1. Introduction

This Smart Fare Collection and Vehicle Management Solution comes with the following features:

- Modern, future-proof, state-of-the-art architecture;
- Suitable for all ticket media (paper, smart card, barcode, etc.) and ticket types;
- Including cashless sales via debit and credit cards;
- Affordable and easy-to-install vehicle hardware;
- Extremely reliable and robust vehicle hardware;
- Cloud-based back office system (software as a service).

This system solution focuses on the essentials needed for a modern ticketing and vehicle management system, eliminating unnecessary components. This results in low procurement, installation and operating costs. However, no compromises are made when it comes to the extremely reliable and robust vehicle hardware.

The system software, both for the vehicle systems and the back office system, is modularized accordingly. We offer a complete solution that essentially contains all major functions. These functions can be implemented immediately or sequentially. Customer-specific extensions or modifications can also be made later at any time.

This basic system can be expanded in many ways, even retrospectively, depending on the requirements. On the one hand, this applies to the vehicle hardware, the vehicle software, and the interfaces to other vehicle systems including existing systems. On the other hand, it applies to the back-office software and the interfaces to third-party systems.

2. Vehicle Business Processes

2.1 Fare Collection / Ticketing

The basic solution consists of a driver unit with a paper ticket printer and a validator. This solution enables the following business processes:

- Sale of all types of paper tickets: single tickets, multi-journey tickets, season tickets, and much more;
- Sale and/or validation of smart card-based media such as Mifare Ultralight, Mifare Standard, and much more;
- Sale and/or verification of all types of barcode tickets; paper ticket with barcode or Smartphone-/App-based barcodes;
- Cash sales or cashless payment via bank cards;
- Recording all sales data including shift account reports.

Paper tickets are often used for single tickets, Mifare Ultralight for multi-journey tickets, or Mifare Standard for season tickets or groups such as students or pensioners. We process positive or deny lists. We can verify barcode based tickets, paper-based or Smartphone-/App-based. Specialty services such as vouchers for tourists or reservations for intercity buses are also possible. The systems can also be used stationary for sales at customer centres or at kiosks. We are able to adapt to all possible standards, including proprietary ones.

2.2 ITC Intelligent Transport Control / Vehicle Tracking

The solution includes vehicle management systems (ITC Intelligent Transport Control / Vehicle Tracking), which include among others:

- Detection of the current vehicle position via GPS;
- Transmit the current position to dispatcher in real time;
- Automatic determination of departure stop and zone;
- Routes are displayed; Various routes are possible; Stops and routes can be assigned to fare zones;
- Messages from the dispatcher to the vehicles or vehicle groups or messages from the vehicle to the dispatcher;
- Real time data is provided for passenger information at the web or for mobile or stationary passenger displays;
- System can operate with or without integrated timetable or planning system; existing timetable systems can be integrated; alternatively we provide a timetable and planning system.

Here, too, we are able to adapt to all possible standards, including proprietary ones.

2.3 Extensions

It is, of course, possible to adapt or expand this basic system. The vehicle hardware can be enhanced or interfaces to third-party systems can be created within the vehicles.

If a smartphone/app-based ticket sales solution is being considered or is already in operation, such tickets can also be checked within the vehicle at the validator.

It is also possible to increase the number of validators in the vehicle, even up to the implementation of a paperless, so-called ID-based ticketing system (IDBT).

The focus of the approach described here is on a cost-effective, complete solution that should be suitable for most areas of application. However, this solution can be extended to include for example:

- RTPI real-time passenger information systems,
- vehicle announcement systems,
- driver communication systems,
- sales systems for points of sale or private kiosks or
- portable solutions (handhelds) for inspectors.

3. Vehicle Hardware

The basic solution consists of a driver unit with a paper ticket printer connected to a validator.

3.1 Driver Unit

The driver unit consists of a powerful industrial processor with a 10-inch touchscreen and a full-graphic thermal paper ticket printer with maximum printing speed of 200 mm/sec. The device is very easy to operate thanks to its vandal proof touchscreen. The device is compact (only 260 mm wide), making it easy to install in any vehicle. The device has a smart card reader, an audio speaker and further interfaces and is able to control vehicle RTPI or voice announcement.

