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MODEL OF SERVICE-ORIENTED B2B INTEGRATION IN THE TRAFFIC SAFETY AREA

ABSTRACT

One class of methods for black spots identification is based on the analysis of: traffic accidents (TA), road parameters, and traffic intensity. The data used in the analysis can be grouped into the information about: roads, persons participating in TA, vehicles participating in TA, traffic accidents and their consequences, and traffic. These categories of data are usually under the jurisdiction of different traffic and non-traffic subjects. Therefore, it is necessary to exchange traffic safety data among the following sources: traffic police, road manager, and health and judicial sector. This paper proposes a model for the exchange and integration of traffic safety data into a single database, which allows the calculation of risks for road sections, as well as the classification and ranking of the sections. The model is based on B2B integration of service-oriented applications. This paper describes a practical example that demonstrates the proposed integration model.

KEY WORDS

B2B, interoperability, traffic safety, traffic accident, traffic safety data, road sections ranking, service-oriented architecture

1. INTRODUCTION

Business of transport and traffic companies is based on quick decision-making, efficient application of decisions, flawless coordination, efficient communication and information sharing. Information is shared among numerous service divisions: control, risk, safety, maintenance, management, traffic control etc. There are two factors which cause erroneous decision-making in the area of traffic and transportation: *knowledge gap* and *communications gap* [1]. This paper proposes a model of communication between traffic and non-traffic business information systems (IS) which is supposed to help in bridging these gaps.

Interoperability, in the broad sense, is the ability of two or more systems and/or system components to exchange information, but also to use the exchanged information. Interoperability of traffic and non-traffic subjects provides two or more business entities with the ability of exchanging or sharing information and using the functionality of one another in a distributed and heterogeneous environment [2].

In the area of building Web-based IS, the interoperability of IS has come to the fore, in allowing the sharing of data and services between heterogeneous systems [3]. The traffic and transportation systems indeed, are heterogeneous systems which do have the need for exchanging information, which is the primary reason why achieving interoperability of their IS is necessary. This paper studies the model of interconnecting traffic subjects, as well as connecting traffic companies with other types of businesses, based on the interoperability of their IS.

The authors in [4] confirm claims that the "*Safety-in-Numbers*" principle is indeed relevant in the area of traffic safety. However, to implement this principle in real circumstances, "Numbers" must be a product of interoperable information systems, as opposed to manual calculations done by the researchers. *The main problem that is solved in this paper is achieving of interoperability of traffic and non-traffic subjects in the traffic safety area.*

The rest of this paper is organized as follows: in the second section, a model of information exchange between traffic and non-traffic information systems based on integration of service-oriented applications is proposed and analyzed. In the third section, a case study of the application of the proposed integration model is presented. The case study demonstrates how interoperability is achieved between Public Enterprise “Roads of Serbia” as the manager of roads and the Ministry of the Interior in the Republic of Serbia. Finally, conclusions and literature are given.

2. B2B INTEGRATION MODEL IN THE TRAFFIC SAFETY AREA

The design of new applications or modification of the existing applications in order to enable exchanging of data and functionalities is called *software integration*. The integration allows the users to have a unique view of data which are physically stored on different hosts [5]. Data sources are independent, and accessed by the users or applications through local or public network. The *application integration* is an efficient and orchestrated resource and/or data sharing between applications used by one or more companies. *Business-to-business (B2B) application integration* means safe coordination of information between business systems and their information systems.

The proposed model should enable information exchange between traffic and non-traffic companies, which means that it is a candidate for B2B application integration. B2B application integration focuses on the development of business-to-business partnerships and transforms of inter-organizational relationships. Therefore, in this section a model of interoperable traffic and non-traffic systems – data sources, is proposed, based on B2B integration of their applications.

2.1 Background

The Commission of the European Communities [6] in the area of traffic policy promotes the *“Three I” principle: interconnectivity, intermodality, and interoperability*. Interoperability, as one of the basic attributes of the new EU transportation system implies a local and global way of connecting services, traffic systems, as well as connecting traffic systems with other types of businesses. The EU supports the development of this property of transportation with directives on unified statistical reports, defined for all types of transportation.

The authors in [7] have noticed that the human factor plays an important and potentially complicated role in functioning of an *Intelligent Transportation System* (ITS). The most frequent requirement is the availability of information updated by different businesses. In order to avoid the potentially negative impact of the human factor, communication between people should be avoided, promoting instead automated data exchange between interoperable information systems.

