SYGEME, INTEGRATED MUNICIPAL FACILITIES MANAGEMENT OF WATER RESOURCES: TOOL PRESENTATION, CHOICE OF TECHNOLOGY, MAN-MACHINE INTERFACE, AND PROSPECTS

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ABSTRACT:

Water management raises questions related to global climate changes, rising demand of resources in emerging economies and decisions on energy policy about the exploitation of hydropower and water protection.

The alpine regions are characterized by important seasonal and geographical differences of water availability, both quantitatively and qualitatively.

Local authorities have the responsibility to manage various flows that serve the cities (water, gas, electricity, district heating, ICT) and thus ensure safety and quality in the services to customers.

Specific tools already exist but a web integrated tool which allows a global and comprehensive vision of the network steering and management is not available yet.

Since 2007, experts from the Research Center in Energy and Municipalities (CREM) and the Ecole Polytechnique Fédérale de Lausanne (EPFL) in collaboration with Depth SA, ESRI Switzerland SA, SD Ingénierie and SIG Genève, have worked on the development of a web-based management tool for integrated urban utilities networks, applied to the water cycle (SyGEMe).

The objective of this project is to develop a new web-service and a tool for communities and network operators, which includes a monitoring system (real-time measurements) and a system for knowledge management, relied on a geographic information system (GIS) as main user's interface.

Through this tool, the platform allows:

- Real-time analysis of network operation
- Management of automatic alerts upon non-standard situations
- Sustainability of practical network knowledge through the access to a structured and intelligent information system.

SyGEMe has entered its final phase. The current version offers many features already such as: documentation and georeferencing of network components and events registered by measuring devices, tasks and standard procedures management and the access to real-time telemetry.

The paper aims to present the SyGEMe web-tool, to comment the technologies that have been used and summarize the future prospects of the project.

1. INTRODUCTION

In 2005, Swiss “glaciers” had more than 45 billion cubic meters water. This is 30 billion less than in 1980. Despite the melting of ice, Switzerland is a very important water tank in Europe because of the raining (twice more than European average).
An increasing demand for water and the climate change are new problems appearing in the water management: geographical differences and unequal disponibility are another challenge in alpine water resources.
In our alpine regions like in other areas around the world, local administrations (collectivities) have the duty to manage water resources and distribution. The quality, the availability, quantity and the cost of water may vary spatially, from valley to valley and from village to village. Very often, when big differences exist, a waste of this precious resource may occur along the distribution channel.

In order to enhance the services dedicated to drinkable water distribution and reduce the associated costs, experts from CREM (Center for Energy and Municipal Research), EPFL (federal technical school in Lausanne) in collaboration with private partners (such as informatics development enterprises, ESRI and engineering companies) have been working since March 2007 on the project SyGEMe: a web-tool for integrated municipal facilities management of water resources.
The main goal of the project was to manage and enhance the management of all urban networks but in a first step, it has been dedicated on drinkable water network of a collectivity. The innovations of SyGEMe are:

- Union of different platforms on a GIS web platform: integration of dynamic data (real-time telemetry for flow, tank level, pressure…) and a knowledge expert system.
- The possibility of evolutive network management using a modular and parametrable web platform rather than a fixed software whose upgrades depend on different people.
- A new approach centered on services which means that the platform is developed for all-day water management users
- Integration of auto-adaptative software using an evolutive system for knowledge management, filled-in by users’ experiences.
- Innovative development methodology concerning all network aspects in relation with :
- Collectivity demand in network management.
- Functions optimization after a utilisability study and interfacing.
- Integration of real use-cases during the development of SyGEMe.

In order to do that, the first step was to define a structuration methodology for available data or which ones have to be accessible on different SyGEMe web services. This first step aimed at offering a new interactive web product to users, in which it was possible to publish, access and modify different data coming from measurements, tasks, reports or situations related to drinkable water management.
All those elements are dynamically visualized on a cartographical basic service.
On this platform, a layer for knowledge management is added. The expert system has different databases for tasks, reports, modelization rules and a special core which can give tasks to the user related to the situation he encounters on the water network.
Knowledge management is evolutive in the sense that it can always be modified through parametring from users who have experience in exploitation and special situations. The knowledge management system can also be a decision help tool.

The architecture of SyGEMe is based on the WSOA type (Web Services Oriented Architecture). It permits to adapt the web platform to different needs, users, development technologies and to offer many services.

