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A context aware mobile GIS: design, architecture and first implementations

[155]

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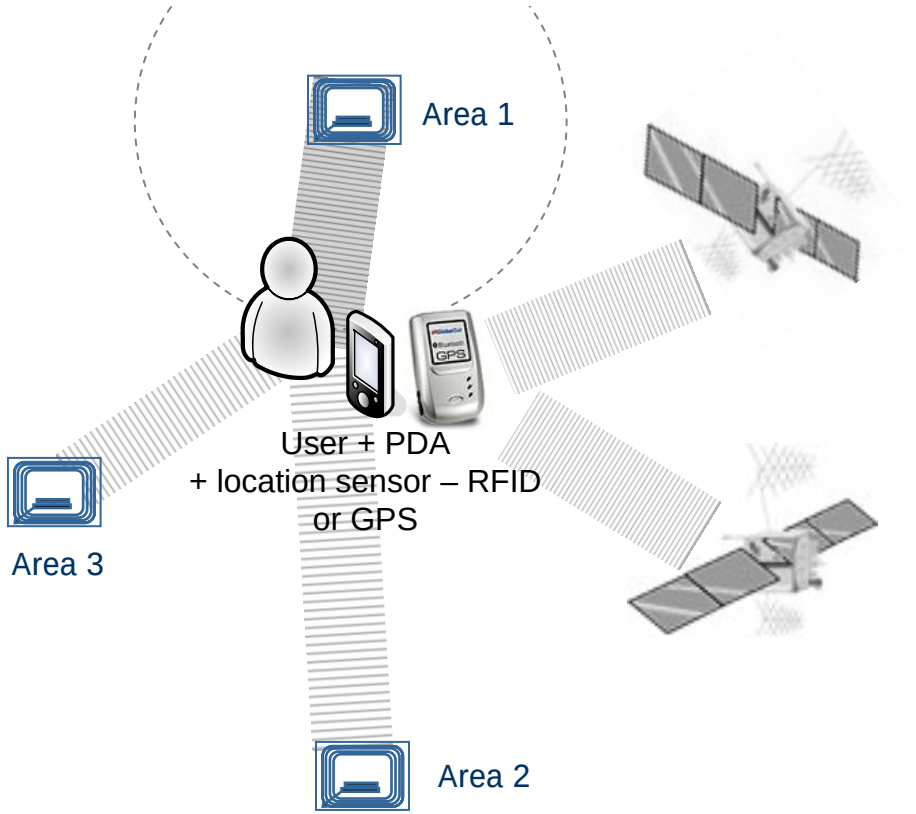
Goal

Implementation of a context aware mobile GIS, with these properties:

- Basic GIS functionalities
- User location on the map by GPS positioning
- Objects of interest location on the map by RFID tags
- Other kinds of context awareness (such as used devices, contrast/brilliance, contents deepening)



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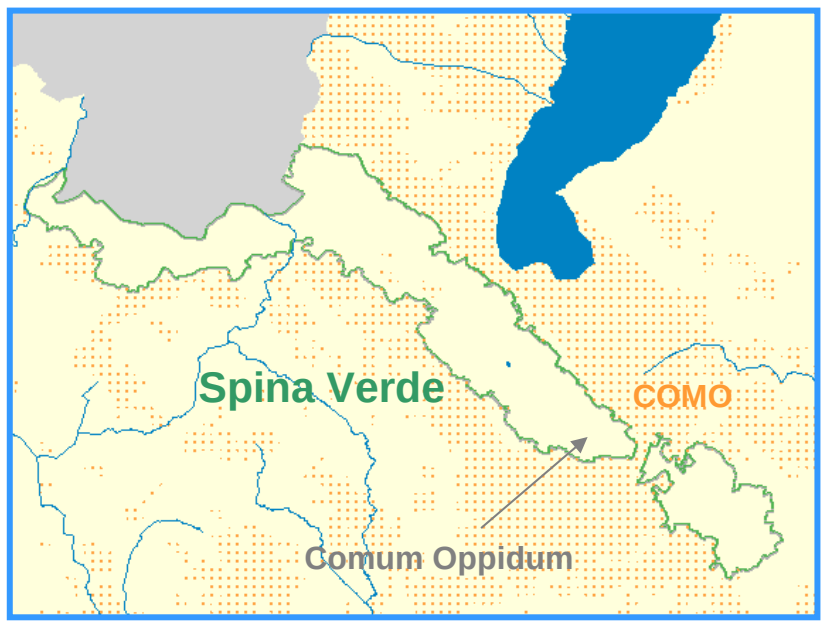
Specific context

The mobile GIS we are going to talk about is dedicated to a specific archaeological site, Comum Oppidum, a preroman settlement within the Italian Regional Park of Spina Verde, near Como (Northern Italy).



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Comum Oppidum: some pictures

Baradello Tower

The Big Rock Room

Monument-made Spring of Mojenca

Rupestrian inscriptions of Pianvalle

ArchaeoGEW

The Geomatics Laboratory already implemented ArchaeoGEW (Archaeological GIS Explored by Web) for the settlement of Comum Oppidum.

