Towards a Monitoring System for High Altitude Objects

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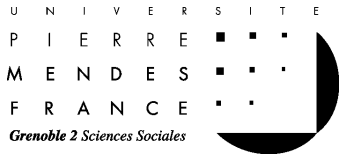
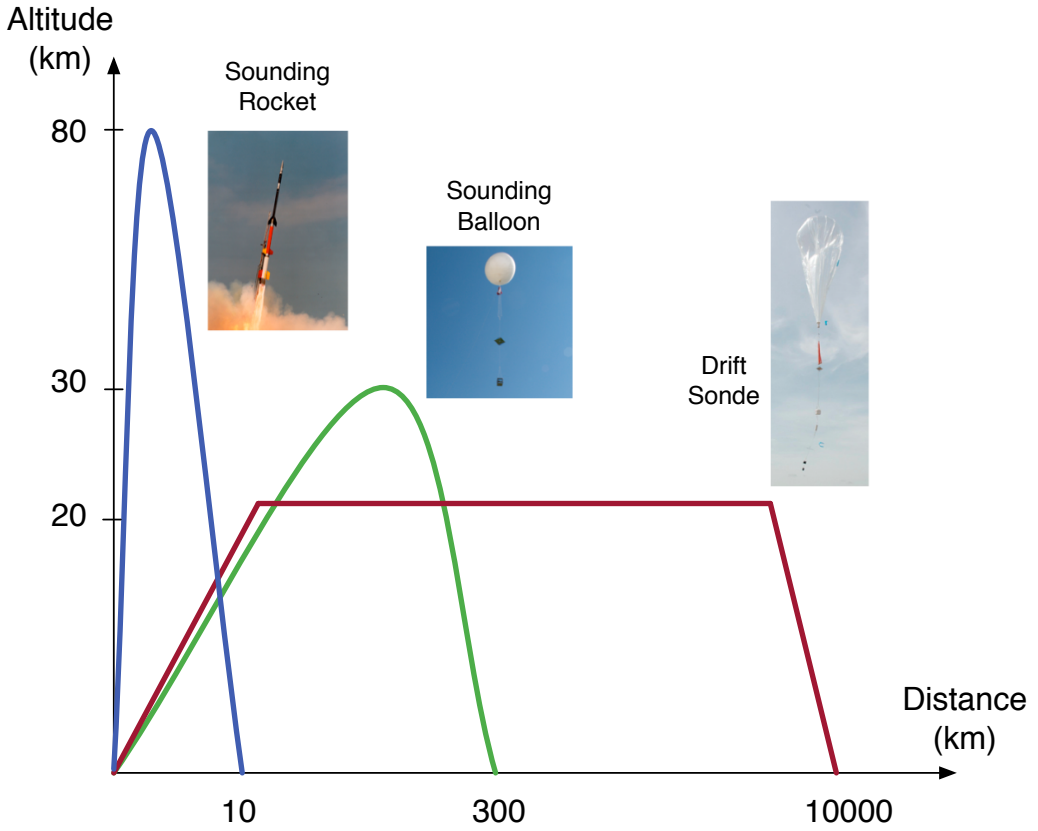


High Altitude Objects (HAOs)

- Flying objects reaching the stratospheric layer
- Collecting (storing and/or transmitting) environmental data
  - Weather, Pollution, ...
- And/or embedding scientific experiments



HAO Tracking and Recovery

- Why recovering?
  - Data sometimes too large to be sent (e.g. pictures)
  - On-board samples to get back for analysis
  - Payload/object cost
- Why tracking?
  - Difficultly predictable landing point
  - "Real-time" monitoring of collected data

HAO Tracking *Vs* Communication

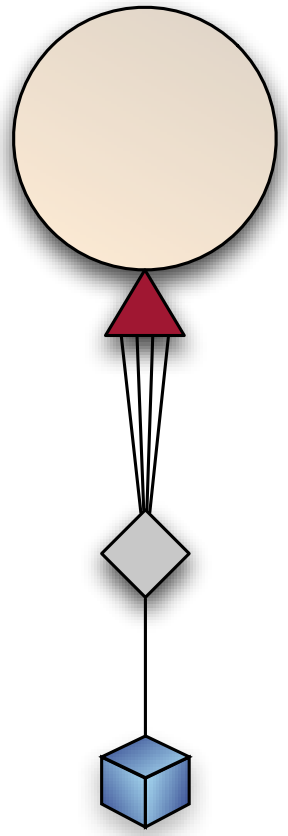
- Key factors
  - Distance, power, throughput, cost per byte (on operated networks)
- Relevant technologies
  - Satellite
    - Long range, high throughput, no blackout, but hard to set up
  - GSM (SMS / Packet)
    - Short range, low throughput, some blackouts, operated network
  - HAM Radio
    - Long range, low throughput, line of sight

HAO Tracking *Vs* embedded system

- Low cost
- Extensibility
  - Various set of sensors across experiments
  - Various communication technologies
- Energy efficiency

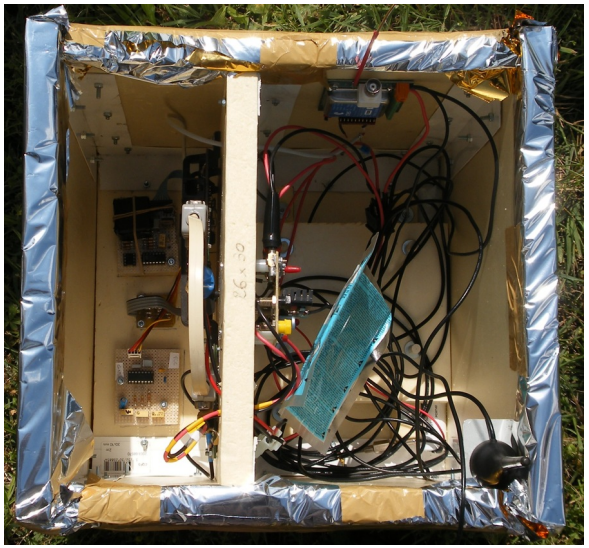
First Sounding Balloon experiment (2008)

- Educational purpose
  - Embedded system project
  - 4 undergraduate students
- CNES (French Space agency) sponsorship
  - HAM Radio emitter loan
  - Radar deflector, Helium, balloon offered



First Sounding Balloon experiment (2008)

- HAO embedded system
  - Microchip PIC18F microcontroller-based architecture
  - I^2C pressure and temperature sensors (no local storage)
  - RS232 GPS receiver & GSM interface (SMS)



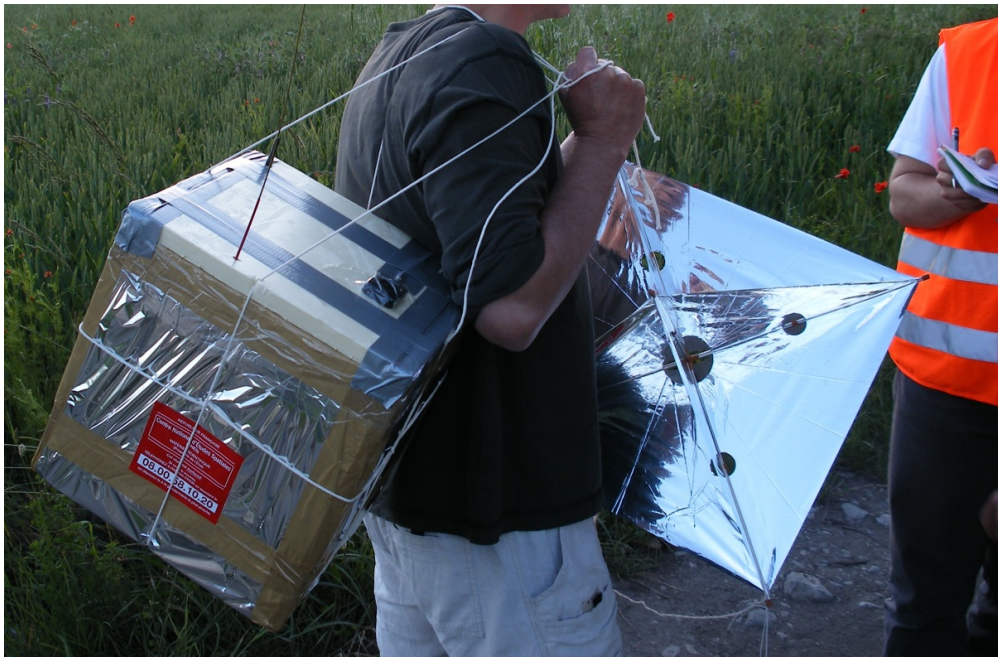
- Communication
  - ASCII-based frames with time + location + sensor data
  - HAM radio, downstream only
  - SMS requests from ground to get back an instant frame by SMS