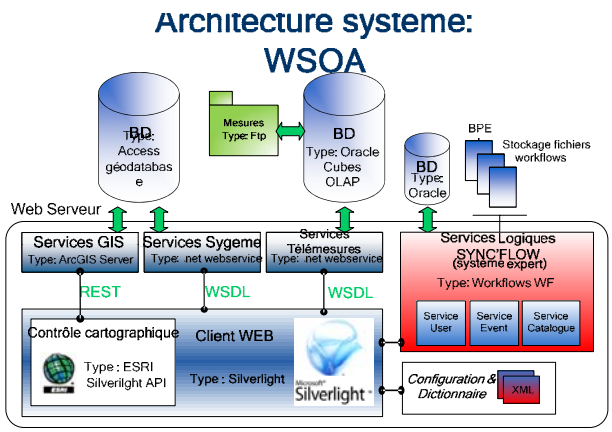
The display communicates with a GIS service system (ArcGIS) for cartographical features, a webservice which access a OLAP type database for getting real-time water telemetry.

This paper aims at presenting the tool, commenting on the choice of technology, explaining the man-machine interface work and finally speaking about the prospects and the future of SyGEMe.

2. CHOICE OF TECHNOLOGY

2.1 SyGEMe architecture

The architecture of SyGEMe is a WSOA type (Web Services Oriented Architecture), architecture oriented on services, implemented with web services.
The choice of such a structure comes from the flexibility it offers. The modular architecture permits a high potential of evolution and a high degree of replication (for example a replication of SyGEMe for other urban networks). Interoperability of transversal functions and high diffusion potential (through the web) make this architecture a really interesting choice corresponding to the SyGEMe imperatives.



A SOA system structure needs the management of different layers concerning norms and specific protocols. Those are used in SyGEMe:

- WSDL : Web Services Description Language
- SOAP : Simple Object Access Protocol
- XML : eXtensible Markup Language
- REST : Representational State Transfer
- HTTP et TCP/IP : data transfer protocols

In a SOA architecture, all actors (services provider and users) must have the same way of getting (SOAP) and describing the data (WSDL and XML).
The main components in the architecture of SyGEMe are a client application, of silverlight type for the first third, different

webservices and ArcGIS for the second third and SGBD Oracle and Access database for the last third.

2.1.1 The client application

The SyGEMe interface proposed to the user through the web is in charge of man-machine interactions, which permits the consultation of geographic data and attributes of the network (network elements, plans…), to create events, consult tasks or telemetry measurements, everything included in a "GIS-like " network environment with its basic functions (navigation, pan zoom,…).

SyGEMe is developed with the help of Silverlight Microsoft client application and gives many advantages as object oriented development, using design patterns, vectorial interface and high interactivity with the user.

- The cartographic controls

SyGEMe uses the new ESRI API which permits the display and cartographic controls in a Silverlight application. This application has a communication with map services diffused by ArcGIS server through a REST interface.

2.1.2 Webservices

- Telemetry service

This service is used by a user in order to get real-time network data. The data are sent to a database whose architecture permits a high number of data, in function of their dimension, temporal for example. Those data are called on a FTP server, which publishes the real-time measurements.

- GIS service

It is based on a REST diffusion: ArcGIS server publishes map and geoprocessing services offering for example the graphical preview of the network and the functions and tasks on data models. Those services are used by the graphical control Microsoft Silverlight of the client application, which shows the network in the application.

- SyGEMe service

This service .net permits an access to the data model through an ODBC connexion. This access permits non cartographic data as well as creation, suppression and edition of the model's data.

SyGEMe will implement the following main GIS services:

- Localization and Identification
  - Find an address
  - Get attribute of a pipe
  - …
- Queries on attributes
  - Show all pipes with a diameter > 2"
  - …
- Spatial queries
  - Show the consumers within 100m distance from the pipes
  - …
- Simple geometry network analysis
  - Show path downstream from a chosen valve
  - ..
- Simple attribute data edition
  - Modify a pipe type

