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An Application to Display Lightning Data Using SCALAR Information System

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***Abstract* —** During the last fifteen years, the number of services based on information provided by the Lightning Localization System has increased, making data exchange and integration between the services a demanding task. Rapidly evolving web services, which became standardized and are nowadays widely available, have been used in a new lightning mapping software SCALAR FlashClient to overcome the time-consuming integration and to simplify the implementation of service variety. The SCALAR FlashClient can, furthermore, use services from several server domains where different Web Map Services can offer a different geographical information system to the end users. The lightning domain server platform also contains common services like the authentication and the authorization of the user. The discovery service helps the client to discover the domain server capabilities and therefore simplify user's access to the lightning server. A new modern user interface is introduced to the new SCALAR FlashClient which is based on JavaFX technologies. The implementation is operating system independent and uses OpenGL standards to boost the user's graphics experience.

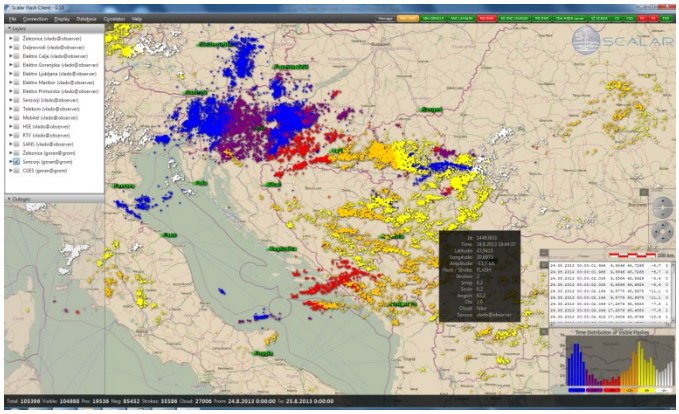
Keywords—ScalarFlashClient, LLS data real-time presentation, Geographical information system, Weather data presentation, Lightning statistics presentation

I. INTRODUCTION

Eletric power research institute Milan Vidmar (EIMV) is a Slovenian engineering and scientific research organization active in the area of electric power system engineering and general energy. Since 1997, EIMV owns, runs and develops SCALAR lightning localization system. At the beginning, the lightning information system was developed primarily to fulfill the needs of the electric power utilities. The SCALAR system is mostly used by Slovenian transmission system operator utility and distribution utilities.

The 15 years of operation, new technologies, especially JavaFX and Web Services, have emerged and become standardized. They are nowadays widely available and are, together with much more powerful computers and easy Internet access, becoming a platform of choice for new development. Therefore, we decided to improve our old user interfaces based on years of experience with much more advanced mapping capabilities and functionalities. The user can now access the lightning data much easier and is able to perform data analysis and monitor weather data in real time. Custom GIS, alarming and correlation services can now be integrated in a whole new way.

Fig. 1. SclalarFlashClient user interface



After 2 years of development and integration of the above-mentioned technologies, the lightning mapping software SCALAR FlashClient (SFC) becomes our new lightning information system.

II. NEW SCALAR INFORMATION TECHNOLOGY

A. Definition of requirements

At the beginning of the development of SCALAR's new system platform, we defined the general requirements that are needed by our users and operators of the SCALAR system. Several specific requirements define which technology and solutions meet the criteria. The basic criteria are:

- All SCALAR services have to be accessible from single entry point, for example an integration bus like SCALAR interface – web service (see Fig. 2).
- The lightning domain server platform has to contain a set of common services like the discovery, authentication and authorization of the user. The discovery service helps the client to discover the domain server capabilities and therefore simplifies user's access to the lightning server.
- Administrator must be able to create user profiles to which several SCALAR services can be attached. This simplifies procedures of creating and setting up user's permissions.

- The life cycle of software solutions should be at least 10 years long.
- The lightning mapping has to use advanced techniques and maps.
- All displayed lightning and weather service data have to be in vector format.
- User interfaces on the client side must offer high performance of data and maps displaying.
- The SFC has to be capable of using other services from several server domains. Different Web Map Service can offer different geographical information to the end users (see Fig. 3).

