To the Evaluation committee of WITSA Global ICT Excellence Awards 2016

INTEGRATED SYSTEM FOR AUTOMATIC VEHICLE LOCATION AND AUTOMATIC FARE COLLECTION FOR THE SKOPJE PUBLIC TRANSPORT COMPANY

DETAILED TECHNICAL DESCRIPTION OF THE SOLUTION
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1. AUTOMATIC VEHICLE LOCATION SYSTEM

1.1. High level system architecture and components

EuroGPS SmartTracker Public Transportation is a telematics solution for public transport, providing a comprehensive set of tools for automation of all processes of planning, real-time control, and management of mass transit operations in urban and extra-urban areas.

The EuroGPS SmartTracker Public Transportation is a centralized system with 3-tier architecture (application, database and presentation layer) and a separate communications server to manage all communications with the vehicle equipment.

It is managed at a central level by various user groups: administrators, users and operators, and allows management from multiple locations, in accordance with their management rights.

The system is governed and managed centrally in the Municipal Control Center and facilitates planning, operational control, providing real-time passenger information (RTPI - reporting system for passengers).

Client application

The solution comes with web application that provides passenger information in real time (virtual signs for bus stops, planning trips, etc.), together with a Windows thick client application for the control center employees.

The Windows thick client application is a fully functional solution for massive transport control that enables fleet management, operational management, planning timetable and the timetable in real time, control of public transport vehicles, including buses, trolleybuses and trams.

Benefits for the City

- Up to 30% reduction of municipal mass transport operating costs
- Control and management of all processes in the public transport
- Optimization of transport processes in urban and extra-urban areas, including transport scheme, timetables, vehicle and driver rosters, etc.
- GPS vehicle tracking and real-time control of timetable and schedule execution
- Driver assistance services
- Passenger counting
- Electronic ticketing

Benefits for public transport passengers

- Real-time passenger information in vehicles, at public transport stops, online, and on mobile devices
- Visual information, voice announcements, and SMS notifications
- Fully-featured trip planning via public transport in urban and extra-urban areas
- Infotainment and online services in public transport vehicles and at public transport stops
The diagram below shows the overview of the solution high-level architecture.

1.2. Digital map

The application possesses its own advanced tool maps, creating a fully functional Geographic Information System with powerful and rich functionalities:
- Geocoding of unlimited number of objects and adding zones with arbitrary shape and size as points of interest (POI’s) on the map, which enables high-quality analysis and processing of geo-spatial data regarding bus stops, depots, terminals, garages as well as all other sites / facilities within the system for mass transit.
- Creating zones with arbitrary user-defined rules for the behavior of the vehicle (advanced geo-fencing (geo-fencing)),
- Planning a route and timetable and performance monitoring of the actual route and timetable, stopping in areas and regions, entering or leaving the area, visit the geocoded objects and other data analysis, based on geographic information

All cases of rule breach can be immediately reported to the central system through various ways of signaling (via SMS, email, instant messaging and visual and audible alarms in the graphical user interface (GUI)) and recorded in various structured reports by the application reports.

1.3. Vehicle equipment

**Main vehicle module - EuroGPS SmartTracker ALM-3A**

GPS devices collect data in real time for the location, direction, route, speed, engine status, fuel level and other information of optionally connected sensors, such as: doors, gates, speed, engine rpm, temperature in the cargo refrigeration compartments or cabin, buttons for panic, RFID readers, the actual amount of fuel, number of passengers in the vehicle and allows connection of more additional sensors or devices such as flow meters, sensors, fuel temperature and pressure, security devices and more.

EuroGPS SmartTracker ALM-3A uses GPRS communication to transfer all information to the central system. The data communication mode can dynamically be switches between “operating mode in real time” and “mode of optimization of data traffic.” In operating mode optimization of data traffic, GPS device sends information to the central system at intervals of approximately 70 seconds. This interval is considered almost real time and is fully acceptable to control the operation.

