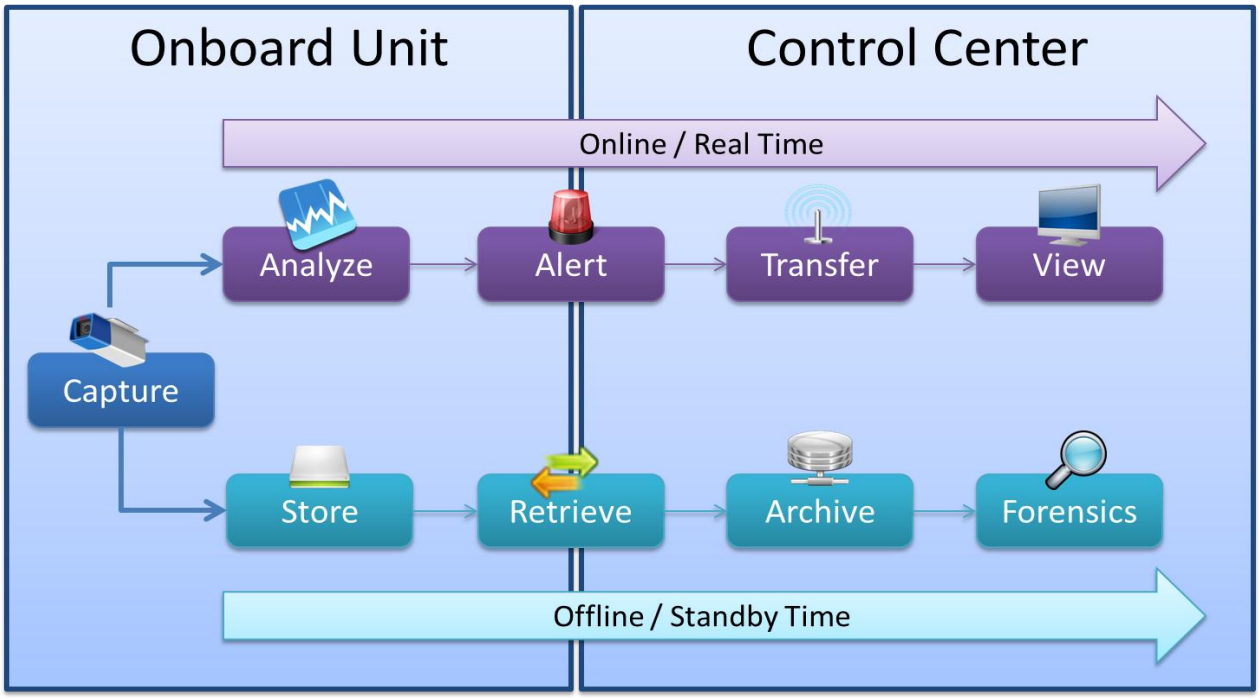
The challenge from an application standpoint is to ensure passenger safety and security on-board public transport systems. While the issue can be approached using multiple methods, this whitepaper will detail into how technology deployments have addressed it.

Concept

The concept of the solution is to have real-time data for preventive actions and post-event data for reactive and forensic actions. From an application standpoint, hence, the solution should have a two-pronged approach – Online and Offline.

The online thread would capture information (video, audio, location etc.), analyze it, and trigger an alert to the control center in case any event is reported. It would also then, begin transmission of live video and audio feed for the control center to assess the situation and take appropriate action. This real-time transmission would have information sufficient for emergency services to locate and track the vehicle identity and location. Each data point is coupled with a unique vehicle identity and its GPS location.

The offline thread would be used to retrieve, archive and store the data to a common repository for forensics and reporting.



As we elaborate this concept in the next section, we will also dive into the challenges that could come up in building a solution to match our requirement.

The Solution

For simplicity, we take the example of a *bus fleet*. While we will elaborate on the solution and its features for bus transit networks, the solution by itself can be adapted on other modes of transit like cabs, trains and subways without compromising on effectiveness and benefits.

