Smart and Sustainable Bus Management

Laurent TAILLANDIER, Managing Director of Urban Traffic Management Systems, THALES

Lei ZHANG, R&T Engineer, THALES

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1. Introduction

1.1 Context THALES

Thales Group dedicates considerable investment and concentrated on the sectors of Aviation, Space and Ground transportation of China market. With great efforts, Thales wins a lot of successes in transportation domain including the modernization of Beijing Air Traffic Approach Center to prepare Capital airport for the 2008 Olympics, and modernization of the ticketing systems and signaling systems of Beijing, Shanghai among other cities, metro lines.

Other than the outstanding achievements, Thales does not stop evolution in technology in order to provide perfect techniques and solutions. In transportation domain, Thales offers a series of solutions and products in functions of City Surveillance, Control Center, Traffic Regulation, Communication and Law Enforcement. With our solution/platform, users can be profited an overall secure environment protected by Thales services.

1.2 AFMS (Advanced Fleet Management System)

An AFMS main objective is to provide a bus operator with an efficient operation tool that would reduce its operation costs while ensuring a good quality of service. It is basically composed of a central computer, equipment on-board each bus or tramway vehicle, a radio network linking both of them, and other positioning, information, communication, control and safety equipment. The demanding requirements in terms of transmission speed and regulation reliability, safety measures, equipment robustness, etc. make an AFMS significantly different from a telematics fleet monitoring system.

Thales has pioneered the fleet management in the 1970's, addressing at that time new needs of bus and tram transport operators to automatize some of their operations. Since 40 years, Thales continuously evolved its solution integrating new technologies and new operational functions.

TransCity is a Thales fleet management solution.

The TransCity Advanced Fleet system has the capacity to manage a fleet of heterogeneous vehicles which can consist of types of following vehicles:

- Bus (minibus, standard, articulated, mega-bus)
- Trolley bus (standard, articulated)
- Tram (simple train, train doubles)
- Vehicle of service or maintenance

The systems supplied by Thales offer the following benefits:

- ✓ Efficient safe operation of the fleet by providing
  - Intelligent radio-communication system
  - Continuous vehicle positioning (with or without GPS)
  - Managing schedules, headway and interchanges
  - Management of priority at traffic lights
  - Integration with vehicle and crew scheduling systems
- ✓ Provide real-time information to users
  - On board-vehicles
  - At stops and interchange stations
  - Directly through Internet or mobile phone communications
- ✓ Provide condition monitoring by
  - Real-time transmission of operating alarms
  - Permanent monitoring of vehicle mileage,, etc.

- ✓ Monitor the performance of the network by providing
  - Daily reports and statistics
  - Analysis of operating data