EuroGPS SmartTracker ALM-3A is highly adaptable and intelligent GPS AVL device with OTA setup, remote diagnostics and firmware (software) update, remote accessories provider, activate / deactivate the service, remote control and adjust operating parameters, and enables connection to external devices, LCD touch screens, two-way communication with the driver, multimedia applications and more.

1.4. Info-displays for passenger information

The LED displays placed at the bus stops provide the following functionalities:
▪ Data transfer management between the Data center and the Information displays
▪ Updating the displayed information,
▪ Following the status of the display and its hardware and software (are there any malfunctions in the display),
▪ Information transfer to the data center

1.5. Functional description of the EuroGPS SmartTracker Public Transportation

Basic features
The system monitors in real time the position and movement of each vehicle as well as the status of various associated sensors. This controls the overall related equipment, including but not limited to the terminal driver, connected displays in the vehicle, validators, system public announcements, which allows sophisticated control over the whole process of operation of the system of public buses.

Bus timetables
EuroGPS SmartTracker application for public transport, allows advanced functions for the preparation of timetables and driving schedules for drivers with tools for analysis, visualization and optimization. The system includes a custom application for maps, which supports different types of maps of different sources in the same system.

The EuroGPS Smart Tracker app for transit, gives the user the ability to create new regions and areas and to geocoded objects directly from the user interface (UI) by clicking the object on the map.

Shift schedules for the drivers
EuroGPS SmartTracker provides functions for creating timetables for the drivers based on flexible rules for drivers carrying out a random group of predefined services and monitor planned vs. actual schedules of driving for drivers.

The system supports detailed database of vehicles, their owners and drivers, can assign names and marks to the vehicles, as well as store images of the vehicle, driver and owner along with their detailed information, including the sector name, responsible person, registration number, the next oil change following the date of service, mileage, etc.

Automatic vehicle location
The data based on the events are read in real time as data from the validators, data from RFID readers for registration of drivers, data from the terminal to the driver, and so on.
EuroGPS Smart Tracker uses GPRS communication to transfer data between the GPS devices in the vehicles and the central system. This is a real-time two-way data communication (only delay the GSM / GPRS network of the network operator, which is less than 5 seconds). Hence, the system can be used for traffic priority signaling when connecting the system with intelligent traffic signaling.

Route tracking
The system offers rich features for control and monitoring of various vehicle information, such as: route tracking, stopping at bus stops and speed control.

- Current location, speed and movement direction
- Kilometers, maximal and average speed of every journey
- Engine tracking in on/off mode;
- Tracking the buss stopping times (at the bus stops and other places)

Bus timetable tracking
The system monitors the current schedule in real time and uses this information for the passenger information sub-system. The system calculates the “rush” and “delay” compared to the planned timetable in real time for each vehicle and displays this information based on pre-defined time tolerance parameters. For example, if the tolerance is 30 seconds, then the possible deviation of 30 seconds (regardless whether it is a rush or delay in relation to the timetable) system displays as deviation.

Operational status data
EuroGPS SmartTracker provides display for all relevant information to dispatchers, drivers and other users according to their user rights assigned as well as information about the operating status displayed in graphs, tables, text and map.

Information about the vehicle driver
This device has a touch screen and a monitor that displays the following data:
- Date, time
- Vehicle number and driver
- Bus line number
- Communication link status
- GSM network status
- The name of the last bus stop
- Information about the tariff
Statistical information
EuroGPS SmartTracker has advanced modular reporting tool with powerful functionalities for creating various reports, at random intervals for all data within the system. The system is able to provide information on the following: bus drivers, timetables, timetable for lines, timetable for bus stops, number of vehicles used by type and garages number; scheduled hours of effective work and waiting times; scheduled kilometers per line; hours of waiting; realistic kilometers per line.

