Case Study #2: A DSS for Flash Flood

Bringing together Geo-science systems and Decision Makers

Ontology mapping issue
Rationale

- Flash-Flood Early Warning estimate is a complex task requiring a wide set of geospatial data providing information about current and future values of heterogeneous parameters (hydrological and not).

- Most common sources
  - Raingauge networks
  - Satellites
  - Weather radars
  - Local Area Models
  - GIS

- Generally speaking, Decision Makers are NOT computer scientists or Hydraulics Engineers.

- A DSS to be effective needs to express results according to Decision-Makers ontology.
The Service-Oriented Approach
The Starting Scenario: main issues

**Organization:**
- Data sources were managed by many different data providers;

**Technology:**
- Data were accessed through different communications protocols and they were encoded in proprietary formats;

**Content:**
- No specific pre-processing for flash flood early warning was available;

**Semantic:**
- Information was expressed according to data providers (scientists, researchers,...) or hydrologists conceptual models;

**Presentation:**
- Data were visualized through legacy applications that were not specifically designed for flash flood early warning problem;
The Starting Scenario: overview

Decision-makers can access a lot of information, but they can utilize only a small part of them, effectively.
Our approach for a DSS

The DSS is made up of two main components.

The first component acts as an Expert System:
1. It extracts useful information from data sources;
2. It integrates and processes the information (according to a specific model);
3. It provides a “standard” and “open” situation report.

A second component acts as a Presentation System:
1. It carries out proper presentation of the situation report.
2. It enriches the presentation with useful graphical and presentation features.
3. It contextualises the rendering according to the client device configuration.
- **MARTE system**: a ground-based sensors network providing data every 15/30 minutes, in a legacy format. It is managed by the National Hydrographic Service.

- **RAMS system**: a Local Area Model providing forecasted precipitation data for the Tuscany Region. It works out one map per hour within 48 hours forecasting time. Maps are provided in legacy binary format along with a metadata text file. It is managed by the Regional Laboratory for Applied Meteorology.
The three Ontology Views

- Domain specific Ontologies
- Hydrology Ontology
- Decision-makers Ontology

- RAMS forecasted precipitation data
- MARTE measured precipitation data
- Other data

Hydrogeologic parameter extraction
Decision-making parameter extraction

Expert System

DSS Client Application

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Domain Ontology

To be effective the system needs to express results according to the Decision-Makers ontology.

Generally speaking, Decision Makers are NOT computer scientists or Hydraulics Engineers.
The Ontology Integration issue

Hydrology Conceptual Model

(Simplified View)

DSS Conceptual Model

(Simplified View)
Hydrogeological Model

An Hydrogeological Model developed by the Polytechnic of Milan is the core component of the expert system.

It defines the procedures to extract information from the input data and generate the hydrological outputs which are mapped to the DM’s concepts (Conceptual Model).

- Briefly, the expert system tasks are:
  - To update the situation (sub-basins critical sections status) each time a measured map (from MARTE) or a forecasted map (from RAMS LAM) is available;
  - To aggregate the rainfall on each sub-basin;
  - For each sub-basin, to check the existence of a rainfall event according to the value of the aggregated rainfall;
  - For sections with active events, to compute and compare the cumulated rainfall with a threshold, based on hydrological parameters;
  - To manage section status, each section is in one of three possible status (no event, event without warning, event with warning);
  - To achieve the model output: a summary of the situation (sections status, rainfall series,...)
Computational Architecture

- Component-based approach;
- Multiplatform approach;
- Extensible solution;
- Distributed solution
MIMÌ Technology baseline

Adopted technologies:

- Java Platform (J2SE, J2EE, J2ME, Java Web Start);
- Web Service technology
  - XML/XSD; XSLT;
  - SOAP/HTTP(S); HTTP/HTTPS;
  - WSDL;
- SVG;
DSS Implementation

- **Expert System**
  - Hydrological Model Implementation
  - Ontology Mapper

- **Presentation System**
  - Content Collector
  - Contestualised Presentation Adapter

- **Client Application**
  - Thick Client
  - Thin Client
  - Mobile Client
DSS Implementation

- Expert System
  - Hydrological Model Implementation
  - Contestualised Presentation Adapter

- Presentation System
  - Web Servers (Presentation Information Publishers)

- Client Application
  - Thick Client
  - Thin Client
  - Mobile Client
MIMÌ Human-System Interaction Model

The Java-based thick client is specifically designed for decision-makers showing DMs ontology information in a user friendly manner.