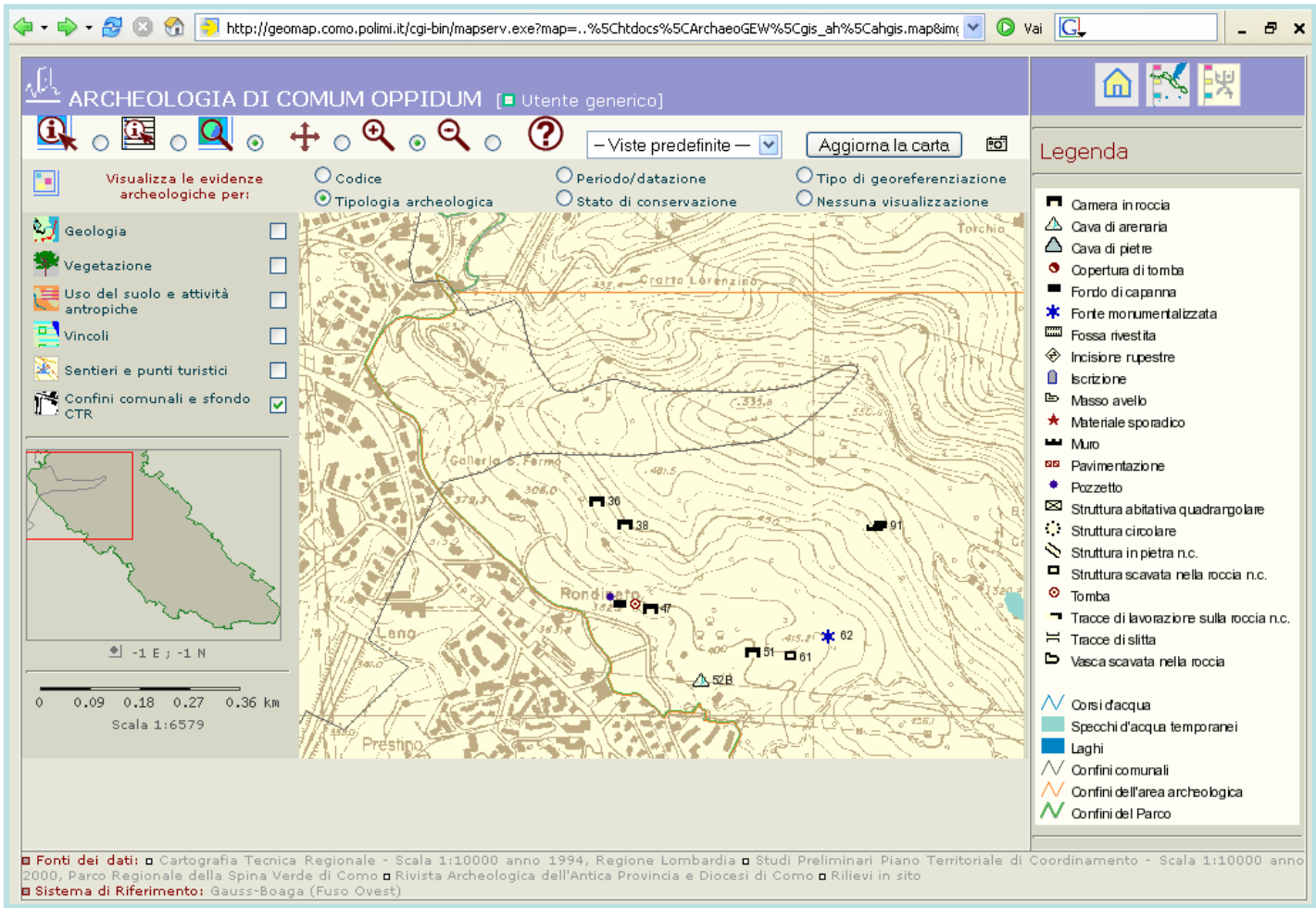
ArchaeoGEW is a web GIS with these characteristics:

- Apache 2 http server on Windows O.S.
- MapServer 4.6.0 , CGI architecture
- Connection to PostgreSQL tables by PostGIS

Now, the mobile GIS is aimed to transfer the information of ArchaeoGEW to handled devices and to improve it by some context aware functionalities.

Website: http://geomap.como.polimi.it/agew/

ArchaeoGEW



An archaeological map of ArchaeoGEW

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From specific context to any context

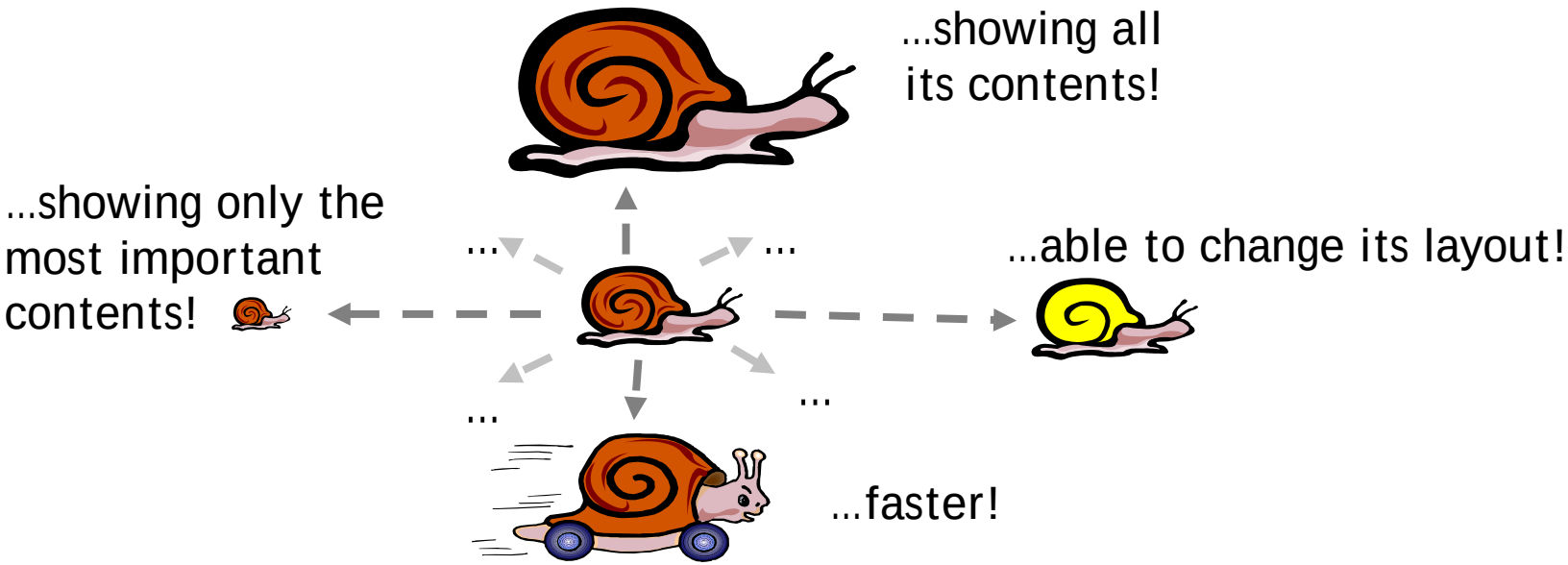
At the moment, the context aware mobile GIS is being implemented for the specific context of Comum Oppidum.