Management
The fleet management system provides tools and features that help the dispatchers in managing the regular traffic in the event of interruption of traffic (accidents, emergencies, special events, etc.). This is achieved with two-way voice and text communication with drivers through the terminal driver, which allows:

▪ Sending and receiving pre-defined text messages
▪ Sending tasks and possibility for the drivers to accept or reject them
▪ Operational navigating functionality sent by the control center for alternative routes
2. AUTOMATIC FARE COLLECTION SYSTEM

The sub-system for electronic payment in the JSP Skopje vehicles (AFC – Automatic fare collection system in vehicles), is a highly professional solution for automatic charging which can function as an independent solution or as integrated with the existing AVL. The AFC solution is scalable, configurable and supports remote administration, monitoring and updating. The solution consists of several modules and components such as terminals (validators, POS terminals...) units for encoding, contactless smart cards and processing center.

2.1. Functional Applications of the Integral City-wide Payment System

The Integral City-Wide Payment System (ICPS) uses rechargeable stored value accounts accessed by citizens’ mobile phones or specially issued contactless cards in order to support electronic transactions within the geographically limited area of the city.

Due to the innovative design of the system, both of the instrument types can serve several different functionalities, with the contactless card and the mobile phone allowing the user to:

1) Pay for and conveniently use the city public transit services,
2) Pay for general products and services at all affiliated locations and
3) Establish his or her identity at various venues.

ICPS Fare Collection Functionality

Being a core element in the ICPS system, public transit related transactions have been given special attention by our team of engineers. As a result, the system now allows for great efficiency in conducting and managing these transactions, covering everything from topping up of the individual user’s account and his actual usage of the service to the well thought out provisions for post-payment fare control, conducted by on-board conductors.
The fare collection system is largely automated, as everything from the account topping up to the actual validation at vehicle-entry can be accomplished without service personnel intervention. Yet, the already established ways of buying tickets at newsstands and tobacconists have been maintained, thus maintaining both the familiarity of the existing ticket-sale system and guaranteeing future existence of ticket-resale networks at the same time.

**ICPS Payment Functionality**

Next to public transit system, numerous other services and products can be made available by affiliating the system with partnering institutions and organizations, creating new points of acceptance for the system’s payment instruments. One of the most obvious and benefiting is the inclusion of parking service operators, thus allowing superior Park & Ride system to be implemented and managed effectively. Additionally, points-of-interest such as museums, galleries, recreational facilities and all other tourist attractions can all be included, integrating them into a unified system. Solutions such as tourist cards thus become possible, integrating all the various points-of-interest into a virtual system where users can easily move around in a more time- and cost-effective manner.

**ICPS Identification Functionality**

Numerous real-life situations only require people to establish their identity to be able to gain access to services. Think, for instance, of the libraries, where money changes hands only occasionally and just are liable identification instrument is usually required for day-to-day usage. Other similar examples may also include various Bonus & Loyalty Programs, SOS stores and, last but not least, Employee Time & Attendance Programs.

Obviously, each contactless card and personal mobile phone can – next to the basic personal data of the carrier – convey numerous other pieces of information. Various carrier statuses can be included onto the account, meaning eligibility for special discounts and/or special treatment can be established anywhere within the ICPS system on the basis of just a single instrument.

**2.2. Public Transit Ticketing Solution – Technology at a Glance**

All devices relevant to the public transit payment system are connected to a central database, the Processing System. Two-way transmission of operational data between automatic ticketing equipment and back-office is automatic and is realized via LAN or GPRS.
The Automatic Public Transit Payment System scheme is depicted below:

2.3. Description of the mobile payment concept

Mobile payment as part of this process provides the key elements of comfort, reliability and security. The solution for mobile payments is a comprehensive, measurable, flexible, safe and proven, and allows anyone to pay goods and services using their mobile phone in various sales points with or without staff, improving the experience of users with convenient, safe and secure payment option. Users no longer need to carry cash or multiple credit cards, but through their mobile phones can access any of your accounts.

Mobile payment functionalities

More accounts, one device
Any purchase, whether micro or macro, can be collected from any user's account - existing or newly created bank account, credit, debit, stored value or even from the account on his cell phone. Users no longer need to carry multiple credit cards in their pockets; instead, they can use their mobile phones to access any of their accounts.