Providing roads safety is one of the factors which exerts influence upon the reduction of road accidents and the resulting injuries and fatalities. Thus, identification of the safety criteria of roads and the evaluation and *ranking of the roads* on the basis of these criteria will be effective in fulfilling this goal [8]. There is need for new types of road classification procedures that incorporate advanced algorithms and support *multiple data sources* [9].

There are two classes of methods for black spot identification [10]: objective methods (based on the analysis of traffic accidents, roads, and traffic) and subjective methods (based on the analysis of attitudes and opinions of experts or road users).

The objective methods of black spots identification are based on the calculation of risks for the road sections, ranking and selection of the most dangerous sections on the basis of the calculated risk, and finally - the identification of black spots. In the calculation of risks the data about road sections for the given time period were used: the total number of traffic accidents (TA) on the road section, the number of traffic accidents including fatalities, the number of accidents resulting in injury, the number of accidents resulting in material damage only, the number of fatalities, the number of serious injuries, the number of light injuries, Annual Average Daily Traffic (AADT) on the road section, and the section lengths. All these data, according to the source that provides them, can be classified into several categories. Data about road, section length and traffic load on the section are provided by the road managers. Basic data about TA (time, place and participants in the accident) can be obtained from the relevant ministry or other institution from the Government sector. Health and judicial government sectors have the data about the consequences of TA. Therefore, it is necessary to ensure the retrieval of data from heterogeneous sources and their integration into a single database.

The types of application integration, according to their technical implementation, are classified into the following general categories:

- information-oriented application integration,
- portal-oriented application integration,
- business process integration-oriented application integration,
- service-oriented application integration.

Two systems use Web services to communicate when an application creates XML document in the form of a message and sends it through the network to a Web service [11]. Optionally, Web service sends a response to the request in the form of an XML document. *Web service is a software system designed to* *support interoperable computer interaction through the network*. We indicate the interoperability side of Web services, because all of them use the same standards, common communication protocols, and do not depend on technologies in which applications calling them are developed. Concerning our task to enable interoperability of traffic business systems by offering functionalities of one system to another, we propose an application integration model based on *Web service architecture*.

There are four styles of software integration: import/export files, shared database, remote procedure calls, and message bus. The proposed model of traffic business systems interoperability is based on *integration style of exchanging messages*.

There are three categories of barriers for the interoperability of information systems [12]: conceptual barriers (syntax and semantic incompatibility), technical barriers (incompatible technologies), and organizational barriers (incompatible work styles, organizational structures etc.). The proposed model of interoperability of traffic business systems overcomes all three previously mentioned types of barriers. Syntax and semantic incompatibility is avoided by defining syntax and semantic of calculation within one special type of Web service. Thus, every end user gets identical data, calculated in the same way and with unique meaning.

2.2 Model design

Incompatibility of technologies in the proposed model was overcome by using *BizTalk Server 2010*. BizTalk Server is a Microsoft toolset which allows data exchange between different computer systems. It is a collection of components whose sole purpose is to allow integration. By using BizTalk Server, companies can communicate with broad spectrum of different platforms and applications. *Windows Communication Foundation (WCF) Framework* is the key component of BizTalk Server 2010 platform, which in turn serves as the basis for Microsoft service-oriented strategy. The purpose of the WCF framework is to provide a single transport-neutral development paradigm with common aspects for security, transactions, and exception handling. The tasks that are required to build a WCF application: define the service contract, implement the contract, configure the service, host the service, and build a client application. Basically, WCF is a framework which allows creation, hosting and using of WCF services.

The integration efforts are greatly hampered by the absence of clean interfaces. Microsoft created a set of different adapters, i.e. specific application interfaces from one or more companies towards BizTalk messaging engine. By using *adapter technology*, WCF services can communicate with different platforms, sources, and data formats (*Figure 1*). *In this way our model overcomes the technical barriers. In the proposed application integration model the client application calls WCF services that use BizTalk SQL Adapter to download data from the SQL Server database.*

