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Andrej Beden graduated from the Faculty of Civil Engineering. After graduation he continued education in the direction of computer programming where he reached the status of MCSD (Microsoft Certified Solution Developer). In recent years, he has acquired extensive experience in programming web GIS solutions.

Matjaž Ivačič graduated in geodesy and also completed postgraduate study of spatial informatics. During the study he improved knowledge in Delft University of Technology in the Netherlands and worked as GIS experts in the Oil for Food Programme under United Nations in Iraq. He has experiences in technical and management aspects of GIS related projects.

Title: Integrated Road Weather Information Systems in Slovenia

Abstract:

A few years ago Slovenian motorways were equipped with a dozens of Road Meteorological Stations, which differed by age, installed sensors and manufacturers. Only few stations were locally integrated and others not. Therefore, at that time, road maintenance relied on relatively small amount of weather data. Subsequently, a decision was made to include all of the weather stations to create an integrated and comprehensive Road Weather Information System. It was a challenge to create services that support different protocols, to create a unique data model and database, and to create a web based application that supports the final user and diverse road maintenance activities. The system consists of three main parts:

Collection - services for collecting data from different weather stations and for their conversion into the appropriate form for input to the central system.

Evaluation and processing - service for evaluating the data against different thresholds and alarm conditions, input of the data into the central database, informing contractors about alarms that have been triggered.

Presentation - web based application for reviewing the data (current and past weather data, detailed previews with charts, previews of weather stations equipment and its condition, system administration, and tools for statistical forecasts and data exchange).

For general users the most important information is shown on electronic information boards. Therefore the GeoRSS syndication was developed, which includes current weather data and alarm situations.

Introduction

Road Weather Stations have been utilized to assist Traffic Management Services in Slovenia for many years. The need for this assistance is particularly pronounced in the winter time since Slovenia is located in a meteorologically diverse territory between the western Alps, northern Adriatic and Pannonian Plain. With the growing number of RW stations, their integration into a comprehensive road weather information system - RWIS, became inevitable. Management and maintenance of the road network in Slovenia is divided between the Slovenian Roads Agency (DRSC), primarily responsible for main and regional roads, and the Motorway Company in the Republic of Slovenia (DARS), responsible for motorways. Each of the two has its own network of RW stations that are installed on representative road sections or constructions.

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Owing to gradual and long-term network construction process, the RWIS systems of both road management companies differs substantially by their age, installed sensors, manufacturers, and other characteristics. The Slovenian Roads agency was the first organization to begin integration followed shortly by Motorway Company in the Republic of Slovenia. For this particular reason we have now two partly different systems that are likely to be integrated in a comprehensive RWIS in the future. Nevertheless, due to many similar characteristics, the functionality of the two systems can now be described as one uniform and comprehensive system.



Photo: Winter conditions on a highway.

System Architecture

The system architecture is divided into three parts which perform the three main functions of the system.