One account, multiple users
The system allows users to register secondary users and provide the same controlled mobile access to one or more of their current accounts. Thus, banks can reach users who do not have bank accounts and benefited from the larger volume of transactions.
More services, a proven partner
The system allows building an extensive network of third party merchants and offering users the opportunity to quickly and easily pay for material goods and various services - including parking, public transport, entry, even tickets and more.
The system offers multiple services through one reliable device - a mobile phone. Pure payments can easily be supplemented by a bonus or loyalty programs and mobile gifts with mobile coupons.

Benefits of mobile payment
Benefits for the customers
- Safe payment,
- The customer maintains full control over their balance and use,
- Automated top-up mechanisms,
- The customer can get individually adjusted rewards and offers,
- Easy to use and flexible,
- Can also be used with other electronic payment services (mobile phone, Internet).

Benefits for JSP Skopje
- Guaranteed competitive transaction costs for payment transactions,
- Supports numerous business models,
- Simpler automated cash collection for sale of electronic services/ products in cash.

2.4. Bus AFC device – Validator
General Characteristics
The proposed validation device (called also the smart card collection device) is intended for the usage inside the bus or other public transportation vehicle. Usually, it is mounted near the front door where the passengers enter the vehicle (as well as near the driver). However, it can be placed near the other doors as well. This is particularly case when the Check-In Check-Out (CI-CO) scheme of passenger validation is enabled. The device is positioned in that way, so that the passengers entering the vehicle can quickly and easily come close and tap the card. This position also allows execution of all tasks for the maintenance of the engine and the bus.

The smart cards collection device enables registration of the tickets of passengers who boarded the vehicle, and has a LCD display for information for passengers. The validator is easy for use. The smart
cards collection device is safe for payment and withdrawal, accurate in its calculations and reports, and safe for preservation and transmission of data. Under normal operating conditions, processing of data from the cards does not require assistance from the driver or by any other professionals (except in the case when the passenger requests additional tickets for accompanying persons). The device automatically determines that the ticket that is entered is original, authenticate, and that it is in accordance with the established conditions for use. The device operates under environmental and in operational environment which are present on the buses on the field, and is produced in such a way to have a high degree of security against violence and/or unauthorized use. The device provides specific information about daily operations, including funds collected, the types and volumes of collected tickets, and other information necessary to prove the funds and to monitor the equipment.

The device supports different remote-reloadable and configurable tariff systems (based on area, distance, with a gradual increase, fixed, etc.) where the passenger chooses to travel to the area (zone) by pressing the touch screen or buttons. The validation device supports various groups of users with corresponding discounts (students, disabled persons, commercial, etc.). The device enables easy mounting and disassembly by trained maintenance personnel without the use of special tools.

**Functional description**

The validation (smart card collection) device performs the following functionalities:

1. Reads information from the smart cards and the special smart card,
2. Identifies the valid and the invalid cards,
3. Deducts the value from the cards,
4. Writes the deducted value on the cards,
5. Enable selection of an area of travel (or destination) through touch screen or buttons,
6. Can work also in the so-called Check In - Check Out mode for payment according to the real past distance defined by GPS coordinates, which the passenger passed.
7. The device sends all transactions and GPS data to the center via GPRS or WiFi through internal (each validator has integrated GPRS module) or external device (driver’s unit or AVL engine) in the vehicle. These two technologies are simultaneously available. The WiFi is preferred for transmission of large amount of data.

The smart card collection device is equipped with the following user interfaces:
1. Graphical user interface (GUI) which informs the passenger about the validation procedure progress and result, status, card validity, tariff statuses.
2. Sound signal is different for different results of the validation process (valid, invalid etc.).
3. Touch screen or buttons are used for passengers to enter the destination of the travel.

The device signalizes the type of tariff (student, labor, and pensioner) of any amount deducted from the ticket. The smart cards collection device verifies the validity of the card, subtracts value from the current driving value card in accordance with the tariff for driving. The appliance has a LCD display for passengers that clearly shows the passenger’s tariff class type, as well as the deducted and remaining amount on the card. The display has enough illumination to enable easy reading in daylight. The display for passengers passes through several different messages when the device is in position “ready”. These messages are automatically adapted depending on the operating status of the device. The smart cards collection device can deduct the amount of several bus journeys if there is sufficient balance in the card. For example, if the bus is driving a four member family, the device takes four amounts of a single ticket for each member of the family separately (driver enters the number of persons on its driver’s control unit).