2. TransCity General Architecture

2.1 General Description

The following figure displays the general architecture of the system

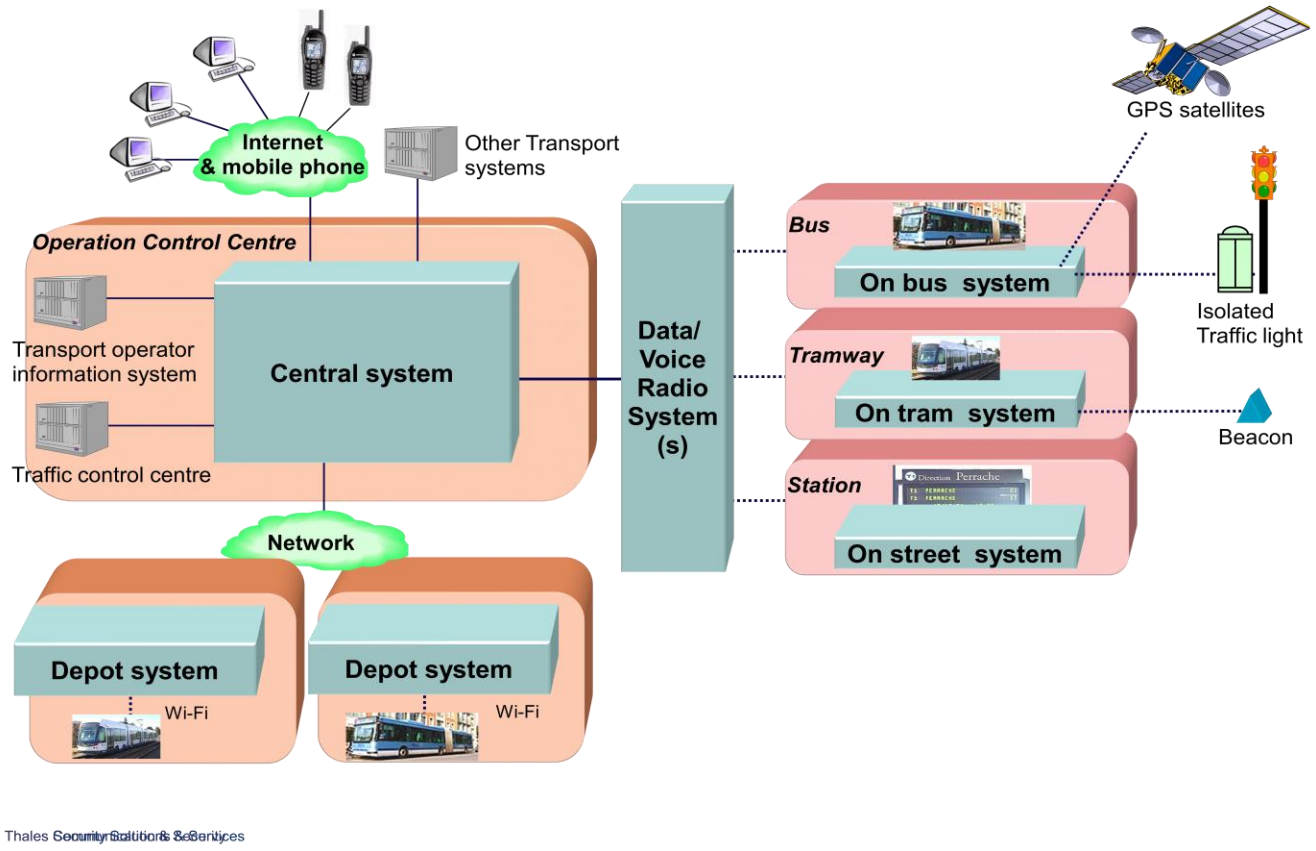

Figure 1 TransCity general architecture

The TransCity Advanced Fleet Management system consists of:

- ✓ A central system intended to collect the information of all the vehicles, to coordinate the movements of vehicles and to transmit the relevant information to all the external systems
- ✓ Specific posts in the garages and a short-range radio system, used to exchange the information relative to the configuration and to the operational data
- ✓ An on board system on each of the vehicles of the fleet
- ✓ A long-range radio system allowing the communication voice and data between the central system and all the participants (vehicles, mobiles)
- ✓ A set of equipments (bus/tram signs) or of external systems (Information system of the Customer) with which the TransCity Advanced Fleet Management system is going to exchange information

2.2 Central Architecture

2.2.1 Real-time Server

The Real-time Server provides the functions:

- ✓ Fleet management functions
  - The management of the voice calls
  - The management of the distress calls
  - The management of the transmission of data in interface with the server of radio communication or nodal radio
  - The processing of help in the interventions
  - Control of the operation (localisation …)
  - Enhanced service control management
  - Driver Management
  - Supervision and management of the alarms
  - The management of the interfaces with the external systems (reference table data operation, centralized server by management of crossroads)
- ✓ Traveler information functions
  - The information management traveler (commercial messages, messages of disturbance, waiting time) for all the signs at bus or tram stations
  - The information management traveler (commercial messages and messages of disturbance) for all the headbands of information travelers installed aboard vehicles
  - The supervision of the equipments of information travelers (signs) in station directly connected to the real time server

2.2.2 Delay Server

The delayed server allows the user to do statistical analyzes by querying the database with predefined reports or by building themselves their own reports. The delayed server provides the treatment of automatic removal of obsolete data (exceeding online archive of statistical data). Note that the system can restore previously saved data and can exceed the nominal duration of archiving to perform analyzes over periods greater or comparisons between different periods.

2.3 Garage Architecture

2.3.1 Garage Server

To exchange larger data volumes with embedded computers in vehicles, a repository server and a WiFi infrastructure are implemented at each garage.
The garage server is responsible for:

- ✓ To distribute the necessary data to the onboard computers in vehicles to ensure its functions, including location, passenger information (including talking dictionaries and text), monitoring schedule (including hourly forecasts), both for the current operating day or the next day
- ✓ To distribute a new version of embedded applications.
- ✓ To distribute an implementation schedule for each day defining operational lines, type of schedules that is applicable, the version numbers of the data to apply and the version number of the application to implement.
- ✓ To collect statistical data and laboratory developed and recorded by the onboard computer, and make these data available in the central system in order to import it into the delayed server.

This storage capacity allows the onboard computer to have a fully autonomous mode of operation over several days, whether in the event of unavailability of communication with the garage server or unavailability of the central system.