Fig. 2. SCALAR information architecture

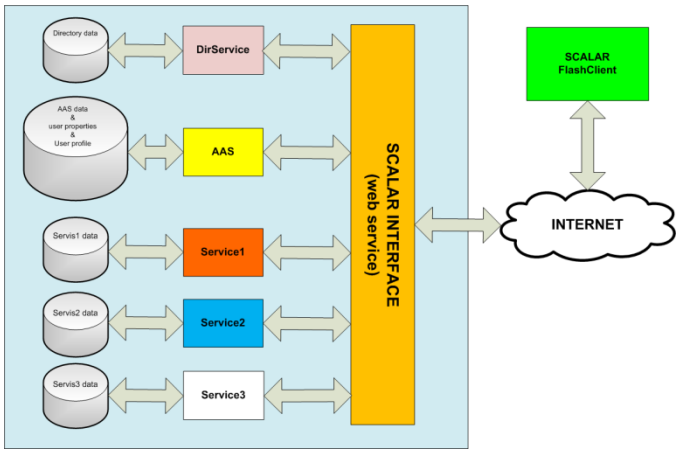
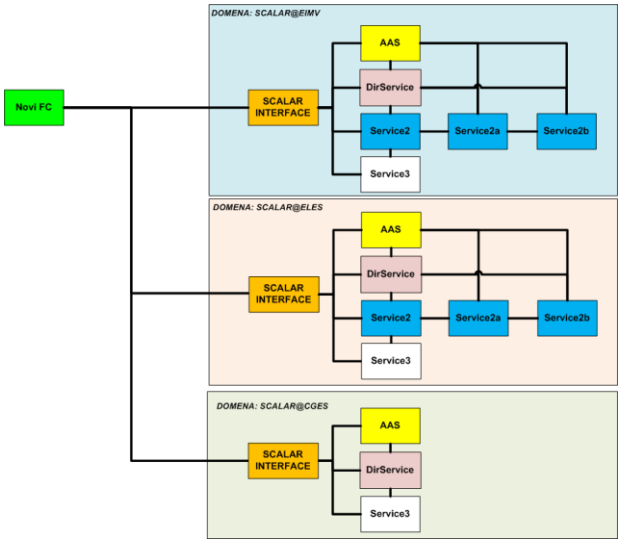


Fig. 3. Multi-Domain connections



B. Selected technology

In general, we can divide the selected technologies into server and client sites. The server side is service-oriented and is basically hidden from the user.

Server site:

- Uses a standard communication protocol SOAP/WSDL over HTTP/HTTPS protocol.
- Business logic is implemented in Java EE 6.0.
- Enterprise Java BeansEJB 3.1 is used as builder.
- Persistence / Database access:
  - Java Persistence API JPA 2.0 and
  - Java Transaction API 2.0.
- Java message service JMS 1.0 as message builder.
- Java application server GlassFish 3.1 as Web Service server.
- Administration module on server site is implemented in Spring Web technology.
- Databases:
  - PostgreSQL database
  - MySQL database.

The client side is more focused on the user interface and display performances, as this are the first things the user experiences. While selecting the technologies, modern graphical user interface was also taken into account. Client side SFC is based on JavaFX technology which offers OS independent solution and uses OpenGL standards to boost the user's graphics experience.

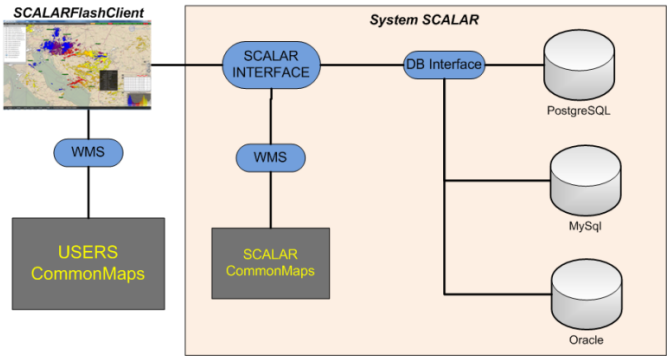
GIS implementation:

- SFC supports Open Geospatial Consortium (OGC) specifications. It is implemented with Geotools Java libraries, which support almost all standard data formats, Shape-files, WMS, WFS etc.
- It supports raster maps of OpenStreetMaps tile – Slippy Map protocol, rendering of map tiles is optimized and customized from the user side with JavaFX technology.
- Weather data (rainfall radar reflectivity and satellite imagery) is supported and stored in PostgreSQL database.
- Calculated statistic data (high-resolution flash density map) is supported and stored in PostgreSQL database.