First Sounding Balloon experiment (2008)

- Ground stations
  - Fixed station
    - HAM radio receiver & FSK demodulator
    - CNES software for monitoring, raw frames local storage
  - Mobile station
    - Two HAM radio receivers (without FSK demodulator)
    - No monitoring neither storage

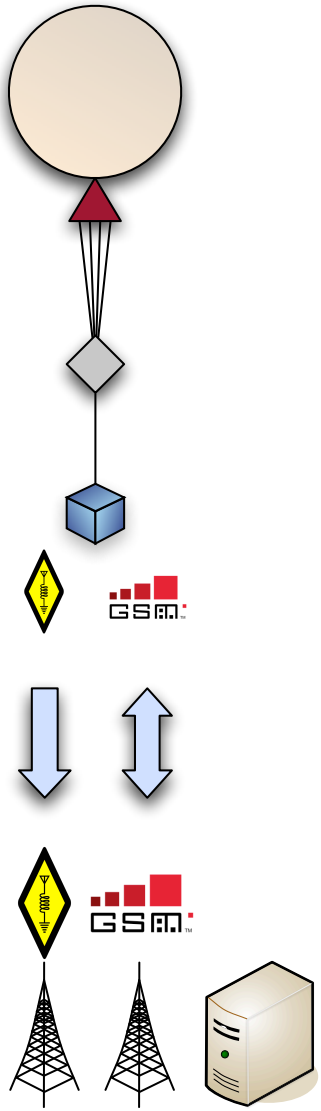
First Sounding Balloon experiment (2008)

- Results
  - 3 hours flight (2 hours up, 1 hour down)
  - $\Delta XY \simeq 150km$, $\Delta Z \simeq 31km$
  - Signal lost during the descent $\rightarrow$ data loss
  - Landing area uncovered by GSM operated network
  - Recovery using HAM radio triangulation



