
Heritage Saveguarding – Design of a RFIDs-based Tracking and Monitoring Solution

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Outline

- ☞ Background - application context
 - Contribution :
 - RFIDs
 - Localisation system
 - Monitoring system
 - Conclusion along future work
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Background - Application Context

- Previous disasters have shown a great potential of destruction
 - Disaster protection is of primary concern
 - In September 06, a new legislation appears
 - Any institution welcoming people should maintain an up-to-date urgency plan
 - A variety of urgency plans appears
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Background – Urgency Plan

- An Urgency plan is a report answering to the following questions
 - How will you protect people ?
 - Save people first, then ... art-crafts
 - How will you protect art-crafts?
 - Which high value art craft should be preserved?
 - How to move the art craft so as to lower damages?
 - Where is the meeting point, command center ?
 - An urgency plan is given to the firefighters at their arrival
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Background - Disaster in a Museum

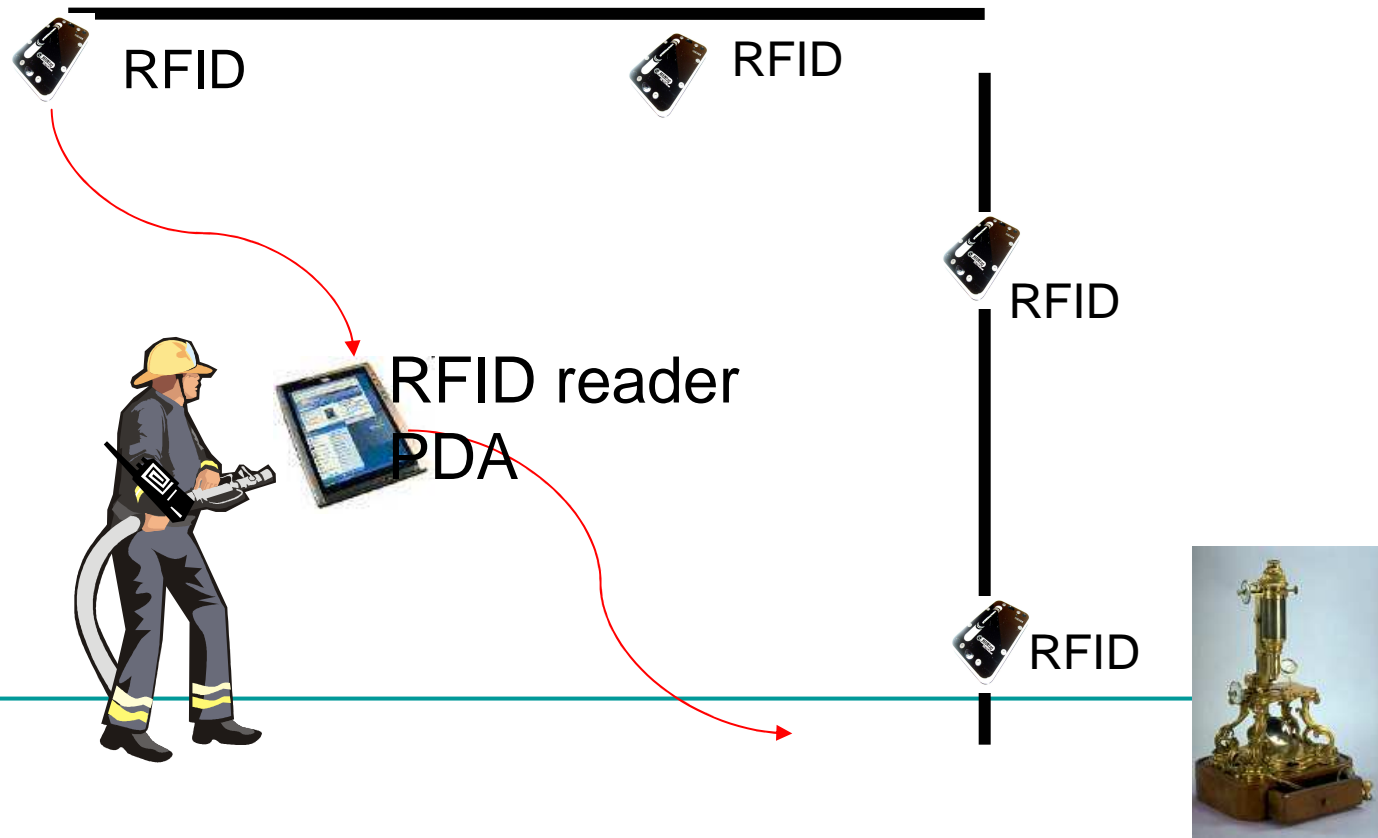
- Firefighters are guided by the urgency map, following 3 priorities
 - Save life (people, firefighters)
 - Save art-crafts
 - Fight fire
 - Despite ...
 - The lack of visibility (smoke) which renders difficult to
 - Locate art-crafts
 - ↓ Existing solution : visual painting
 - Guide rescuers & find unconscious rescuers
 - ↓ Follow a map
 - ↓ Communicate through a dedicated network (walky talky)
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Background – Challenges

