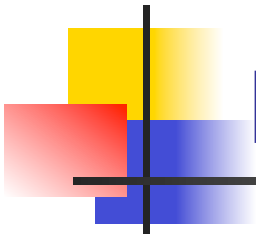
University of Athens
Department of Informatics &
Telecommunications

Pervasive Computing Research Unit

http://p-comp.di.uoa.gr

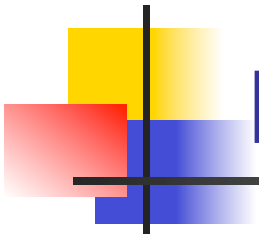
Presentation of Research Activities

May 2012



Pervasive Computing Research Unit

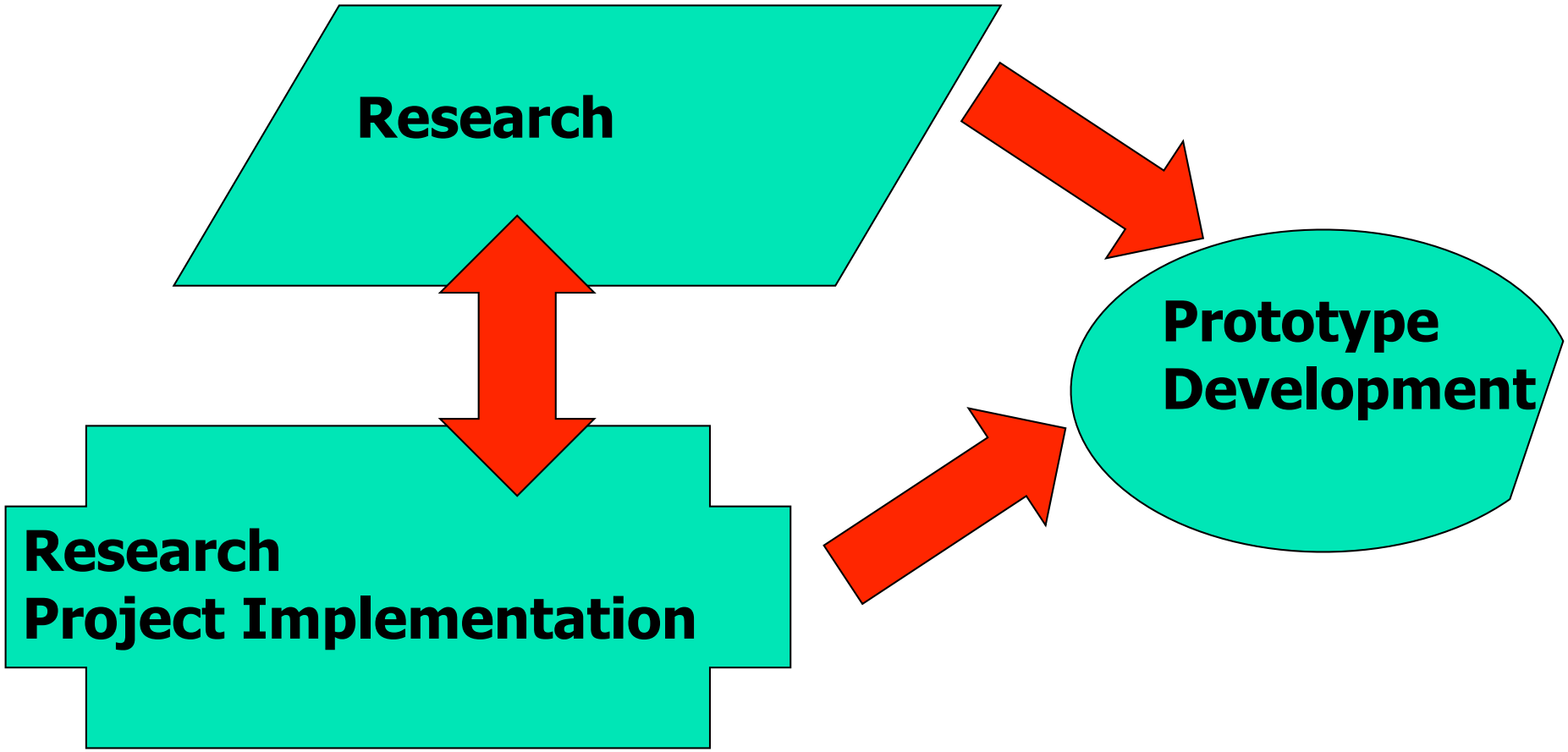
- ~ 20 members (faculty, Ph.D. candidates, postdoctoral researchers, M.Sc. and B.Sc. students)
- Research Unit within NKUA DIT
- Web site: http://p-comp.di.uoa.gr