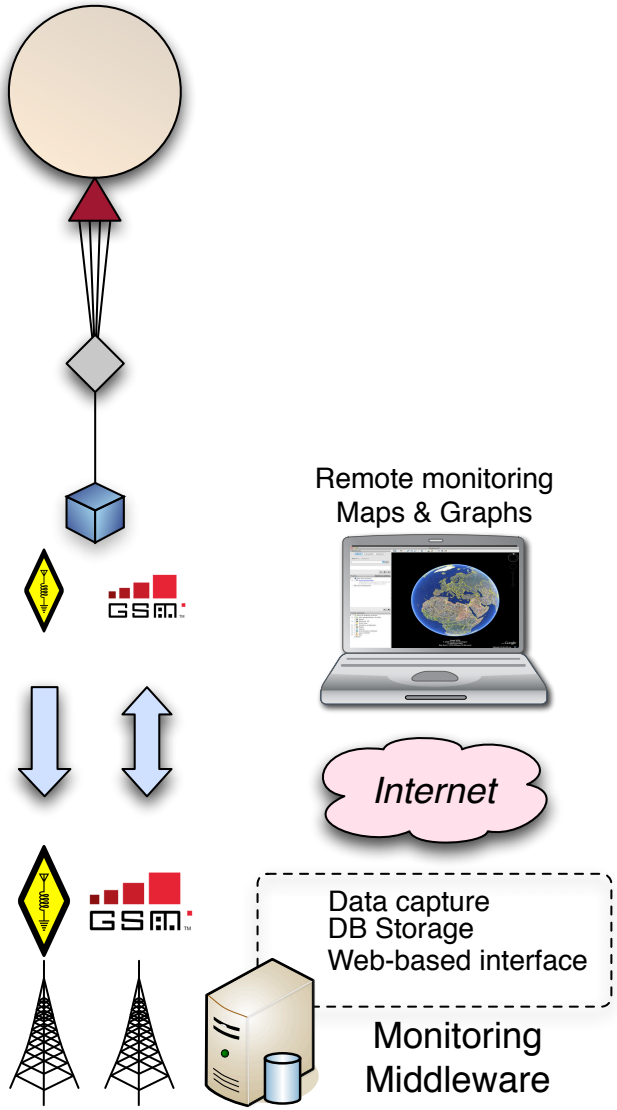
Lessons learned

- Multimodal communication as a mandatory requirement



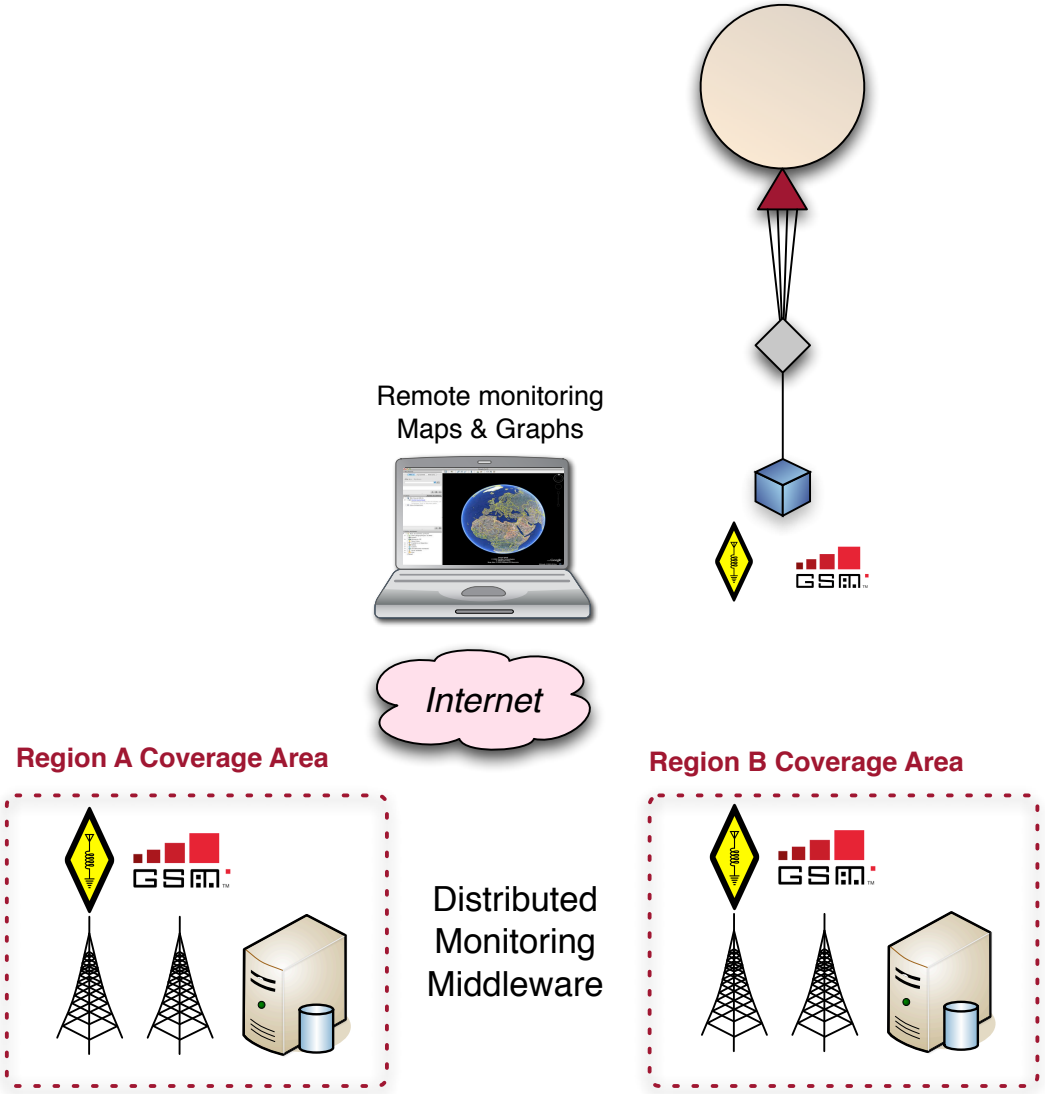
Lessons learned

- Monitoring middleware needed, with storage and rich GUI



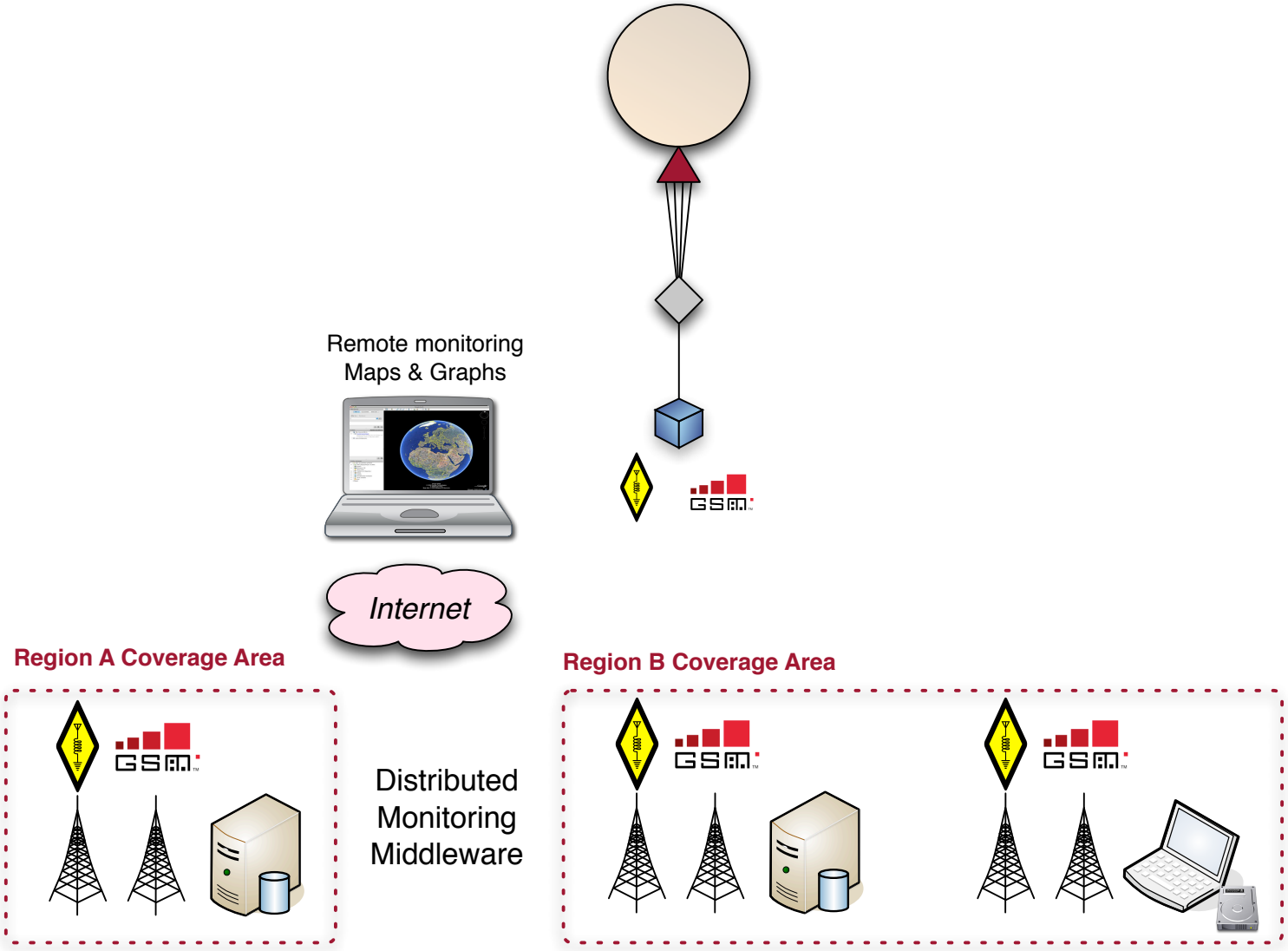
Lessons learned

- Distributed middleware, with federated DBs



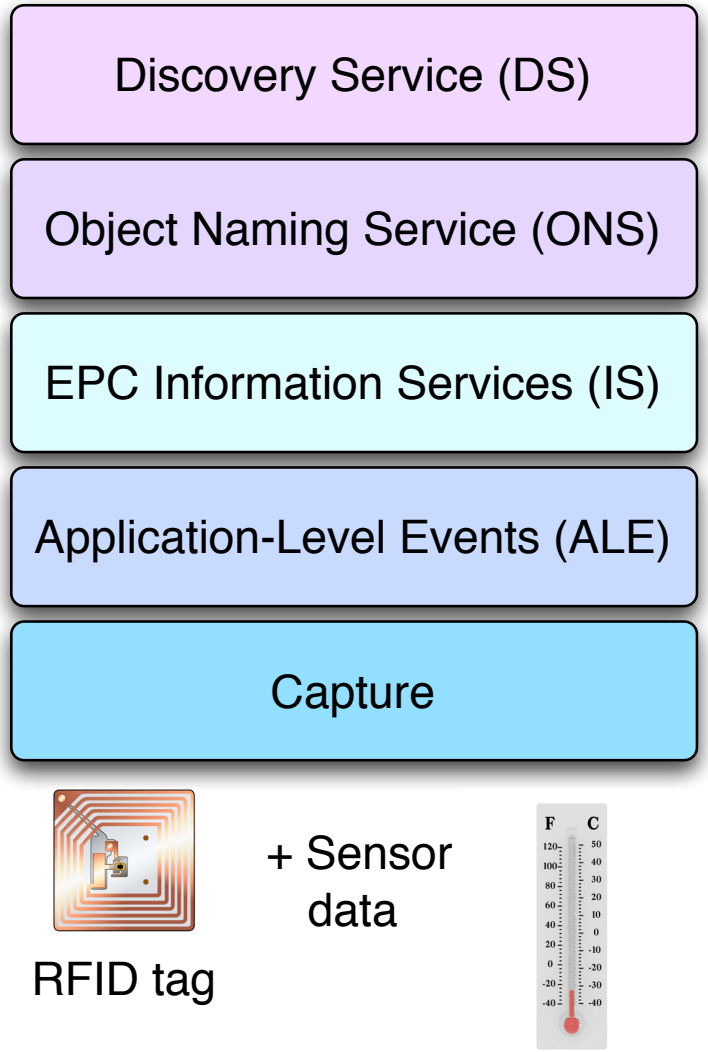