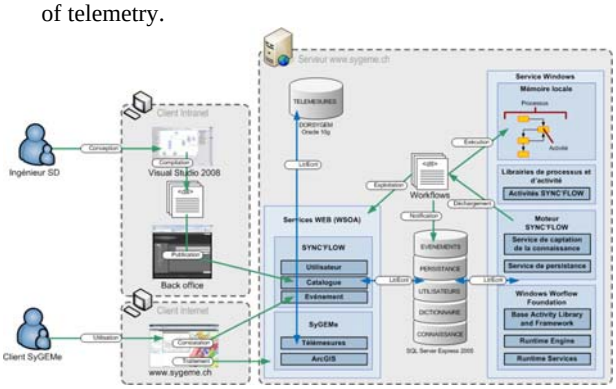
2.2 Sync'flow architecture

The architecture of SYNC'FLOW is also from WSOA type (Web Services Oriented Architecture), which permits to stand totally independent of applications and working tools it has to manage.

It is implemented with Microsoft standard technologies (Visual Studio 2008, .NET Framework, Workflow Foundation and Silverlight).

SYNC'FLOW is implemented in a database divided by 5 data models (>40 tables);

- a Windows service in which the workflows are executed ;
- 3 services Web SOAP (Utilisateur, Catalogue, et Evénement) ;
- a back office managed from a web browser which lets manage the users and the workflows catalog ;
- a database and a web service for the storing and the access of telemetry.



3. MAN-MACHINE INTERFACE

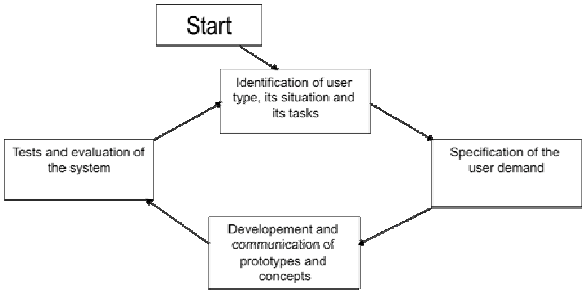
The user-centered approach is useful for the development and the graphical conception of applications for the terrain. The final users are often technicians and experts of their domain and can test the system, which will be potentially developed for them. SyGEMe is consequently based on this approach.

The difference between a standard GIS application and the SyGEMe web application is that the web based application doesn't require the knowledge of a GIS expert. In fact, the cartography is the main element for interaction and the graphical conception of this cartography is very related to human perception. As a consequence, the application interface must be adapted and well developed.

Systems development related with the main rules of man-machine interaction (IHM) implies to get experience from the final user all along the steps of the project. The final goal is to reduce the cognitive efforts of the user. The IHM theories are based on those central elements:

1. Implementation of systems centered on the user. This helps to identify the users and their needs
2. Interface conception: concepts, metaphors, display, interaction techniques and application development methodology
3. Cartographic and webmapping methodology

This figure shows the first notion:



Requirement specifications of the user are not only a list of wished functions but also mention reflexions on graphical conception and technologies used during the development. Those specifications have been used on the basis of SyGEMe project, in conformation with the logic described before. The implementation is based on application prototypes, which must be tested and evaluated in the following step. The non-validation of a prototype gives birth to a new analyzing cycle of the user's needs.

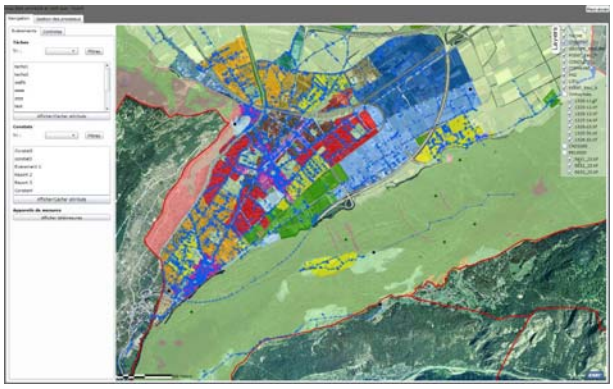
4. TOOL PRESENTATION

4.1 Main platform

The main goal of SyGEMe is to offer a tool to users working on a water network in order to enhance its management. The objectives of the system are to maintain the knowledge and experience acquired during a life-time working network technician, reduce the response time after a non common situation in the exploitation of the network, and optimize the predictive maintenance of the infrastructures.

The structuration steps concerning data and management workflows analysis have served the panel of services (functions) that must have been developed. The system offers documentation, georeferencing of network objects and events on it. There are usual components of the network as physical attributes and events related to the flows such as telemetry data or reports/tasks whose consequence is a variation of flows (leaks, regulation…).