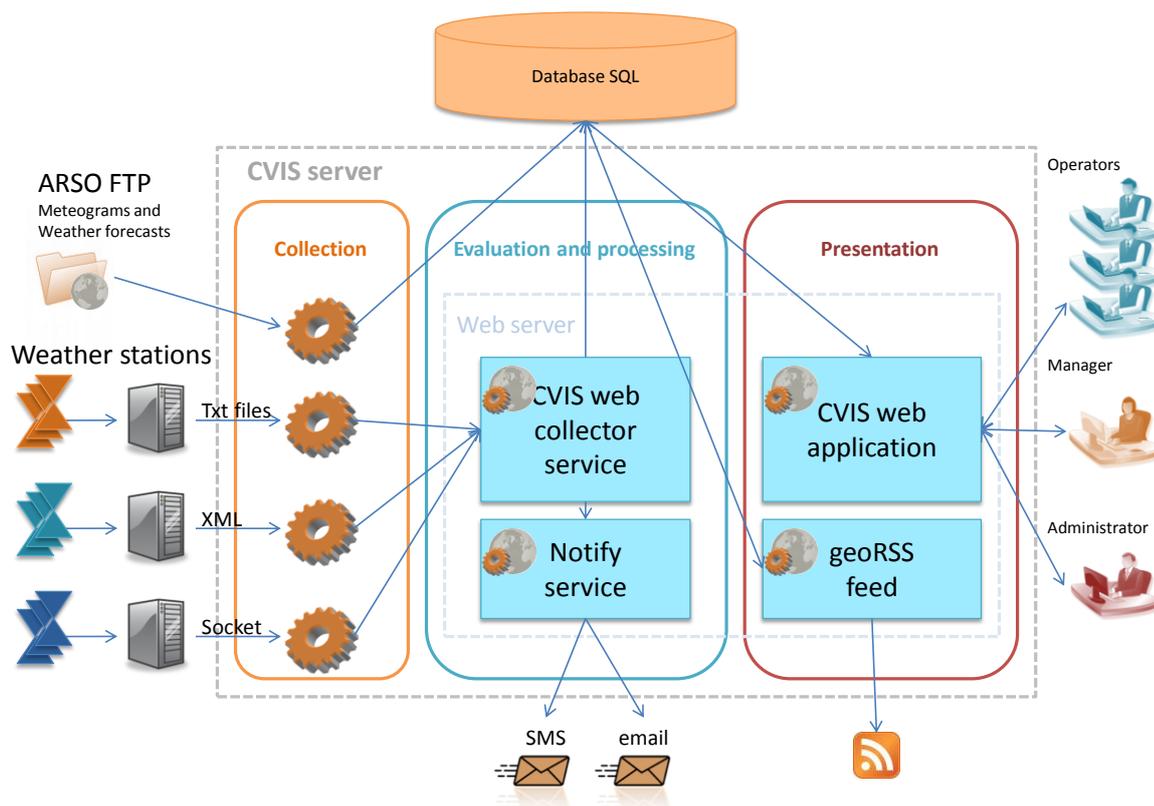
The first part consists of modules in form of Windows services and these are intended for data collection from individual basic (Black box) systems, and basic inspection and adjustment of the data to a uniform standard. Only after this procedure the weather data is forwarded to the second part of the system - the Data Collection Web Service.

The second, central part of the system consists of a Data Collection Web Service, which enables independent execution of the procedures for inputting the data into a database. At the data input stage the system performs verifications of logical conditions to establish accuracy of the measurements, and conditions for triggering warnings and alarms. After the verification, all the necessary entries in the relational database tables are performed. At the same time the contractors are informed, by email and SMS, about measurement errors and triggered alarms.

The function of the third part of the system is to present the data to all the users of the RWIS. The data is available through the RWIS web site application and RSS notifications. The web application enables the display of data and complete control over the systems operation. It is possible to add new road weather stations, to add and modify installed sensors, and to set other parameters such as

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the conditions of alarms, types of measurements recorded, classification of measurements, conditions for informing contractors, etc.



RWIS Windows Services

Data collection – windows service part

RW stations of different manufacturers differ by measurement data formats (txt files, web XML services, socket listener, FTP ...). For the purpose of the data input to a uniform system it was necessary to develop different services that access the data in the basic system, verify the data, and forward the data to the RWIS web collector service.

A special emphasis is placed on verification, unification, and conversion of individual types of data into a form that enables comparison and give a uniform view of the weather situation.

Measurement:	Original value:	Insert to RWIS
Wind velocity	km/h	m/s
Wind direction	N,NE,E,...	0,45,90,...
Weather condition	Precipitation type	SYNOP
	Precipitation intensity	

Table: An example of conversion station data to unique standard.

In addition to services for data collection from RWS, special services for graphic and textual weather forecasting were developed.

Database server

The central part of RWIS is a database server, where all the data from station sensors is directed. Relational database is organized in the MS SQL Server 2005 environment and it comprises of all

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the data about the weather stations, sensor types, maintenance, alarms, etc. Most of the tables in the data model are used for dynamic implementation of applications, while the most extensive tables are those containing the weather data.

The administrative section contains all the data about a RW station, e.g. the producer, type of the weather station, year of the installation, location, mileage of traffic sections, installed sensors, types of sensors, last calibration, etc.