But new possible “archaeological instances” will be discussed on the next months for applying this solution to other archaeological sites.

Moreover, this solution can be transferred to other fields (e.g.: public protection, fleets management, hiking).

Context awareness

- The Web has become movable
  - Different situations
  - The context changes
  - The user changes his location
- A mobile service must be able to perceive the environment
  - React to changes



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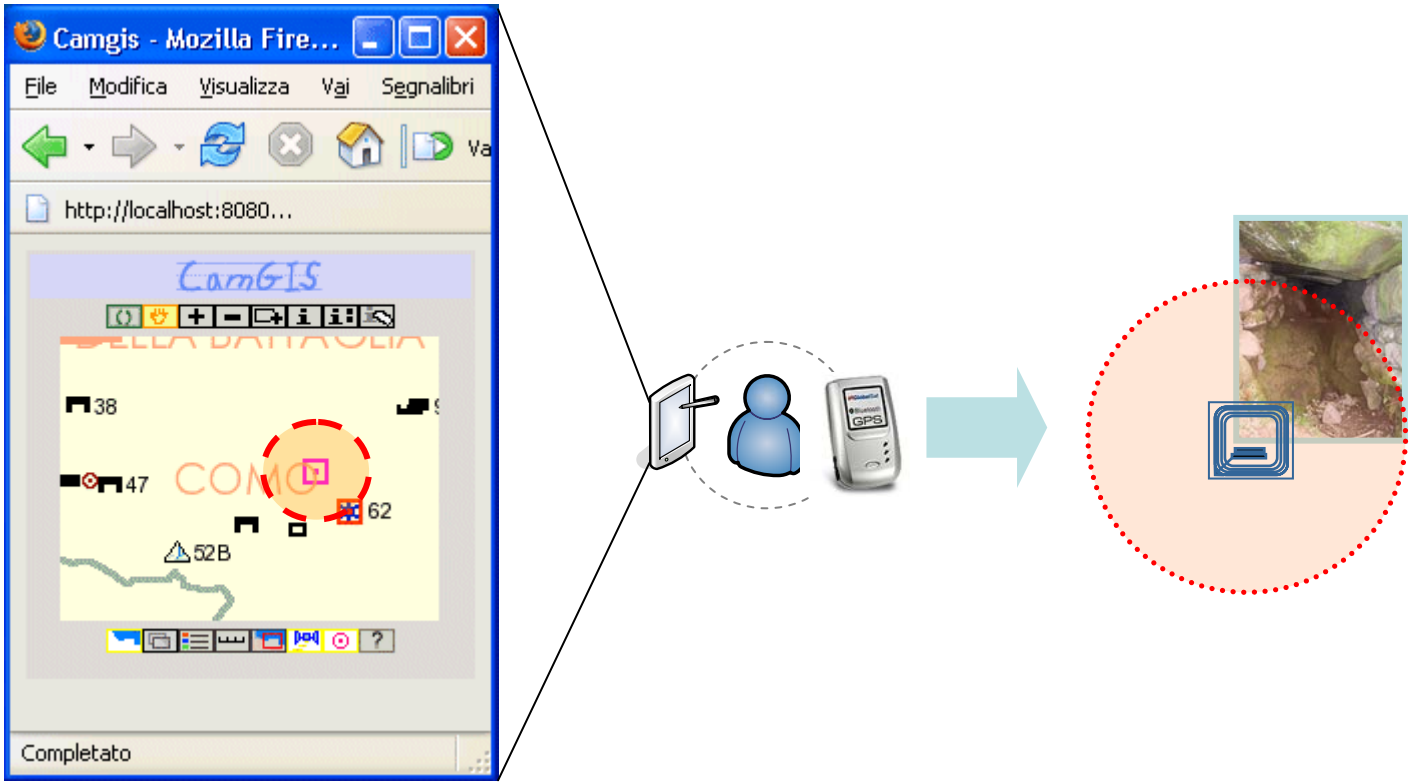
Expected result



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Context Aware Mobile GIS: adopted approaches

The analysis of requirements and possible planning solutions produced the following approaches to the project:

- Implementation of a service with Web based architecture
  - Suitable for mobile clients
    - PDAs
    - Smartphones
- Model Driven Development (MDD)
  - Definition of models to describe :
    - Context
    - Service
    - Adaptation strategy
- Need to improve the study of the possible ways to integrate the context aware functionalities into the mobile GIS
- Use of already acquired experiences about mobile GIS (Geomatics Laboratory) and context awareness (Cefriel), and mutual know-how