The information and content considered for this process could be

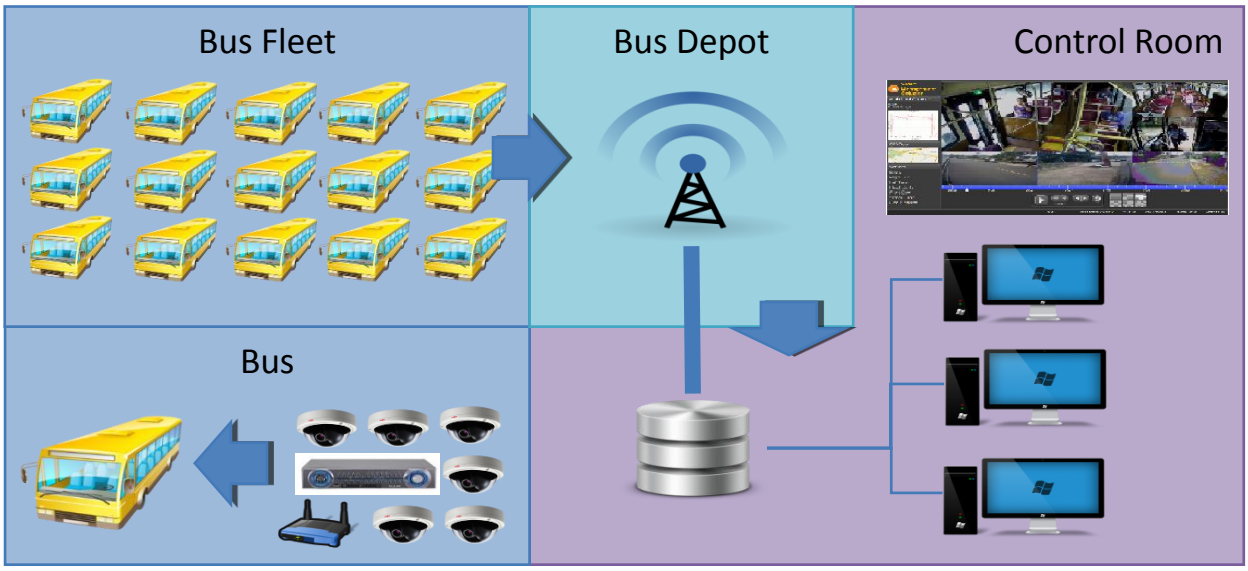
- Primary structured information (GPS Coordinates, timestamp etc.)
- Primary unstructured information (Video, Audio etc.)
- Secondary / Derived information (Vehicle Identity, Speed, Acceleration, Braking etc.)

The solution architecture needs to make adequate flexibility for all this information to be collated and interwoven into a single channel feed, and the ability to add other custom information later in the product lifecycle.

Storage of this information is complex, considering the quantity, versatility and variability of data expected to be available - over long periods and from multiple sources. The solution should generate event-triggered alarms and transfer real-time video and information feeds using cellular technologies (2G, 3G, WiMAX etc.). Archival Process indexes and segments the captured data for forensic analysis and record-keeping.

Solution Components

The solution comprises the Bus System, Depot System and the Control System.



Bus System

The bus system captures information relevant to forensics and analytics requirements. This information could be primary, secondary or derived. It can connect to multiple peripherals like camera, mic, vehicle telematics, GPS, accelerometer, siren and breath analyzer, among others.

Depot System

The Depot System is the relay and storage point for data captured on the Bus Systems' local storage. This is accomplished using Wi-Fi or Wired (USB/Ethernet) connections. This data is classified, segmented and archived for record-keeping and forensics.

Control System

The system comprises of multiple client terminals (proportional to the transit network expanse and the number of buses) that have access to the data uploaded from the Bus Systems on the Depot Systems to perform forensics, observations and analytics.

The control system would have a disaster monitoring process with a few dedicated alert stations that monitor real-time event triggers from different buses on the network.

Information Available

- In-Vehicle Video + Audio (Multiple Channels)
- Video + Audio from outside the Vehicle
- Vehicle Location and Timestamp (GPS Coordinates and Sync)
- Vehicle Speed, Acceleration, Braking intensity (Accelerometer, Location Track)
- Fire, Smoke, Accident Impact and Flood Alarms
- Engine Ignition (On/Off) and Telemetry
- Door Position (Open, Close, Lock etc.)
- Driver Check (Absent, Present, Attention, Inebriated, Driving/Stationary)

Analytics and derived benefits

Analytics	Benefits
Passenger Count	Counts the number of passengers boarding and alighting at each stop, number of passengers onboard
Audio Analytics	Generates Alerts and records video on capturing loud noises (collision, explosion, etc.)
Out-of-Route alert	Tracks the bus being on a pre-defined route, generates alerts if it moves away from the expected route
Tamper Alert	Generates alerts on detection of damage/tamper to surveillance equipment installed onboard
Driver Report	Composite report of average speed, top speed, acceleration, braking and other driving parameters
Localization Services	• Location based Emergency Services • Location based Advertising and Information Services

Design Challenges

Here are certain challenges product design teams are likely to face in building the architecture for a complex and critical system as the Bus Surveillance System.