3.2 Validator

The validator is designed for passenger operation, which screen also serves as a passenger display. The validator processes all types of smart card based or barcode tickets. The device also supports cashless payments using standard debit and credit cards like Mastercard, VISA, Amex, Discover and others including Apple Pay™, Google Pay™ et cetera, preferable based on the MTT/PAYG standard. Optional touchscreen or validators with larger screens are available too. It is also possible to operate multiple validators in the vehicles.

3.3 Installation and Operation

In-vehicle installation is easy and can be carried out by the transport operators themselves. The driver unit is connected to the vehicle via a bracket; minimal space within the vehicle is required. The validator is mounted facing the passengers; here also minimal space is required. Both devices are connected to the vehicle's power supply and linked to each other via a LAN cable.

All data is supplied via cellular data (3G, 4G, option 5G). This also applies, of course, to all software updates and other related issues. Only paper rolls need to be replaced occasionally; otherwise, the system is maintenance-free. The cellular and GPS antennas are integrated; external vehicle roof antennas are not necessary.

The vehicle system is connected to the back office via mobile data communication and the Internet. It is a fully online and partly also a real time system. It is not needed to transfer data manually between the vehicles and the back office. During operation, the systems can be accessed online from the workshops at any time.

4. Back Office

4.1 General

The back office is implemented as Software as a Service on a web server. We take care of the whole server and back office software administration. Access to the back office is purely browser-based via any end device (PC, notebook, tablet) without additional client software needed at the end device. For reasons of (operational) security we only use Linux as operating system.

The back office system is used for system administration and monitoring of the vehicle systems done by the sales department, the dispatcher office or the workshop. Standard language of system - driver units and the back office system - is English. But any other language can be added via specific language translation files.

The back office system is operated on a dedicated server located in a highly secure, ISO 27001-certified environment from Germany's largest provider. The available computing capacity, storage space, and transaction performance are individually tailored to specific customer requirements. The servers are connected to key European internet exchanges with multiple redundant connections, each with at least 5 Gbit/s connectivity and have nearly 100% availability. By default, a primary system is delivered, with daily data backups. A second standby system can be operated upon request. The systems are extremely secure against external attacks; in the last twenty five years we have not had any problems with external attacks.

4.2 Business Processes / Modules

The system contains several modules for example such as:

- Device Management
- Tariff / Sales Management
- Smart Card Management
- Shift Management
- Payment Service Provider Interface
- ITC / Vehicle Tracking / RTPI
- Data Base Management
- Process Management
- User Management

4.2.1 Device Management

The device management administrates the driver units and the validators. Software versions and configuration data are hold in the system and can be send to the devices. It is possible to configure device groups. The status data of the different devices are received from the devices. The status data are shown at the back office. It is possible to get many different reports about the devices.

The whole process (upload, download) is done automatically, so no need to do something for the workshop or the driver personal. Configurable monitoring monitors are possible depending on the user's task. The tabular or graphic representations are based on the recorded data.

It is also possible to manage different device generations in one single system. It is also possible to manage different vehicle configurations in one single system. It is also possible to manage systems from other manufacturers within the system. Unusual conditions can trigger alarms, which can also be reported via email.

4.2.2 Tariff / Sales Management

Here all tariff and sales related data are managed. These data are necessary for the sales and the check processes. Part of these data are the different ticket types for different passenger groups plus the zones where the ticket types are valid or sold for. The distribution and update processes to the vehicle systems are done automatically.

Various price models are possible, such as flat price, distance price, price based on customer categories et cetera. There is a layout editor to create graphical print templates. There is an editor to put together ticket assortments. A further editor is available to create relation-based tariffs using matrices.

Sales based on paper tickets also with barcodes or smart cards are recorded in the system and can be evaluated there. The same applies to shift accounts. All data can be evaluated in the system itself or transferred to company internal or third-party accounting systems.

4.2.3 Card Management

This modules manages the smart card related business rules. The rules can be configured differently depending on the ticket type. The displays (texts and graphics) on the validator or driver unit may also differ depending on the ticket type.

This business rules are administrated at the back office and then distributed to the vehicle systems automatically. This module receives all smart card check or processing data. These data are vehicle / vehicle number related. The import of these data from the vehicle systems and the later export to the accounting system of the transport operator is done automatically.

