

# TOWARDS INTELLIGENT INFORMATION SYSTEM FOR PUBLIC INTERURBAN ROAD PASSENGER TRANSPORT MANAGEMENT

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*ABSTRACT: Public road transport forms a complex and dynamical domain that encompasses fields of traffic, business and politics. Management of the system poses a challenge for governmental entities which are responsible for coordination, control and data gathering from private transport companies.*

*A need for IT support is obvious.*

*The paper systematically describes a distributed enterprise information system named AVRIS developed for the Directorate of the Republic of Slovenia for Roads. AVRIS adds new value to the management and coordination of the domain for public interurban bus transport. First a theoretical work flow model, consisting of processes, phases and states is defined. Built upon the model a multi-tiered IS architecture is developed which incorporates a number of advanced IT concepts, like application server, shared communication space, MVC, etc. The concepts are implemented using latest open source Java technologies.*

*First real experiences with AVRIS are evaluated and presented in the paper.*

*KEYWORDS: traffic engineering, public passenger transport management, traffic informatics, decision support, shared space, work flow, open source, Java.*

## 1 INTRODUCTION

Apart from two adjacent IT intensive domains, namely ITS (Intelligent Transportation Systems) and/or Telematics, the work described in the paper targets IT solutions for better governing public road passenger transport (PRPT) affairs. Generally, PRPT includes all forms of land transport that carry passengers for reward including buses, trains, trams, hire cars and taxis. However our project includes bus transport only because the cross-integrated (vertically and horizontally) network of passenger transport services involving all modes of public passenger transport in Slovenia is yet to be established.

Public transport authorities worldwide are responsible for various public transport issues, most typical are:

- provision of higher quality of public transport services in order to attract more private vehicle users which results in reduced roadway congestion and environmental deterioration [2]
- subsidies for public bus operations [3]

With the increase of data complexity public transport authorities invest money into information systems for decision support. The information systems must provide collection of data in digital form (i.e. concession reports, transport provision, economic and financial planning, timetable management) and analytical functions to study the potential effects of decisions before implementation.

To this end, the PRPT domain has become popular test-bed for various research projects ([1], [6]).

In [1] a decision support system for public transport management at a city level (Athens, Greece) is presented.

In [6] authors focus on decision support system based on society of software agents that assist traffic operators in mobility management centre in the Bilbao area (Spain). They receive information about the traffic state by means of loop detectors, and take decisions on the control actions to apply in order to solve or minimise congestions.

However, the research projects address only some of the above issues and mostly have a local initiative, while on the other side our project has a nationwide perspective.

Directorate of the Republic of Slovenia for Roads (DRSC) is a public transport authority that oversees the creation, registration and maintenance of public bus transport schedules within the country. Our project ambitiously aims to develop an information system supporting nationwide public transport service that DRSC and around 60 public bus network operators will use for:

- collection of decision-relevant data,
- assistance for transportation policy decision-makers in exploring the meaning of the collected data, so as to take decisions based on understanding,
- generation of spatial data for higher effectiveness of decision making while solving transport network problems,

- improved communication of operational data (stations, routes, operational regime, timetable proposals) between bus line operators and DRSC,
- improved on line timetable data management (approval/rejection, cancellation),
- on-line communication of concession accomplishment reports (monthly, semi-annual).
- raising level of IT acceptance among bus operators,
- better bus fleet management

## 2 PREVIOUS WORK

The system AVRIS (in Slovene: Avtobusni VozniRedni Informacijski Sistem, originally the acronym stands for bus timetable information system which best describes the scope of the first version in 2000, last version includes many new functionalities, but the name remains in use for practical reasons), developed at Faculty of Civil Engineering (University of Maribor), was first deployed in year 2000. Its users were DRSC and public transport companies (bus operators - small and medium sized private companies) in Slovenia. At the time the information system was a standalone desktop application that basically enabled a migration of work from paper to computer. Its characteristics were (Figure 1):

- data exchange between DRSC and bus operators was facilitated through import/export mechanism using a proprietary format,
- application was developed in Visual Basic/MS Access,
- target operating system was Microsoft Windows.

