Open data based RWIS for mobile devices

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Abstract
Road Weather Information System (RWIS) is basically a decision support system for road maintenance professionals. The aim is to optimize the driving conditions and minimize the resources used. The operational data used by a RWIS is gathered from road weather stations, weather cameras, weather radars and satellites and complemented with forecasts. The data are typically collected and pre-processed by national transport authorities. The authorities have recently started to open this data to public use. The topic of this study is to present a system architecture and mobile client applications for a RWIS implementation which is based on open data sources. The study is is focused in professional use of a RWIS and is based on an ongoing development project in Intrinsic, Ltd.

Keywords:
Open data, road weather information system, mobile device

Introduction

A Road Weather Information System in general is a system consisting of, at least, devices or interfaces providing road weather data, back-end IT applications to collect and store the data and end user applications to serve road maintenance professionals, research, road users, and so on.

At the moment RWIS applications are mostly used in a non-mobile monitoring room type environment. However, most road maintenance vehicles are nowadays equipped with on-line data terminals used to keep track on various maintenance operations. On the other hand, maintenance decision makers carry a smartphone, tablet, laptop or all of them. This implies that the RWIS must also offer end user applications tailored to mobile use with mobile devices.

The Finnish authorities have started to offer interfaces to publish different weather information as open data. Most of the observation data used in a commercial RWIS can be derived from this open data. However, in a RWIS, the most important information for the user lies in the forecast information in various forms. All the needed forecasts are not available as open data in the seeable future. This means that in order to offer proper content for the user the system must include also information from commercial sources. Typical information of this kind is point forecasts for road weather stations, weather radar pictures and forecasts and satellite pictures.

Intrinsic has a long history in developing and supplying customer specific RWIS applications for Finnish Transport Agency. The objective of this open data based RWIS developing project is to put up an in-house RWIS back-end system with road weather database and the needed connections to open and commercial data sources. On top of the in-house back-end we develop mobile clients with the basic RWIS functionality. The aim is to use the developed system as a reference and a basis for further customer specific and other projects.

Benefits

The basic objective of a RWIS is to help to improve the safety and smooth flow of wintertime traffic. As a decision support system (DSS), the road weather information system increases the cost efficiency of wintertime road maintenance in varying weather and road conditions (for example timely skid prevention, fast mobilization and optimized road salt usage).

The opening of the weather data enables commercial offerings in the RWIS area. This makes it possible to design more customer specific solutions. For example, embedding RWIS applications in existing maintenance vehicle data terminals may help to streamline the field work. On the other hand, using DSS applications in mobile devices gives the decision makers tools to analyze the road weather situation and react anywhere when needed. This brings obvious benefits because the cost efficiency of the winter maintenance is directly depending on the quality of the maintenance decisions.

System Architecture

The developed system is aimed to be used as a basis for probably several coming RWIS implementations. Keeping this further scenario in mind the system architecture design had the following top-level requirements:

- Modularity. The architecture must support adding new functionality without major modifications in the existing implementation
- Scalability. The size of the RWIS implementation should not affect system architecture, applications or overall system performance.
- Connectivity. Well-defined interfaces to third party systems like forecast data, data analysis tools, traffic control systems, other RWIS systems and public interest services (TV, radio, services on the Internet).

The overall system architecture is shown in figure 1.