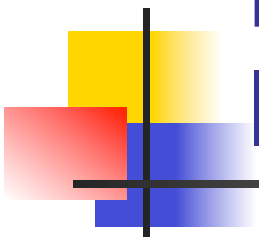
Research Focus

- Different aspects of Pervasive Computing
  - Context-aware and location-based services (modeling, middleware, applications, smart spaces)
  - Ontology-based knowledge engineering with Semantic Web technologies
  - Algorithmic issues: context-* (compression, prediction, discovery, dissemination)
  - Wireless Sensor Networks (middleware + information management, sensor data fusion)
  - Security and Trust management
  - Personalized Multimedia Communications, intelligent services and middleware

Activities


Research
Research
Project Implementation
Prototype
Development

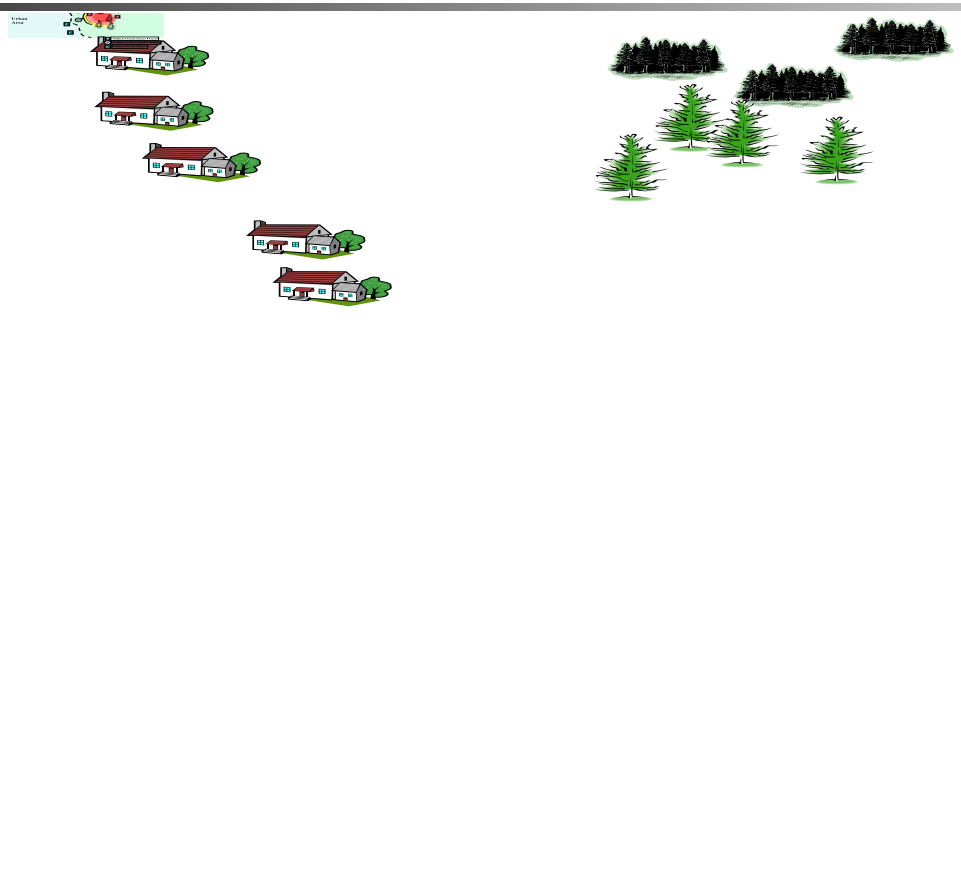
Research **Project Implementation**

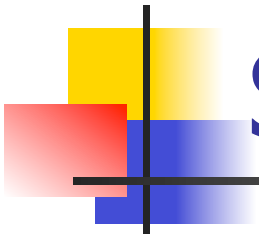


PoLoS*:* An integrated platform for location-based services

- IST STREP– http://polos.di.uoa.gr
- Middleware for creation, deployment and provision of LBS