- We need a solution that
 - Keeps track of the firefighters' location
 - Firefighter localization tool
 - Locates art-crafts & provides a manipulation guide
 - Art-craft localization tool
 - Embedded practical handbook
 - Deals with changing connectivity
 - Distributed & pervasive
 - Provided context awareness
 - Monitoring/sensoring tool
 - Exploits actual technologies ...
 - The Internet of the things
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Our Solution ? : The Internet of the Things Invades a Museum

- RFID tags embedded on art-crafts, walls, rescuers
- RFID reader equipping rescuers



RFID

- RFID = an efficient way of identifying object and people
 - Each object/people is attributed a unique id
 - Each object contains a practical handbook
 - Tags and readers communicate together
 - Contact-less transfer due to an electromagnetic field
 - No need of visibility, goes through objects (smokes)
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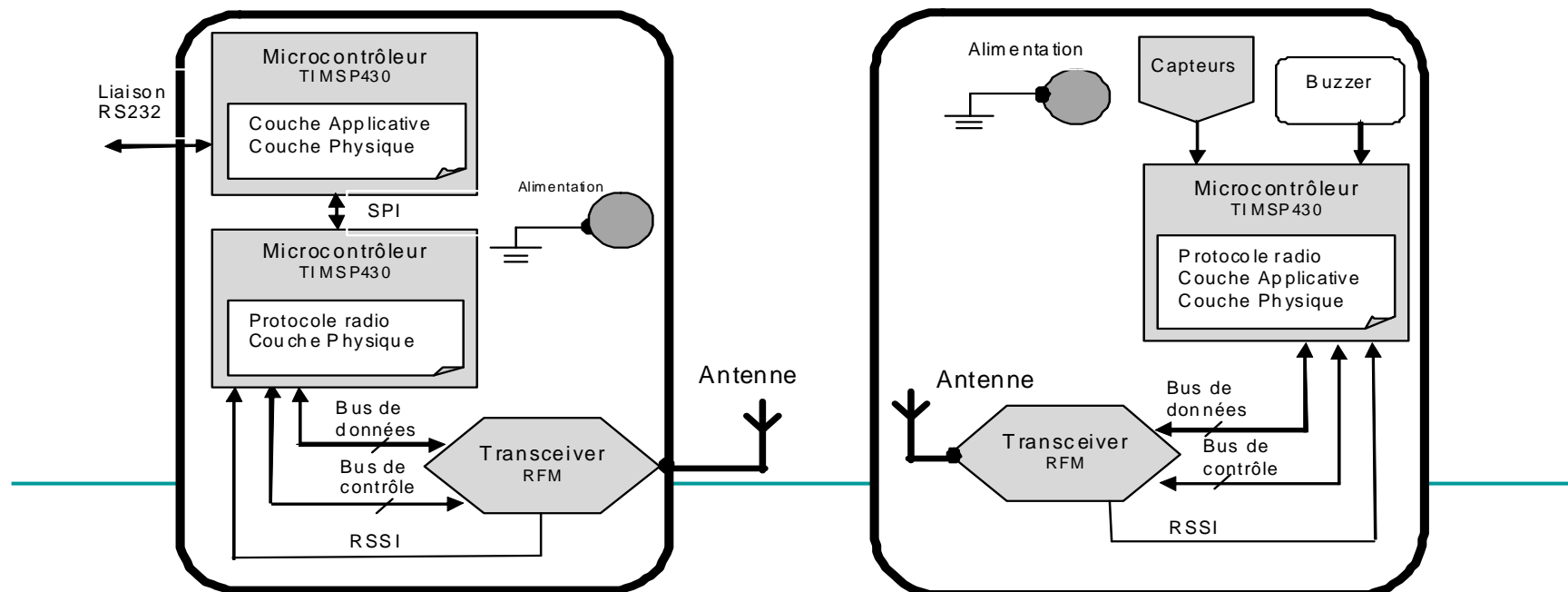
RFID – Design Rational

- Make a choice between
 - Passive RFID
 - ✓ Do not include battery
 - ↓ Provides low-distance
 - ↓ Implies a high financial investment for covering a museum
 - Active RFID
 - ✓ Provides medium-distance communication within ISM frequencies
 - ↓ Is battery powered
 - Needs for a battery monitoring
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RFID - Hardware



- Reader and tag both include
 - A battery
 - Micro-controller : Texas Instrument MSP430F
 - Reader : 4.9 Mhz , tag : 2 Mhz
 - ✓ Minimise energy consumption
 - ✓ Increase the life of the RFID tags (up to 3 years)
 - Transceiver with omni directional (inside/outside) antenna