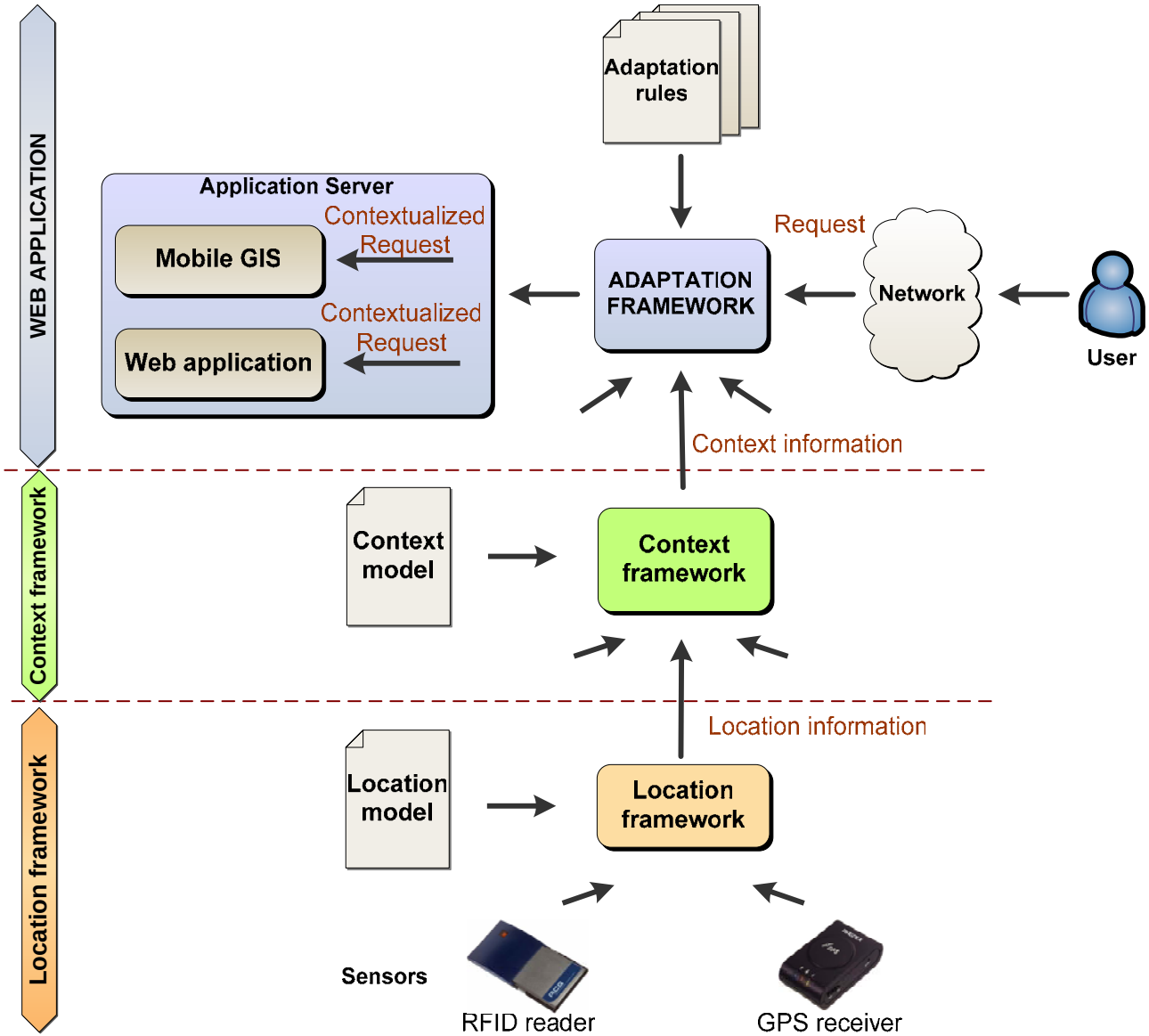
Logical Architecture

- The architecture is logically organized in **3 levels**:
  - **Sensor management** level: manages sensors to obtain context data. For exemple GPS receivers or RFID readers to determine user's position;
  - **Context framework**: aggregates and manages context information coming from different sources
  - **Web application**: delivers services adapting contents, presentation and layout to context data collected by the context framework

The **http request** is modified by the adaptation framework according to **policies** defined by the developer in the **adaptation rules** and the context information

Context information is colected and managed by the **context framework**

Sensor information is collected and managed by a set of specific components, like the **location framework**



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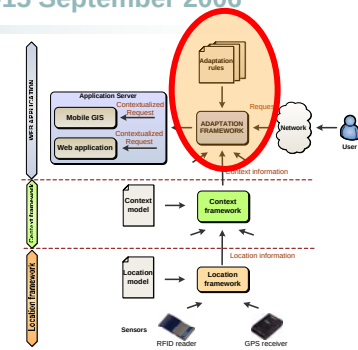
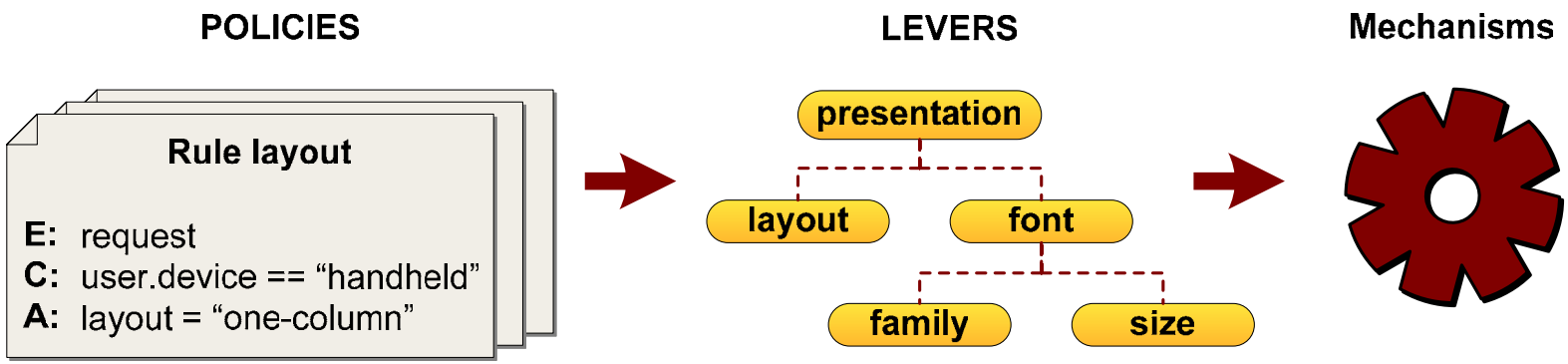
Architectural components detail

- Architecture designed to integrate pre-existing prototypes
- **Apache Tomcat** as application server for:
  - **mobile GIS**
  - **context awareness framework**
    - Mantains the base architecture of the *context awareness framework*
- Mobile GIS developed using Java MapScript,
    - More suited to use into a servlet container
- 2 more independent processes
  - **Context** server
  - **Location** server

Adaptation model



- We use the concept of **adaptation lever** to separate adaptation **mechanisms** and **policies**
  - **Policies** are expressed by the developer using ECA rules
  - **Mechanisms** are the software scripts that concretely implement the behavior described by policies
  - Levers are a hierarchy of key-value pairs
    - The value of a lever is set by a policy
- Rules are defined:
  - **explicitly** by the designer in the adaptation model
  - **implicitly** in the platform, for pre-defined behaviours