The smart cards collection device communicates with the server information center. The device receives all system parameters from the application server for settlement and sends data for the location and driving through the application server to database information center and keeps the records there. The system parameters are the blacklist, the table with the bus tickets (tariff system with pricing information) and other necessary configurations. The smart cards collection device reads first the pseudo number of the blacklisted smart card. If the pseudo number is on the blacklist, the device warns the driver with audio
and blocks the card. Then the card cannot be used any more in the system. The value (amount) of driving is calculated according to the bus tickets table (tariff system) with respect to the tariff class stored on the contactless smartcard (student, pensioner, worker, pupil, etc.).

**Method of operation**

When the validation device is switched on, the smart cards reader and main processor are constantly active and wait for the passenger’s smart card or special smart card. When the smart card is accessing to 0-7,5 cm, from the area of the device called “Target” the following steps are performed:

- The information in the card is read and the card unique ID (CUID) number is compared with the list of numbers on the black-list.
- If the card is on the black-list, it is refused and disabled. Special transaction is sent to the information center in order to inform the detection of the blacklisted card. Optionally, the driver can get the notification via the driver’s computer.
- If it is confirmed that the smart card is valid and configured as a value ticket, one fare is deducted by the amount indicated on the card or in the tariff system (this decision should be made by the City of Skopje).
- If the smart card is configured as a ticket, then one fare is deducted from the card.
- If passenger wants more than one persons travelling with one card, then the multiple fare amounts or multiple fares are deducted from the card. This operation is done by driver via its driver’s control unit. Driver’s control unit is connected to the validation device which performs appropriate action with the passenger’s contactless smart card.

**Card registration**

As soon as it is confirmed that the card is valid, reader in the smart ticket collection device sends an appropriate signal to the electronic logic of the ticket collection device. At each transaction, they forward the information to the records in the device (non-volatile FLASH memory) in order to preserve the following:

1. The total amount received from the device since last time used,
2. The total amount received by the device after the last installation is made or the clearing of the memory,
3. Transactions of the cards sorted by type, including received and issued money transfers
4. All transaction data are transferred to the information center and can be used to prepare the management reports.
Tariff system
The AFC System supports dynamic tariff system configuration. This means, that the tariff can be prepared at the Information center and then remotely distributed on all terminals on the field. The terminals (i.e. smart cards collection devices on buses) interpret the received tariff and perform ticket validations as parameterized in the tariff system. The tariff system can have programmed at least 10 groups of ticket prices (price lists with all tariffs). The smart cards collection devices are able to store and interpret this tariff in its electronic logic. In one group of prices (the price list) the prices of all the different tariffs for different categories of passengers (so called tariff classes) can be specified by the City of Skopje. By setting the group of prices in the tariff that information is automatically stored the in memory of the smart card collection device. The reprogramming does not require physical replacement of parts in the device. Under normal circumstances, the price list is updated by the information center at each start of the device.

2.5. Smart cards used in AFC System in the City of Skopje
The contactless smart cards operate on a short wavelength radio frequency (RF) at the frequency of 13,56MHz and are compatible with the proposed ticket collection device - validator. We have procured modern, state-of-the-art contactless smart cards that comply with all the security requirements:

- Mutual triple-pass authenticity check,
- Coded data in a radio frequency channel with intrusion detection (TDES encryption, MACing),
- Unique serial number (CUID) for each device.

The cards are made of plastic, consistent with the ISO standards are suitable to carry in a pocket or a wallet/purse without getting broken and/or folded. The surface is printed on both sides with the “Skopska” logo and can be further customized with different colors depending whether it is personalized, non-personalized or an employee card.