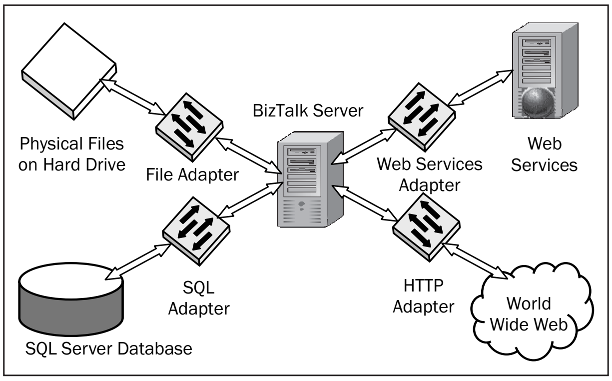


Figure 1 – Model of information exchange based on BizTalk Server adapters

The proposed model requires exchanging of the existing data between systems in question. The decision regarding data exchange is made on the highest level of management of both business systems. Data are exchanged using software, not people, so that the interoperability model is not influenced by organizational incompatibilities of business systems. Also, WCF is a framework for exchanging messages between systems. When using WCF services, request and (if applicable) response messages are exchanged. The proposed model uses *Request/Callback pattern* for data exchange (*Figure 2*). This data exchange pattern uses non-blocking asynchronous service invocation, with service response which contains current data.

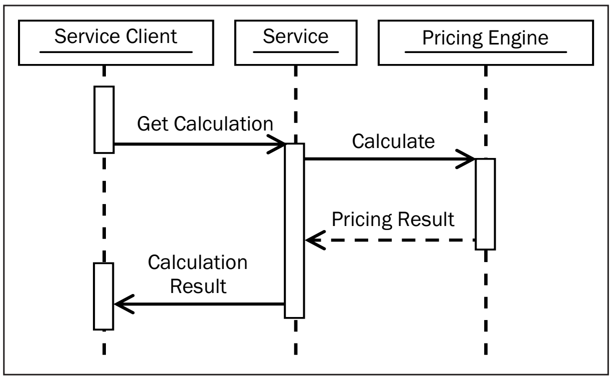


Figure 2 - Request/Callback pattern of exchanging messages between service and client

3. IMPLEMENTATION OF THE PROPOSED INTEGRATION MODEL

Our example is concerned with the Ministry of the Interior and the Public Enterprise “Roads of Serbia” (PERS) interoperable e-business. Naturally, all other bodies can exchange and use information regarding road accidents in a similar manner. The Ministry of the Interior is concerned with the accident analysis from the micro view, because this body has the information necessary for this type of analysis (data on people involved in the accident, circumstances, causes, and consequences). PERS analyzes accidents from the medium view, because it has information on road properties on which the accident actually happened.

3.1 Case study from Serbia

Statistical data on road accidents are one of the basic parameters when defining measures for improving road safety. Road accidents on road network in the Republic of Serbia are the responsibility of different state and economic institutions: the Ministry of Infrastructure, the Ministry of the Interior, Road Traffic Safety Agency, PERS, and so on. The Ministry of the Interior owns the road accident database (data on the number of road accidents, causes and consequences of road accidents), while PERS is a body in charge of maintaining the existing state roads in the Republic of Serbia; therefore responsible for the safety on the network of state roads. Consequently, statistical data on road accidents are necessary for PERS functioning.

If PERS had information on the number of accidents and consequences on road sections, then this body would be able to identify dangerous road sections and black spots. Dangerous road sections would be subsequently analyzed from traffic, civil engineering, financial, and social aspect, and decisions would be made on types of maintenance and/or reconstruction of the analyzed sections. On the other hand, if the Ministry of the Interior knew which road sections are dangerous, it would certainly influence the traffic control on these sections. The conclusion is that permanent cooperation of the two bodies, the Ministry of the Interior and PERS is necessary in order to improve road safety in Serbia. This cooperation actually implies the exchanging of information relevant to the area of road safety. The information systems used so far by these bodies did not support automatic information exchange, i.e. they were not interoperable. The model of information exchange proposed in the previous section allows achieving interoperability.

3.2 Results of the model implementation

Microsoft Visual Studio 2010 Integrated Development Environment was used for developing *Windows client application - BLACK SPOTS* whose task is to enable ranking and classifying of road sections. Road sections can be ranked according to the following criteria:

- Corrected Collective Risk of Accidents – *CCRA*:

$$CCRA = \frac{\sum_{i=1}^{T} WNRA_i^*}{L \cdot T} \quad \left(\frac{\text{accident}}{\text{km year}}\right) \tag{1}$$

where: L – the length of the road section, km, T – number of years, $WNRA_i^*$ – Weighted corrected Number of Road Accidents for year i, $i = 1, \ldots, T$:

$$WNRA_i^* = WNRA_i \cdot (1 + (d_i/(l_i + s_i + d_i))) \tag{2}$$

where: $WNRA_i$ – Weighted Number of Road Accidents for year i:

$$WNRA_i = n_{i1} \cdot k_1 + n_{i2} \cdot k_2 + n_{i3} \cdot k_3 \tag{3}$$

where: d_i – number of fatalities, s_i – number of serious injuries, l_i –number of light injuries, n_{i1} – number of accidents resulting in material damage only, n_{i2} – number of accidents resulting in injury, n_{i3} – number of accidents involving fatalities, k_1, k_2, k_3 – coefficients determined in relation with the total costs of accident with different consequences.