The main navigation interface is the following:

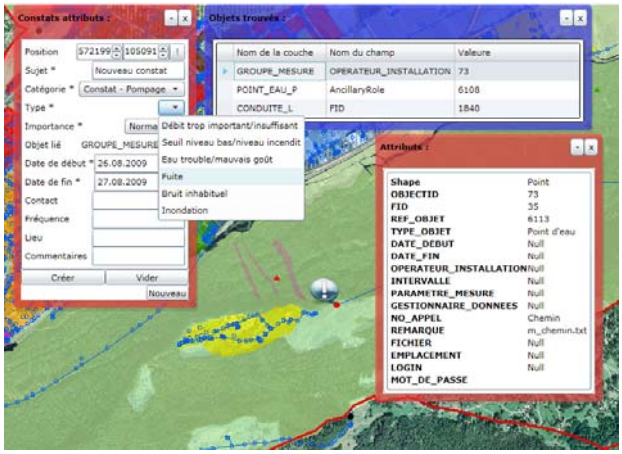


The client who uses SyGEMe can watch the attributes of the network objects. On the web platform, different layers include geographical objects whose details can be consulted. We can mention here data of the pipes (diameter, construction year…), valves, tanks (size…) zones attributes and many others. That information is centralized in a database and available in any time.

4.2 Georeferencing and agending

Georeferencing and agending all the reports is done through an online fill-in form in which the user can register structured information. The event is also georeferenced on the cartography and can be attached to an object of the network (for example a tank or a section of pipe). This task can also be automatically generated by the expert system if it is related to an alarm concerning real-time telemetry.

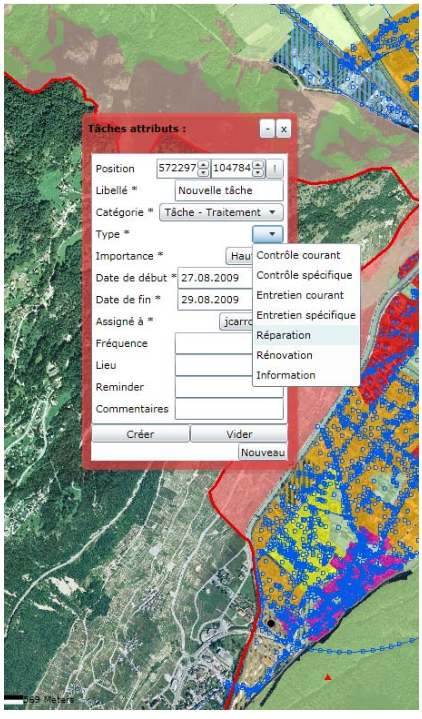
The report is agended and accessible by the network manager or technician who can receive an alarm when a new report is created.
When the report is selected on the map, the attributes of the report and those from the network objects are shown in pop-up windows.



Georeferencing and planification are also used for tasks. The user can create a task, fill-in all attributes in the online form and assign a task to a technician or another SyGEMe user.

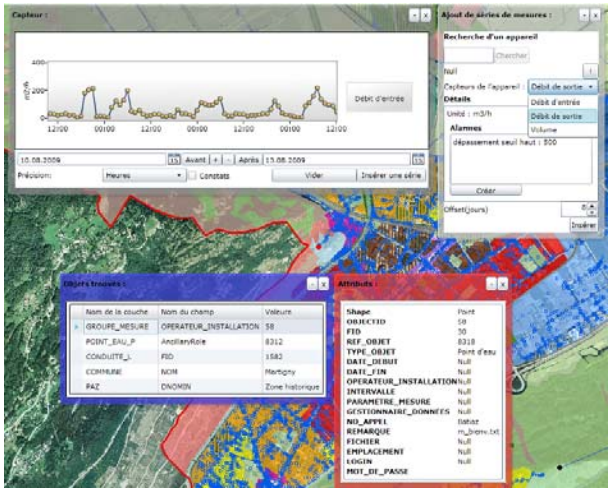
The task is now planified (timeline) and accessible for the assigned technician. He must validate the task and modify it as done or rejected if he has done it or not.

In parallel, the expert system can create automatic tasks. When there is a problem on the network, a special event detected through telemetry (leak, tank level…), the system edits a list of reports and tasks that can be assigned to one or many users.
Those automatic tasks must first be imagined and introduced in the expert system to grow the knowledge database.