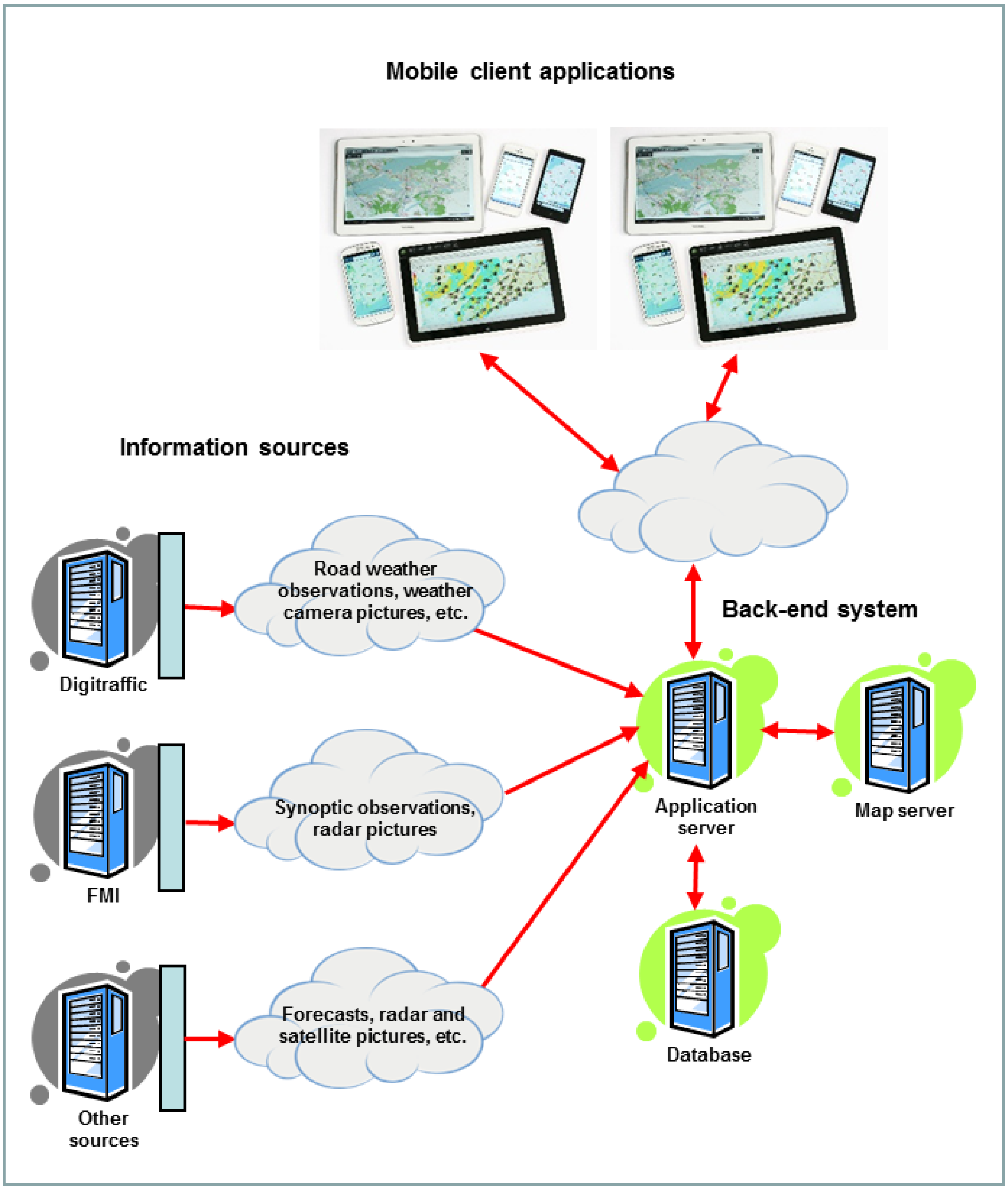

Figure 1. The overall system architecture.

The basic sub-systems of the architecture are:

- Information sources.
- Back-end system
- Mobile client applications

The sub-systems communicate over the internet using standard internet protocols.

Information sources

The system uses information from Digitraffic, FMI and other (commercial) sources.

Digitraffic

Digitraffic is a service which offers real time and historical information about road weather and traffic on the Finnish main roads through Web service interfaces. The service is provided by the Finnish Transport Agency (FTA), and it is addressed for organizations developing information services or working with traffic management and planning. The observation data which is available in Digitraffic is provided by the Finnish Road Weather Information System run by FTA.

The Following dynamic data sets are available in Digitraffic [1]:

- Real-time data from road weather stations
  - Observations from stations and status of stations
- Weather Camera Picture delivery
  - Real-time weather camera pictures
  - Real-time status information of road weather cameras
- Driving condition forecasts in winter time
  - Forecasts are provided for road segments (about 300 segments in Finland)
  - 2h, 4h, 6h, 12h forecasts
- Real time data from traffic measuring devices
  - Traffic volumes and average speed observations and current free flow speeds
- Real time fluency and travel time data
  - Fluency classes, travel times and current free flow speeds
  - Average daily fluency class data

The system fetches all the data above excluded real time fluency and travel time data. The data available in Digitraffic is a subset of the data which is available in internal systems of FTA and shown for example in some of their Web pages.