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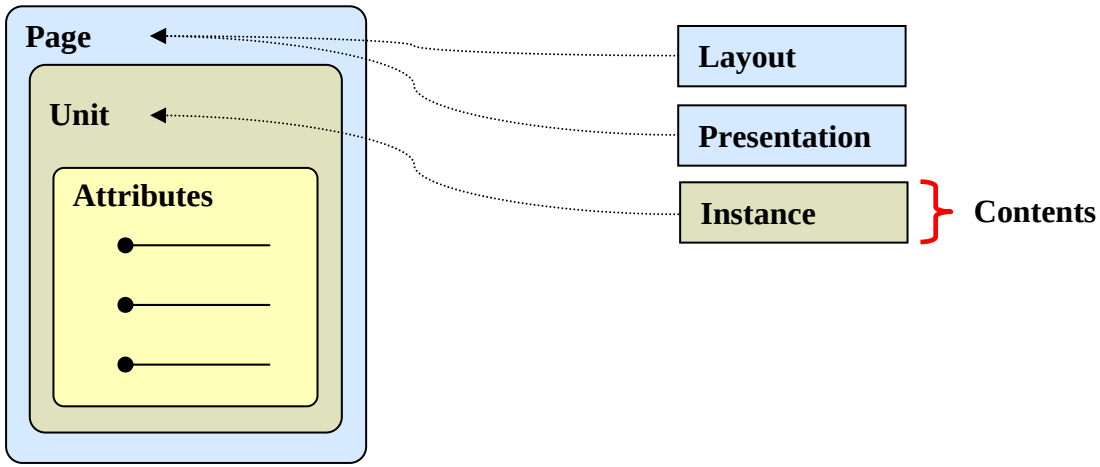
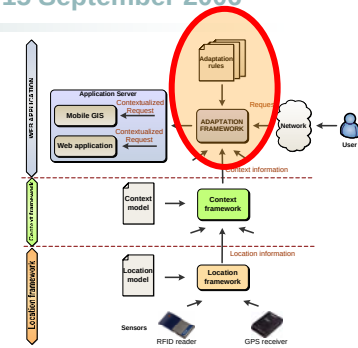
Adaptation levels





Kind of adaptation at the different levels of the model

- **Layout**: adaptation of disposition of objects in the page space
- **Presentation**: adaptation of color scheme, font type and font size
- **Entity instance selection**: selection of a specific instance of an entity

Context parameters used

- **User location**
- **Kind of device used**

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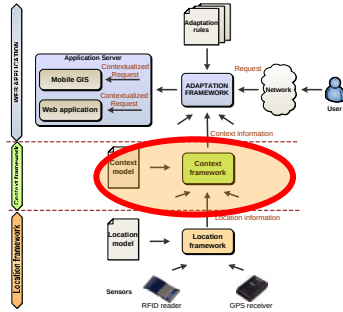
Context manager



- Context **acquisition** and **management**
  - The context model is a set of **Java classes** composed by 3 elements:
    - **Entities**: objects for which the context must be managed (for example a user)
    - **Context data**, associated to entities (for example, location = “The Big Rock Room”)
    - **Relations** between data and entities (for example, the user is near “The Big Rock Room”)
- **Inference** of context properties
  - Inference rules based on:
    - Parameters
    - Conditions
    - Actions
  - The context manager evaluates the involved parameters every time they change

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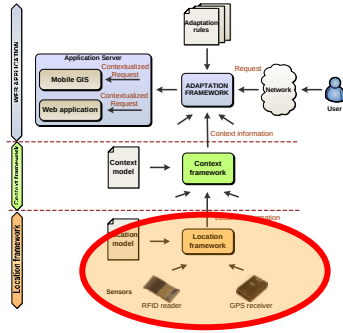
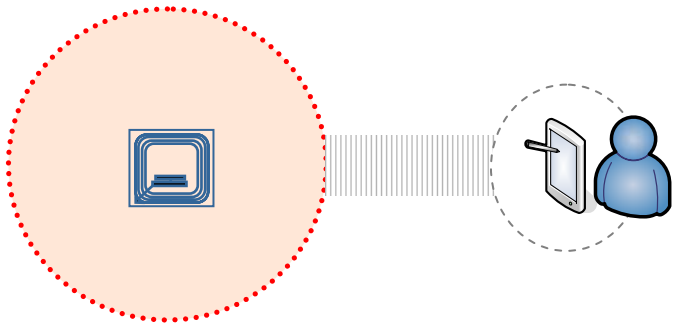
RFID technology



- Instrumented environment
- RFID technology
  - Tags in the environment
  - Reader onboard the mobile device
- Proximity sensors



- Every RFID sensor defines a "cell" in space
  - Cell intersections define zones
- Need for a **learning** phase
  - Association between RFID tags and physical locations where they are set

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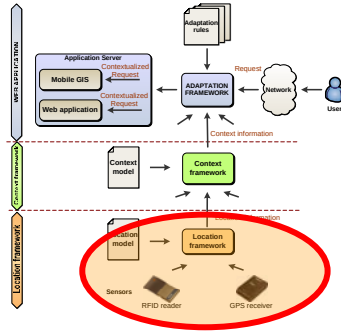
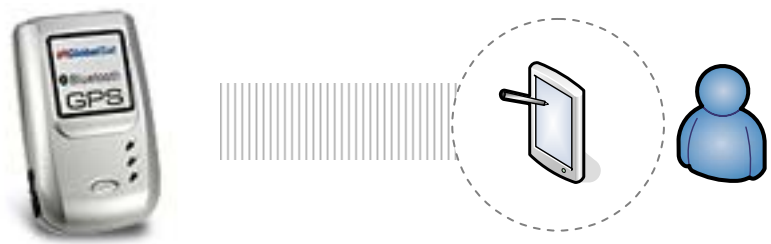
GPS technology



- Adopted receiver:
  GlobalSat BT-338 Bluetooth GPS Receiver
- Characteristics:
  - Signal: C/A on L1
  - Positioning accuracy: 10 m
  - Data transfer protocol: NMEA-0183
  - Handled devices connectivity: Bluetooth



- Test with other GPS receivers are planned for next months

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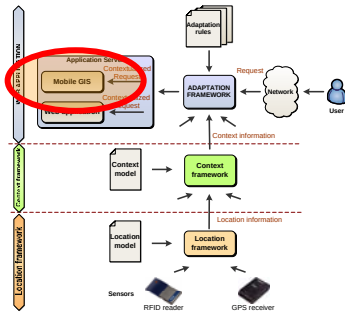
Architecture of the mobile GIS component



GPS

RFID

Configuration files
(map file, fontset, symbolset)