2.6. Supplementary funds loading device
Supplementary funds loading device is a special device, which loads, smart cards and the special smart cards (write one or more tickets, increase the value of the card’s electronic wallet). The supplementary funds loading device is portable with its own accumulator battery. The device has its own connection to the Information center via built-in GPRS modem. Important part of the Supplementary funds loading device is the security coffer. This is special hardware (SAM module, secure part of the microprocessor) and software application (crypto algorithms) in which the database checks the credit of each Supplementary funds loading device.
The supplementary funds loading devices is able to send the transaction data to the application server of the information center using GPRS. During the data transfer, if there is a communication problem or a failure in supply, the system prevents duplication of transferred data. The supplementary funds loading devices can store at least the last 2000 transaction (all information about credit or product buy operations) to its internal non-volatile FLASH memory. The supplementary funds loading device is not be under influence by adverse working conditions such as: AC power disturbances or loss of electricity, moisture, vibration, and static electricity. These adverse conditions do not affect the functioning of the supplementary funds loading device such as card data writing and/or data transferring. The supplementary funds loading device supplements the smart cards with a value determined by the tariff and tariff class of bus transport (student, pensioner, employee, etc.).

2.7. Cards checking device

The Mobile cards checking device (also called the controllers inspection terminal) is the same as the terminal for the Supplementary funds loading device. However, the uploaded firmware, application, and other configuration data and parameters are dedicated for contactless smart card inspection. The Mobile cards checking device is used for control and verification of appropriate electronic payment using cards in the vehicles of public transport. Device identifies the use (or misuse) of false and invalid cards.

The Mobile cards checking device performs the following tasks:
1. Checks whether the correct value is withdrawn from the card for driving,
2. Shows the value of the card on the alphanumeric display,
3. Gives a bill after the entering,
4. Enables sanction calculation and billing based on special sanction tariff system downloaded from the Information center.

If the passenger uses discount journey, the controller has the right and opportunity to check the validity of the card to request the passenger to show his/her identity card on the basis of which the discount is made (such as student / student card, pension card). If there is a misuse of the cards, the device enables a penalty to be imposed on the passenger. The penalty can be charged and the bill for the transaction can be made (controllers decision via terminal’s GUI).

2.8. Self-Service Terminal

Automated self-service terminal is a free-standing multipurpose & customizable terminal combining several of our technologies and solutions, which can be chosen and customized to fit the self-service
terminal purpose. Next to providing a unmanned way of buying an anonymous card and topping up a city card account, these terminals can also be used to provide passenger and tourist information, advanced electronic advertising channel, etc.

The self-service terminals are used for:

- accepting payments via various payment methods: bank notes, coins credit cards and mobile phones
- card dispensing,
- replenishing prepaid accounts,
- checking the account balance,
- delivering infotainment and advertising services,
- enabling bill payments,
- buying and/or validating tickets – paper, mobile..., 
- distributing various types of vouchers.
3. PROCESSING SYSTEM ARCHITECTURE

Introduction
The figure below shows the Processing System components:

The Telecommunications Access Point part is an interface between the Mobile Network Operator and the System. Due to the mediator role, MTAP is connected directly or indirectly (through protocol converters) to Mobile Switching Center (MSC) on one side and MPS on the other. If multiple MNO-s are connected to the system then multiple MTAP-s are installed, one for each network operator.

The main task of the MTAP is to provide a telecommunication interface to MNO-s telecommunications infrastructure. Furthermore, it provides transparent and secure communication between the terminals and the processing system (by using a unified interface regardless of the input communication channel: voice, GPRS...). It integrates an IVR system that guides the user through the whole process of using the system.

Processing System Administration
The Processing System Administration is a powerful tool intended to handle the administration of the system. It is a web-based application, to monitor and manage all necessary entities to perform complete mobile payment service. It is designed to link up Acquirers, Service Providers and Issuers, to register terminals, to maintain terminals, to accompany statistics, logs and alerts of mobile payment transactions.
It is ready to use for all organizations in the process such as Service Providers, Distributors, Acquirers, Merchants, Issuers, Terminal handlers...