In the weather data section, all the data from the measuring network are recorded and stored at between 3 and 10 minute intervals. Different types of data are recorded: data on air temperature, road surface area temperature, temperature at 5 and 30 centimeters under road surface, humidity, visibility, salinity, road condition, weather conditions, and other data gathered by the installed sensors.

RWIS Web server

The web part of the RWIS is designed on Microsoft web server (IIS) in Microsoft.NET framework 3.5 technology.

Data Collection - web part

The web service enables independent data collection to the RWIS. An individual windows service forwards collected data from RWS to a web service, which upon the entry of data verifies logical conditions:

- Boundary values of measurements (minimum, maximum) – to detect rough errors
- Warning and alarm values – for alarm triggering.

RWIS Application

The web application is designed to allow role based access control. There are several groups of users:

- User can access current weather information, weather forecasts and archive.
- Manager has broader access, also to various types of reports, RWS metadata, data on installed sensors, data on maintenance, and permission to import or export different data.
- Administrator can, in addition to all other described permissions, also manage whole administration of users, measurements, sensors, etc.

End User's View

A basic part of the application is intended for AC database users, who monitor conditions on their specific road section, neighboring sections or across the country. A basic user window gives numeric data relating to temperature, humidity, wind gusts, weather and road conditions, and also overview of all active and confirmed alarms. In periods of more dynamic weather it is particularly important that a user can access all the key information in one place.

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 uporabljen: neprijavljen uporabnik PRUJAVNA

POSTAJE POROČILA
 TRENUTNI PODATKI NA POSTAJI VREMENSKA NAPOVED METEOGRAMI

TRENUTNO STANJE NA OBMOČJU: Vsa območja

	zadnja meritve	t _{zraka}	t _{ceste}	t _{rosišča}	t _{zmrz.}	Rh	veter hitrost sunki	vidljivost	stanje vremena	stanje vozišča	slanost [g/l]	opozorila		
		[°C]				[%]	[km/h] [km/h]	[m]			[g/m ²]	nova	potrjena	
Mura	A 03.11.2009 08:13	11,4		11,4		100		2000	rahlo pršenje					
Kresnica	B 03.11.2009 08:07	0,3	0,8	0,3		99	10	2000	rahel dež	mokro	59			
Hoče gramoznica	V 03.11.2009 08:10	1,3	2,0	1,3	0,0	100		2000	rahel dež	mokro / soljeno	0			
Devina	V 03.11.2009 08:10	1,7	2,1	1,6	0,0	99		1637	rahel dež	mokro / soljeno	0			
Vrhole	B 03.11.2009 08:06	0,5	2,0	0,5		99	7	1100	zmeren dež	mokro	53			
Škedenj II	B 03.11.2009 08:06	0,0	1,3	0,0		99	11	2043	rahel dež	nije sneg	84			
Slatina	B 03.11.2009 08:08	1,1	1,3	1,0		99	26	928	rahel dež	mokro	73			
Žepina	B 03.11.2009 08:06	0,2	-0,5	0,1		99	3	701	rahel dež	nije sneg	75			
Savinja most	B 03.11.2009 08:06	0,3	-0,8	0,3		99	0	1	321	rahel dež	nije sneg	89		
Ločica	B 30.10.2009 02:51	6,5	7,6	6,5		99	2	5	1881	ni padavin	suho	0		
Črni Mlinar	B 03.11.2009 08:06	1,1	-1,8	1,1		99	2	4	390	rahel dež	nije sneg	81		
Šentožbolt	B 03.11.2009 08:09	0,4	-1,0	0,2	-1,4	99	5	8	666	rahel dež	led	100		
Petelinjek	B 03.11.2009 08:07	0,9	-0,2	0,5	-4,1	97	11	15	593	rahel dež	mokro	86		
Radomlja most	B 03.11.2009 08:06	2,4	2,4	1,4	0,0	93	4	16	1637	zmeren dež	mokro	40		
Mlake	A 03.11.2009 08:12	1,4	3,3	0,5	0,0	94		2000	rahel dež	suho	0			
Sava Šentjakob	L 03.11.2009 08:10	2,2	4,7		0,0	100		15995		vlažno				
Malence razcep	B 03.11.2009 08:06	2,4	2,0	2,4		99	4	1996	zmeren dež	mokro	28			
Kozarje razcep	V 03.11.2009 08:10	1,0	2,2	1,0	0,0	100	3	10	2000	rahel dež	mokro	0		
Verd	L 03.11.2009 08:10	0,3	0,0	0,0	0,0	95	0	1269		mokro sneg				
Ivanje selo	B 03.11.2009 08:08	2,0	0,6	1,5		96	5	15	1268	zmeren dež	nije sneg	88		