All displayed geographical information is organized in layers, which means that only certain information is displayed at a predefined zoom level. This results in clear, readable maps which are easy to use and offer good orientation to the end user.

The users can also apply their own geographical data which are compatible with the OGC specifications. In this case, a multi-GIS connection is established and all GIS data is merged into one at the user site (Fig. 4).

Fig. 4. Multi-GIS connections



III. EVOLUTION OF SCALAR FLASHCLIENT USER INTERFACE

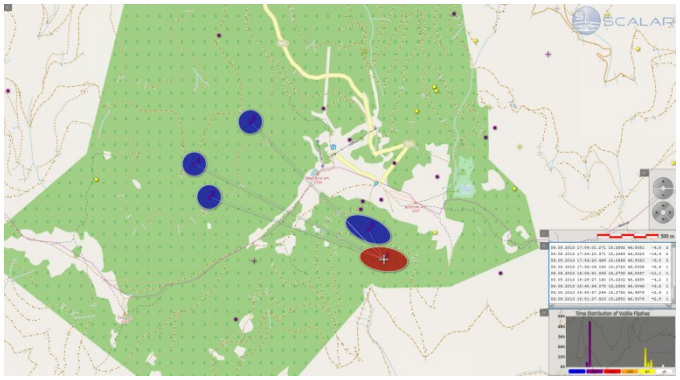
Most of our users utilize SFC to access to the lightning data. Therefore, we devoted a lot of attention to the final appearance of the

new interface, particularly the functionality that will provide operational reliability for the user, the ease of use and simplified procedures for data analysis processing. The basic idea was to serve the user with the desired results and views as fast as possible. Layout optimization of user interfaces and procedure to reach the desired functionality were based on years of experience.

A. Features of ScalarFlashClient

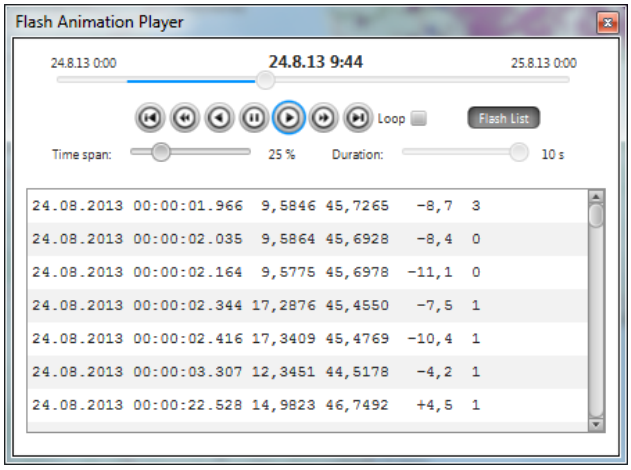
There are several new features in the SFC that need to be addressed. A completely new one in lightning localization world is displaying lightning data in a vector format with the visual connection lines between all the strokes related to a single flash (Fig. 5). This gives the user a quick overview of the stroke multiplicity and spatial dispersion over the area. The first return stroke is colored differently and is clearly marked.

Fig. 5. Flash and strokes relations



A time lapse lightning and weather data animation is another new feature added to the SFC. So called 'Animation mode' (Fig. 6) allows to setup speed, duration and time span of animation which offers an easy way to browse through the stroke list from historian data.