- Portable, scalable and platform-independent solution for LBS lifecycle management
- Complex business models
- Connects to GIS, positioning servers and other network facilities (SMS Gateways) through open APIs (Parlay-X)

SCIER: Sensor and Computing Infrastructure for Environmental Risks

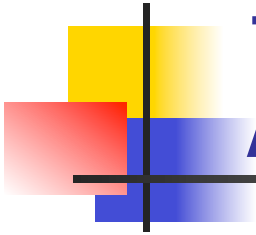




SCIER details

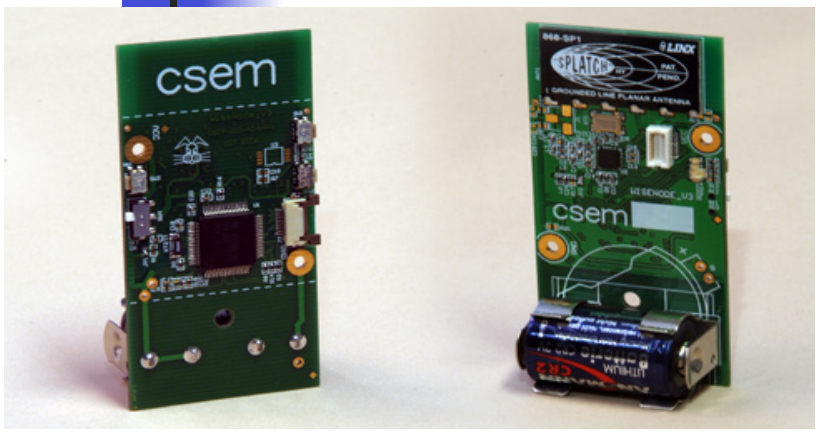
- IST project on the management of natural hazards at the Urban-Rural-Interface (URI)
- Real-time monitoring of environmental phenomena
- Key technologies:
  - Autonomic sensor networks
  - Information fusion techniques
  - Mathematical and GIS-based environmental models
  - GRID infrastructure for efficient data analysis
  - Alerting and communication systems
- WWW site: http://www.scier.eu

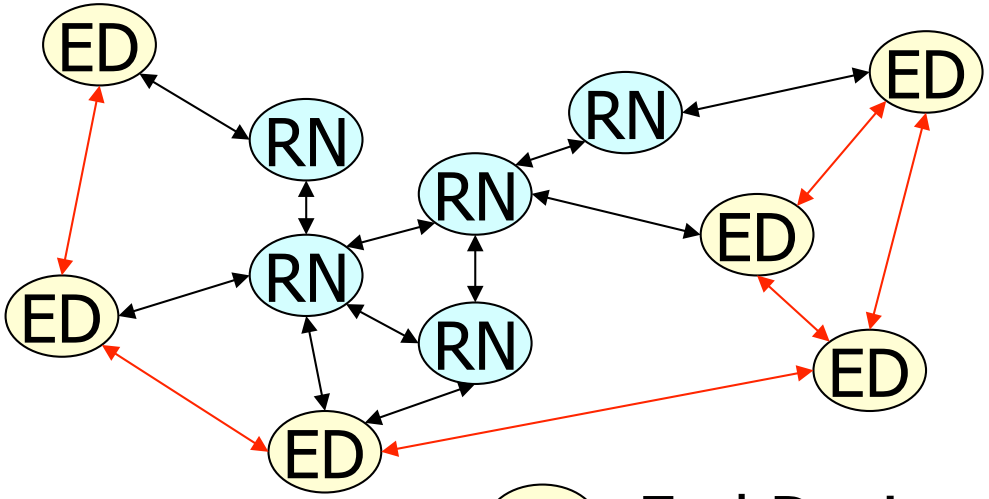
IPAC: Integrated Platform for Autonomic Computing