IP Camera Power

While the IP cameras cope with one wire connecting to the Bus System, an additional wire would be required to supply power. Considering the spread of the IP Cameras within the Bus, it would be an installation nightmare for the Bus System.

High Definition (HD) Recording

While ideally we would like all video to be captured in HD, it is highly inefficient from a data storage standpoint, where data that is potentially of no use would consume a large storage capacity locally as well as at the repository.

Since the technology is available, the system should be smart enough to realize when HD recording is required, and more importantly, when HD recording can be turned off.

Memory Size and Type

The local memory storage of the Bus System should be an SSD, considering that the system would be subject to vibrations and shocks. Having an SSD though, would limit the storage capacity while driving up the product cost significantly.

Having a SATA HDD would reduce the cost of the overall solution, though compromising on the data reliability because of the high-accuracy moving parts inside the enclosure that might be subject to vibrations.

Additional Capacity

The solution should be scalable for more inputs. Hence, a modular design with a provision to accommodate additional IP cameras or other custom inputs as required in the future would serve well in the long term.

Data Transfer

There is typically very little time between two trips, leaving with little time to transfer the collected data to the Depot System over wireless. Considering that multiple Bus Systems would be accessing the Depot System at any given time, the transfer link should be wireless, high-speed, inexpensive and reliable.

Alternatively, there can be a removable memory module that can be swapped at the end of each day or journey. The complexity involved here could be the compliance and training of the fleet employees.

Design Approach

Considering the complexity and flexibility envisaged in the architecture and design of the solution, our teams recommend certain approaches that would overcome the challenges mentioned above.

- Use Power-over-Ethernet (PoE) to power the IP cameras, thereby reducing the wiring installation and maintenance complexities and costs
- The Bus System could capture pre-event HD data for 7 minutes and post-event HD data for 3 minutes, and archive it on the local and remote storage for forensic analysis
- There should be an intelligent balance between access to the SSD and the SATA HDD, keeping costs in check while reaping the benefits of the SSD
- The solution can have 2 modules – one with 4 ethernet ports and another with 8 – which can then be configured for 4, 8 or 12 (4+8) IP cameras
- There should be 10 custom inputs for future use with other required peripherals
- The wireless data transfer can be done using multiple Wi-Fi Access Points at the Depot System while the Buses are stationed there
- Even while the ignition is off, as the Bus Device should transfer the collected data to the Depot System using power from the bus battery

Technology Expertise

The transit safety solution involves bringing together a gamut of technologies working in tandem to achieve maximum benefits. From a system perspective, the solution requires experts from multiple domains and technologies to work together as early as the design and architecture phase, and continue to alter the designs as we discover new challenges on the development front. Some important technologies involved are listed here.

DOMAIN	TECHNOLOGIES
Video	H.264, MJPEG,
Audio	AMR/WB-AMR, AAC
Wireless	GSM, (E)GPRS, UMTS, GPS, Wi-Fi
Networking	IPV4/IPV6, Fiber, LAN, Power-Over-Ethernet
Storage	Solid State Drive, SATA HDD
Container	Proprietary (based on standard formats like avi and mp4)
Interfaces	CANBUS, USB, HDMI, Ethernet, Multi-screen Display
Analytics	Tripwire, Event Capture, Audio Trigger
Other	RTP/RTSP, HLS

Potential Benefits

The bus safety solution derives multiple benefits for all the stakeholders involved – fleet operators, law enforcement agencies and passengers.