Mobile GIS

Background Data
(raster, vect)

Background Data
(PostgreSQL)

Archaeological Data
(PostgreSQL)

PostGIS

Graphics

Camgis servlet

Template file (XHTML)

CAMGIS = Context Aware Mobile GIS

JavaScript functions

Java MapScript

it.polimi.como.geomatica.camgis package

Network

Request

Response

User

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Mobile GIS: software and technology

- GIS engine: **UMN MapServer**
  - *Firstly designed architecture:* ***CGI*** *on* ***Apache http server***
  - Final architecture:
    Java MapScript 4.8.4
    on **Apache Tomcat 5.5.17** servlet container (JDK 5.0 Update 6)
- DBMS: **PostgreSQL 8.0**
  - Spatial extension: **PostGIS 0.9**

Proper mobile GIS: approach for the template file

- XHTML + CSS
- Unique template file with on/off elements:
  - map,
  - dynamic legend,
  - reference map,
  - scalebar,
  - predefined views list,
  - query by attribute form,
  - query results list
- Use of external JavaScript functions
- All is managed by the servlet of the mobile GIS (Camgis servlet)
- Form (named msform) to add GIS functionalities, based on hidden parameters and buttons

Proper mobile GIS: approach for the template file

List of the msform parameters

Parameter (type)	MS CGI analogy	Functionality
mapext (hidden)	[mapext]	Actual map extent
mode (hidden)	MODE	MapScript mode: browse, query or intemnquery
zoomdir (hidden)	ZOOMDIR	MapScript zoomdir: 0, 1 or -1
bloccaext (hidden)	-	For freezing the actual extent
layers (hidden)	[layers]	List of visible layers
addGps (hidden)	-	Drawing GPS position on/off
addRfid (hidden)	-	Drawing RFID location on/off
savequery (hidden)	SAVEQUERY	For saving query results in the MS temp folder
saveQyTesto (hid.)	-	For saving, keeping in memory and writing query results
carta (hidden)	-	Drawing map on/off
sbar (hidden)	-	Drawing scalebar on/off
toc (hidden)	-	Drawing dynamic legend on/off
refmap (hidden)	-	Drawing reference map on/off
viste (hidden)	-	Drawing predefined views list on/off

Proper mobile GIS: Java classes list

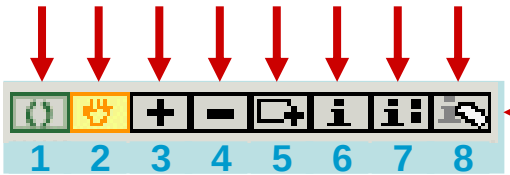
Camgis	Main servlet of the mobile GIS
MapFile	Class for creating and saving map images, setting layer status, pixel to coordinates conversions, drawing new layer features
navigaCarta	Class for map browsing functionalities: pan, zoom, predefined views
queryCarta	Class for features and attributes queries
TOC	Class for dynamic legend generation and management
scriviTemplate	Class for writing the template file and its on/off elements
varMS	Interface; list of the variables used in the mobile GIS
datiIntegrazione	Interface; list of predefined views and variables for query by attributes

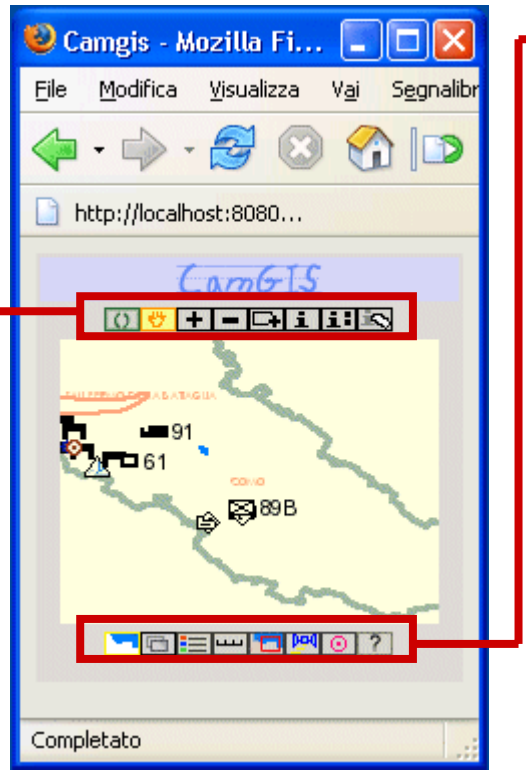
Package: it.polimi.como.geomatica.*

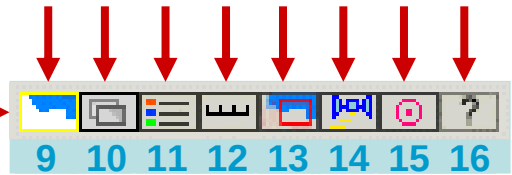
Camgis servlet structure

HttpServlet; doGet (HttpServletRequest request, HttpServletResponse response)
response.setContentType, response.getWriter, request.getServerName, request.getPort
Map File settings: mapObj generation; imagepath, imageurl, extent initialisation → request.* methods, MapScript methods, MapFile.class methods, varMS.class variables
msform values acquisition or initialisation during the first loading of the template file → request.* methods, MapScript methods, MapFile.class methods, varMS.class variables
Call of the method for **inserting GPS coordinates** → MapFile.class methods
Call of the method for **inserting RFID coordinates** → MapFile.class methods
Map browsing management (zoom factor evaluation, zoom by point, msform extent update) → MapScript methods, navigaCarta.class methods, varMS.class variables
Query management (feature query, query by attributes) → queryCarta.class methods
Map drawing and saving → MapFile.class methods
Scalebar and Reference Map drawing and saving → MapFile.class methods
Dynamic legend writing and management → TOC.class methods
Predefined views writing and management → navigaCarta.class methods
Template file writing, with this order: 1. Header and title, 2. Superior toolbar, 3. Map, 4. Inferior toolbar, 5. Query (research form or results), 6. Scalebar, 7. Dynamic legend, 8. Predefined views, 9. Reference Map → scriviTempl methods, varMS.class variables

