ArcGIS Server helps water resources management

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In Alpine regions like in other areas around the world, local administrations (communes) have the duty to manage water resources and distribution. The quality, the available 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. Web GIS technology may help to share geographic knowledge and improve water cycle management.

With a financial aid of the Swiss Confederation[1], a group of private firms, public administrations and universities are currently carrying out a project on Integrated Municipal Facilities Management of Water Resources (SyGEMe), in western Switzerland.

SyGEMe's goal is to build up a common IT infrastructure and web services to support small water network managers. GIS is the best platform to carry out specific analysis over a bigger water basin and helps managers to synchronize their actions on the network.

This paper presents some interesting aspects of this project and emphasizes the role of ArcGIS Server.

Introduction

In the Swiss alpine canton of Valais, Martigny has been a "laboratory town" since 1986 when the Urbistics Competence Center (CREM) was created. CREM plays a pivot role in energy and land management R&D activities and guarantees support to Local Technical Services (LTS). Among the innovative projects that CREM leads, SyGEMe is the most important and the most recent one.

SyGEMe project started a few years ago to improve water resources and network management. Water is a key asset for the entire region as it is consumed in large quantities for tourism, agriculture and hydroelectric energy production. Besides, water reserves play an important role for facing fire alerts. Water availability is conditioned by the following main factors.

- Sources and water network infrastructures are often difficult to access due to land morphology and seasonal climatic variations.

- Historically, many little isolated networks coexist due to the fragmentation of local administrations that own their water system.

- Water demand highly varies geographically and seasonally due to heavy tourist activities.

As a consequence, communes need to

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[1] KTI/CTI, *Office federal de la formation professionnelle et de la technologie*, Effingerstrasse 27, 3003 Berne, Switzerland

- Optimize their network infrastructure

- Share their patrimony and their technical knowledge in order to promote the whole region effectively and to improve their resources in a sustainable way

- Implement a preventive and coordinated approach to guarantee continued and optimal services to customers all year long

SyGEMe provides a common and innovative solution and satisfies the communes' needs. It proposes to integrate geographic information and dynamic data coming from an automated data acquisition system into a generic expert system to effectively help managers during decision making processes and for technical knowledge management.

The System Architecture

SyGEMe proposes a web solution built on the following three main related components (see figure 1):

- Geographic Information System (GIS)

- Monitoring System (MS)
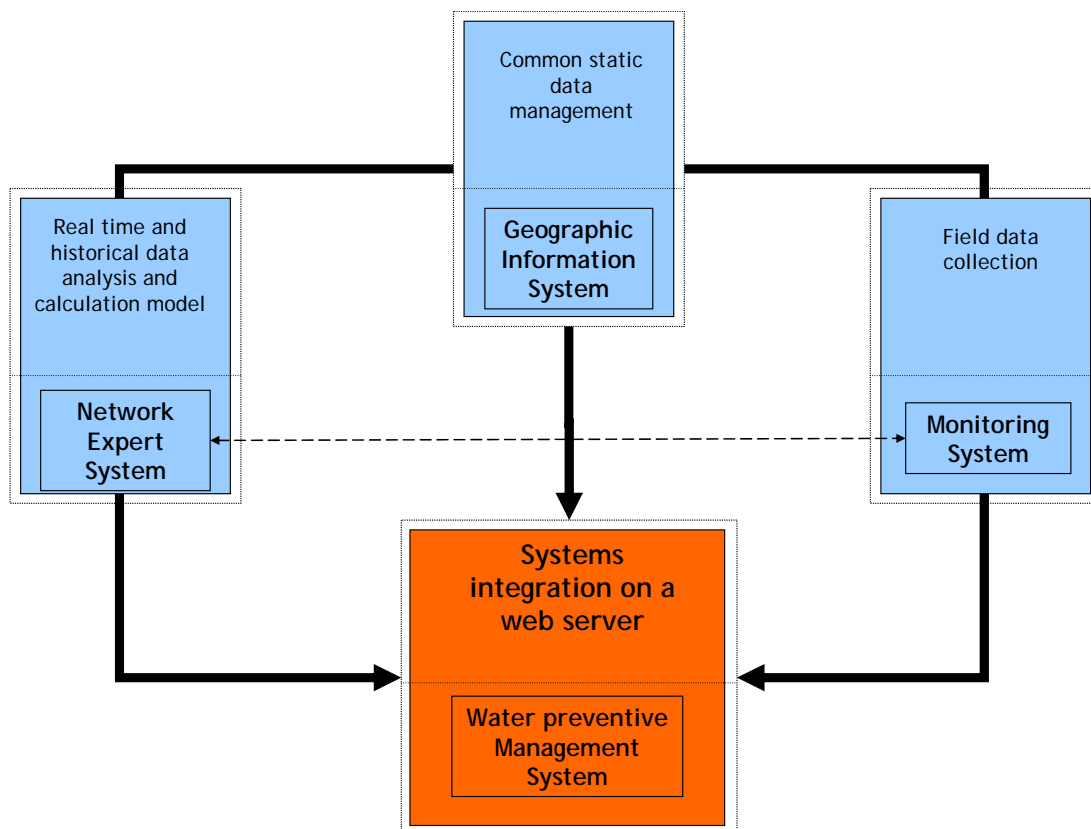
- Network Expert System (NES)