- FP7 ICT Project
- Middleware and service creation environment for embedded, intelligent, collaborative, context-aware services in mobile nodes
- IPAC scope: diverse applications in a collaborative nomadic environment
  - Humanitarian Relief Operations
  - Industrial Environments
  - Intelligent Transportations
- IPAC services are supported by knowledge and ontology engineering techniques, dealing with interoperability, integration, and re-configuration/ adaptation issues
- WWW site: http://ipac.di.uoa.gr/

IPAC Environment



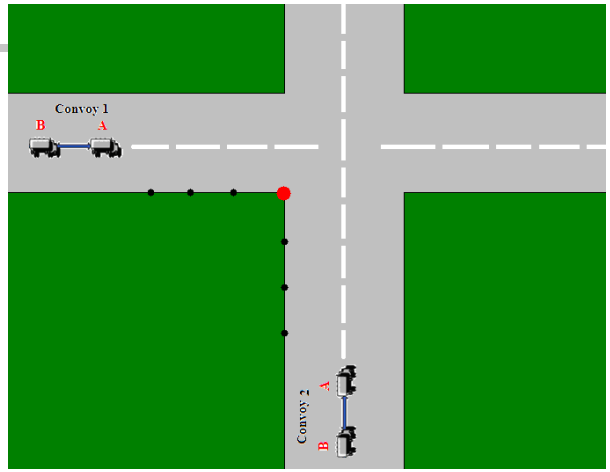


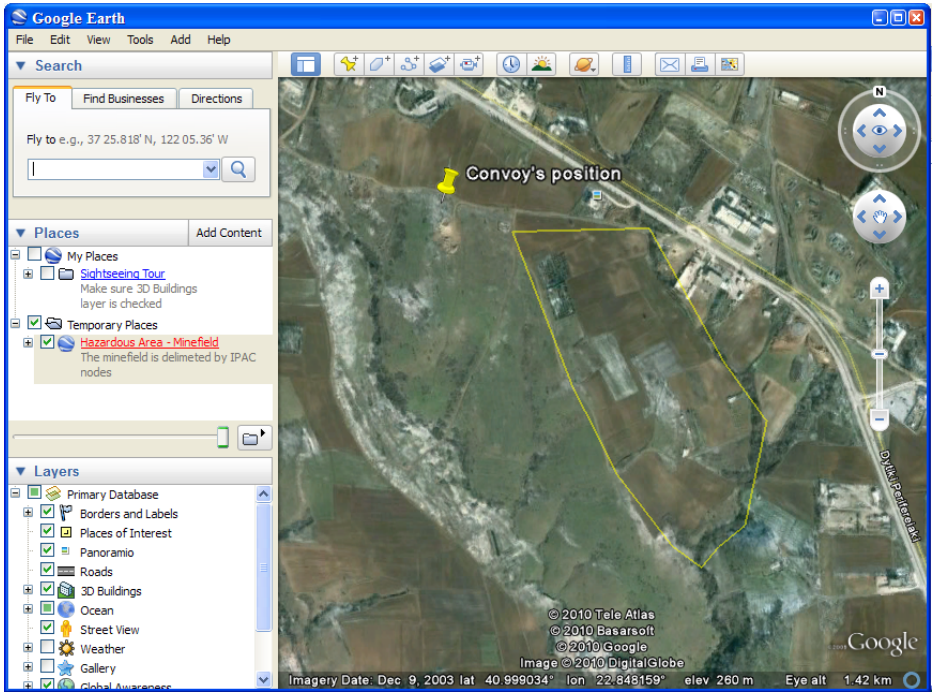
ED End Device

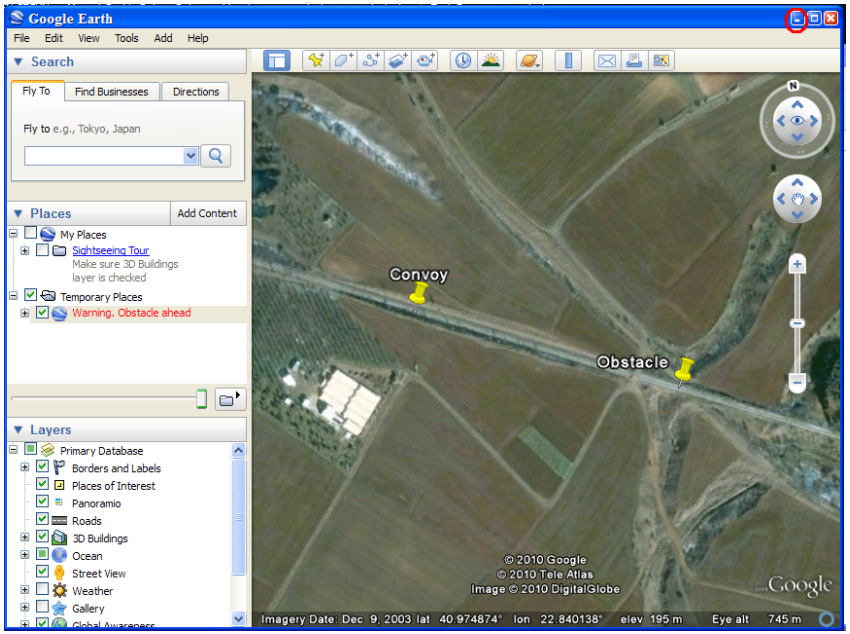
RN Relaying Node

Humanitarian Relief Operations

- E.g.
  - Obstacle/Hazardous area avoidance
  - Road availability, movement control
  - Chemical detection, Ice alert