Mobile GIS: look and functionalities







1. **Refresh**
2. **Pan**
3. **Zoom In**
4. **Zoom Out**
5. **Zoom Rectangle**
6. **Feature query**
7. **Query by attributes**
8. **Clear query results**

9. **Map** on/off
10. **Predefined views** on/off
11. **Dynamic legend** on/off
12. **Scalebar** on/off
13. **Reference Map** on/off
14. **GPS** coords visual. on/off
15. **RFID** coords visual. on/off
16. **Help on-line** on/off

First look of the mobile GIS (after initialisation)

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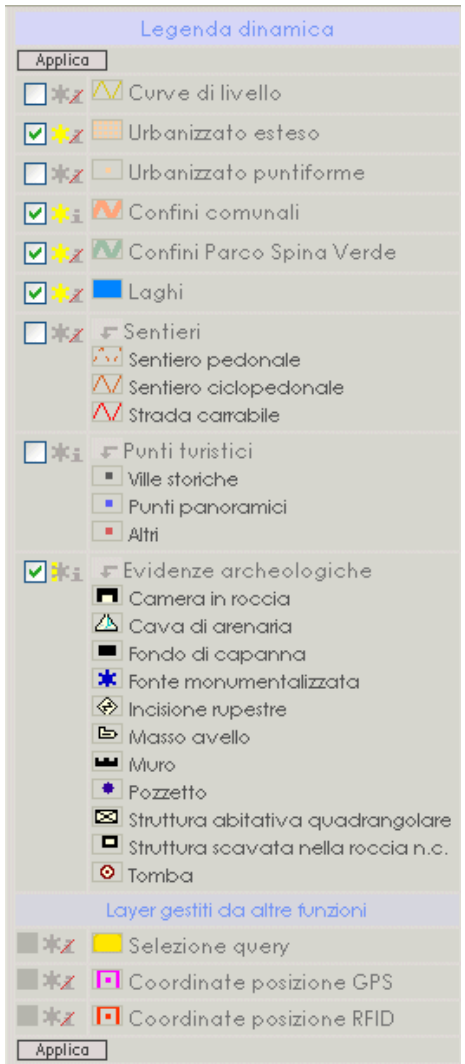
Mobile GIS: look and functionalities

Scalebar

Reference map



Dynamic legend

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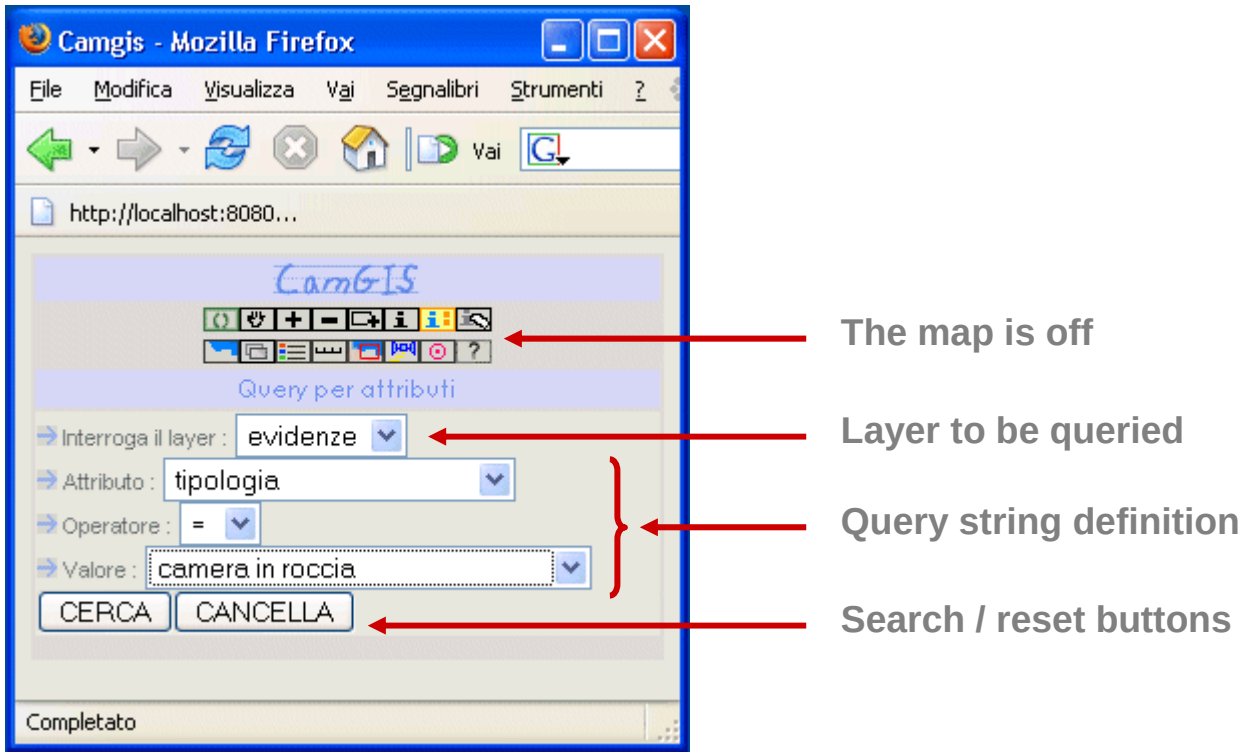
Mobile GIS: look and functionalities