- Corrected Individual Risk of Accidents - *CIRA*:

$$CIRA = \frac{\sum_{i=1}^{T} WNRA_i}{L \cdot 365 \cdot \sum_{i=1}^{T} AADT_i} \cdot 10^6 \quad \left(\frac{\text{accident}}{\text{mil. km veh.}}\right) \tag{4}$$

where: $AADT_i$ – Annual Average Daily Traffic for year i.

- Collective Risk of Injuries - *CRI*:

$$CRI = \frac{\sum_{I=1}^{T} WNI_i}{L \cdot T} \quad \left(\frac{\text{injuries}}{\text{km year}}\right) \tag{5}$$

where: WNI_i – Weighted Number of Injuries for year i:

$$WNI_i = l_i \cdot k_4 + s_i \cdot k_5 + d_i \cdot k_6 \tag{6}$$

where: k_4, k_5, k_6 – empiric determined coefficients in relation to total costs of different consequences

- Individual Risk of Injuries - *IRI*:

$$IRI = \frac{\sum_{i=1}^{T} WNI_i}{L \cdot 365 \cdot \sum_{i=1}^{T} AADT_i} \cdot 10^6 \quad \left(\frac{\text{injuries}}{\text{mil. km veh.}}\right) \tag{7}$$

- Collective Risk of Death and Serious Injuries - *CRDSI*:

$$CRDSI = \frac{\sum_{i=1}^{T} (d_i + s_i)}{L \cdot T} \quad \left(\frac{\text{d. and s.i.}}{\text{km year}}\right) \tag{8}$$

- Individual Risk of Death and Serious Injuries - *IRDSI*:

$$IRDSI = \frac{\sum_{i=1}^{T} (d_i + s_i)}{L \cdot 365 \cdot \sum_{i=1}^{T} AADT_i} \cdot 10^6 \quad \left(\frac{\text{d. and s.i.}}{\text{mil. km veh}}\right) \tag{9}$$