Figure 1

Web technology lets the users access the whole system in the most simple and flexible way.

The MS provides real time dynamic data. The NES maintains knowledge about water system operations and analyses data.

GIS Implementation

GIS is the natural common support for most of the information. The Canton administration provides standard base maps. Each LTS provides and maintains data about their own network infrastructures like water sources, conduits, vaults and tanks. Information is structured in a common and simple data model.

In many cases a schema is useful for visualizing complex network situations. Nevertheless, SyGEMe's GIS team chose not to use this kind of representation because of the simplicity of the network. Schematics may be implemented in a later stage upon specific users' request.

Expert System

The goal of the NES is to manage the knowledge about the operations and the activities related to the maintenance of the network. The amount and the complexity of the knowledge required for most decisions that managers have to take and the risk to concentrate on an individual some critical information about processes impose the use of an IT system to guarantee a valid and reliable support.

The system will gradually store the experience and the know-how of technicians in the form of simple and documented processes.

SyGEMe's NES is based on the work of Stefano Gianella [1], [2] and [3].

An initial collection of processes has already started. The current document template is based on the following structure:

Process :	<name>
Category:	<breakdown/maintenance/self-control/…>
Actor :	<name of every actor in the process>
Start :	<name and description of the starting event>
Action :	<name and description of single actions in the process - sequence>
End :	<name and description of the final event>
Links :	<name of related actions in other processes>
Information:	<name and description of the datasets involved in the process (I/O)>

Here is an example:

Process:	Fix the network after an accidental water leak
Category:	Breakdown
Actor:	Civil engineer Enterprise, network manager
Start:	Customer calls network manager on the phone
Action:	
End:	Mailing action with excuses to customers affected by the breakdown
Links:	
Information:	

SyGEMe's ES team chose the UML[2] formalism of BPMN[3].to describe processes (workflows)

This formalized description offers the advantage or providing BPEL[4] ,an exchange format that fits to SOA[5] architectures.