Finnish Meteorological Institute (FMI)

The Finnish Meteorological Institute offers an online Web service interface which allows searching, browsing and downloading the weather information data sets in machine-readable format. The implementation of the service follows the requirements set in the INSPIRE directive. The technical implementation of the service is based on Open Geospatial Consortium (OGC) standards such as OGC Web Feature Service (WFS). The service offers a large scale of meteorological information [2]:

- Weather, marine and climate observations
- Weather radar images and lightning observations
- Data from national weather forecasting and marine models

For a RWIS use the most useful information types available in the FMI service and fetch by the system are:

- Synoptic weather observations
- Weather point forecasts (based on HIRLAM weather model)
- Weather radar pictures:
    - Rainfall intensity
    - 1, 12 and 24 hour precipitation

The synoptic observations and the corresponding point forecasts are shown in the client applications as a complement to the road weather information downloaded from Digitraffic. The point forecasts available in the FMI service have one hour resolution with 48h time span. The forecasts are updated in every 6 hours which is not frequent enough for decision making purposes in rapidly changing wintertime weather conditions.

Other sources

Generally, a RWIS must be able to connect to other external information sources like commercial weather information suppliers because all needed weather information is not available as open data at the moment. This lacking information includes point forecasts for weather station points, satellite pictures and radar picture forecasts. No plans have been published if, for example FMI, will include this essential information in a RWIS use in its open data offering.

The needed information which is not available as open data must be purchased from commercial weather information suppliers in order to put up a sound RWIS offering. In business context this gives a strong control point to these suppliers (e.g. FMI and Foreca in Finland).

Back-end system

The IT back-end is the central part of the system and consist of the following components: the application server, the map server and the database. The components can be all run in the same physical (or virtual) server equipment or can be distributed to different servers. For example, the customer organization may already have a map server and a centralized database installations in use and then it may be feasible to utilize those directly. The back-end system is implemented with open source software components.

Application server

The application server includes the functionality to collect the data from the information sources, store it in the database, run the application processes and administrate the system. Because the information sources vary in connection technology and data content sense there is always a separate tailored data collection component for each information source. The components convert the collected data from different sources into system internal standard form in which the data is then stored in the database.

The application processes implement the server side functionality of the RWIS mobile applications. The main task of these processes is to handle the database and provide the client applications with the requested data. The application processes cover also a variety of other functionality, like coordinate transformations.

The system administration includes tools to administrate the system metadata, user accounts and other system parameters. Certain monitoring is also done concerning user accounts and overall system performance.

Map server

The map server provides the applications with the needed map data. The map server contains the maps and other geospatial information in Shapefile format and then makes the map tiles (in GIF format) for the client applications to use. The map tiles are cached in the map server to maximize the system response. The map server and the application processes communicate through a Web Map Service (WMS) interface. This standard interface makes it possible to utilize also other map servers, like an existing map server already in use in the customer organization.

The system uses the open map data from National Land Survey of Finland. Also any other map data can be used if it is in GeoServer supported format (e.g. Shapefile, ArcSDE)

Database

The collected information and the system metadata is stored in a relational database. All observation data collected from the information sources is stored in the database forming history time series for every measurement. The pictures are stored as files outside the database system. The metadata includes the information about the available stations and sensors, information about the pictures stored and certain system parameters.

Mobile client applications

The main client application provides all essential road weather information through a single map interface optimized for tablets and smart phones. The UI design guideline is that the application must be usable in rough field conditions, for example in road maintenance vehicles. The main functionality includes:

- Map view with symbols for weather stations and cameras
- Animation of weather radar and satellite pictures on the map
- Graph view to present sensor values in trend graphs
- Weather camera pictures and animation
- Table view. Shows station observations in table form

Some of the key functionality of the applications is described below.

Map view

Map view is the central application view and all other information can be obtained through it. The map is based on vector map data and the maps can be zoomed and dragged on the screen. The chosen symbols (road weather stations, traffic stations and weather cameras) are shown on the map. By clicking a symbol the corresponding station or camera data opens. In the figure 2 an info box showing the last measured sensor values of the station has been opened on the map by clicking the road weather station symbol. By clicking the graph icon in the info box a trend graph view of the station is opened.