Lessons learned

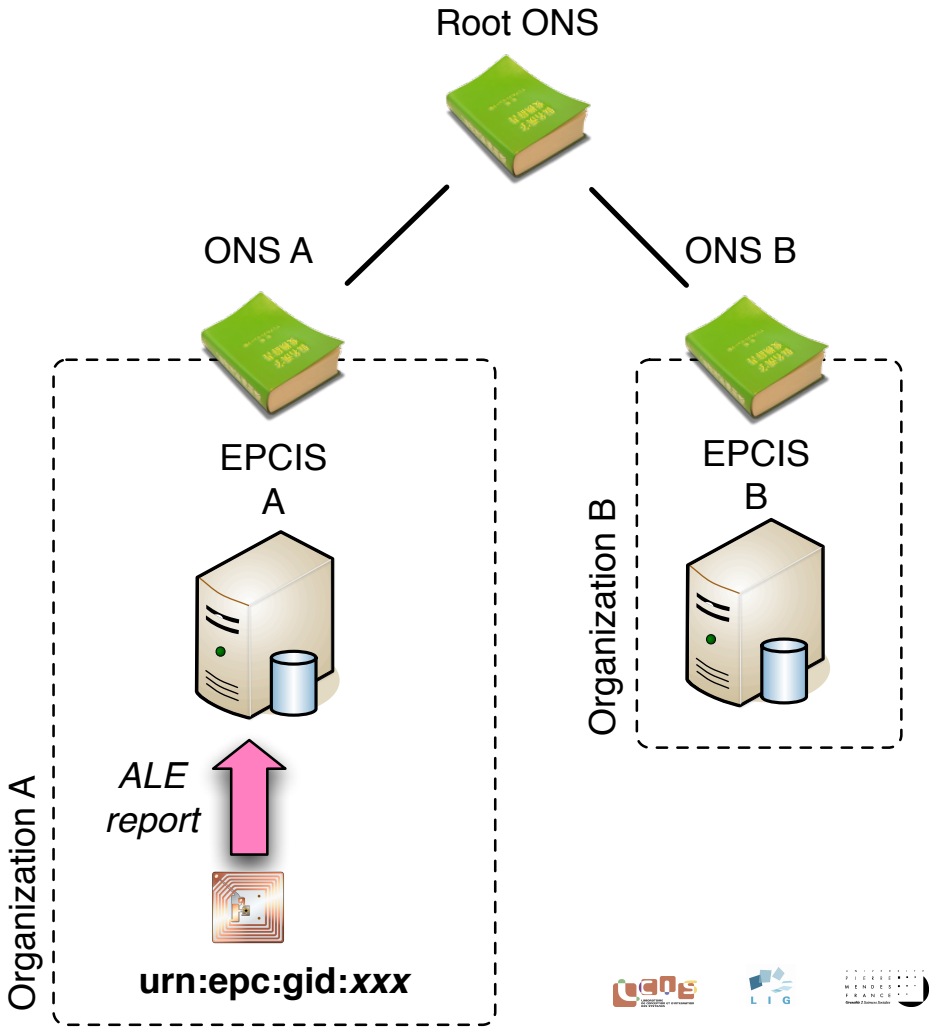
- Multiple stations, fixed or mobile, online or offline data merging



EPC global RFID-centric middleware as a candidate

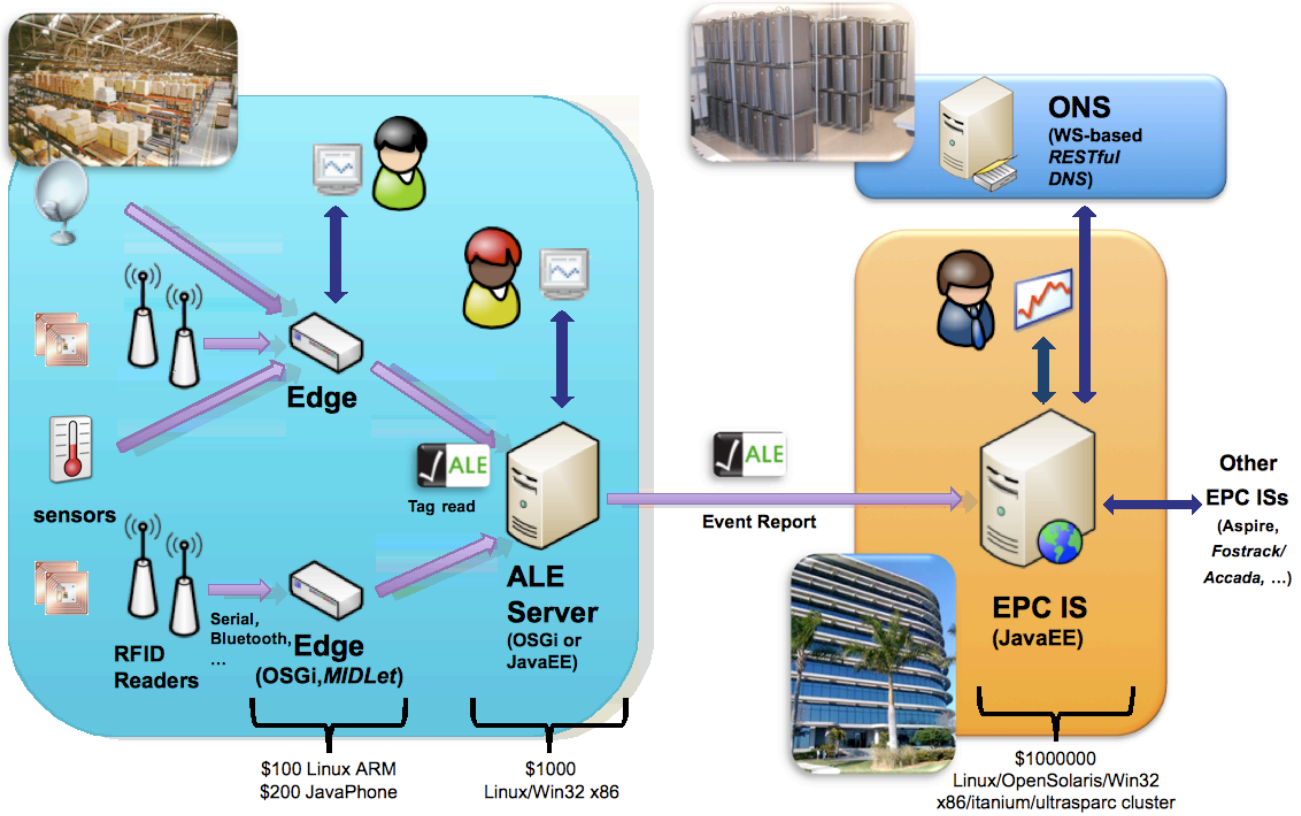
- Distributed Architecture for RFID-centric supply chain management
  - Initiated by MIT's AutoID center, promoted by EPC Global