Monitoring System

In order to detect standard breakdown events and to analyse most parts of common critical events, a simple flow meter that sends data every five minutes to the server, is used.
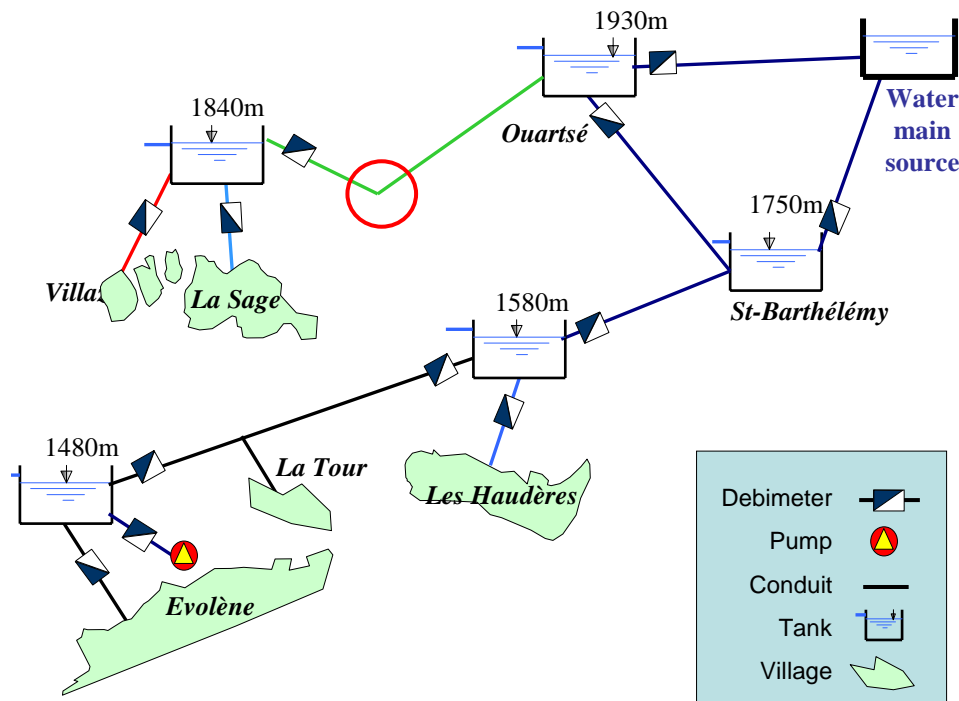
Anomalous values generate alerts in the Expert System. This appropriate process workflow will allow starting opportune actions.

Figure 2

An example

This example (also reported in [4]) shows the flaws of the current off-line MS which registers water flux in conduits. In Martigny region, most of the tourist villages depend directly on water collected in tanks near the mountain sources as shown in figure 3.

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[2] Unified Modeling Language – http://www.uml.org
[3] Business Process Modeling Notation – http://www.bpmn.org
[4] Business Process Execution Language - http://www.bpmn.org
[5] Service Oriented Architecture - http://en.wikipedia.org/wiki/Service-oriented_architecture

Figure 3

A breakdown event happened at 5:30 pm on February 12th on a conduit between two tanks, as indicated by the red circle in figure 3.

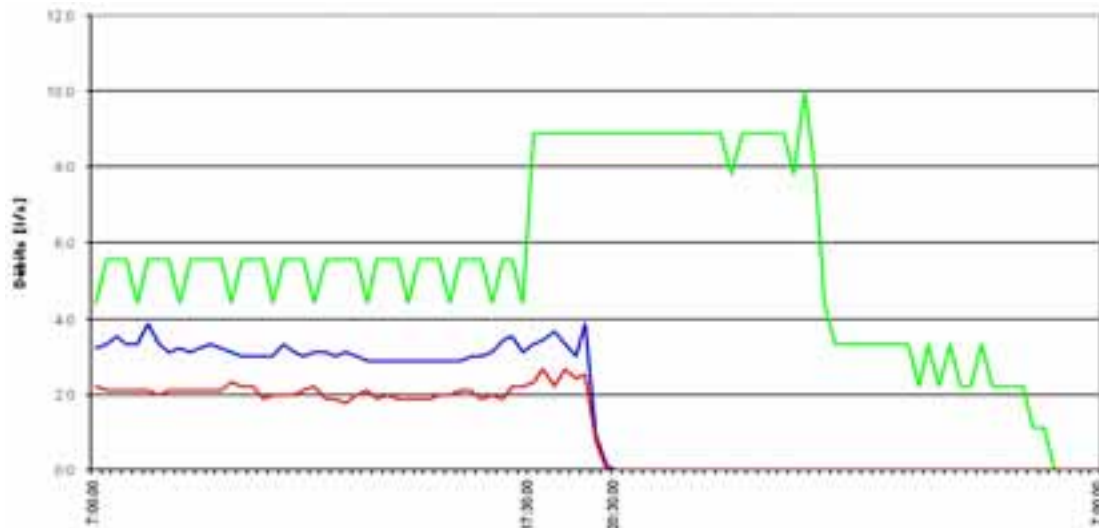Three data loggers registered the values reported in figure 4.