Picture: Basic user window with current data on weather on specified road section.

A click on an individual RW station activates a detailed view of current measurements and a linear diagram of measurements over a period of time. Current data is displayed on the left side of the screen. In the centre there is a collection diagram with data for last 24, 12, 6 or 3 hours. The size of the units of measurement is adjusted automatically. On the left uppermost side of the user's window, the newly triggered alarms are displayed. After confirmation they move lower, under the history of switched and confirmed alarms. Under the diagram it is possible to monitor weather and road conditions for the whole period. Above the diagram alarms about the beginning and the end of slippery ice, wind, and visibility are displayed.



Picture: Detailed overview of events on a chosen Road Weather Station.

In addition to the graphical display of data it is possible to view a table with all data recorded in any chosen period in the past.

Operator's View

To enable reliable system operation it is also important to monitor the installed equipment. The operator of the RWIS has, in addition to the data overview tool, also tools for inspection and maintenance of the installed equipment. It is possible to plan regular and extraordinary maintenance works, check calibration validity, and perform other interventions on the installed equipment. Picture A gives an example of the information provided by three sensors for a chosen weather station. The first sensor on the picture could be forwarding incorrect data and has to be calibrated. The second sensor is at the end of its operational lifetime and will have to be replaced in a month. The third sensor operates correctly, there are no interventions scheduled.

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uporabnik: sales.petrinc@cgplus.si ODLJAVA

ZEMLJEVID POSTAJE POROČILA NAPOVED NASTAVITVE
TRENUTNI PODATKI NA POSTAJI IZVOZ ROČNA MERITEV VZDRŽEVANJE CESTNOVREMENSKE POSTAJE

VZDRŽEVANJE CESTNOVREMENSKE POSTAJE
Nov poseg - delovni nalog Pregled posegov - delovnih nalogov Pregled nameščene senzorike

1. Izberi pogoje prikaza:
Cestnovremenska postaja: Kranj - Kranj - Delavski most
Senzor: Prikaži vse
Status senzorja: Aktiven
ali
Poišči senzor s serijsko številko:

Pregled nameščene senzorike:

Vremenska postaja	Koda senzorja	Serijska številka	Namestitve	Sortiraj po datumu:	Naslednja kalibracija	Življenska doba	
Kranj - Delavski most	LF-TPX1	234-234-234	Datum namestitve:	22.04.2007	22.11.2009	22.04.2007	<input type="button" value="Podrobnosti"/>
Kranj - Delavski most	CS-TAIR101	1-2-3-1	Datum namestitve:	22.04.2007	06.01.2010	22.04.2007	<input type="button" value="Podrobnosti"/>
Kranj - Delavski most	CS-TZMRZ	2355469	Datum namestitve:	08.12.2009	08.12.2009	08.12.2009	<input type="button" value="Podrobnosti"/>

Also available are tools for: process management, control of records, and editing lists.