Functions of the Processing System Administration:
1. Terminal management & logistics
2. Transaction management & monitoring
3. Account management
4. Contract commission management
5. Distribution Contract Management
6. Acquiring Contract Management
7. Company management
8. System monitoring & management
9. Reporting engine (pdf, excel, MS Access)

Clustering and Scalability
Each software component is installed as a cluster meaning that the instance of such component runs on multiple servers. To improve performance bottlenecks component clusters can be extended to introduce additional nodes (linear scalability). There is no limitation on a cluster size, meaning that there is no limitation on number of nodes within the cluster. This way, the load is distributed among all available servers and in case of a failure of single server, the system continues to operate without interruption.

All connected components (services) including the core server are “internally pinged” for keep alive info. If these connections fail, their status is changed (status down or status dead) so e.g. the core server uses
other available components (redundant components of the same type as the dead one). The following example illustrates the applied clustering, redundancy and scalability model (please see the figure below):

- input call to component A (MTAP),
- transaction forwarded to component B (Core server MPC), and
- Transaction forwarded to component C (MPG) that interfaces 3rd party system.
- All components do some processing and the answer is sent back to the terminal.

All components of the same type are clustered (in terms of redundancy they run on a minimum of two servers), so there are let’s say A1, A2; B1, B2 and C1, C2 component instances. A cluster (A1 and A2) is connected to B cluster (A1 and A2 are directly and cross connected with B1 and B2 (all-to-all)); in the same way, B cluster is connected to C cluster (B1 and B2 are directly and cross connected with C1 and C2 (all-to-all)).

Load Balancing
Each component is installed on a minimum two servers - to ensure redundancy as well as load balancing. Usually, in order to achieve efficient load distribution, the round-robin strategy is used, while in other cases, the priority-list pattern is applied (where first available server from a list is selected for a operation).

Redundancy and Failover
All transactions between the center and terminal have double confirmed acknowledge. Only double confirmed transaction is treated as a successful one and only in this case the service is delivered (payment, top up, Blp...). If the transaction somehow fails, the terminal initiates “service call” to the MPS (only if GPRS available) and sends data about the previous (failed) transaction. On the other hand, the terminal in the current transaction always sends the result of the previous transaction (necessary for some types of transactions e.g. offline prepaid...).

On processing level each transaction has two phases – online phase where the communication to a request’s source (e.g. terminal) is active and an offline phase that includes transaction completion, clearing and settlement. If there is any kind of interruption while a transaction is on online phase, certain operations might fail or timeout and those operations can be repeated or be treated as failed ones. If they were repeated, in case of a component failure, they would be redirected to another component (of the same type). Otherwise, the transaction would fail and the end customer will be notified about the nature of the problem. Operations processed within the offline phase are, upon failure, repeated by default so transactions processing will resume towards another component instance that is operating normally.
4. **E-CLOUD**

4.1. **Description of the connectivity solution**

The foundation of the connection technology is based on the verified and well known optic infrastructure that enable the employees in JSP, the City of Skopje and the other private transport companies to work as if they were within the same local network within a single building.

In this manner, the service of Makedonski Telekom enables connecting the network of JSP and the Data Centre of Makedonski Telekom into a single integrated network, simple for management. The acquired solution constitutes a single network, a single technology, and a single system that your IT personnel already knows excellently, therefore this personnel can easily implement and upgrade, as well as efficiently manage all application that function and operate through the solution.

The detailed network connectivity is shown in the picture below:

The implemented connectivity has the following characteristics:

- **Committed information rate (CIR)** – Makedonski Telekom possesses the basic network infrastructure (core network) through which the service is provided. This enables the monitoring of the access speed and the possibility to offer a guaranteed speed of data transfer.
- **Loss of packets in the network of Makedonski Telekom AD < 0.05%;**
■ Flexibility regarding the upgradeability of the speed;
■ Flexibility – solutions of Makedonski Telekom have infrastructural possibilities for connecting multiple locations with different speeds, thus enabling the monitoring of your requests and needs;
■ Reliability – through the guaranteed speeds and availability.