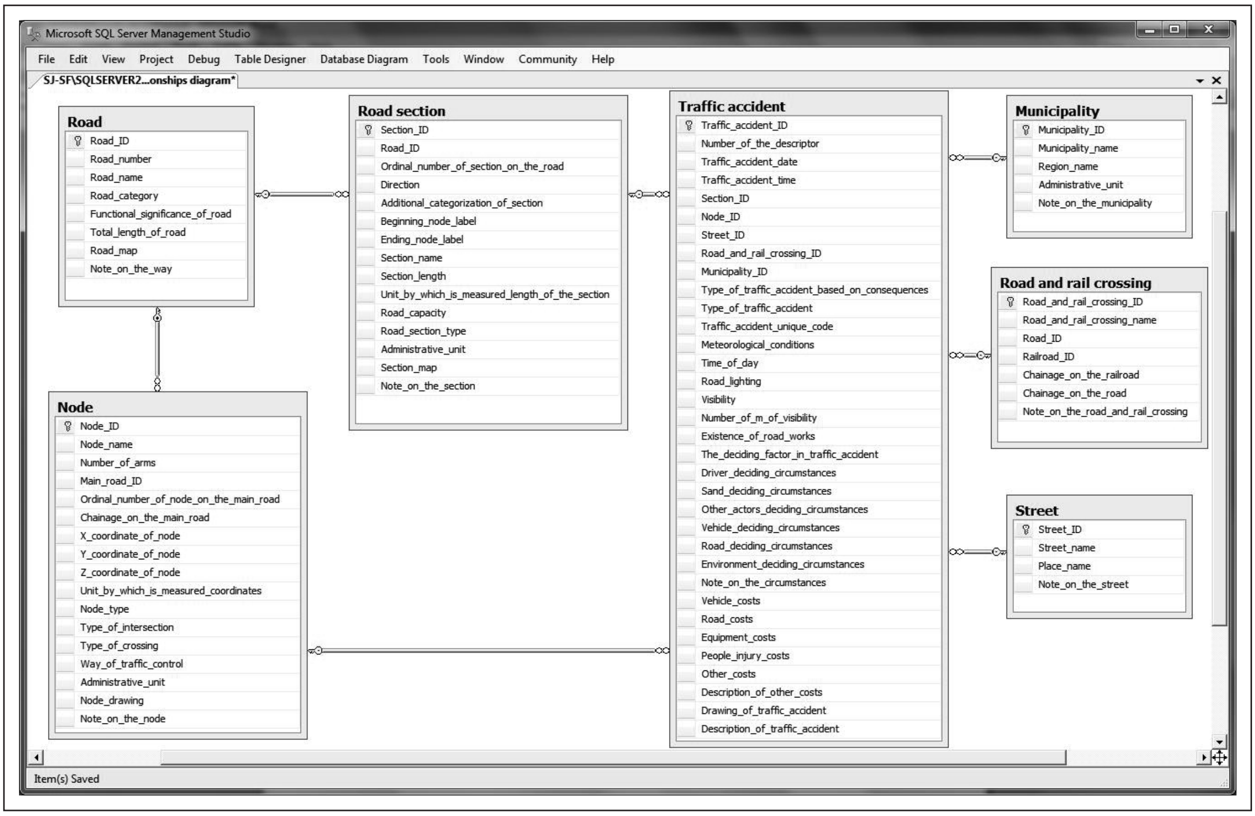


Figure 3 - Relationship diagram of the Traffic accidents database

– Collective Risk of Death - *CRD*:

$$CRD = \frac{\sum_{i=1}^{T} d_i}{L \cdot T} \quad \left(\frac{\text{deaths}}{\text{km year}}\right) \tag{10}$$

– Individual Risk of Death - *IRD*:

$$IRD = \frac{\sum_{i=1}^{T} d_i}{L \cdot 365 \cdot \sum_{i=1}^{T} AADT_i} \cdot 10^6 \quad \left(\frac{\text{deaths}}{\text{mil. km veh.}}\right) \tag{11}$$

A number of traffic safety data is stored in the SQL Server Traffic accidents database which is updated by the Ministry of the Interior (*Figure 3*).

The originally developed WCF Adapter service named *WCFAdapterServiceTrafficAccidents* downloads traffic safety data from *Traffic accidents database*. Part of the WCFAdapterServiceTrafficAccidents configuration file is presented in *Figure 4*.

Client application - BLACK SPOTS receives traffic accidents data by calling the service *WCFAdapterServiceTrafficAccidents* (*Figure 5*).

The main result of the proposed integration model in the field of road safety is the following: road sections are classified according to calculated risks into the five categories (*Figure 6*). The darkest sections are the most dangerous ones, less dark sections are less dangerous etc., while the brightest road sections are the least dangerous.

The developed BLACK SPOTS application supports automatic generation of numerous graphical views. For example, one road sections ranking, obtained by combining four selected criteria, is shown in *Figure 7*.

```
<service behaviorConfiguration="customServiceBehavior"
    name="TableOp_dbo_Traffic_accidentClient">
    <endpoint address="" behaviorConfiguration="customEndpointBehavior"
     binding="basicHttpBinding"
     bindingConfiguration="TableOp_dbo_Traffic_accidentClientBindingConfig"
     name="TableOp_dbo_Traffic_accidentEndpoint"
     contract="TableOp_dbo_Traffic_accident" />
</service>
...
<client>
   <endpoint address="mssql://sladjana/sfsql/MI RS?" binding="sqlBinding"
    bindingConfiguration="SqlAdapterBinding"
    contract="TableOp_dbo_Traffic_accident"
    name="SqlAdapterBinding_TableOp_dbo_Traffic_accident" />
</client>
```