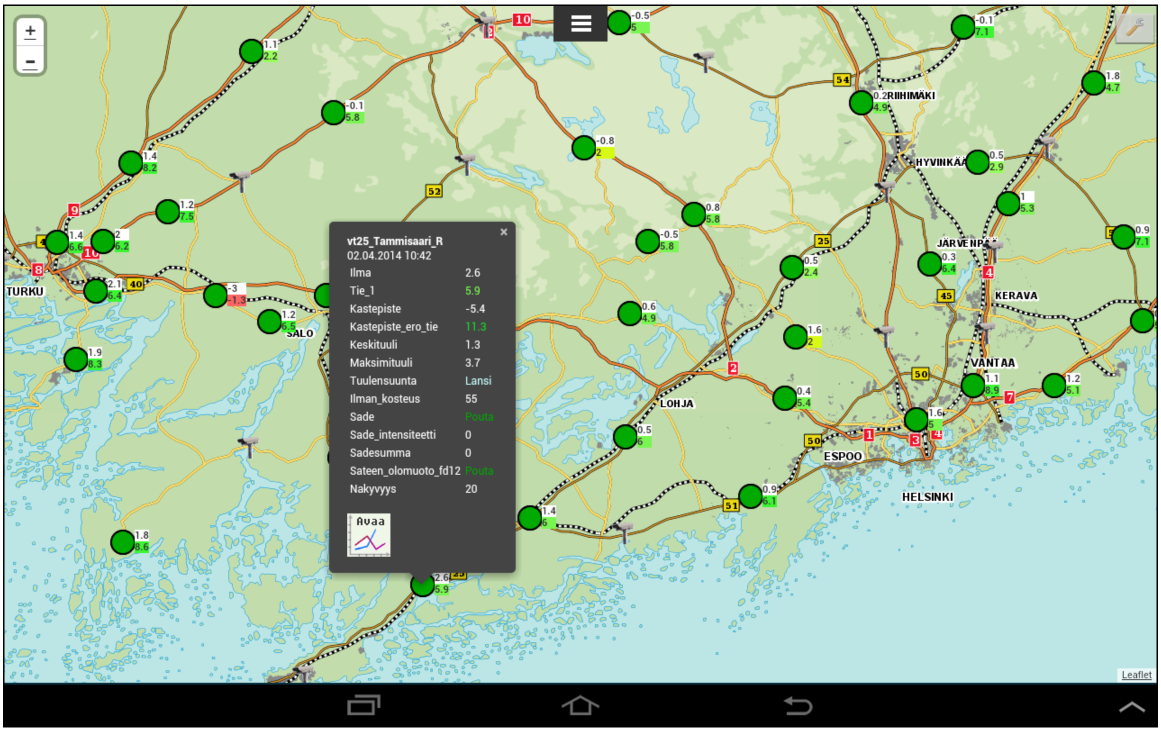

Figure 2. Example of map view.

A road weather station symbol on the map can be colour coded according to a sensor value. The sensor value and its colour coding scheme can be defined by the customer.

Trend graph view

The example of a trend graph view with wind information is shown in the figure 3. On the right side are the buttons to control the application. The sensors which values are shown in the graphs are customer definable and the definition (style) can be named and stored. Depending on the number of defined sensors in a style there can be one or more sequential graph views in which the information is shown. The green arrows are used to scroll the views.

The red vertical line represents the current time and the curves to the left are observations and to the right are forecasts. The curves can be scrolled in the timeline with the clock buttons.

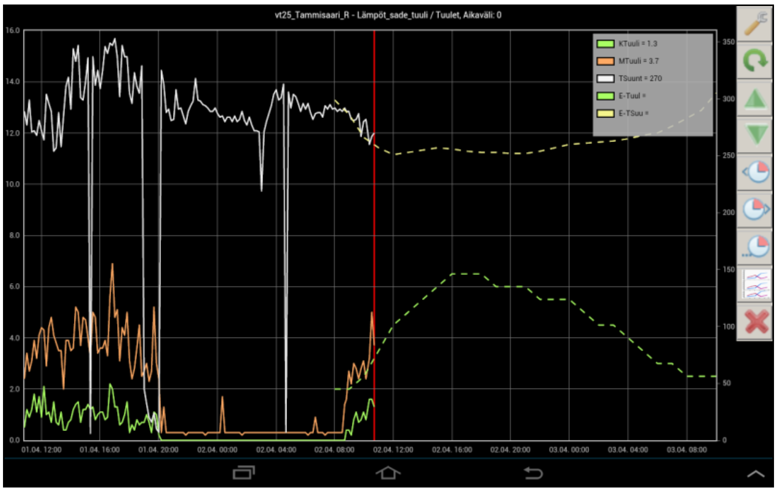

Figure 3. Example of trend graph view.