Figure 4

As a result, the tank started emptying immediately. At 8:30 pm, two villages had no more water supplies and some consumers started calling the technical service.

The tables in figure 5 show how SyGEMe could have reduced the response times in such a critical situation.

Without SyGEMe

Num	Time	Event	Time Axis
1	17h30	Breakdown of the supply conduit, at a lower location than the water tank	0h00
2	17h30	Quick growing of the supply flow (from tank to the leak in the conduit)	
3	20h00	Water supply of the two villages isn't guaranteed anymore	
4	20h30	First complaints of the inhabitant	
5	20h30	Manager gets the first information about failure	
6	21h00	Manager sees that the tank is empty	
7	07h30	Pipe is repaired and supply system operates	14h00

With SyGEMe

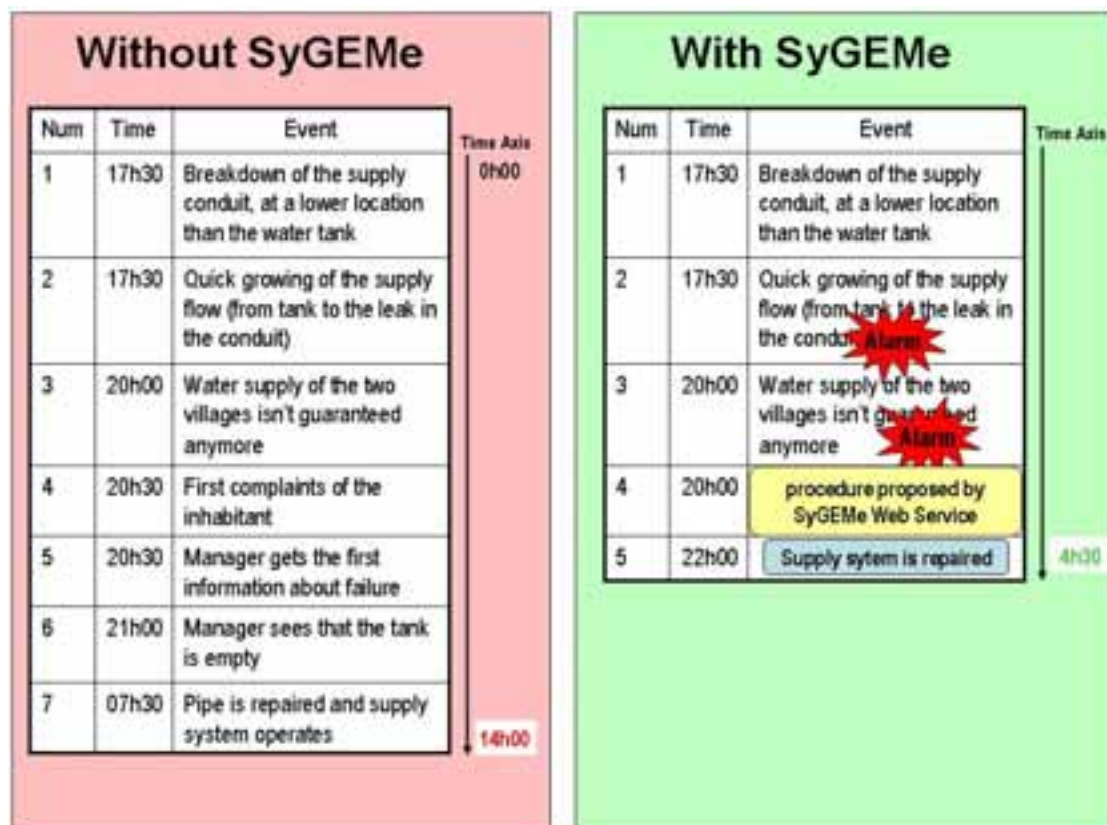| Num	Time	Event	Time Axis
1	17h30	Breakdown of the supply conduit, at a lower location than the water tank	
2	17h30	Quick growing of the supply flow (from tank to the leak in the conduit Alarm	
3	20h00	Water supply of the two villages isn't guaranteed anymore Alarm	
4	20h00	procedure proposed by SyGEMe Web Service	
5	22h00	Supply sytem is repaired	4h30

Figure 5

Actually SyGEMe detects anomalous data and their source location and it alerts concerned people. Its expert system analyses the possible causes and proposes a procedure to solve the problem.