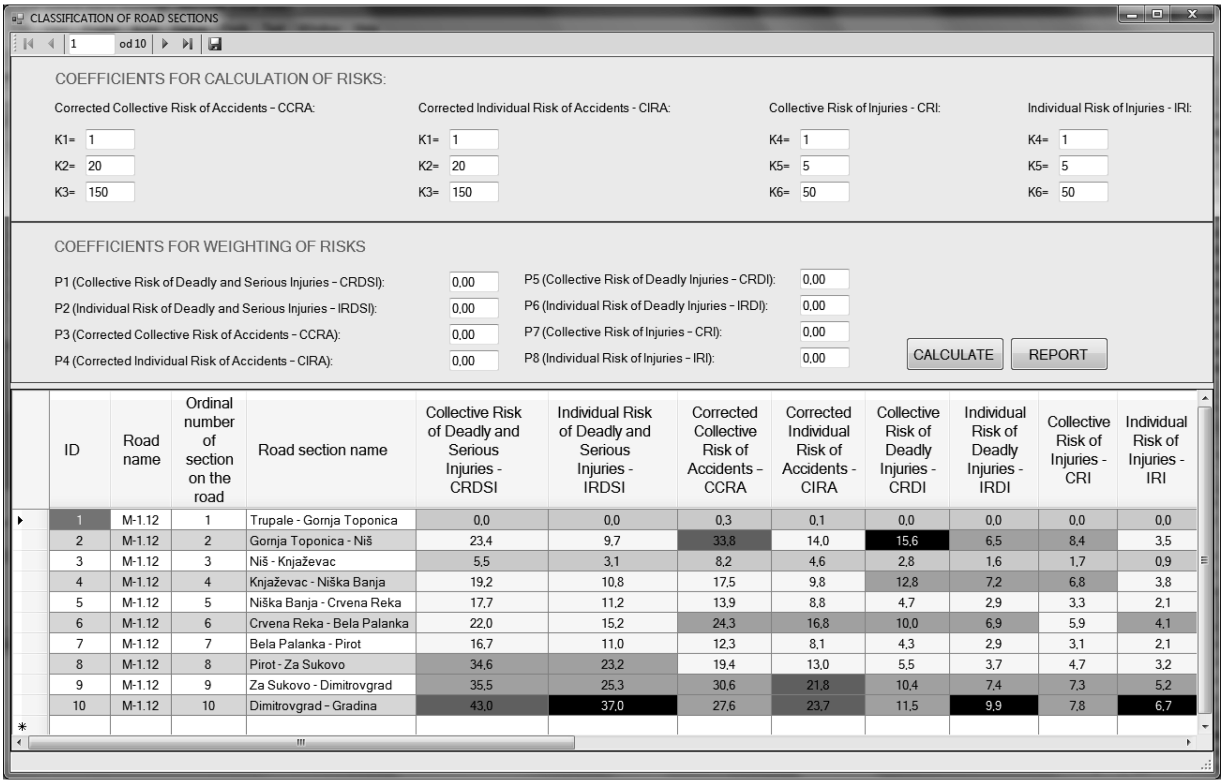
Figure 4 - WCFAdapterServiceTrafficAccidents – part of the web.config file

```
Dim client1 As WebReferenceTA.TableOp_dbo_Traffic_accidentClient client1 = _
New WebReferenceTA.TableOp_dbo_Traffic_accidentClient()
 Try
   Dim columnString As String = "*"
   Dim queryString As String = ""
   Dim batchResults1 As WebReferenceTA.Traffic_accident() =
   client1.Select(columnString, queryString)
```

Create a WCF Service Client

Call a Select Service Operation

Figure 5 - Client BLACK SPOTS application calling the service WCFAdapterServiceTrafficAccident



ID	Road name	Ordinal number of section on the road	Road section name	Collective Risk of Deadly and Serious Injuries - CRDSI	Individual Risk of Deadly and Serious Injuries - IRDSI	Corrected Collective Risk of Accidents - CCRA	Corrected Individual Risk of Accidents - CIRA	Collective Risk of Deadly Injuries - CRDI	Individual Risk of Deadly Injuries - IRDI	Collective Risk of Injuries - CRI	Individual Risk of Injuries - IRI
1	M-1.12	1	Trupale - Gornja Toponica	0,0	0,0	0,3	0,1	0,0	0,0	0,0	0,0
2	M-1.12	2	Gornja Toponica - Niš	23,4	9,7	33,8	14,0	15,6	6,5	8,4	3,5
3	M-1.12	3	Niš - Knjaževac	5,5	3,1	8,2	4,6	2,8	1,6	1,7	0,9
4	M-1.12	4	Knjaževac - Niška Banja	19,2	10,8	17,5	9,8	12,8	7,2	6,8	3,8
5	M-1.12	5	Niška Banja - Crvena Reka	17,7	11,2	13,9	8,8	4,7	2,9	3,3	2,1
6	M-1.12	6	Crvena Reka - Bela Palanka	22,0	15,2	24,3	16,8	10,0	6,9	5,9	4,1
7	M-1.12	7	Bela Palanka - Pirot	16,7	11,0	12,3	8,1	4,3	2,9	3,1	2,1
8	M-1.12	8	Pirot - Za Sukovo	34,6	23,2	19,4	13,0	5,5	3,7	4,7	3,2
9	M-1.12	9	Za Sukovo - Dimitrovgrad	35,5	25,3	30,6	21,8	10,4	7,4	7,3	5,2
10	M-1.12	10	Dimitrovgrad - Gradina	43,0	37,0	27,6	23,7	11,5	9,9	7,8	6,7

Figure 6 - BLACK SPOTS Application – Road M-1.12 section classification

The abbreviations that appear in the chart legend are explained in the text above the formulas which were numbered 4, 1, 9, 8, respectively. Also, the abbreviations are explained in the BLACK SPOTS application from which a chart is generated, as can be seen in *Figure 6*.