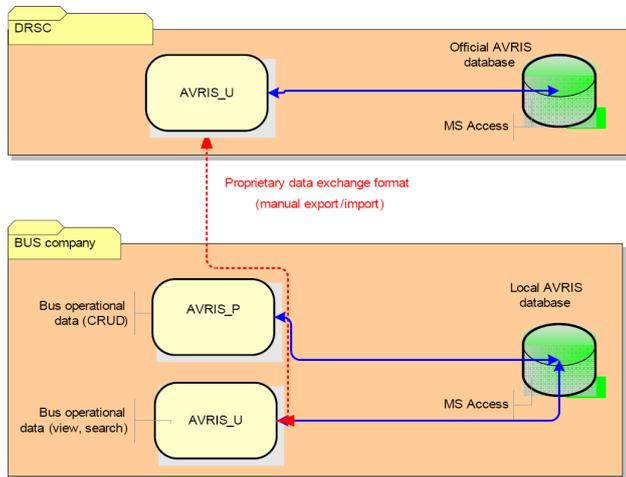


Figure 1. first AVRIS architecture (2000-2005)

Two software programs built the original AVRIS system:

- AVRIS\_P (IS for bus operators): standalone application (Visual Basic) for CRUD (Create, Retrieve, Update, Delete) support of bus company's operational data (stations, routes, operational regime, timetables)
- AVRIS\_U (IS for DRSC and bus operators): standalone application (MSDE - MS Access Runtime) for analytical operations (data preview, timetable search, operational planning, number of trips, number of km planned)

In 2004, after 3<sup>rd</sup> and 10<sup>th</sup> maintenance release for AVRIS\_P and AVRIS\_U, respectively, development

team started signaling concerns because AVRIS configuration matrix (Visual Basic, MS Access Runtime on Win95, Win98, Win2000 and WinXP) was causing many dependency problems; downward compatibility changes with each new MS Access Runtime version, DAO (Data Access Objects), ADO (ActiveX Data Objects) issues, emerging .NET technology discontinued support for some older technologies.

Obviously, AVRIS was too tightly-coupled with operating system. Technologically a critical point was reached at which further strategical questions related to future AVRIS development needed to be answered:

- How to diminish dependence on operating system?
- How to efficiently handle technological heterogeneity of existing legacy software (AVRIS\_P and AVRIS\_U)?
- How to achieve better software adaption to DRSC requirements changes?
- How to achieve B2B (Business to Business) collaboration using Internet?
- Is existing legacy software well-suited for multi tiered architecture design?

On the other hand .NET and J2EE technologies just arrived and open source solutions started grasping their share.

## 3 REENGINEERING REQUIREMENTS

In 2005 the AVRIS was completely re-engineered towards distributed collaborative information system with latest software technology concepts applied.

The reengineering process started with the domain workflow and technological requirements in mind:

- public transport domain workflow (business process) must be analyzed and modelled using business process modelling tools,
- Open source and Java solutions can provide efficient software platform for internet oriented information system as required from the DRSC. Maintenance and upgrade of such information system is a longterm low-cost alternative to the information system based on the closed source software.

Additionally to the technological requirements the following functional requirements were also implemented:

- optimization & upgrade of legacy database schemas
- data versioning & data ownership support
- secure communication (data encryption)
- concession contract support

### 3.1 Domain workflow

Analysis of activities inside participating businesses (entities), namely *public transport companies* (i.e. bus operator companies), *public transport authority* (i.e. DRSC) and *data transaction operator* identified two groups of activities:

- operational data management process for domestic and international crossborder transport,
- concession contract report process.

These two groups of activities can be regarded as main business processes. Public transport organization is any

company that operates public passenger transport service in line with its concession contract. Data transaction operator is an independent body with expertise in IT (service oriented and communication technologies). It “sits” between the public transport company and the public transport authority. Its main role is to provide a communication gateway, a message driven and shared communication space (blackboard), that enables interception of messages from public transport companies and implementation of business rules. The communication concept is based on “data pull” instead of “data push”.

Public transport company and public transport authority send requests to data transaction operator.

Operational data management process groups activities related to CRUD operations on the data that result in new bus lines, updated bus timetable, definition of new bus stops, bus line assignment to a new bus operator or subcontractor, changed bus operation regime, etc.