4.2.4 Shift Management

This module receives all sales data and end of shift data. These data are sales personal / driver personal related. This affects all sales via paper tickets or smart cards. The import of these data from the vehicle systems and the later export to the accounting system of the transport operator is done automatically. This module also manages the sales personal means the drivers. Each driver has a personal login with a personal PIN. Use can also be linked to a driver smart card. Regarding every sales personal a specific account is managed.

4.2.5 Payment Provider Interface

We provide an interface to a transit PSP (Payment Service Provider). Payment processing is almost entirely automated. The PSP processes the payments through an acquirer, which automatically credits the cashless payments to the transit company on a regular basis. Paper-less ticketing such as ID-based / ABT account based ticketing is also possible.

4.2.6 ITC / Vehicle Tracking

The drivers can select a journey and a block which the driver is driving. I journey contains the start stop, all stops of a line and the destination. To each stop the location data = the GPS coordinates and the zones are assigned. This information on the vehicle is used for the automatic zone detection. Because the actual vehicle locations are send constantly and in real-time to the back office, the actual vehicle location is known to the back office in real-time. There are different views possible like for example the actual vehicles in use.

These real time information is used for the dispatcher and for real-time passenger information if such systems are implemented. There are also Geo Maps possible showing the actual vehicle locations. Such real-time passenger information can be distributed via the web, external stationary real-time passenger information displays or display within the vehicles.

This current vehicle information is used for passenger information. We can share this information with various online information systems or with stationary or in-vehicle displays.

GIS reports, programmable charts, and customizable pages for long-term statistics are possible. Furthermore, there is AI-based vehicle tracking and announcement. The system automatically learns from the regular vehicle movements and then makes predictions about their actual locations. The goal is to inform dispatchers if, for example, a line or vehicle is unplanned out of service.

4.2.7 Data Base Management

The database tables are managed in the back office. A large number of tables for device management, tariffs, products, sales, shift accounting, smart card data and so on are affected. Reports can be executed via standard SQL scrips.

4.2.8 Process Management

The data from the data base can be evaluated manually or automatically via automated processes. Automated processes lead, for example, to automatically generated monitors, to watchdogs sent via email or to regular import and export of data.

4.2.9 User Management

The back office users are managed in user management module. The users can be combined into user groups. Different access rights can be assigned to each user or user group. For example, the sales, accounting, dispatcher or workshop departments can have different user rights. Other specific access rules and rights are possible. The user languages are also managed in this module. The default language is English, but any language can be added. The individual user determines its language.

4.2.10 Interfaces

The back office interfaces with other systems already existing at the transport company. This point needs to be discussed again in detail. As of today, the following interfaces are likely:

- Transfer of sales data to third party systems at the billing department for example.
- Online export of real-time vehicle data to third party applications or systems.
- Payment service provider interface for open payment with debit or credit cards.

5. Services and support

We provide all the services necessary for implementation and long-term support:

- System planning, system installation, etc.
- Training (workshop, sales department, dispatcher)
- System operation (back office)
- System support

System operation is typically split between our customers and us. This split varies from project to project. Usually our customers manage the vehicle systems themselves. We then operate the back office. Our customers handle the day-to-day tasks themselves. In exceptional cases, we work closely with our customers together. Support is provided via service tokens, emails, and our proprietary video conferencing tool fully integrated into our back office system. The systems - both vehicle and back office - are monitored automatically via watchdogs. These procedures have proven successful over the past twenty five years.

6. Commercial Framework

Our customers typically purchase the vehicle systems; however, we have also worked with leasing companies. The back-office servers are leased, and we charge only the cost price. We then issue software licenses, which are billed during the usage period. Support and maintenance costs are also added. The final amounts for licenses and support depend on the system functions and modules actually deployed.

Before starting a project, we typically develop a detailed specification containing all essential system features. This includes the vehicle hardware, the front-end software, and the back-office functions. This also includes interfaces to third-party systems and a delivery plan.

The software is provided in parallel with the production, delivery, and installation of the vehicle hardware, with the latter primarily involving the customer-specific system configuration. Depending on the complexity or size of the project, this process can typically take a few months. If cashless payment is desired, the transit PSP and the acquirer will also be integrated during this time.

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