Administrator's View

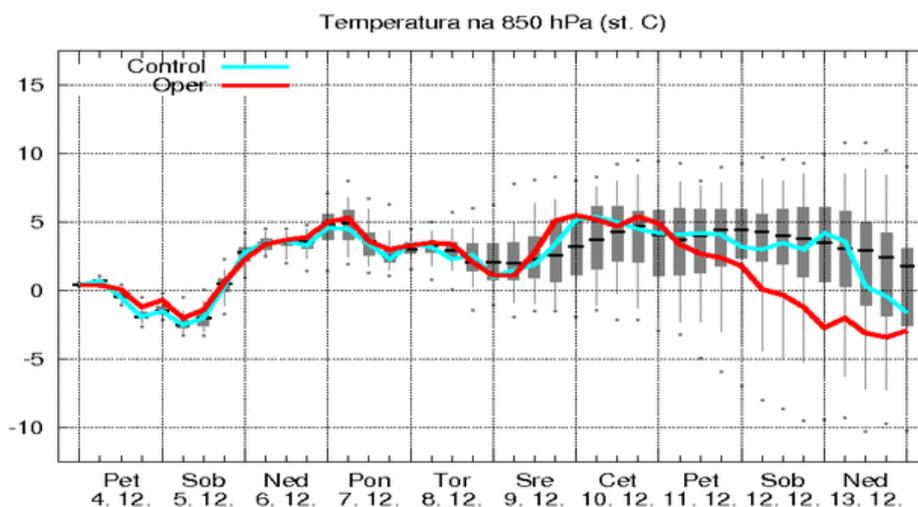
The administrator of the system has permission to use additional tools for comprehensive system management. Tools are available for adding new RW stations; RWS management; measurement selection management; selection of parameters of data display, lists display, and classification tables display. One of the most important tools is for alarm management. It enables alarm categories to be set, the conditions for alarms to be triggered, the form of alarm display, and lists of contractors to be informed.

Weather Forecast Integration

Besides the current road weather data from the weather stations owned by an individual road manager (DRSC or DARS), there is also specialized weather forecast, provided by the national meteorological service within the Environmental Agency of the Republic of Slovenia. For central Slovenia (Ljubljana) there is a weather forecast for 10 days in advance, and for other regions (other 15 towns) a more detailed forecasts are made for a period of 54 hours in advance.

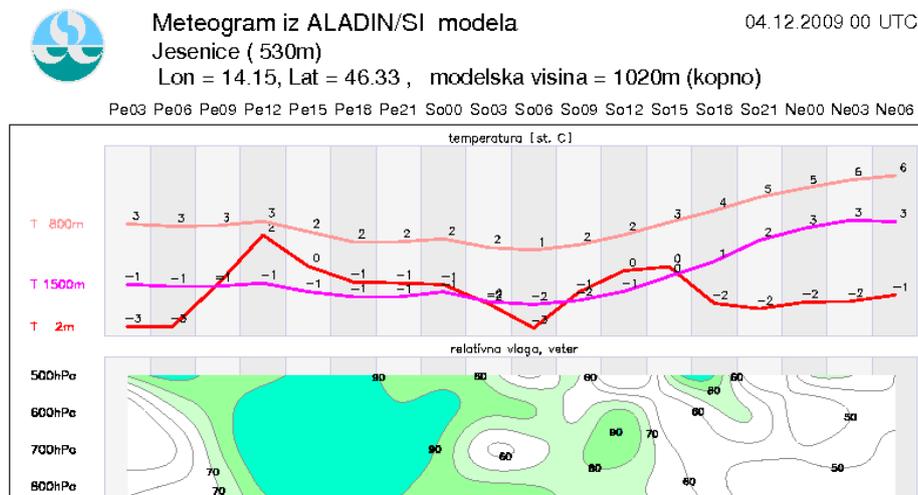
10 days General Forecast

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Picture: Example of 10 days weather forecast for temperatures in central Slovenia

54 Hours Regional Forecast



Picture: A section of a forecast for 54 hours for the town of Jesenice (NW part of Slovenia).

Cooperation with other users

RWIS data service called geoRSS was developed to ease cooperation with other systems within the Motorway Company in the Republic of Slovenia. The service forwards all the data on a given geolocation to the users. The basic structure of the GeoRSS server was extended with more detailed current data and active alarms for the purpose of more detailed weather data information on road information boards, GIS intranet sites, and other public applications.

Conclusions and future improvements of the system

The established RWIS has improvements in storing, maintenance and accessing RW data from central database. Now it is possible to view different data that comes from RW stations in a unique and standardized form.

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Next winter we are going to make another progress and start modeling weather forecasts and start integration with supervisory control and data acquisition system - Scada. It's our intention to integrate an additional module for visualization of data in GIS.

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