Camera view

By clicking a weather camera symbol on the map the corresponding camera view is opened. An example is shown in the figure 4.

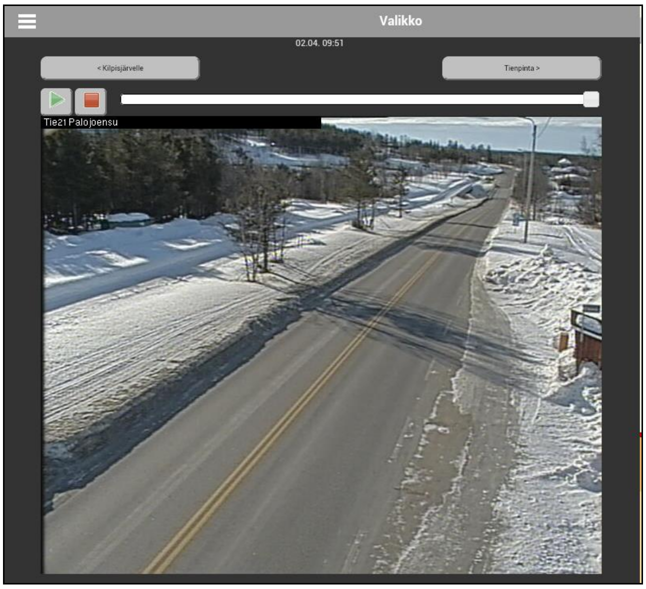

Figure 4. Example of weather camera view.

The pictures can be animated on a timeline. If a camera has different predefined and named view angles (for example in opposite directions of the road) the angle can be changed by pressing the corresponding button.

Other applications types like embedded chat are under consideration. The client applications are developed with tools under the HTML5 technology umbrella. So they run in any browser supporting these technologies. The map services are based on Leaflet map component library.

Project status, road to market and conclusions

The current status of the project is that the back-end and the data gathering from Digitraffic, FMI and the certain other information sources are up and running. The development of the mobile client applications is ongoing with still some work to be done with the radar and satellite picture animations on top of the map interface.

The aim of the project was to use the developed system as a reference and a basis for further customer specific and other projects. Discussions with first potential customers are ongoing. Customer hosted and SAAS business approaches (not mutual exclusive) have been under consideration.

The system developed in this project is in operation in-house and fulfils the aim to be used as a reference and a basis for further customer specific and other projects. The project showed that the open data interfaces provided by FTA (Digitraffic) and FMI work well and the default service level is acceptable even for professional use. It is possible to develop a RWIS based on open data but not solely on it. In the project it was clearly observed that the open data provided by FTA and FMI does not cover all needed weather information content. The main missing content is forecasts. In RWIS use the point forecasts for weather stations and in more general use, once in hour updated, high enough resolution synoptic forecasts. Lack of all needed content implies that a RWIS implementation needs data from commercial sources in addition to open data. The same applies to other types of professional weather information systems as well.

On the client application side the development work is still partly ongoing and for example no field usability testing has been done so far. However, some first conclusions can be made at this point. In mobile decision support system use the size of the screen of the device seems to be critical. Anything under 10” screen makes it hard and error prone to perceive the weather situation resulting probable problems in decision making (because not all needed information can be shown in one view). On the other hand, devices with phone size screens can be used in basic status reporting and background information sharing type of applications. The chosen client application development technology (HTML5 family) has not caused any major surprises and the work has been quite straight forward. At the moment there is still some deviation how different browsers support different HTML5 technologies.

On the whole, the project has so far fulfilled its aim and continues with further development of the client applications and commercial utilization.

Acknowledgements

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References

1. Digitraffic. *http://www.infotripla.fi/digitraffic/english/utilise.html*, Downloaded March 12, 2014.
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