The most important result achieved in the field of interoperability is in the way PERS takes the traffic safety data from the Ministry of the Interior. PERS uses BLACK SPOTS application for ranking and classification of road sections. BLACK SPOTS application, on user command, calls the software service

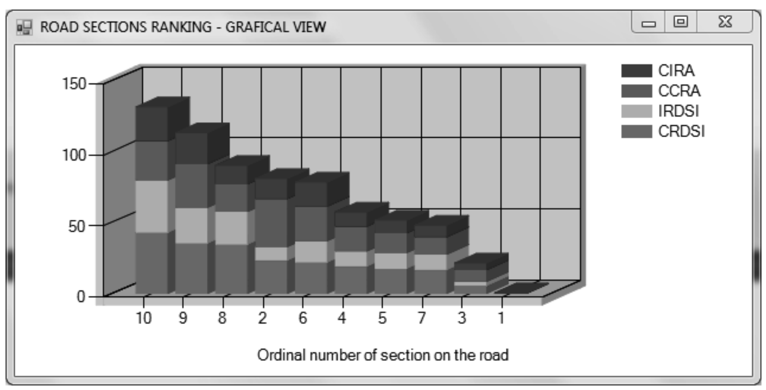


Figure 7 - BLACK SPOTS Application – Road M-1.12 section ranking graph

that takes data from the Ministry of the Interior database. The downloaded data have pre-defined, unchangeable structure and format. Thus, manual takeover, resizing, and re-entering of data is avoided. Automated data exchange (at the software level) eliminates the mistakes in entering, and provides almost instantaneous retrieval of data whenever the need arises.

To help choose the most dangerous sections, the application supports section filtering based on the values of calculated risks. The most dangerous road sections are subject to detailed analysis. The analysis of the space distribution of traffic accidents is performed. The goal of such analysis is to identify black spots on the selected road sections or on the road network. Following the detailed analysis, depending on the available material support, a decision is made on how to improve the black spots.

4. CONCLUSION

This paper analyses the possibilities of interoperable e-business of traffic and non-traffic subjects in the area of traffic safety. A model for enabling interoperability of subjects in the traffic safety area is proposed, based on which an original software system is implemented. The model and the implemented software are demonstrated on a practical example of cooperation of two businesses in the Republic of Serbia. The proposed model is based on B2B integration of service-oriented applications, using Microsoft adapter technology and WCF services. In [13] the authors have emphasized that Web services, available to business systems, can be used by anyone, at any location, at any time, and on any platform type. The practical example implemented and described in this paper confirms this claim.

The implementation of the proposed model makes it possible to:

1. improve updating of data in different databases which are part of different traffic and non-traffic business systems. Each business system will update only data for which it is responsible. As a result, a task is done only once and by the system which is the most competent for the task in question. Also, data redundancy is avoided and at the same time, data integrity is provided.
2. synchronize traffic business systems activities which are interdependent, and had been done independently before;
3. generate identical, unified reports which improve business cooperation between traffic and non-traffic systems and joint decision-making;
4. generate reports needed for other involved businesses based on the data from the database updated by businesses in question.

The BLACK SPOTS application, when implemented, should:

1. increase operational efficiency of bodies interested in road safety improvement;
2. enable customizability of bodies in the area of road safety by using loose coupling systems. Loose coupling systems enable quick changing without subsequent negative effects;
3. increase information correctness and help faster and better decision-making in order to prevent update delay.

The proposed model of B2B integration could be implemented in other aspects of traffic and transport by developing appropriate applications or by modifying the existing ones. This is an efficient way of sharing data and services among any number of business entities. The future work plans to focus on implementing the proposed model of B2B integration among the following traffic subjects: "Serbian Railways" – the Ministry of the Interior of the Republic of Serbia, "Serbian Railways" - Public Enterprise "Roads of Serbia" and Road Traffic Safety Agency of the Republic of Serbia – the Ministry of the Interior of the Republic of Serbia.