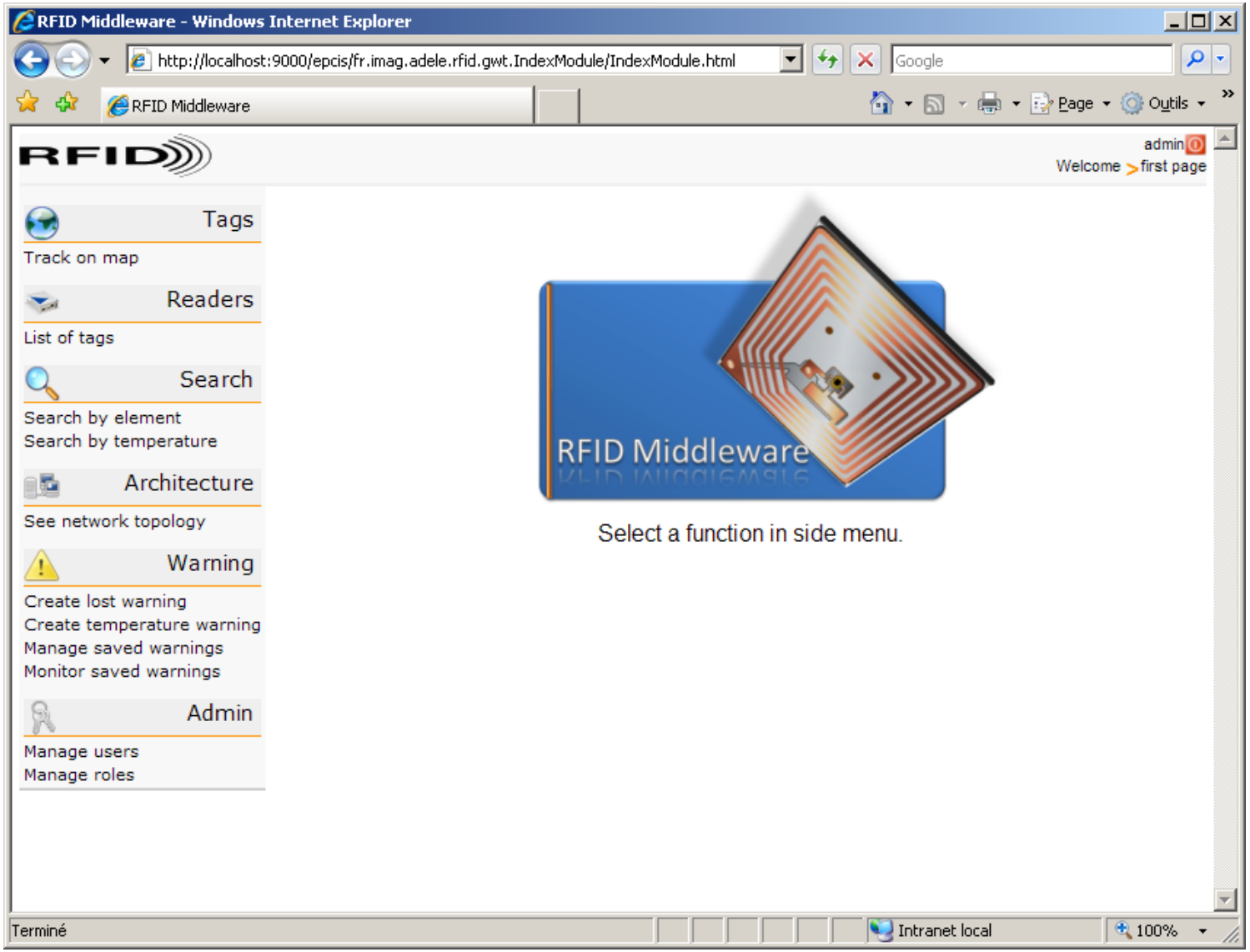
AspireRFID RFIDSuite

- Open-source EPC-compliant middleware, developed by LIG Lab.
  - ASPIRE FP7 EU Program
  - Hosted by OW2 open source consortium



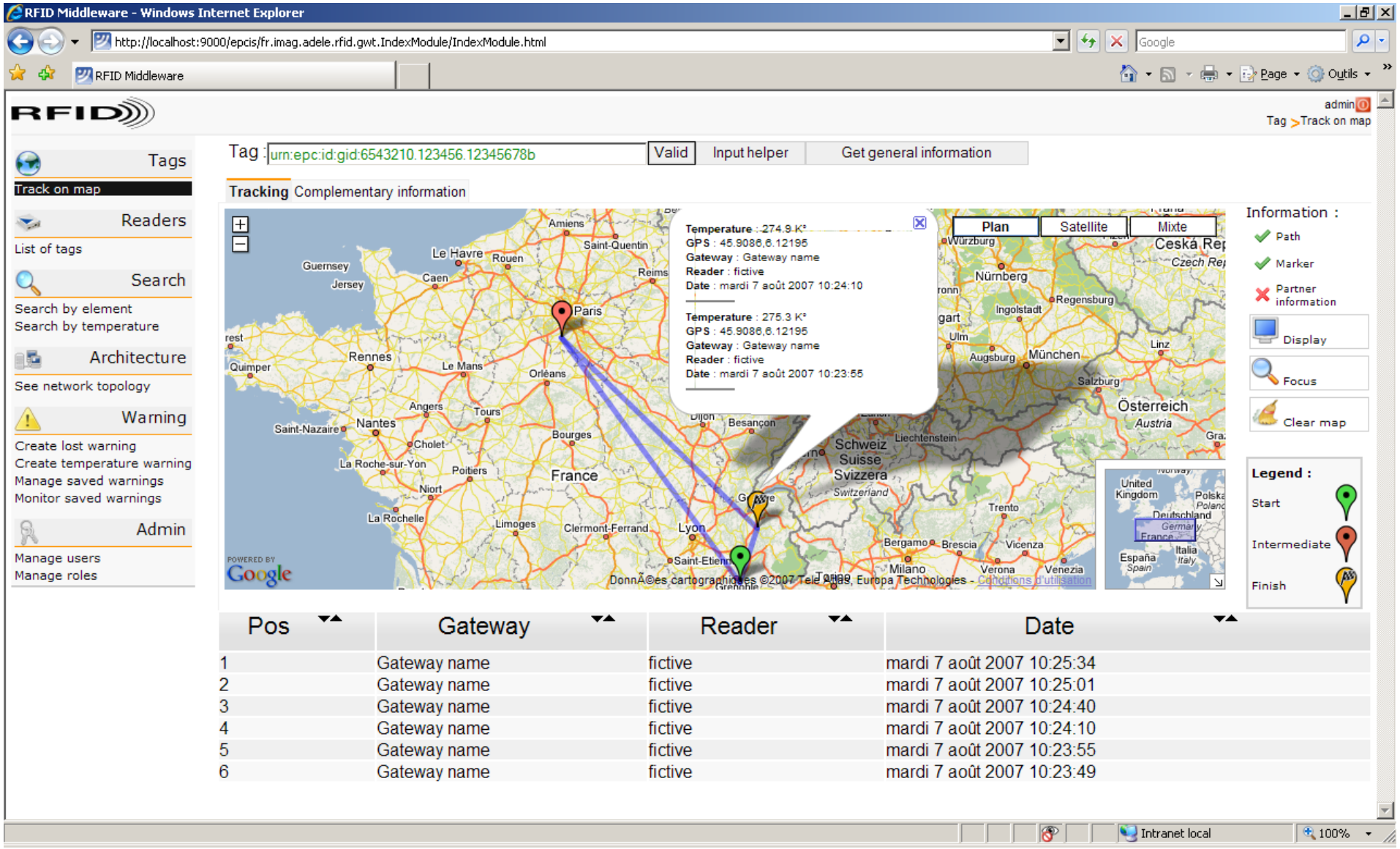
AspireRFID RFIDSuite

- Web-based interface (main page)