Concession contract report process groups activities related to bus operator's accomplishment of contract requirements, i.e. compensation requests, bus operation income, number of tickets (one way and return) sold, number of monthly cards sold, number of luggage deliv-

ered, number of passengers transported, number of driver hours realized, average number of vehicle km driven, operational costs.

### 3.2 Business process model

Above activity descriptions of the two business processes can be more formally modeled with a standard graphical notation for drawing business processes in a workflow, Business Process Modelling Notation (BPMN, [4]). The model is set out in Figure 2.

Data manipulated within the two processes are further attributed by discrete *phase* and *state* values. We call this Process-Phase-State (PHS) approach. Each single data record in the database is described by its phase and state value:

- Phase denotes a period of activities that relate to formal transport management procedures in terms of a lifecycle: *data-in-operation period*, *data changes period*, *data registration period*,
- State describes the impact of the process to a single record and can have the following values: „registered“, „changed“, „new“, „canceled“

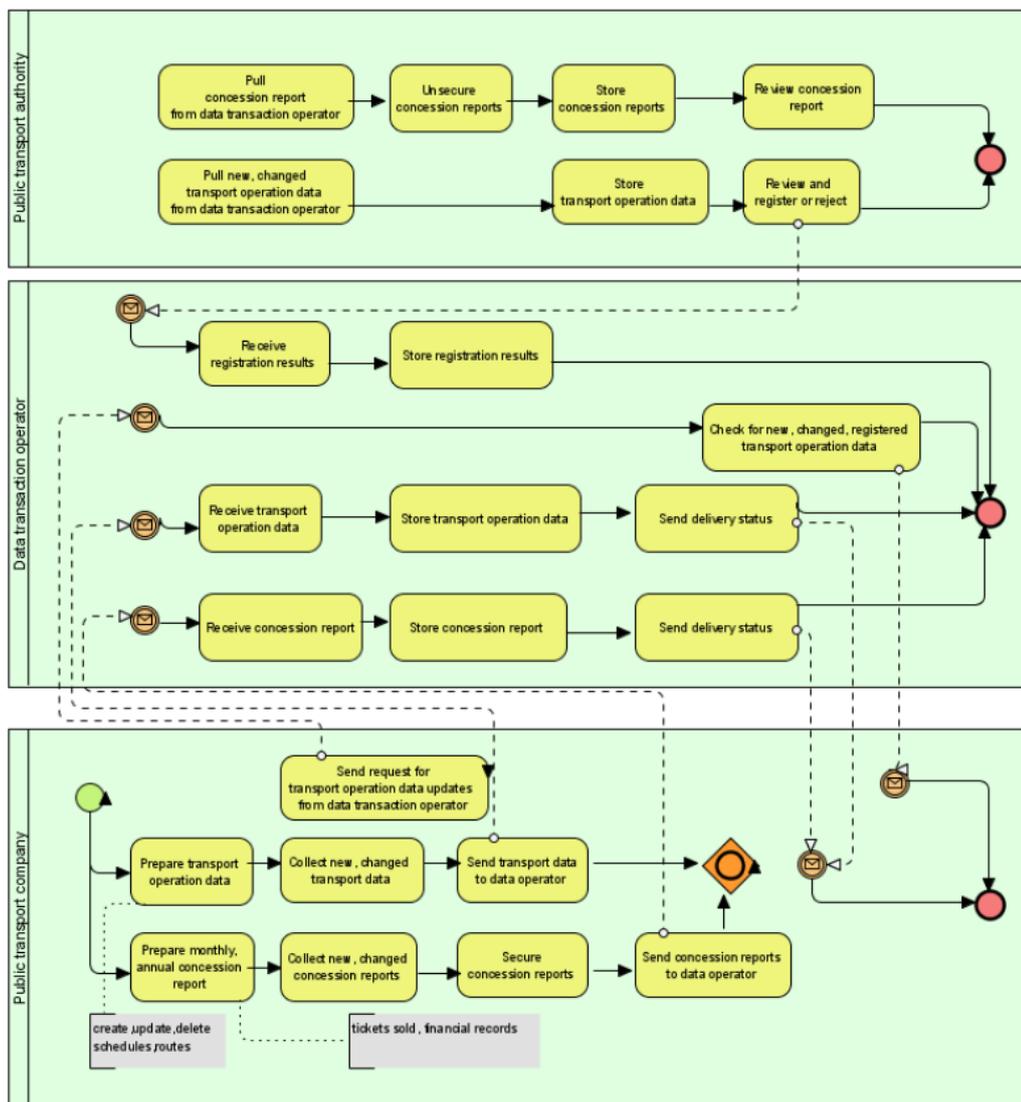


Figure 2. High level business process model diagram (BPMN, [4]) for public transport domain with three key entities: public transport company, data transaction operator and public transport authority.

