A Model for Integration of Railway Information Systems Based on Cloud Computing Technology

Slađana Janković[1], Snežana Mladenović[2], Slobodan Mitrović[3], Norbert Pavlović[4], Slaviša Aćimović[5]

Abstract - **This paper proposes the *Enterprise Application Integration (EAI)* modelin the field of railways, based on combining information integration and portal integrationin the *cloud computing*technological environment. Information integrationis carried outin a common *SQL Azure* database. The portal integrationis enabled with*Windows Azure hosted service*. The proposed model was implemented in a case studyof integration of information systems that are used for the railroad crossings management inthe Serbian Railways.**

Keywords – **Railway information systems, EAI, Cloud computing, SQL Azure database, Windows Azure hosted service.**

I. INTRODUCTION

Railways corporations(Railways) are the very complex systems, so they are organizationally divided into a great number ofunits, such as directorates, sectors, services, etc.Each organizational unit uses applications and databases designed to meet their specific needs. It is not uncommon that one particular entity from the real system is modeled in multiple databases that are used in different organizational units [1]. An organizational unit of the railways often use the data generated and updated by another organizational unit [2]. For example Sector for transportation of goods and passengers base their work on the data given by the Directorate of Infrastructure (data on construction, electrotechnical, telecommunication and transport infrastructure and its maintenance), the Department for maintenance of rolling stock and the Department for towing trains.In addition, each unit uses its own databases and applications. This creates redundancy and inconsistency of data. This means that cooperation between organizational units are often based on reports that have different syntax and semantics [3].To avoid redundancy and inconsistency of data and to avoid incompatible reports, necessary to enable the integration of databases and *Enterprise Application Integration* (*EAI*) using different organizational units of the railway.

In the second section of paper will be proposed model of *Enterprise Application Integration*that can be used on the Railways. The third section describes the implementation of the proposed model in the case study of IS which is used for the railroad crossingsmanagement in the Serbian Railways. Finally, the paper concludes the most important results achieved by the integration of railway IS according to proposed model.

II. A MODEL FOR INTEGRATION OF RAILWAYIS

We propose a model of integration of railways IS which is based on combining information integration and portal based integration in the cloud computing technological environment. Cloud computing is an area in which highly scalable IT facilities are provided as a service, which is delivered via Web [4]. Cloud includes both software and hardware services. Using the cloud, if not for free, is charged only for what is used and how it is used. This is known as *pay-as-you-go*. In order to use all the services and opportunities that come from the cloud, user must have a Web browser and an Internet connection and also must be logged in. The user does not need to worry for the latest software version or whether the database is updated.

Information integration will be achieved through developing a common database within *SQL Azure* platform. Portal based integration will be realized through development and use of the Web portal that will be hosted as a *Windows Azure* service. Common database and Web portal will be designed to meet the needs of all organizational units within the railways.Microsoft SQL Azure Database is a cloud-based relational database service built on SQL Server technologies. It provides a highly available, scalable, multi-tenant database service hosted by Microsoft in the cloud. Developers do not have to install, setup, patch or manage any software. High availability and fault tolerance is built-in and no physical administration is required. SQL Azure Database supports Transact-SQL(T-SQL). SQL Azure Database can help reduce costs by integrating with existing toolsets and providing symmetry with on-premises and cloud databases.

There are several ways to incorporate SQL Azure in applications [5], however there are two application patterns to access the SQL Azure data:

1. On-Premises Applications,
2. Hosted Applications residing in Cloud.

In a traditional on-premise application, the application code and database are located in the same physical data center. SQL Azure and the Azure Services Platform offer many alternatives to that architecture. The Fig. 1. demonstrates two

[1]Slađana Janković is with the Faculty of Transport and Traffic Engineering University of Belgrade, Vojvode Stepe 305, 11000 Belgrade,Serbia,E-mail: s.jankovic@sf.bg.ac.rs.

[2]Snežana Mladenović is with the Faculty of Transport and Traffic Engineering University of Belgrade, Vojvode Stepe 305, 11000 Belgrade, Serbia, E-mail: snezanam@sf.bg.ac.rs.

[3]Slobodan Mitrović is with the Faculty of Transport and Traffic Engineering University of Belgrade, Vojvode Stepe 305, 11000 Belgrade, Serbia, E-mail: s.mitrovic@sf.bg.ac.rs.

[4]Norbert Pavlović is with the Faculty of Transport and Traffic Engineering University of Belgrade, Vojvode Stepe 305, 11000 Belgrade, Serbia, E-mail: n.pavlovic@sf.bg.ac.rs.