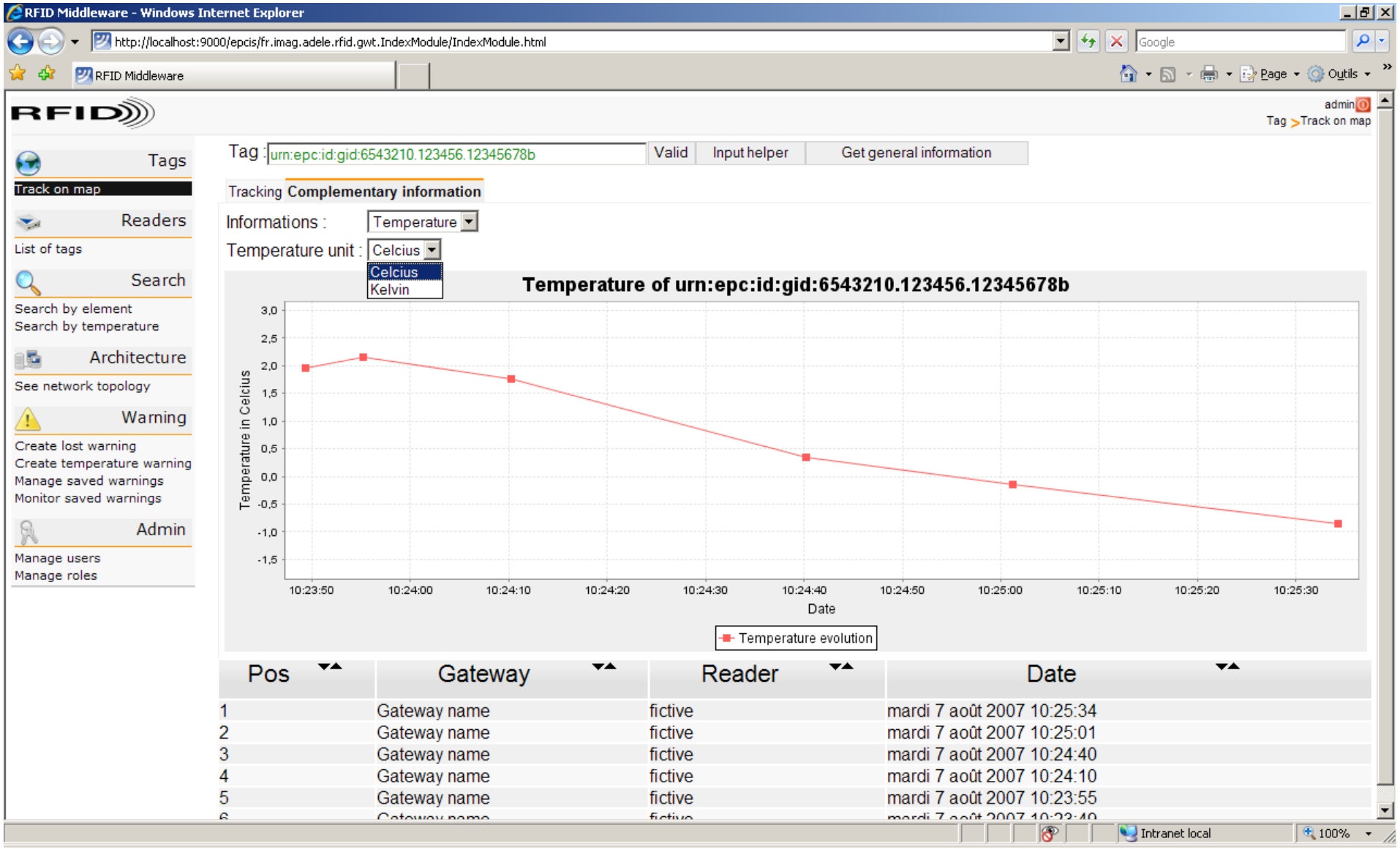
Aspire RFID Middleware interface

- Location tracking using *Google Maps*

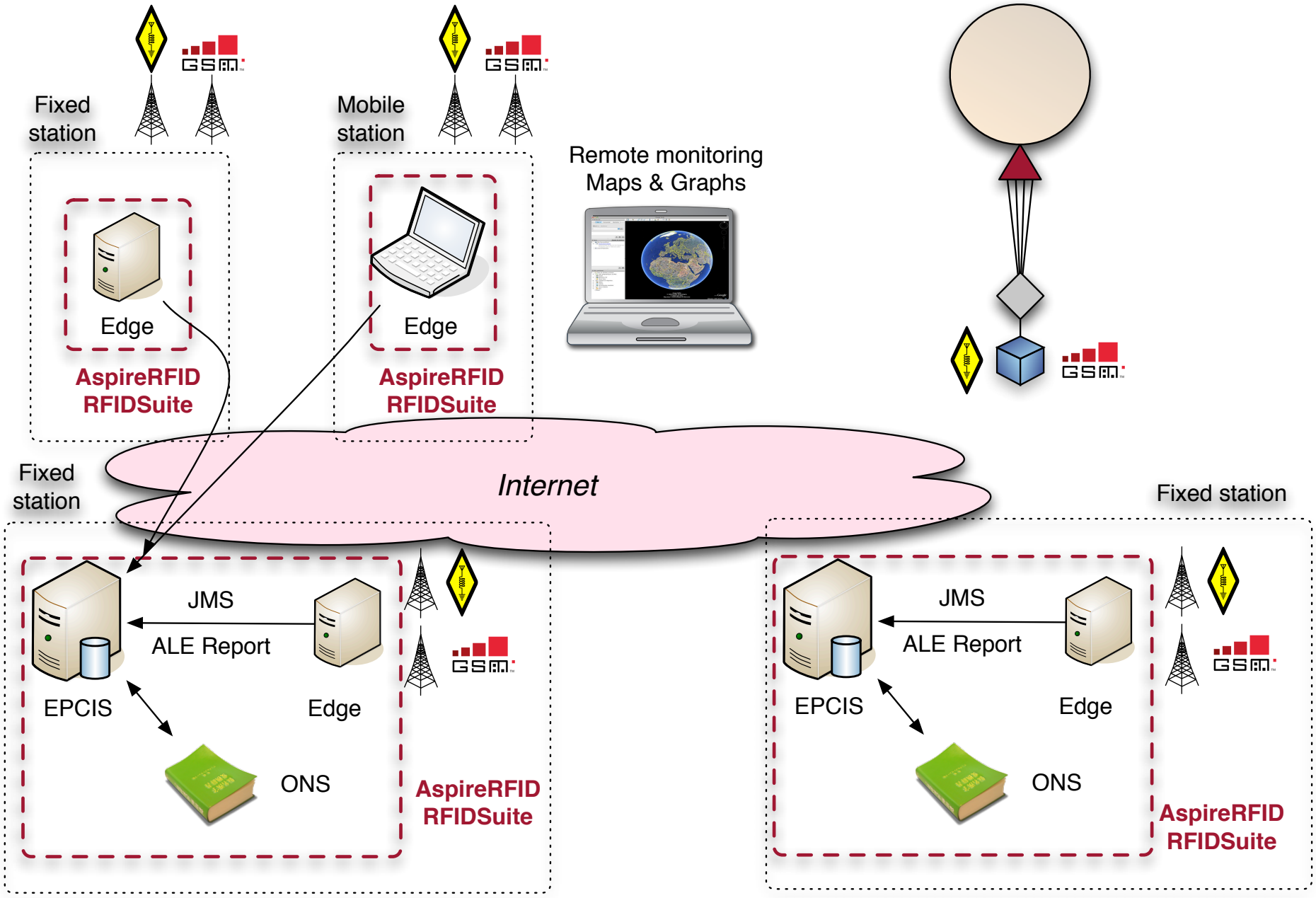


Aspire RFID Middleware interface

- Extensible graph engine using *JGraph*



Using AspireRFID RFIDSuite to track HAOs

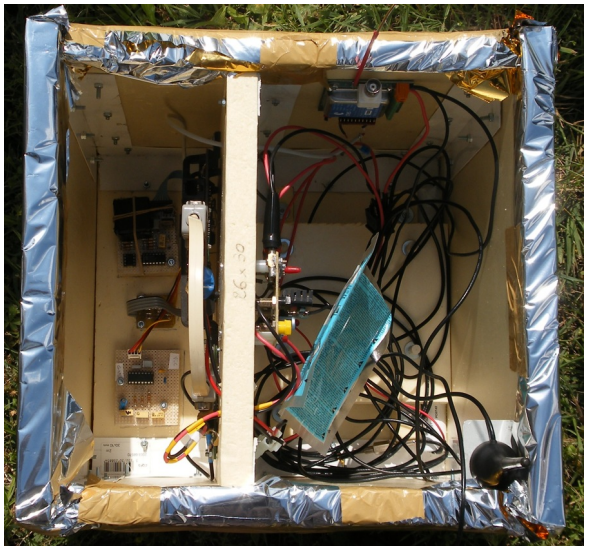


Second Sounding Balloon experiment (2009)