Driver Behavior / Surveillance

- Connect alcohol sensors to discourage drunk driving and reduce associated risks
- Monitor when the driver is not in position, generate alert or turn-off ignition
- Driver report can monitor the driving habits, its impact on customer complaints and traffic violations
- Identify erratic driving habits
- Measure correction and improvements after trainings
- Better fuel efficiency, lower driving offences because of good driving habits

Fleet Operators

- Tracking the whereabouts of the buses in real-time
- Live video + audio feed from any bus available
- Alerts if the bus changes designated route / goes on uncharted routes
- Video capture acts as a deterrent to damage and vandalism of fleet property
- Can provide Expected Time of Arrival (ETA) updates to passengers waiting at bus stops
- Provide training and corrective action against erratic driving
- Reduce unlawful activities, thereby encourage passengers to use public transit networks
- Un-tampered evidence against false litigations available for judicial inspection
- Real-time route changes to avoid traffic blockages
- Real-time Alert if the solution is tampered with

Passengers

- Safety on-board, even while traveling at odd hours
- Real-time alerts of bus location and ETA
- Security and traceability of goods or luggage
- Comfortable travel experience with well-trained drivers

Law Enforcement Agencies

Crime Prevention

- Quick response times from law enforcement agencies
- Immediate information flow for early detection and action

Higher Conviction Rates

- Un-tampered video evidence available against anti-social elements for forensic analysis and litigations

Shorter Trial Periods

- Quick convictions due to availability of strong, un-tampered evidence
- Reduced effort from different agencies, efficient operations

Reduced number of offences

- Owing to deterrent result measures like a higher conviction rate
- 'You are on camera' syndrome

Crisis Monitoring

- Live monitoring of crisis and hostage situations with video and location details
- Real-time alerts in case there are life-threatening events in the vicinity of the bus

Example Use Cases

Assault on Passenger

As a passenger on the bus is attacked, the solution would generate real-time alerts for

- Detect shouts of the passenger being assaulted
- The passenger presses the ‘emergency’ button
- Another passenger on the bus presses the ‘emergency’ button

This alert will transmit real-time video to the control room, with the exact bus identity, and location from GPS co-ordinates. The law enforcement authorities can immediately reach the spot and rescue the victim, while use the recorded video as evidence to force easy and early conviction.

Device Tamper

Some passengers try to tamper with the surveillance equipment, for various reasons including to destroy evidence. Such a situation would generate alerts for the surveillance equipment being dysfunctional / tampered with. The control center can immediately take appropriate actions based on the same.

Inebriated Driver

There have been multiple incidents in the past, where inebriated drivers have caused loss of life and property. With the bus system in place, we can connect a breath analyzer such that the engine ignition is disabled in case the alcohol test fails. The Unit can then send an alert to the control station regarding the event in real time, to ensure appropriate action.

Vehicle Hijack

There could be situations where the driver, voluntarily or under threat, would take a vehicle off the designated route. A solution like the one described in this paper could provide an early warning to monitor and take control of the situation before it gets serious.

Unclaimed Baggage

At times, unclaimed baggage inside vehicles or at Metro/Rail/Bus stations and Depots can be a cause of theft, or even worse – terror attacks. With integrated analytics, the system can generate alerts if there is unclaimed or unattended baggage at any point. Also, the video and data captured can be used for forensics after an event / theft has occurred.

Tunnel / Road / Rail Inspection

Inspection of railways and roads, especially inside tunnels (on roads and subways) has always been an arduous task. The video systems with analytics can be used to automate the process, quicken it and ensure greater accuracy in inspection. With such a system in place, there is no need of special inspection vehicles and off-hours inspections on transit networks. This system can be a retrofit on regular wagons/buses and inspection can be done with day-to-day operations.

Lawsuits

In situations of accidents or passenger injuries, there often are lawsuits filed with insufficient information or evidence. The data recorded on the solution is on a proprietary file format, and hence cannot be tampered with or modified. This makes the recorded content admissible in courts to ensure quick conclusion for lawsuits.

Driving Habits

For drivers that are known to be rash drivers, or with a history of driving mishaps, the system can be used to monitor key data points like acceleration, braking, top speed, max speed and other such parameters. For drivers that have gone through trainings, improvements in driving habits can be quantified and measured using this solution. This would ensure fewer accidents and hence, safe driving.

About Us

eInfochips is an end-to-end product engineering services company, with over 18 years of experience in designing solutions customized to address specific business problems. With a strong focus on product innovation, we have developed over 50 solution accelerators – reusable solution components – that help our clients reduce time-to-market and keep development costs in check.

With 400+ products built for 100+ global clients across 3 continents, our experience runs across key industries like Avionics, Healthcare, Transport, Retail, Security, Surveillance, Media, Consumer Electronics, Semiconductor and Telecom.

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