ArcGIS Server Geoservices

SyGEMe will implement the following main GIS services:

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

Commercial Model

The Utilities Company of Geneva (SIG) participates in SyGEMe project. SIG will host ArcGIS Server, the ES and the Web server. With the support of the federal polytechnic school of Lausanne (EPFL), CREM manages the whole project and will guarantee general coordination among the different actors.

The final users will be technical services of local administrations, Engineering and Surveying Company (ESC) and the SIG itself.

ESC has also set up a business plan. The SyGEMe model can be easily reproduced and implemented in similar environments for other alpine regions in France, Italy and Austria.
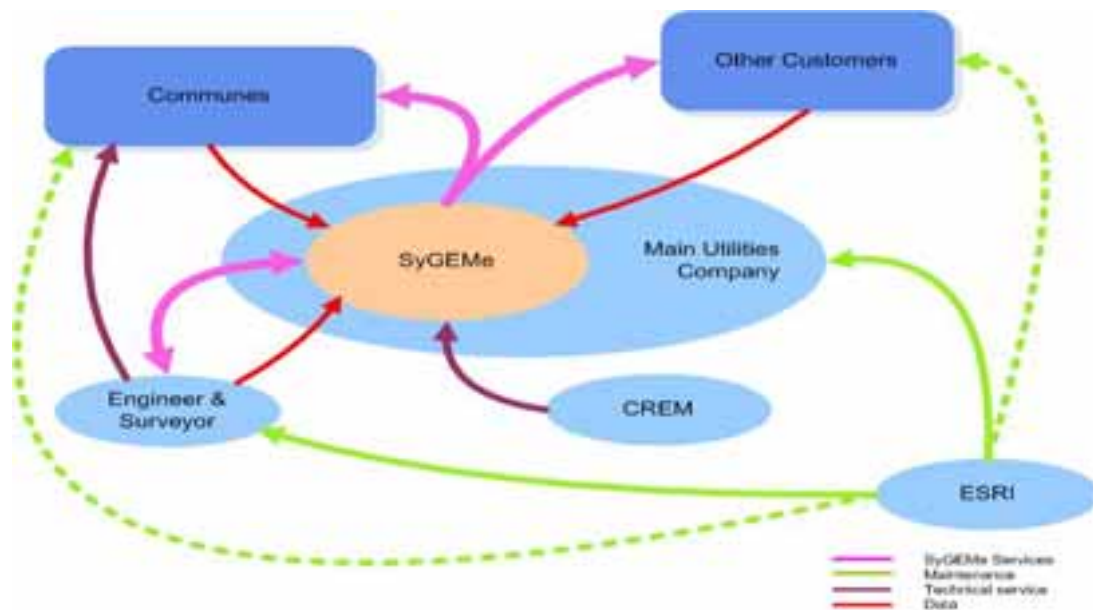
Figure 6

Conclusions

Based on a Web-server architecture, SyGEMe leverages precious amounts of information concerning technical data and component connections that are stored in AGS in order to offer an optimal graphic interface to improve network operations and plan maintenance activities.

The system manages technicians' experience and managers' knowledge by storing them as processes and supports decisional and analytical activities. This solution promotes information exchange among many users and minimizes reaction time during mission critical operations.

Acknowledgments

References

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Dissertation ETH Zürich Nr. 16045: Eidgenössische Technische Hochschule Zürich.
[2] **Gianella, S., Gujer, W. (2006a)**. Improving the information governance of public utilities through an organizational knowledge base. Paper accepted for: *WCEAM 2006: First World Congress on Engineering Asset Management*, 11-14 July 2006, Gold Coast, Australia.
[3] **Gianella, S., Gujer, W. (2006b)**. Modeling critical knowledge for information governance in public wastewater utilities. Paper accepted for: *HIC 06: 7th International Conference on Hydroinformatics*, 4-8 September 2006, Nice, France.
[4] **Storelli, S. (2005)**. *Exploitation et maintenance des réseaux urbains*. GWA Nr. 12/2005 pag.969-974.