Phase and state values are used throughout the information system; for example records with phase equal to „changes performed“ and state equal to „changed“, „new“ or „canceled“ are suitable candidates for the activity Send message (Figure 3).

Table 1 shows transition of state values between phases.

Table 1. Relations between Phase and State values

Phase value	Allowed state value
operation	{registered}
changes	{new,changed,canceled}
registration	{new,changed,canceled,registered}

#### 4 AVRIS – A REENGINEERED IS FOR THE PUBLIC ROAD PASSENGER TRANSPORT MANAGEMENT

Reengineering efforts resulted in a completely new AVRIS software architecture (Figure 4) with three main building blocks: a client software for public transport companies (mainly bus companies), a middleware server software and a software for DRSC. The collaboration is achieved through XML based messaging (Java Message Service and FTP). Message exchange is utilized by a globally shared AVRIS communication workspace (similar to the blackboard concept [5]). Each client software scans changes in its local database and posts them to the shared workspace. These partial data cause other clients to update their local databases. In this fashion, the clients work together to keep the distributed system synchronized. This way we believe to achieve a loosely coupled system that is reliable and fault-tolerant.

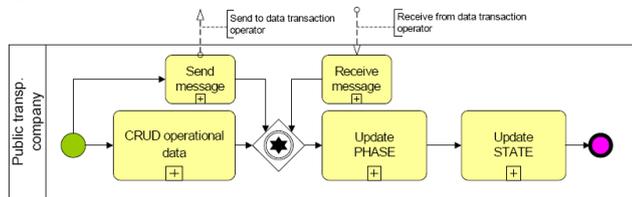


Figure 3. Process – Phase – State approach.

##### 4.1 Software for public transport companies

AVRIS.Prevoznik (Figure 5) is a client software for public transport companies (currently only bus line operators) in Slovenia that are in charge of PRPT service. It is a standalone Java application (Java 2 platform standard edition, version 1.5.0) which functions as a client to the AVRIS.Center. The client contains over 150 Java classes and utilizes the following external open source libraries: JasperReports for report creation (GNU Lesser Public License), Log4j for creation of event logs (Apache License, Version 2.0), JBoss-client for access to application server JBoss (GNU Lesser General Public License), Apache Derby for a back-end database (Apache License, Version 2.0). Apache Derby is a small-footprint relational database AVRIS.Prevoznik enables secure access to all AVRIS data. It should be reliable and fault-tolerant.

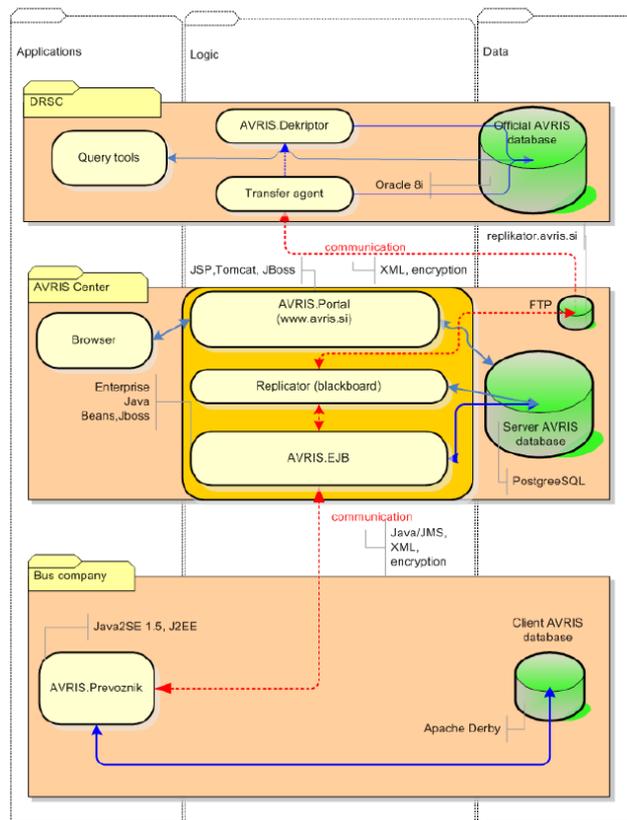


Figure 4. latest AVRIS architecture (2007).