2.3.2 Wireless Communication Network

A communication network type wireless WiFi 802.11 b/g/n is used to perform data exchange with the vehicles.
Data exchanges take place in areas of storage deposits: for this purpose, a collection of databases and antennas is deployed inside the deposit to obtain optimal coverage of all areas.
Data exchanges are based on standard TCP / IP protocol implemented on Ethernet networks such as FTP. This protocol ensures a level of integrity and good safety during the transfer process.

2.4 On Board Vehicle Architecture

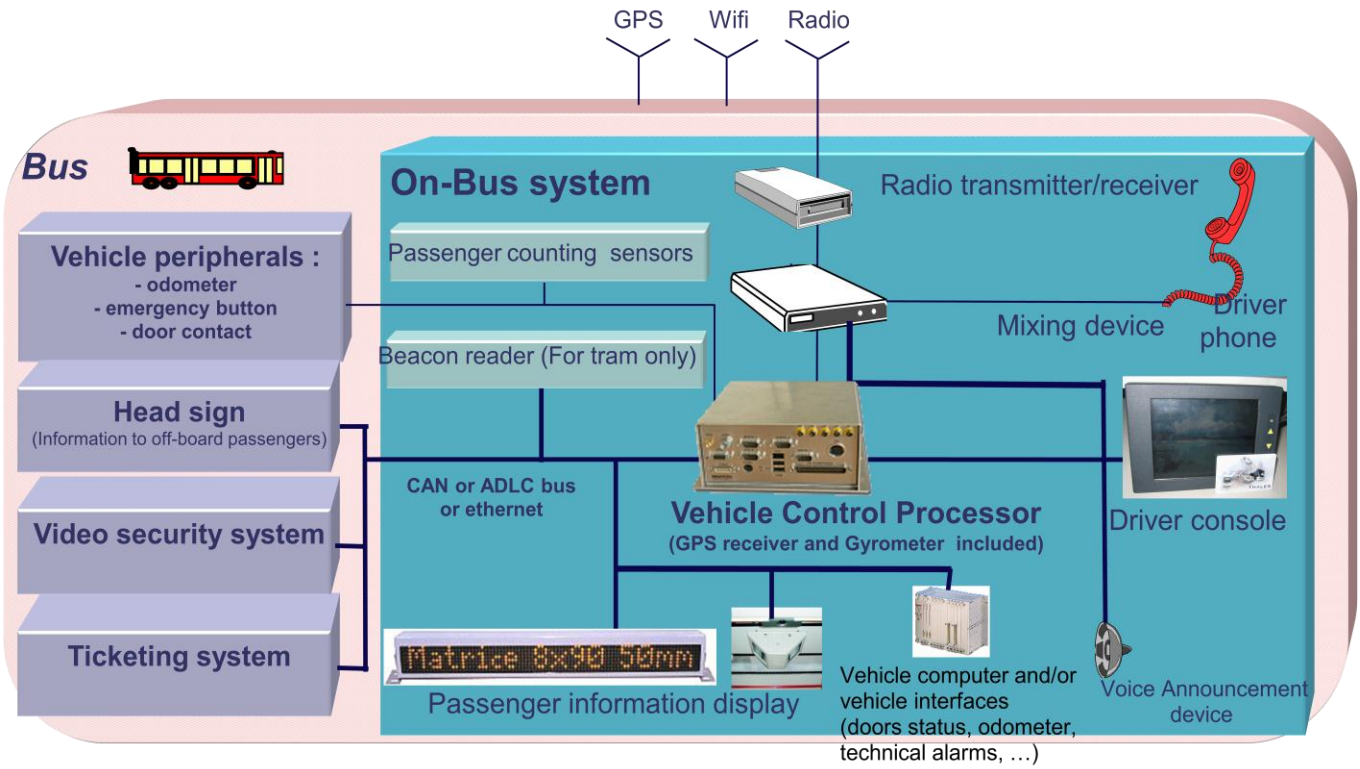

Figure 2 On Board Vehicle Architecture

The calculator provided by Thales manages:

- ✓ Dialogue with the Radio Transmitter/Receiver to
  - Transmit messages to the Central
  - Receive messages from the Central
- ✓ Communication with the tag reader for trams
- ✓ The acquisition of odometric counter
- ✓ The acquisition of unlocking doors
- ✓ The acquisition of GPS coordinates for buses and in option for trams
- ✓ Voice communication (driver, passengers with Public Address System)
- ✓ All information provided by the existing subsystems like:
  - Passenger Counting System or sensors
  - Internal Vehicle Computer if any
  - Ticketing system
  - Head Signs
  - Video Security System