4.3 Telemetry

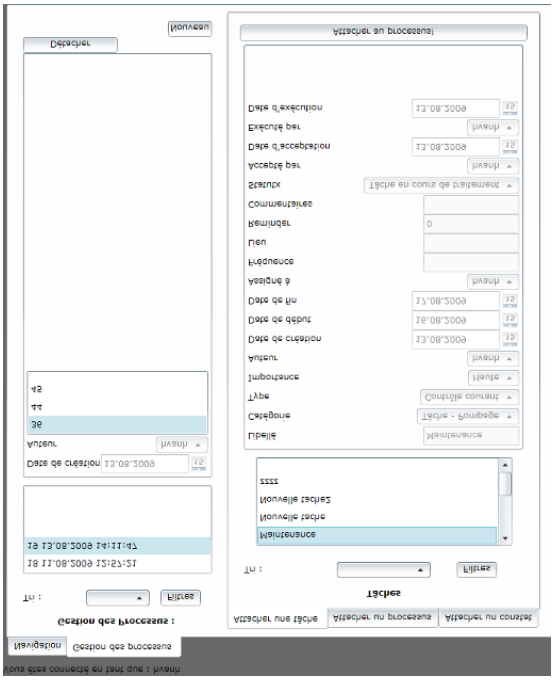
A telemetry window can be shown. On the chart, one or more curves can be selected or hidden. There are also all basic functions, which permit the time translation, zoom on the curve, time interval choice, curve color and so on.



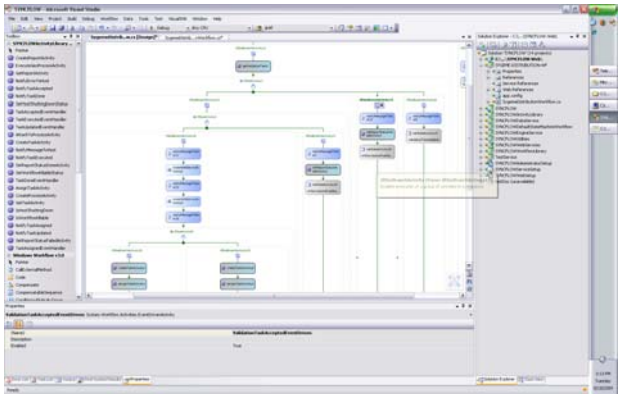
A special function of SyGEMe is also to relate reports or objects of the network to the telemetry curves. In that way, when the report is selected on the chart, the map is centered and attributes are shown. It is possible to explain flow variations in function of the event or the opposite.

4.4 Workflows

Workflows can be managed on a separate window. When a task is realized or rejected, the user could consequently create another task or report. When events are redundant, it is possible to centralize them and create a list of tasks and reports which are part of a process called workflow. Those workflows are then saved in the expert system which will be able to give information on what to do in case of a situation that has been encountered before on the network.



In function of the needs, tasks, reports and even workflows can be added or deleted in the workflow or added to a new one.



5. PROSPECTS

The objective of SyGEMe was to develop an innovative tool for geomonitoring and knowledge management of the drinkable water network.

The innovation was the center point of the project as it offered two fundamental elements:

- Offer to users a unique and integrated platform, which gives an access to a GIS basis, real-time telemetry data and an expert system of knowledge management.
- Give on this platform an expert system, which permits on one hand to make easier the drinkable water network management in analyzing automatically its behavior and on the other hand, ensure the knowledge and experience acquired by network technicians, especially in small collectivities.

After more than 30 months of work, the prototype SyGEMe has been now released and is available to the two first clients.
The system will probably give some interesting prospects, on a technical (research and development) and financial point of view:

- A first market study has denoted that managers of water networks in many middle-size collectivities would need such a system (more than 10 interviews have been realized).
- The quantity of services elaborated in the cahier des charges shows that there is a high potential of development for SyGEMe, whose architecture has been imagined in a way that new services could easily be added.
- Last, the process for information management with georeferencing, the agending of events in the timeline, the measure of real-time flows and the knowledge management system gives SyGEMe many opportunities for others applications. It could be replicated in urban networks (electricity, natural water management, gas network…) or even for all territorial projects, which need an online real-time monitoring system (territory management, transport, agglomeration project…).

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