[5]Slaviša Aćimović is with the Faculty of Transport and Traffic Engineering University of Belgrade, Vojvode Stepe 305, 11000 Belgrade, Serbia, E-mail: s.acimovic@sf.bg.ac.rs.

generalized alternatives available for how application can access SQL Azure data.In Scenario Aon the left, application code remains on the premises of corporate data center, but the database resides in SQL Azure. Application code uses client libraries to access database(s) in SQL Azure.

In Scenario Bon the right, application code is hosted in the Windows Azure and database resides in SQL Azure. Application can use the same client libraries to access database(s) in SQL Azure as are available in Scenario A. The Scenario Bclient premises may represent an end user's Web browser that is used to access Web application. The Scenario B client premises may also be a desktop application that uses the benefits of the Entity Data Model and the ADO.NET Data Services client to access data that is hosted in SQL Azure.

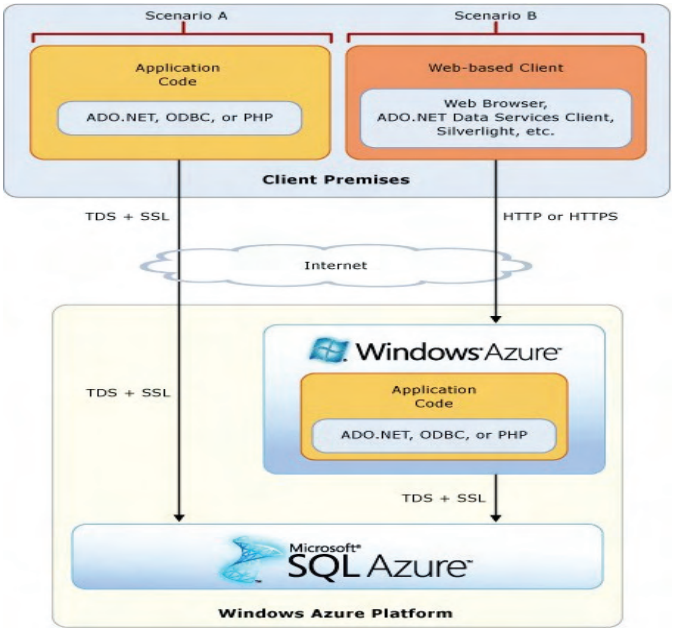

Fig. 1. Scenarios to access the SQL Azure data

Our railway IS integration model based on Scenario B. Scenario would be implemented as follows:

1. To consolidate the data updated and used by different sectors within the railway, proposed the integration of data within a SQL database Azure;
2. Application that includes data access and business logic will be implemented as a Web portal and hosted as a service on Windows Azure platform;
3. Client application will be a Web browser that will allow access to the Web application.

There are three categories of cloud computing services [6]:

- *Software-as-a-service, SaaS* - software that is implemented as a hosted service and can be accessed via the Internet,
- *Platform-as-a-service, PaaS* - platform that can be used for deployment of applications provided by the clients or service provider partners,
- *Infrastructure-as-a-service, IaaS* - computer infrastructure, such as servers and storage.

The model we propose combines all three categories of services. Using SQL database Azure means using SQL Azure platform for development and database management, ie. PaaS and also the using of the infrastructure, ie. IaaS. The using of Web application as Windows Azure hosted service, means using of the SaaS. Cloud computing offers four deployment models: Private Cloud, Public Cloud, Community Cloud, Hybrid Cloud. The proposed integration model of therailways IS involves the Community cloud delivery model. This means that only those computers which belong to Serbian Railways IP range should have right of access to a hosted service.

III. Implementation of the Proposed Model

A. *Architecture of The System*

The proposed model involves the development of the classic n-tier applicationwith the following layers:

- Database layer – SQL Azure database.
- Data access layer – Windows Azure Hosted Service, ADO.NET Entity Framework,
- Presentation layer – ASP.NET application.

B. *SQL Azure Database*

Individual organizational units within the Serbian Railways update the data related to railroad crossings for which they are responsible. This doesn't mean that other types of data are not necessary. In order to properly determine the appropriate safety measures for a railroad crossing, it is necessary to dispose of data about its current state, the actual volume of traffic and safety parameters. All these information categories are merged into a single *SQL Azure* database of Serbian railroad crossings. One of 16 database tables is shown in Fig. 2.