Fig. 6. Sophisticated animation mode



The upgraded features of SFC are a multi-layered organization of geographical information. Nowadays, the GIS system is very complex and is usually organized in several layers. SFC uses two main groups of layers to represent the desired result. The general layers are those which are basically geographical nature:

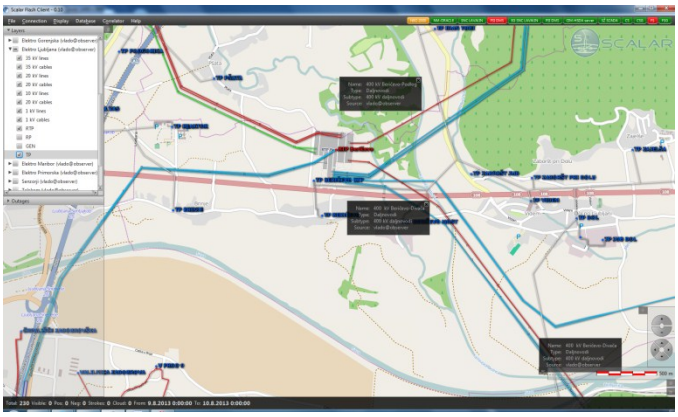
- Basic maps,
- Borders: state borders, sea borders, islands…
- Towns; major towns, towns, villages…
- Roads, railways…
- Transmission (400 kV, 220 kV, 110 kV) and distribution power lines
- Substations and other legal entities
- Custom maps

The second group of layers is more focused on the lightning, weather and other LLS services:

- LLS sensors
- Lightning data
- Radar reflectivity
- Satellite weather data
- Power line outage correlation
- Alarming
- Statistic

Several layers are object-oriented, which means that the user can get additional visual information and other properties of the object (Fig. 7).

Fig. 7. Geographical information in vector format with properties displayed



SFC also offers sound notifications for incoming thunderstorms. For each of the first 20 lightings, SFC produces sound notification and then turns off until the end of the thunderstorm. If a new thunderstorm occurs, SFC produces the sound notification once again.

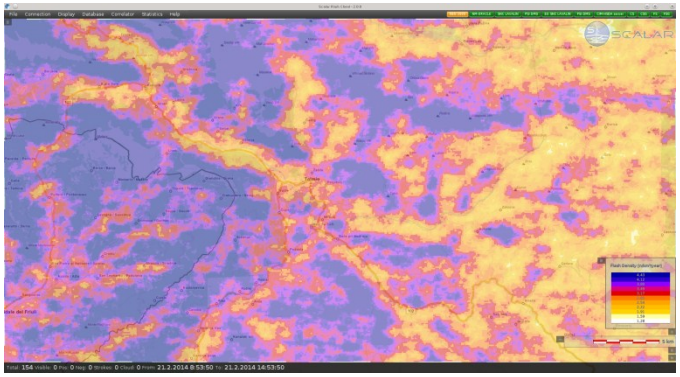
The lack of lightning data sharing was one of the drawbacks of the old interface. In the new SFC, this functionality was upgraded with the export function, which exports all the lightning events listed upon user's request in a numerical fashion (time, location, polarity and amplitude, as well as number of return strokes). Lightning analysis and damage report generation are therefore much easier.

B. Displaying statistic lightning data and weather data layers

The new solution allows the different data layers to be displayed as:

- High resolution flash density maps (Fig. 8).
- Weather data (radar reflectivity rainfall and cloud satellite images), see Fig. 9 and Fig. 10.

Fig. 8. High resolution flash density map of 100m x 100m resolution



SFC displays composite pictures of lightning, rainfall radar reflectivity and (or) cloud satellite data on the same view in real time.

Fig. 9. Rainfall radar data layer

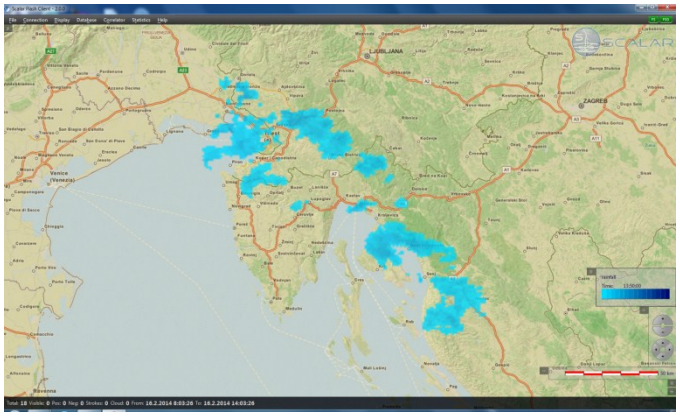
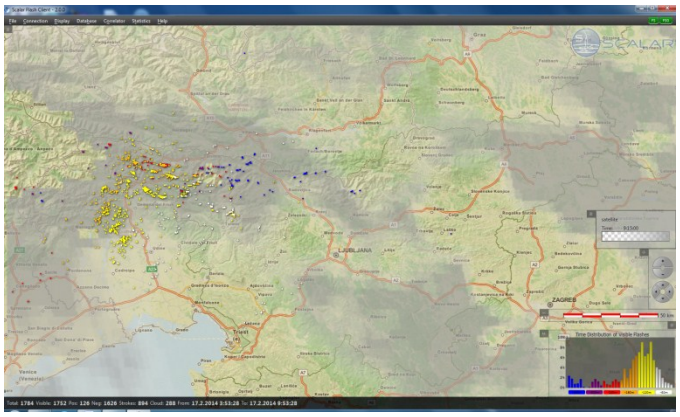