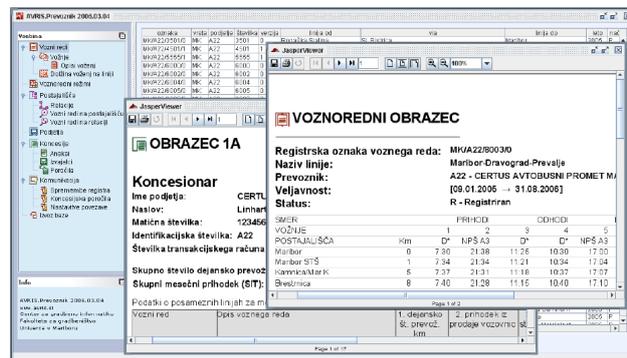


Figure 5. Java Swing based GUI for AVRIS.Prevoznik

##### 4.2 AVRIS Center - a middleware server

AVRIS.Center (www.avris.si, see middle tier at Figure 6) is a collection of middleware Java components (stand-alone, JBoss application server with Tomcat container, JBoss MBeans, Enterprise Java Beans) that form the brain of the AVRIS system. The middleware enables data replication through shared workplace, data management, registration and maintenance. AVRIS.Portal (Figure 6) builds a presentation layer upon the middleware. The web portal and the client software for bus companies demonstrate some redundancy because of similar functionality. The cost of double effort was minimized by introducing standards (common libraries, technology concepts) within the project team.

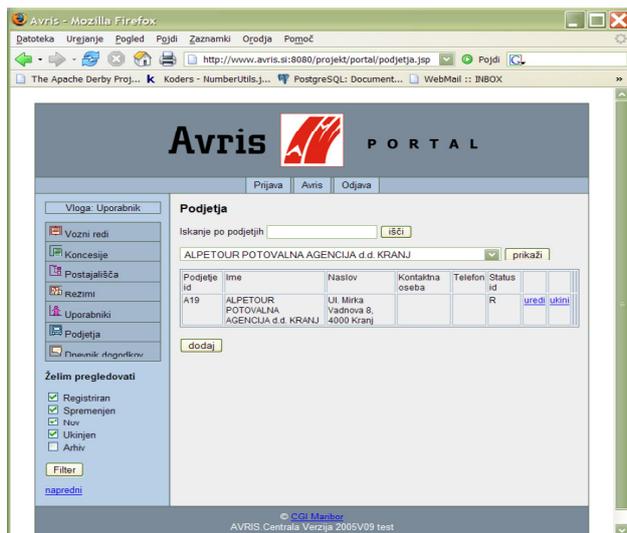


Figure 6. AVRIS Center: Web Portal.

#### 4.3 Software for public transport authority

Software installed at DRSC (see upper tier on Figure 4) does not use the shared communication space mechanism like all the public transport companies do. DRSC's network security policy doesn't allow any proprietary solutions for communication. Therefore, old good FTP service is used for data exchange. Data files in XML format are processed and stored in the Oracle database for further analysis and decision support.

## 5 CONCLUSION

At the beginning of the reengineering project public transport companies were asked to answer the introductory questionnaire with the following invitational text: »technological reengineering aims to enhance the existing AVRIS software. At the end a new AVRIS will be delivered which will enable richer e-collaboration and data communication between public transport companies and

DRSC as a public passenger transport authority. Using the software bus companies will better support decisions within their business processes. During the reengineering process all suggestions from all bus companies will be discussed (i.e. less dependency on operating system, support for actual politics within the PRPT domain; concessions) and best practice information technologies and concepts will be adopted (Internet based IS).«

Based on the positive response from users during the pilot phase (spring 2006), AVRIS authors believe that most of the above goals will be met before the beginning of the official massive deployment (autumn, 2006).

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