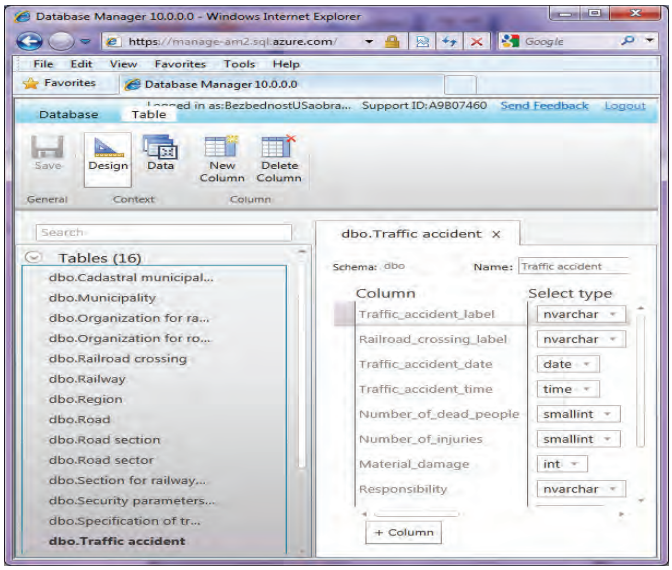

Fig. 2. Traffic accident table in SQL Azure database

C. *Windows Azure Hosted Service*

Windows Azure platform hosts the service calles *Serbian railroad crossings*, supplied with domain http://srrc.cloudapp.net (Fig. 3). This service is developed as WindowsAzureProject in IDE Visual Studio 2010. A Windows Azure application can be created using three kinds of roles: Web roles, intended primarily for running Web-based applications; Worker roles, designed to run a variety of code like a simulation, or video processing; VM roles, which can run a user-provided Windows Server 2008 R2 image. In our case study, the Windows Azure application is realized asWebRole ASP.NET application called SERBIAN RAILROAD CROSSINGS PORTAL(SRCP).

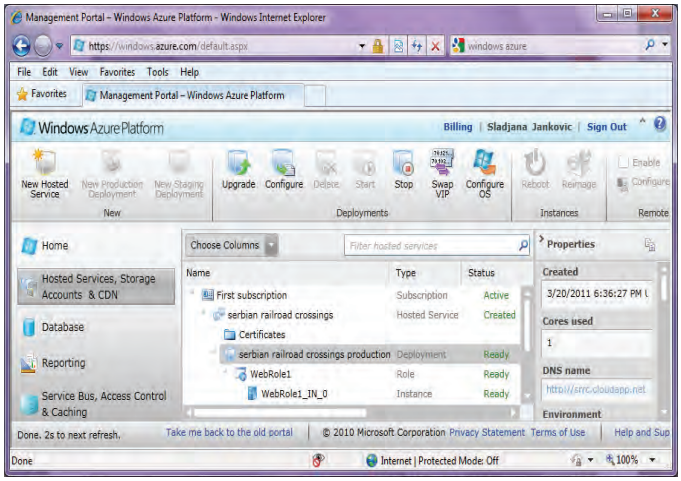

Fig. 3. Serbian railroad crossings - Windows Azure hosted service

The web role provides support for presenting a user facing frontend through IIS. SRCP uses the ADO.NET Entity Framework - a set of technologies in ADO.NET that support the development of data-oriented applications. The EntityDataSource control allows us to bind Web controls on a page to data in our Entity Data Model (Fig. 4).

D. *Web Based Client*

Client Web application *SERBIAN RAILROAD CROSSINGS* PORTAL allows users to view and/or update content of the *SQL AzureSerbian railroadcrossings* database. The main application menu consists of: *Railways, Roads, Railroad crossings, Traffic and Traffic Safety*. For example, *Traffic* menu consist of:

- *Traffic load on railroad crossings,*
- *Traffic load on railroad crossings – structure,*
- *Traffic load on railroad crossings – average retentions.*

*Traffic Safety*menu consist of:

- *Traffic accidents on railroad crossings,*
- *Security parameters of railroad crossings,*
- *Security parameters – responsibility structure.*

Fig. 5. shows Web application page designed for viewing the safety parameters of railroad crossings. Safety parameters are calculated on the basis of data on traffic accidents that occurred on a railroad crossing, which is stored in the same SQL Azure database. It is possible to calculate the safety parameters for the transition to the selected year, or calculate and display the safety parameters for all crossings.