3. Functional Architecture

3.1 Signing On

Vehicle signing-on sets the relationship between a vehicle and a block [runningboard] with a view to defining the vehicle' route and schedule. The operator carries out vehicle signing-on by the Central.
The signing-on process consists can be realized by the driver on board or by the operator on central: only the line number is used, which will link the vehicle to the topology, and a block identifier which will allow the selection of the journeys the vehicle is expected to follow. These data are transmitted to the vehicle over the radio link. If the check succeeds, the signing-on is registered both on-board and at the control centre. If a vehicle leaves a garage without a planned journey, the signing-on process can be performed by using 'special' block identifiers.
Once the signing-on process has been carried out on garage exit, it is not required any further, apart from when there is a change in the vehicle block, or if the vehicle goes back to the garage.
The signing-off process or vehicle end-of-service is implemented at the end of operation of a vehicle automatically when the vehicle enters the garage and the block is finished.
For each block, the AFM system monitors the time of signing-on. If it is not carried out at the planned time (within an authorized delay period), a 'late signing-on' alarm is triggered.

3.2 Vehicle Location

The location of vehicle is the basic information used by the TransCity Advanced Fleet system. Vehicle location is sufficiently accurate to permit the management of relative positions (for example when one vehicle is running behind another), positions on common sections, stop and terminal arrivals and departures, passenger information at stops, and the approach to intersections equipped with traffic lights if necessary.
The location process is based on GPS technology for buses and on beacon technology for trams. It is provided by the embedded systems carried on board the vehicles, which have the information and sensors necessary to identify the position of the vehicle on its route.
The control centre obtains the position of each vehicle by polling the vehicle fleet cyclically with location request messages. The vehicle location polling cycle depends on the long-range radio resources and the refresh frequency. The figure below shows the polling procedure.

The vehicles may be located at any point on the network, and may be on the operating line routes, at stations, at terminus or in the garage.
For each bus in operation, location is determined by:

- ✓ The on-board system, using the information provided by the **GPS satellites**
- ✓ An **odometer** connected to the gearbox output which delivers pulses proportionally to the distance travelled
- ✓ A **single-axis gyrometer** oriented along the vertical axis which generates a signal proportional to the angular velocity of the bus in turns
- ✓ **Door open / closed contacts**

3.3 Fleeting Operator's MMI

This section describes the AFM man machine interfaces, allowing the Controllers to monitor the fleet of vehicles in real time. This MMI is available on the AFM workstations at all AFM workstations.

Ergonomic Principles
The ergonomic principles used for the fleet monitoring MMI are the following:

Non-specialization. The operator workstations are general-purpose workstations except for those which offer touch screen presentation. In either case, the hardware platforms are similar, and the same man-machine interface is proposed on each machine. The functions available on a workstation depend on the profile of the user who opened the work session. The non-specialization of the operator workstations simplifies the centralized administration of the workstations, particularly with regard to user management.

Modularity. The man-machine interface applications are designed in a modular fashion as an assembly of components, each offering a set of functional features. User profile management is based on this modular approach. Each profile is associated with a set of functions, and only the components associated with these functions are active and accessible once the session is opened. This modular approach guarantees good scalability of the man-machine applications.

Look and Feel. The presentation of screens is organized around a main console (menus and hot-buttons), tool bars, graphic windows and dialogue boxes. The operator actions are performed interactively using the keyboard and the mouse or touch panel and stylus. Some elements in the views are sensitive and allow actions to be initiated by direct selection. As a general rule, an ongoing dialogue does not prevent the updating of images or reception of events.

Operating Assignment

Network resources. The network resources are broken down into the following categories: Vehicle operator, garage, lines and vehicles. A vehicle operator owns several garages. A garage comprises several lines. A vehicle is associated with a regular garage and may be assigned on a line.

Data availability. All network resources are available on the non-garage AFM workstations. In the garage, the availability is limited to the resources of the transport operator associated with the garage.

Transport resources assignment. Even if an operator can view any resource available on his workstation (see above), he cannot apply control actions on them without specific access rights. The objective of resource assignment is to allow a controller to apply control actions only on 'his' resources. The resources to be assigned are the lines and the garages. A line or a garage is assigned to a workstation and cannot be shared with another workstation. A controller can only apply control actions to the lines assigned to his/her workstation. The standard configuration consists of managing the garage resources on the workstations located in the garage. The lines can be shared between the garages operators using the mechanism described above.