Query by attributes: research form

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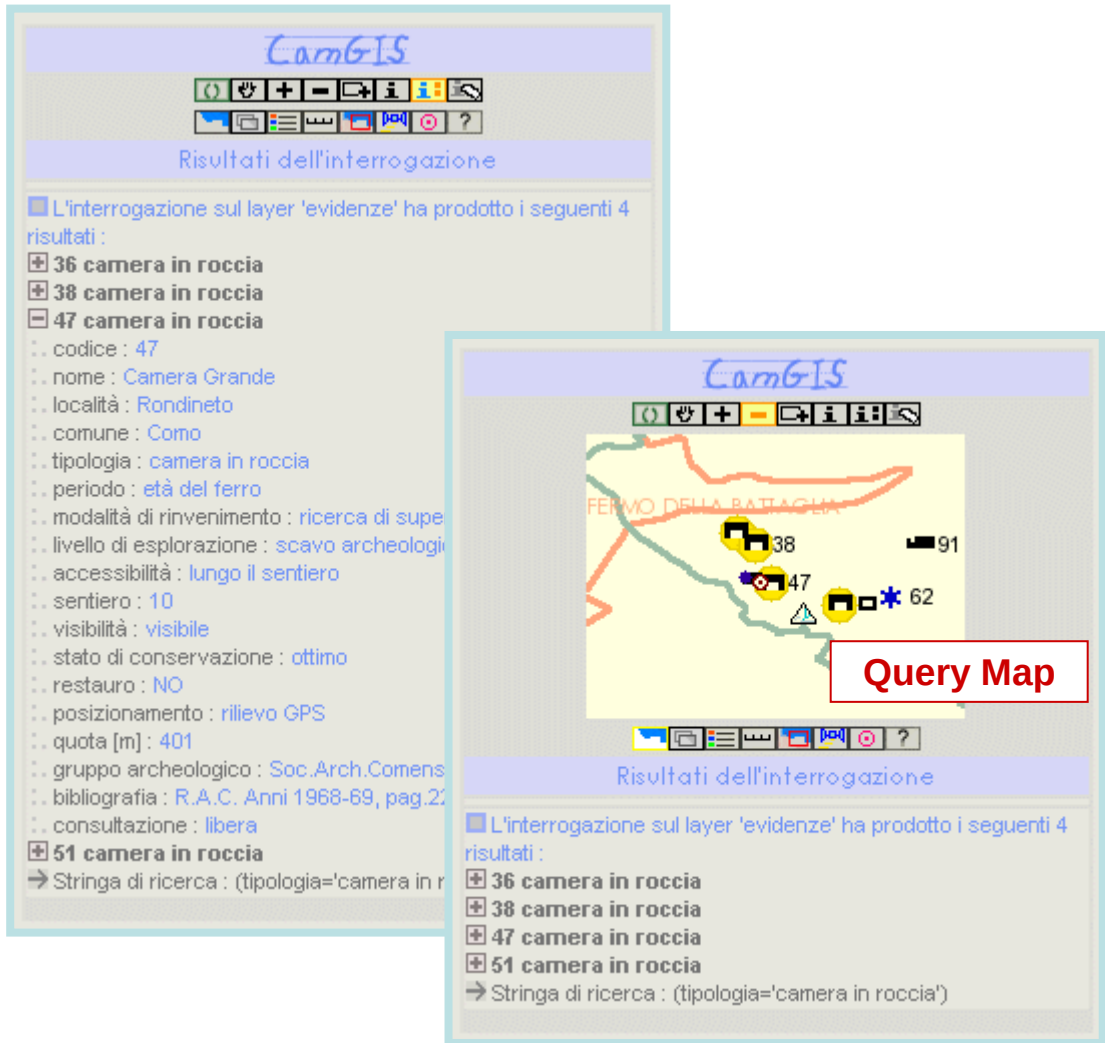
Mobile GIS: look and functionalities

Collapsed list



Query by attributes: results list

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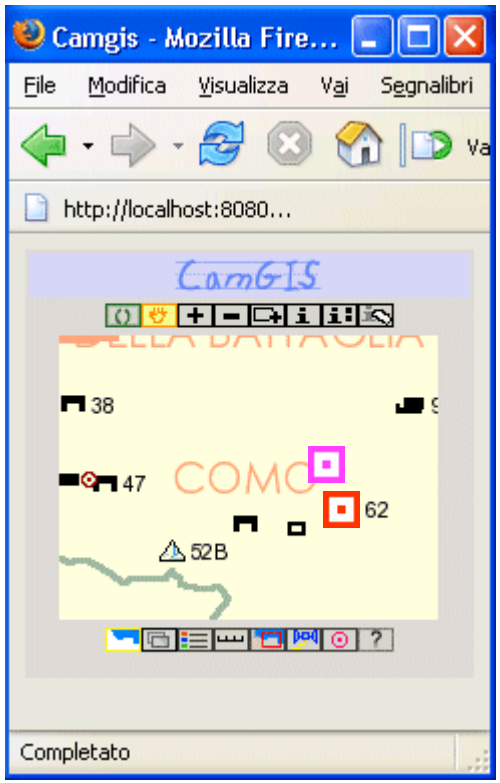
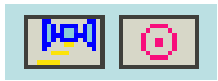
Mobile GIS: look and functionalities



1 

GPS and RFID not displayed

2 

GPS position displayed

3 

GPS position displayed

RFID location displayed

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Mobile GIS: displaying GPS/RFID position

φ, λ coordinates

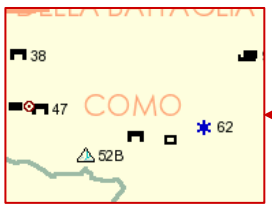
Context aware platform

Camgis servlet

```
sensorName = "gps" OR "rfid"
addSensorVal = { on
               { off
```

```
MapFile.disegnaPosizSensore
(sensorName,mapObjName,φ,λ,z,
addSensorVal);
```

Camgis servlet



S=0, STATUS "off"

S=1, STATUS "on"

```
pointObj sensCoord = new pointObj(φ,λ,z);
lineObj sensLinea = new lineObj();
int s = 0;
sensLinea.add(sensCoord);
shapeObj sensShape =
   new shapeObj(mapscriptConstants.MS_SHAPEFILE_POINT);
sensShape.add(sensLinea);
layerObj sensLayer = mapfile.getLayerByName(sensorName);
sensLayer.addFeature(sensShape);
if (addSensorVal.equals("on")){s=1;}
sensLayer.setStatus(s);
```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Conclusions

- Problems and questions found analysing the possible integration between mobile GIS and context awareness platform steered towards a Java-based architecture
- The use of Java improves also the mobile GIS, especially for the data management and the implementation of functionalities
- We think inadvisable to automate too much processes and functionalities, because it could cause unexpected behaviours of the system
- At the moment, the RFID component is more stable and tested than the GPS one

Future developments

- Awareness of environmental brilliance conditions
- Awareness of the used handled device
- Implementation of other GIS functionalities (help on-line, zoom by rectangle)
- Tests with other GPS receivers
- Adopting of GML (Geographic Markup Language) for the location model (map, RFID) to GML (Geographic Markup Language)

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