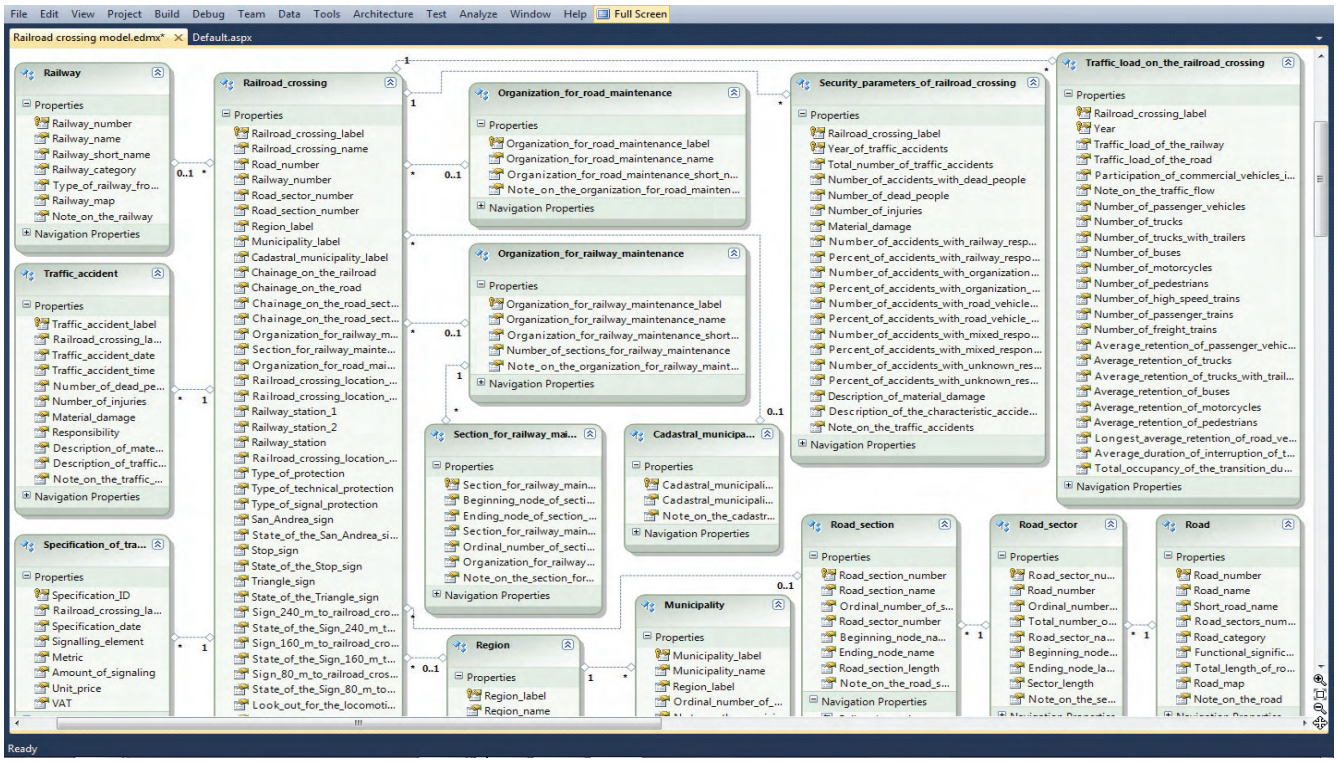

Fig. 4. Entity Data Model of ASP.NET application SERBIAN RAILROAD CROSSINGS PORTAL