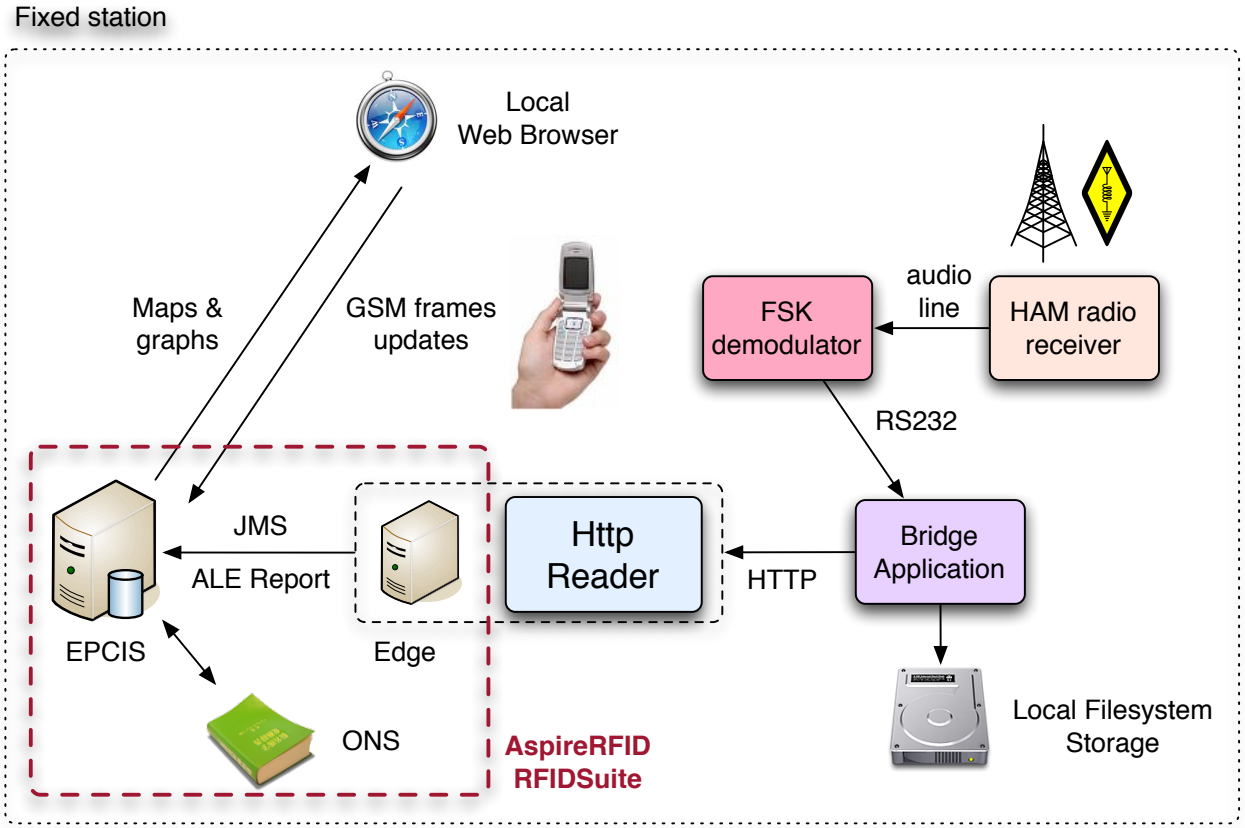
- Teamwork
  - Embedded System : 4 undergraduate students
  - Middleware : 1 PhD student, 1 undergraduate student
  - Sensors : 2 x 20 high school students (science course)
- CNES sponsorship

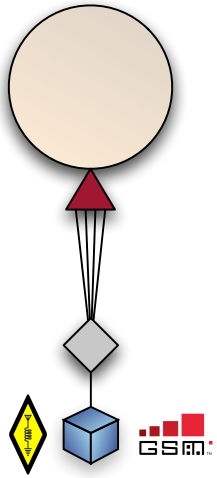
Second Sounding Balloon experiment (2009)

- Same embedded system architecture as previous +
  - Analog temperature and pressure sensors
  - Onboard sensor data storage
  - RC model lightweight VGA camera
    - Still pictures, taken every 30s
    - SDCard storage



Second Sounding Balloon experiment (2009)





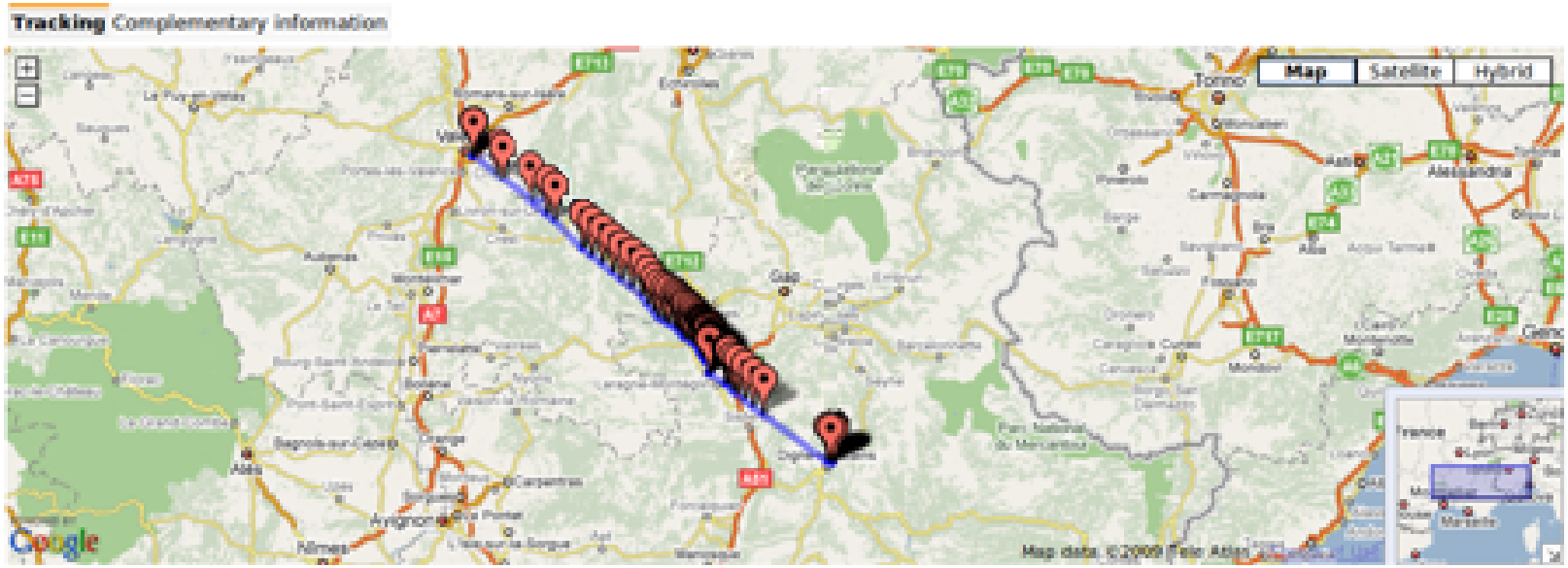
Mobile station

Same middleware as fixed station
no online data merging

Second Sounding Balloon experiment (2009)

- Results
  - 3 hours flight, $\Delta XY \simeq 150km$, $\Delta Z \simeq 26km$
  - Signal ever received by at least one station $\longrightarrow$ no data loss
  - Landing area covered by GSM operated network
  - Easy recovery, by HAM radio operators, using final GPS location

- Real-time location tracking using monitoring middleware



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1	Valence	http	Fri 24 Apr 2009 11:57:58 AM CEST
2	Valence	http	Fri 24 Apr 2009 11:52:02 AM CEST
3	Valence	http	Fri 24 Apr 2009 11:50:36 AM CEST
4	Valence	http	Fri 24 Apr 2009 11:36:54 AM CEST
5	Valence	http	Fri 24 Apr 2009 11:35:26 AM CEST
6	Valence	http	Fri 24 Apr 2009 11:34:01 AM CEST
7	Valence	http	Fri 24 Apr 2009 11:32:36 AM CEST
8	Valence	http	Fri 24 Apr 2009 11:31:10 AM CEST
9	Valence	http	Fri 24 Apr 2009 11:29:45 AM CEST
10	Valence	http	Fri 24 Apr 2009 11:28:20 AM CEST