The GUI is based on typical use-cases defined in collaboration with the final users;

In particular:

-Only the sections status for a given time is normally visible;
-User can select the reference time choosing to view the measured situation or one of the forecasted situations;
-User can inspect a specific section obtaining charts of cumulated and aggregated rainfall
Thick Client

1) Login
Thick Client

2) View the real-time measured situation

Critical Sections
Its status is reported by the shape and the colour
Thick Client

3) Select and view a real-time forecasted situation

Available Forecasted Situations

Just select one and the forecasted scenario is displayed
4) Inspect a basin section for a potentially dangerous forecasted situation

- **Aggregated Rainfall**
- **Cumulated Rainfall**
- **Green = forecasted**
- **Blue = measured**
- **Threshold**
Smart Phone Client

J2ME enabled Device
Cell-Phone Client

XHTML enabled Device

The present situation
At the Sub-basin level

The next forecasted situation
At the Sub-basin level

- Vicchio
- Pontassieve
- San Giovanni Valdarno
- Rignano
- Nave di Rosano
- Rassina
- Subbiano
- Previous
- Next
The Presentation System

To leverage interoperability and extend the DSS

Decoupling Content from Presentation Info

Towards the Cooperative work
To decouple Content and Presentation information

**Content Information**
- Raingauge Network Data (Real Time Data)
- Local Area Model (Forecasting Data)
- GIS Data (Time-invariant Data)

**Presentation Information**
- Web Server (Situation Information Publisher)
- Web Servers (Presentation Information Providers: e.g. River Network, DEM, etc.)

**Presentation System**
- Internet
- Contestualised Presentation Server

**Expert System**
- Hydrological Expert System (Situation Information Generator)
- Thick Client Application (Expert Decision-makers)
- Thin Client Application (Mobile Client Application (Decision-makers))

**Legacy Data**
- GIS Data
- Intranet
- Internet

**GIS Data**
- Time-invariant Data

**Legacy Data**
- MARTE System Hydrographic National Centre
- Hydrogeological Model Polytechnic of Milan
- Hydrological Model Tuscany Regional Meteo-Laboratory

**XSD and XML**
- XSD
- XML
• Sub-basin Situations
• Raingauges Situations

• Basin critical sections
• Metadata

• Basin DEM
• Basin River Network

Device-depended Rendering
Expert System
Thick Client Application (Expert Decision-makers)
Portal System
Web Servers
Contestualised Presentation Server
Collector
Adapter
Internet

Thin Client Application (Decision-makers)
Mobile Client Application (Decision-makers)
Computational Components

Collector

DeviceConfiguration

Internet

Sub-basin Situations
Raingauges Situations
Basin critical sections Metadata
ConsolidatedReport

Presentation Info

Basin DEM
Basin River Network

Content Info

XSD
XML

XXLT

Portal System

Collector

Web Service
HTTP Service

Thick Client Application
Mobile Client Application
Thin Client Application
(Expert Decision-makers)
(Decision-makers)

Client Applications

SVG
HTML

XML
XSLT

Portal System

SVG
XSLT

XML
XSD

Web Service
HTTP Service
Implemented Presentation Services

- Global Situation Service
  - The presentation of the present and future situations for all the basin sections

- aSituation Service
  - The presentation of a given situation for all the basin sections

- aSection Evolution Service
  - The presentation of the present and future situations for a given basin section
Global Situation Service

Thick Client Application
(Expert Decision-makers)

Thin Client Application
(Decision-makers)

Global Situation Collector

Global Report

Device Configuration

Presentation Proxy

Thin Clients need an HTTP-based Presentation Proxy
Low-level Access Services

- Web Service
  - SOAP Message
  - XML/XSD
- HTTP Service
  - HTTP GET/POST Message
Mobile Clients Demo

- Demo: aSituationService
- Client application is any device Web Browser
- Presentations are personalised for:
  – PDA
  – Smart Phone
  – Cellular Phone
Exercises

1. Use a general purpose SOAP Client to access the Collector and Adapter web services
   - [link](http://localhost:8004/glue/src.wsdl)
   - [link](http://localhost:8004/glue/srsm.wsdl)

2. Add a Presentation Resource (SVG fragment)
   - The Tuscany Region boundary