The characteristics of the Internet service are:
■ 24h permanent connection with guaranteed data flow (uplink/downlink);
■ Unlimited traffic;
■ Access speed (CIR): minimum 10 Mbps;
■ Packet response in the network of Makedonski Telekom AD < 50 ms;
■ Loss of packets in the network of Makedonski Telekom AD < 0.05%.

3.3 Platform components

The design of the entire system consists of AVL environment and AFC environment. Both environments consist of:
■ Servers
■ Storage
■ Different software packages and applications
■ Network connection (LAN&SAN);
3.4 Description of the characteristics of the Data Centre

Makedonski Telekom owns three professional Data Centers throughout the Republic of Macedonia, specifically two in Skopje and one in Strumica. The Data Centre where the solution is hosted has been implemented professionally and it is located in the rooms of the Telecommunication Centre – Centre of Makedonski Telekom AD Skopje. The TC Centre itself is equipped with redundant power supply from two connections to the public power distribution network. The transformer station for TCC – Skopje is connected to two independent 10 KVA power lines, as follows:

- From TC 35/10KVA Leninova (Central) which is used as the operational one;
- From TC 110/10KVA South, which is used as the spare one;

The implementation of the Data Centre meets all the standards thus providing the highest security of the data and information of the customers. The elements of design of the Data Centre are as follows:

**Construction implementation of the Data Centre**

In order to guarantee seismic stability, the rooms in the Data Centre are equipped with double antistatic floor. The internal structural cabling has been made in accordance with the recommendations of the standard TIA-942. In addition, the network cables as well as the power cables are placed in separate channels in the double floor.

Due to the need for constant airflow and appropriate temperature for operation of the equipment, the rooms have been divided into warm and cold zones.

**Physical security**

Access control in the very Telecommunication Centre, as well as separately in the Data Centre has been provided through an appropriate system for access control. In addition to the physical security of the facility, access has been enabled only through coded control, i.e. a personal access card and a four-digit access code. The access rights for management are centralized and managed by a special security directorate. All activities for entry/exit are continuously logged and saved.
Within the Data Centre security, a video surveillance system has also been implemented. This system enables 24x7 monitoring of all rooms by the always-present professional physical security.

In order to achieve full security of the rooms and the facility, they are provided by a professional security agency 24x7.

**Stable redundant power supply**

The equipment in the Data Centre is powered by a stable redundant power supply. This ensures uninterrupted operation of the systems. The redundancy means that, in the event of an outage of the public city network, immediately without an interruption of the functioning, the backup uninterruptible power supply systems are activated. The backup power supply systems are a systematic structure of rectifying and inverter systems that, together with the battery blocks, form the UPS. As additional element in the overall system for stable power supply, the Data Centre is equipped with appropriate duplicated Diesel generators.

**Fire protection**

The entire facility - Telecommunication Centre, Skopje, within which the Data Centre is located, has been equipped with a modern and professional fire-protection system. The system is equipped with HSSD (High Sensitivity Smoke Detector) and it is addressable and provides a fire alarm. In the event of a fire, the fire extinguishing system, equipped with FM 200, is automatically activated.

**System for monitoring humidity, airflow, temperature and detecting water flow**

- Airflow: Indicated a problem with the operation of air-conditioning devices
- Temperature: Strategically places sensors throughout the rooms of the Data Centre show the current temperature
Humidity: Strategically places sensors throughout the rooms of the Data Centre indicate the current air humidity

Water: Indicates a problem with air-conditioning devices (leakage of water in the floor)

Particles: Strategically places sensors throughout the rooms of the Data Centre indicate the existence of dust, smoke and other types of particles in the air.

**Air conditioning**

In order to ensure a constant working environment and optimal temperature for the equipment located in the Data Centre, a system of redundant air-conditioning cabinets has been implemented. They are connected to appropriate redundant power supply and they are continuously functioning which enables the prevention of disturbance of the operational parameters prescribed by the equipment manufacturers. The capacity of the air-conditioning devices is designed with 50% spare capacity.