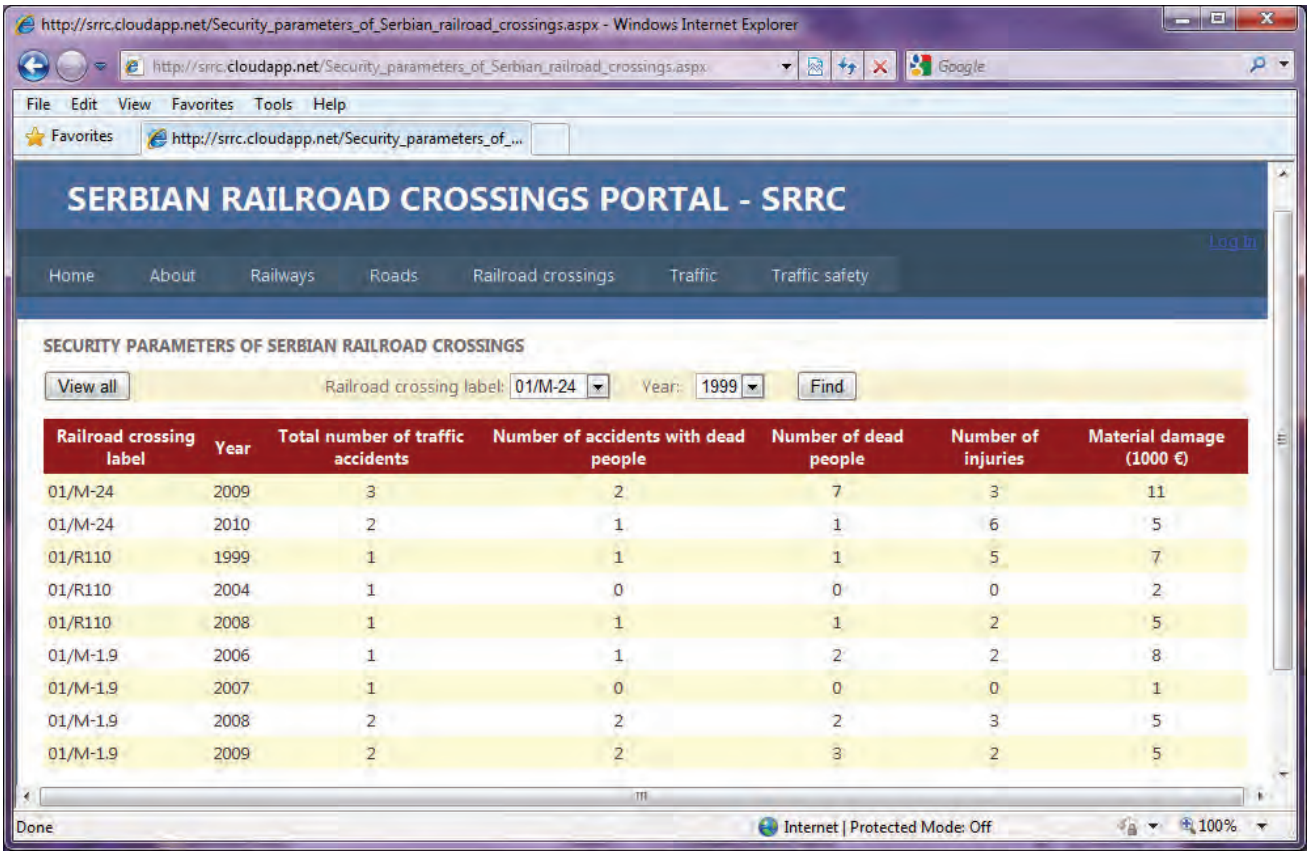

Fig. 5. SERBIAN RAILROAD CROSSINGS PORTAL – Security parameters of Serbian railroad crossings

IV. Conclusion

SQL Azure Database allows consolidation of multiple data sources in the cloud and enable secure access from multiple locations, desktop and/or devices.Hosting application code in Windows Azure is beneficial to the performance of application because it minimizes the network latency associated with application's data requests to SQL Azure.

Development of database on SQL Azure platform as well as Web applications hosted on Windows Azure platform allows different railways organizational units to use the same database, update only the data for which they are responsible, generate uniform reports. This eliminates the redundancy and ensures data integrity. End users of database and Web application should use only a Web browser on their computers.

Cloud computing technology was designed primarily to increase efficiency [7]. Hence, the proposed integration model emphases following benefits: the flexibility, scalability, portability, usage time saving as well as response times, minimization the risk of poor implementation of physical infrastructure, fixed costs reduction and acceleration of innovation process. The most serious drawback of the proposed model and technological solution is its dependence of cloud providers and partial loss of control over the system of governance. Judging by the large international companies that rely on cloud computing technology the risk should be awarded.

Acknowledgement

Thiswork is partially supported by the Ministry of the Science and technological development of the Republic of Serbia under No. 036012.

References

[1] S. Janković, S. Mladenović, “Some Aspects of Interoperability of Enterprises and Their Applications”, SYMOPIS 2008, Conference Proceedings, pp. 71-74, Soko Banja, Serbia, 2008.

[2] S. Janković, “Interoperability of transport business systemsbased on the integration of service-oriented B2B applications”, InfoM, vol. 36/2010,pp. 4-12, 2010.

[3] W. Lee, S. Tseng, W. Shieh, “Collaborative real-time traffic information generation and sharing framework for the intelligent transportation system”, Information Sciences, vol. 180, pp. 62-70, 2010.

[4] D. S. Linthicum, *Cloud Computing and SOA Convergence in Your Enterprise*, Boston, Pearson Education, 2010.

[5] D. Betts, S. Densmore, R. Dunn, M. Narumoto, E. Pace, M. Woloski, *Developing Applications for the Cloud on the Microsoft® Windows Azure™ Platform*, Microsoft, 2010.

[6] J. Krishnaswamy, *Microsoft SQL Azure: Enterprise Application Development*, Birmingham – Mumbai, Packt Publishing, 2010.

[7] S. Marston, Z. Li, S. Bandyopadhyay, J. Zhang, A. Ghalsasi, “Cloud computing - The business perspective”, Decision Support Systems, vol. 51, pp. 176-189, 2011.