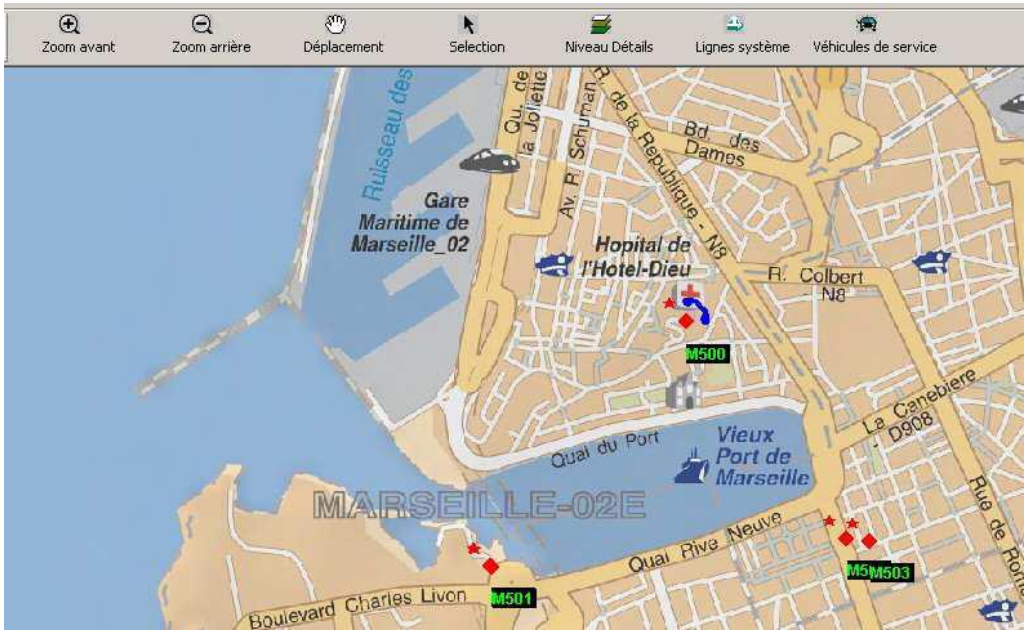

Figure 3 GIS view example for MMI

4. Benefits

The benefits for a bus/tram operator to implement an AFMS
The primary benefit is to utilize a minimum number of buses and capture maximum revenue in return of a good service provided to satisfied customer. It translates in:

- ✓ An efficient real time regulation, with voice communication reduced to the minimum, using an appropriate radio network to carry both data and voice transmission,
- ✓ A boost in the staff efficiency (for example with computer assisted scenarios for decision making process, precise shift management, etc.),
- ✓ Last but not least, savings in other areas as fuel consumption, asset management and maintenance works.

The benefits of an AFMS for a bus or tram passenger

In parallel to the reduction of operation costs, it shall provide to the users a perceived increase in the quality of service and comfort. This goal is largely achieved thanks to:

- ✓ Better adherence between the published time tables and the actual bus/tram arrival times,
- ✓ Information provided via the web and at bus or tram stops, on next arrivals when waiting for your vehicle, especially in case or delays/problems,
- ✓ Modern monitoring and information tools specifically implemented for care and security of passengers,
- ✓ The combination of the above, heavily impacting on the passengers and drivers stress, provides at the end a general feeling of better satisfaction.

5. Thales Solution Benefits

Studies have been conducted, to compare bus operations with and without an efficient FMS like TransCity. Results were very positive: a bus operator can transport the same number of passengers, while providing a better level of service, with the following impacts:

- ✓ Less 5 to 10% in the number of bus/tram vehicles needed
- ✓ It can go down to less 10-15% of bus/tram vehicles when the AFMS is combined with a traffic light management system
- ✓ It can also allow an increased revenue in fare collected, when taking the opportunity to implement a more efficient fare structure and a better control of the fraud, both made possible by TransCity solution

6. Conclusion

TransCity is an efficient advanced fleet management solution, benefiting from Thales 40-year experience in the domain.

TransCity provides an open platform, which allows a bus operator to not only implement an operation tool but also allow an integrated approach with other functional systems of its transport network, for example:

- ✓ Bus and tram ticketing: an integrated system would share communication, localisation and monitoring means for an efficient distance based fare on-board ticketing system
- ✓ Traffic Management: an integrated system would give priority to buses running late at traffic lights

The features and functions of TransCity will bring to any bus operator a powerful platform to implement alternative strategies for improving service, improving fare structure, improving efficiency in term of revenue return, etc…

With TransCity, the expected increase in operational profit rate justifies the investment assumptions.