RFID - Extended Capabilities

- Monitor the remaining energy
 - Energy indicator
 - Include a Buzzer that can be activated in order to
 - Locate RFID tags
 - Indicate low batteries
 - Provide advanced sensing capabilities
 - Temperature
 - Humidity
 - Encompass a practical handbook
 - 256 Ko of RAM (*Random Access Memory*)
 - 8Ko of flash memory
 - Enable art-craft and firefighter localisation
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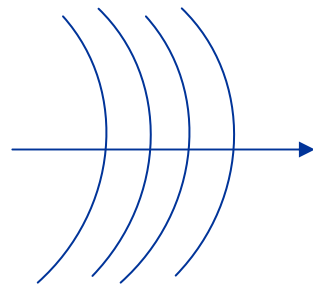
Fire Fighter & Art-Craft Localisation

Triangulate the most effective position of a firefighter & estimate the distance separating firefighters and the art-crafts

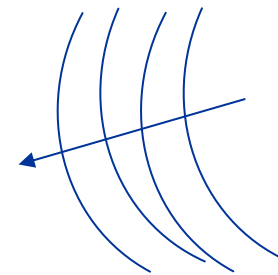
- Analyze the signal strength for each tag
 - Deduct the distance separating the tag and the reader
 - Triangulate the position of the firefighter
 - Guide the firefighter towards available art-crafts
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Localisation - Signal Strength (i)

- Signal Strength is
 - Implemented as a hardware functionality
 - Given by the RSSI (Received Signal Strength Indicator)



Compute the signal strength



Localisation - Signal Strength (ii)

$$P_{received} (dBm) = 10 \log_{10} P_{received} (mW)$$

- Signal attenuation should be taken into account

$$P_{received} (dBm) = P_{emitted} (dBm) - P_{attenuation} (dBm)$$

- Signal attenuation depends of
 - Distance d
 - Context represented by the signal propagation coefficient n

$$P_{attenuation} (dBm) = 10 n \log_{10} d + X$$

- X : signal received at one meter under perfect conditions
- When all comes together...

$$\begin{aligned} P_{received} (dBm) &= P_{emitted} (dBm) - P_{attenuation} (dBm) \\ &= 10 \log_{10} P_e - 10 n \log_{10} d + X \end{aligned}$$

Localisation - Signal Strength (iii)

- Potential source of error during computation of the signal strength
 - Context
 - is time varying
 - Is environment dependant
 - Obstacle
 - Signal reflection
 - Noise and signal perturbation
 - Solutions :
 - Tags are placed at high position
 - Fingerprinting is applied
 - Benchmarking : collect received powers (tuples of the received powers)
 - Use that table to locate accurately the firefighter's position
 - Keep to a minimum the table size (collect information only when needed)
 - Accurate distance is derived from the signal strength
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Localisation - Triangulation

- *Position of a firefighter is given by*

$$(X_p - X_1)^2 + (Y_p - Y_1)^2 = R_{12}$$

$$(X_p - X_2)^2 + (Y_p - Y_2)^2 = R_{22}$$

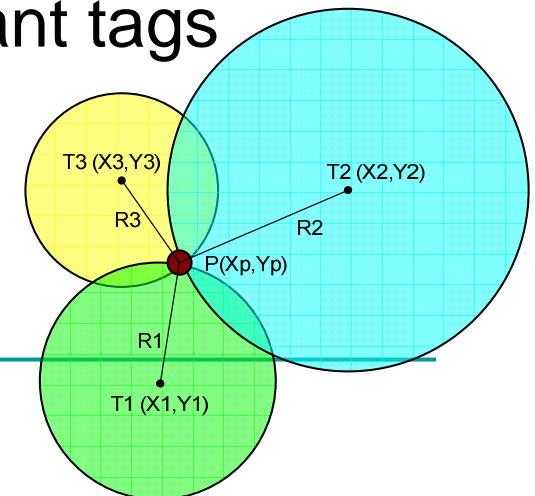
...

$$(X_p - X_n)^2 + (Y_p - Y_n)^2 = R_{n2}$$

- Is the position more accurate with an increasing number of tags?