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APSTRAKT

MODEL SERVISNO-ORIJENTISANE B2B INTEGRACIJE U OBLASTI BEZBEDNOSTI SAOBRAĆAJA

Jedna klasa metoda za identifikaciju crnih tačaka bazirana je na analizi saobraćajnih nezgoda (SN), parametara puteva i intenziteta saobraćaja. Podaci koji se koriste u analizi mogu se grupisati na podatke o: putevima, licima učesnicima SN, vozilima učesnicima SN, saobraćajnim nezgodama i njihovim posledicama, saobraćaju. Ove kategorije podataka najčešće su u nadležnosti različitih saobraćajnih i nesaobraćajnih subjekata. Stoga se nameće potreba za razmenom podataka o bezbednosti saobraćaja između sledećih izvora: saobraćajne policije, upravljača puta, zdravstvenog i sudskog sektora. U ovom radu mi predlažemo model razmene i integrisanja podataka o bezbednosti saobraćaja u jedinstvenu bazu podataka, koja omogućava izračunavanje koeficijenata rizika za deonice puteva, zatim klasifikaciju i rangiranje deonica. Model je zasnovan na B2B integraciji servisno-orijentisanih aplikacija. Rad opisuje i praktičan primer koji demonstrira predloženi model integracije.

KLJUČNE REČI

B2B, interoperabilnost, bezbednost saobraćaja, saobraćajna nezgoda, podaci o bezbednosti u saobraćaju, rangiranje deonica puteva, servisno-orijentisana arhitektura

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REFERENCES

[1] **Cohena, G.**, **Salomonb, I.**, **Nijkampa, P.**: *Information–communications technologies (ICT) and transport: does knowledge underpin policy?*, Telecommunications Policy, Vol. 26, 2002, pp. 31–52

[2] **Janković, S.**: *Interoperability of transport business systems based on the integration of service-oriented B2B applications*, Info M, Vol. 36, 2010, pp. 4-12

[3] **Nicole, C.**: *Interoperability between Distributed Systems and Web-Services Composition*, Encyclopedia of Information Science and Technology, pp. 2210-2215, Information Science Reference, Hershey, 2009

[4] **Bhatia, R.**, **Wier, M.**: *"Safety in Numbers" re-examined: Can we make valid or practical inferences from available evidence?*, Accident Analysis and Prevention, Vol. 43, 2011, pp. 235–240

[5] **Verstichel, S.**, **Ongenae, F.**, **Loeve, L.**, **Vermeulen, F.**, **Dings, P.**, **Dhoedt, B.**, **Dhaene, T.**, **De Turck, F.**: *Efficient data integration in the railway domain through an ontology-based methodology*, Transportation Research Part C, Vol. 19, No. 4, 2011, pp. 617-643

[6] Commission of the European Communities, White paper European transport policy for 2010: time to decide, 2001, at http://ec.europa.eu/transport/strategies/doc/2001_white_paper/lb_com_2001_0370_en.pdf (accessed November 2011)

[7] **Baublys, A.**, **Jarašuniene, A.**: *Statistical probability evaluation of operating ITS*, Transport, Vol. 25, No. 2, 2010, pp. 163–170

[8] **Haghighat, F.**: *Application of a Multi-criteria Approach to Road Safety Evaluation in the Bushehr Province, Iran*, Promet – Traffic & Transportation, Vol. 23, No. 5, 2011, pp. 341-352

[9] **Ćavar, I.**, **Kavran, Z.**, **Petrović, M.**: *Hybrid Approach for Urban Roads Classification Based on GPS Tracks and Road Subsegments Data*, Promet – Traffic & Transportation, Vol. 23, No. 4, 2011, pp. 289-296

[10] **Lipovac, K.**, **Jovanović, D.**, **Nešić, M.**, **Jovanov, D.**: *Database of black spots on main roads in Serbia*, 4th IRTAD Conference, Road safety data: collection and analysis for target setting and monitoring performances and progress, Seoul, Korea, 2009

[11] **Janković, S.**, **Mladenović, S.**: *Some Aspects of Interoperability of Enterprises and Their Applications*, in Proceedings of the 35th "Symposium on Operational Research", pp. 71-74, Soko Banja, Serbia, 2008

[12] **Ullberg, J.**, **Chen, D.**, **Johnson, P.**: *Barriers to Enterprise Interoperability*, in Proceedings of „Second IFIP WG 5.8 InternationalWorkshop, IWEI 2009", pp. 13-24, Valencia, Spain, 2009

[13] **Liapis, A.**, **Christiaens, S.**: *Collaboration Across the Enterprise: An Ontology Based Approach for Enterprise Interoperability*, Semantic Enterprise Application Integration for Business Processes: Service-Oriented Frameworks, pp. 1-18, Business Science Reference, Hershey, 2010