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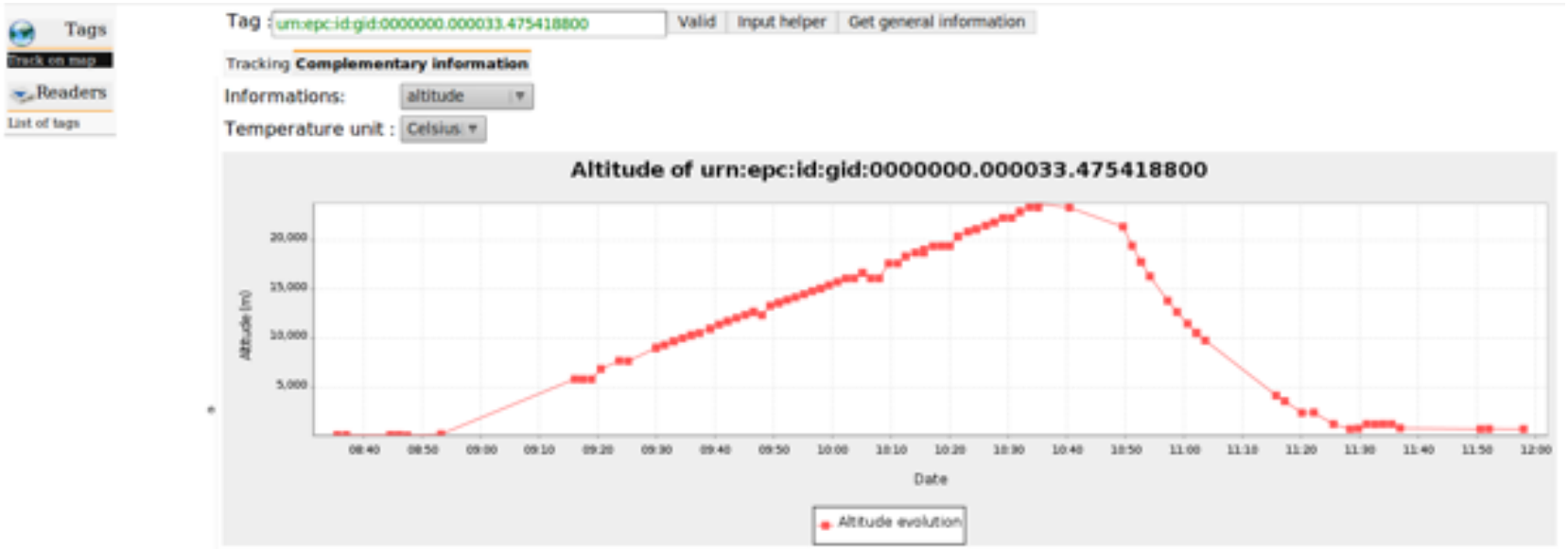
Second Sounding Balloon experiment (2009)

- Real-time data display using monitoring middleware
  - Altitude *Vs* time



Pos	Gateway	Reader	Date
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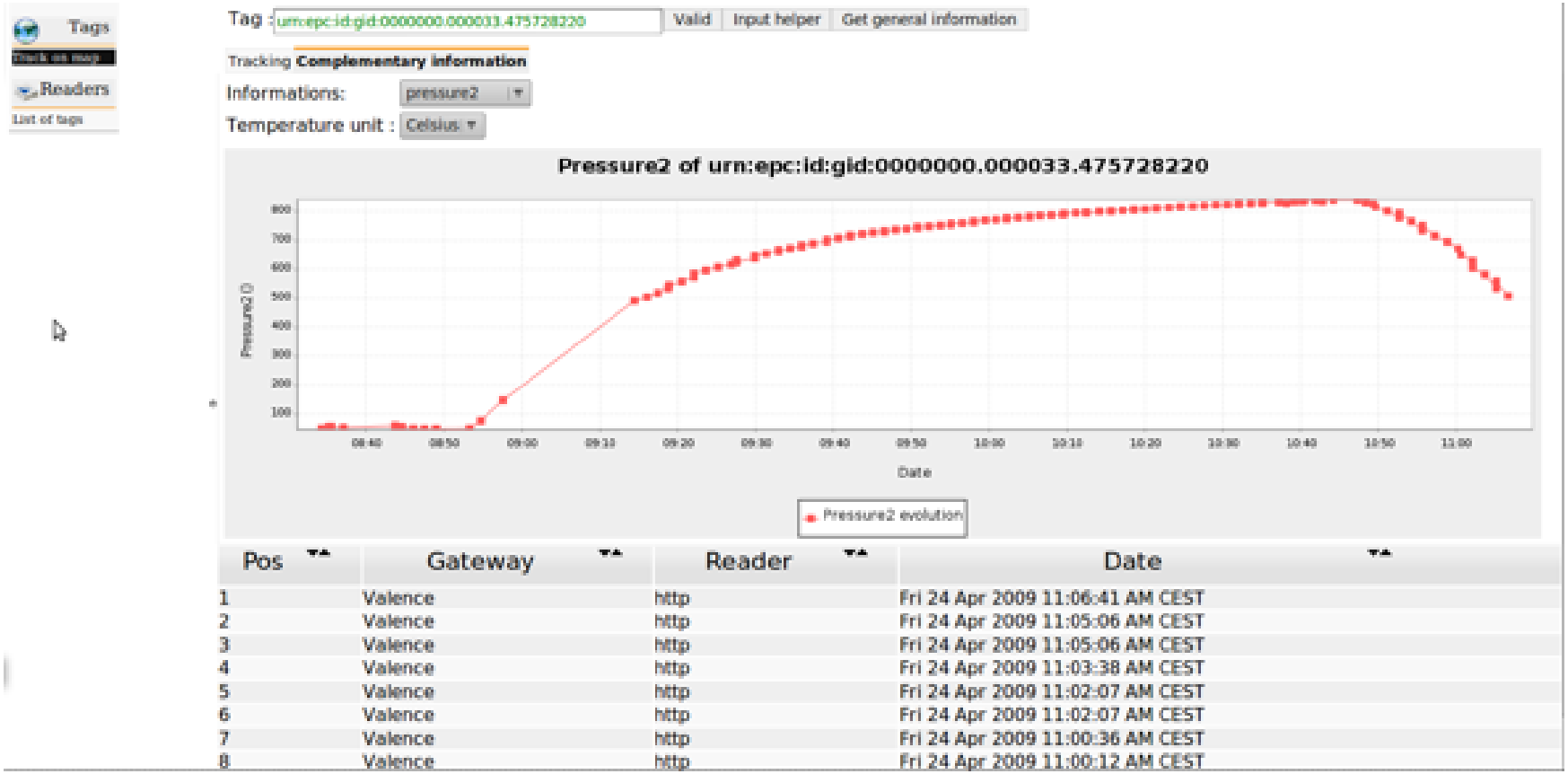
5	Valence	http	Fri 24 Apr 2009 11:35:26 AM CEST
6	Valence	http	Fri 24 Apr 2009 11:34:01 AM CEST
7	Valence	http	Fri 24 Apr 2009 11:32:36 AM CEST
8	Valence	http	Fri 24 Apr 2009 11:31:10 AM CEST
9	Valence	http	Fri 24 Apr 2009 11:29:45 AM CEST

Second Sounding Balloon experiment (2009)

- Real-time data display using monitoring middleware
  - Pressure *Vs* time



Conclusion and Further work

- EPC-compliant middleware is suitable for HAO tracking and monitoring
- A whole cross-organizational architecture remains to be deployed and validated
- *AspireRFID RFIDSuite* has however to be enhanced to ease
  - multimodal communication management
  - *A posteriori* data update (e.g. stored pictures of the flight)
- Software FSK demodulator, using laptop audio cards, could be a ready-to-go solution for HAM radio operators

The end

- Next flight in April 2010 !

- Questions?