- No necessarily, mainly because distant tags disrupt

- The 3 closest tags are selected
- Tag position is then triangulated



Localisation – Exploitability

- Localisation information aims to be used so as to
 - Enable any firefighter to locate its proper position
 - Position on a map are to be visualised on a PDA
 - Provide firefighters the ability to locate an art-craft
 - Inform the command center in order to
 - Keep track of firefighters & art-crafts
 - Guide firefighters
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Outline

- Background
 - Contribution :
 - RFIDs
 - Localisation system
 - ☞ **Monitoring system**
 - Conclusion along future work
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Monitoring - Requirements (i)

- Ensure the element exploitation
 - Monitoring solution
 - Provide self-healing: detect, diagnose and repair problems caused by failures
 - Automatic underlying configuration
 - Advanced diagnosis functionalities
 - Provide interoperability & ease the integration with existing infrastructure
 - Standard in the area of network management
 - Simple Network Management Protocol (SNMP)
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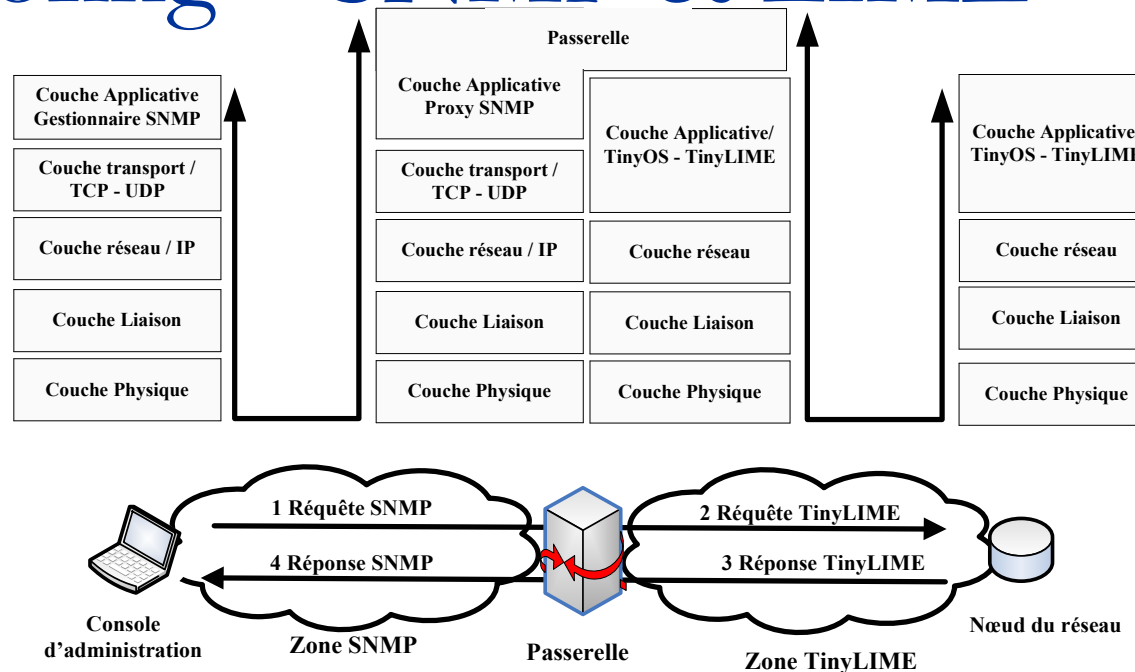
Monitoring – Requirements (ii)

- Enable two operating modes
 - Monitoring mode: lifetime is mostly devoted to maintaining
 - Functional mode: takes place during the sinister
 - Support active monitoring
 - Functional information can be exploited only during a sinister
 - Leverage on existing solutions for data collection
 - Lime (Linda)
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Monitoring - LIME

- Lime/Linda
 - Shared memory = tuple space
 - Tuple space = set of tuples (i.e., set of vectors)
 - Operations:
 - Basic operations : in, out, read
 - Reaction : listener that wakes up and is executed whenever a predefined event occurs
 - Tuples are not replicated but accessible on the data producer
 - Reactive : ask for a data
 - Proactive : event-driven, a listener is executed
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Monitoring – SNMP & LIME



- SNMP manager, IP world
 - MIB, SNMP trap
- TinyLime p2p agent, active RFID, non IP world
 - Tuple Space, reaction
- SNMP gateway: translate & forward
- Monitoring information (microcontroler, transceiver, battery)

Conclusion (1)

Work in progress on supervision of art-craft during disasters

- What is done, what we are currently working on, what we plan to do
 - Active RFID implemented
 - Long-distance usability
 - PVC structure for supporting high temperatures
 - Coupling with a mesh technology (Zigbee)
 - Localisation/triangulation strategy
 - Context/Disaster-aware triangulation
 - Tests, fingerprinting, evaluate performance (future)
 - Hardware calibration for a context-aware analysis of the signal strength
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Conclusion (2)

- **SNMP-LIME-based monitoring**
 - ❑ Easy integration with existing management tools
 - ❑ Data & event collection is adapted to pervasive environments
 - ❑ Evaluate performance, obtain benchmarks
 - ❑ Support remote monitoring (multi-hop communication)
 - ❑ Propose a model of active RFID
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Conclusion (3)

- Provide a user-friendly interface
 - Command center
 - Firefighter (colors, easy to understand)
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