Fig. 10. Cloud satellite data layer and lightning locations



All statistical and weather data layers with custom view are configurable through the GUI on the client site. Settings are subsequently stored on the server site and are available for the next use. The user can therefore use many instances of the application on the different machines and have the same settings setup.

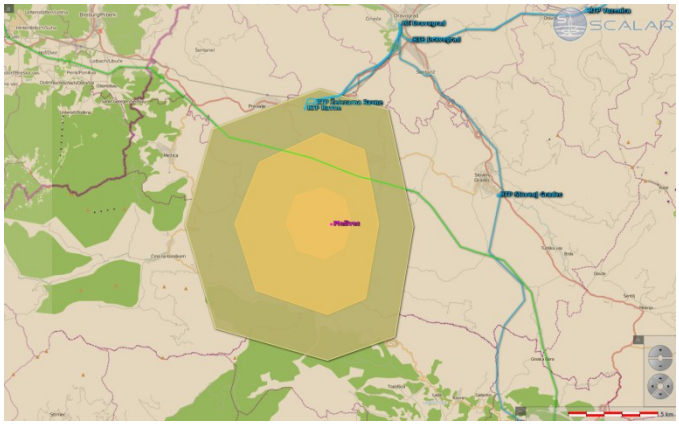
C. Service of added value

During the several years of operation, the SCALAR system developed some additional lightning data services, which have added value to the user's experience:

- Real-Time Alarm services and monitoring alarm service on SFC display (see Fig. 11) and
- Real-Time power line outage correlation for transmission and distribution power lines (see Fig. 12).

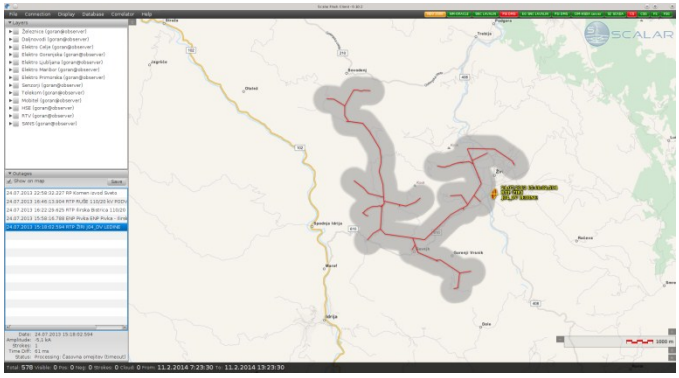
Real time Alarm service enables end user notifications alerts of lightning activity over the desired area. The end user can select the desired zones that are under alarm and monitor their alert levels and post actions.

Fig. 11. Alarm zones visualization with different alarm levels in SFC



Real time power line outage correlation service is one of the most complex services of the SCALAR system. The service has been presented in many academic papers in the past 10 years and is too extensive for this topic. A new feature is the integration into SFC to allow users to monitor the desired powerlines outages in the new GUI. The user can select different views and search events in real time or just browse through the archive.

Fig. 12. Power line outage correlation on a distribution level



CONCLUSION

A new information platform of the SCALAR system and a new ScalarFlashClient has been developed during the last two years. The main result of the development is a modern approach to deliver services to the end users. Lightning data, value added services, weather data and visualization of different maps are combined in the same application. Despite the development being an ongoing process,

the new information system is already running in production and the selected technology has proven to be the right one.

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