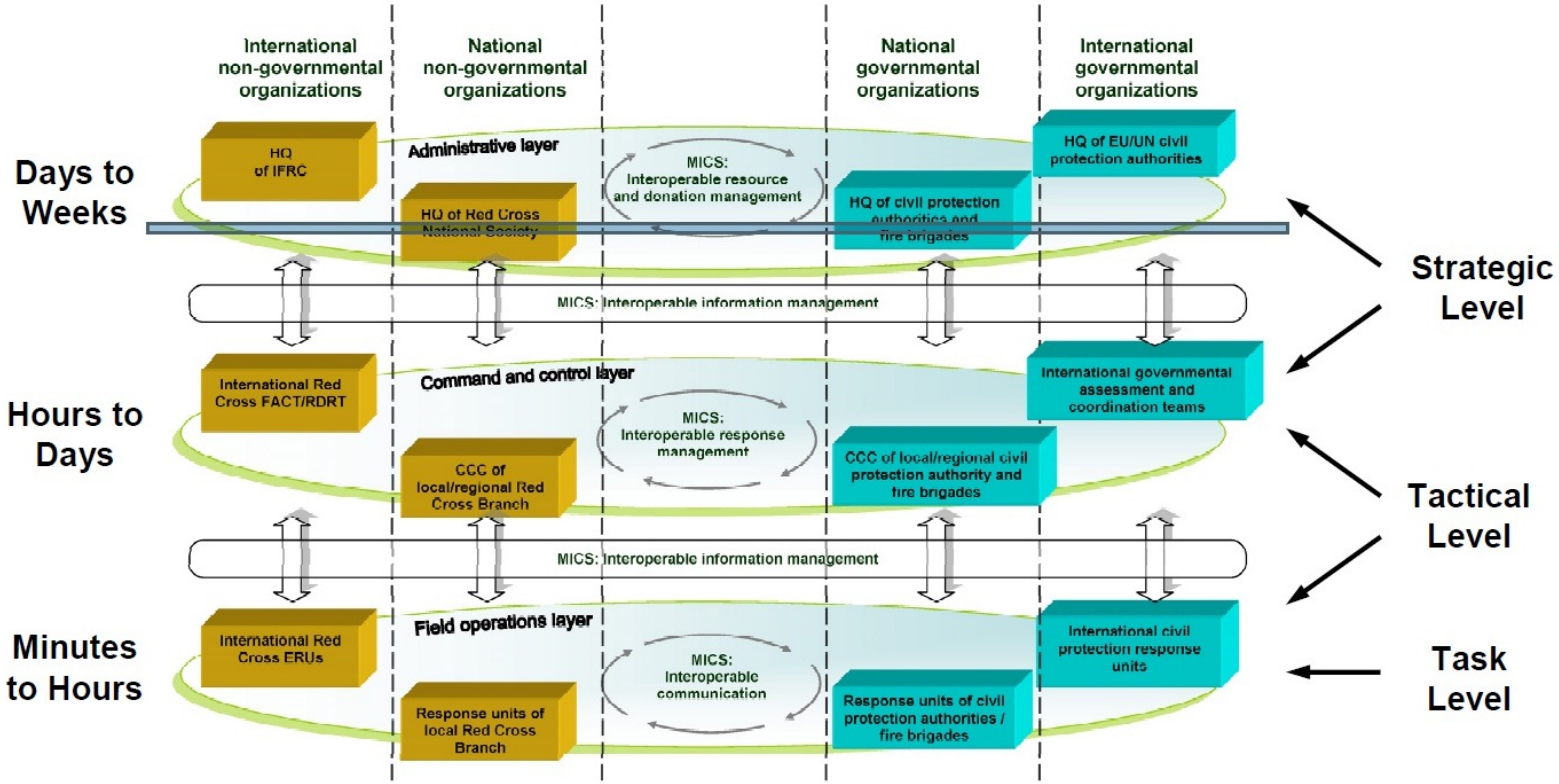


IDIRA

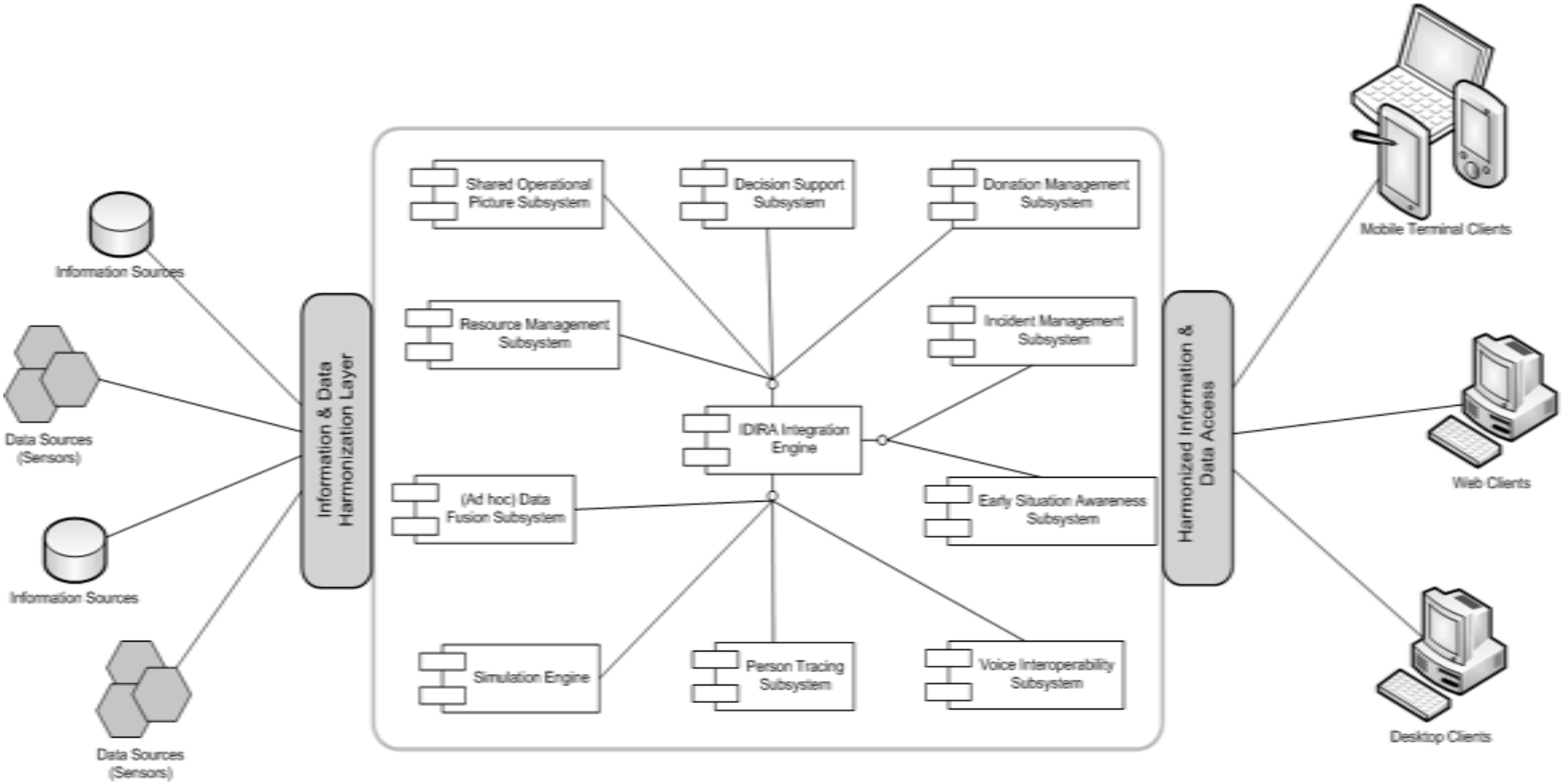
- FP7 – SEC Project, 2011-2014, 18 partners
- Interoperability of data and procedures in large-scale multinational disaster response actions
- IDIRA Scope: provide an integrated solution to support large-scale international cooperation in emergency situations
- Outcome: set of tools, interfaces and procedures
- Trial Scenarios: flood, earthquake/fire, pandemic
- WWW site: http://www.idira.eu/

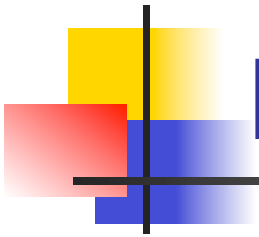
IDIRA Concept

- *"a conceptual framework that supports and augments regionally available emergency management capacities with a flexibly deployable Mobile Integrated Command and control Structure (MICS), which aims at supporting co-ordinated large-scale disaster management"*



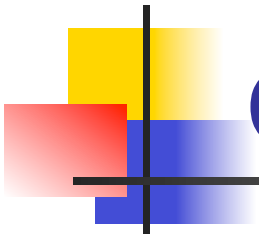
IDIRA Ecosystem





Recent **Research** Contributions

- Context Compression
- Optimal policies for data (context) reporting in WSN
- Context Discovery



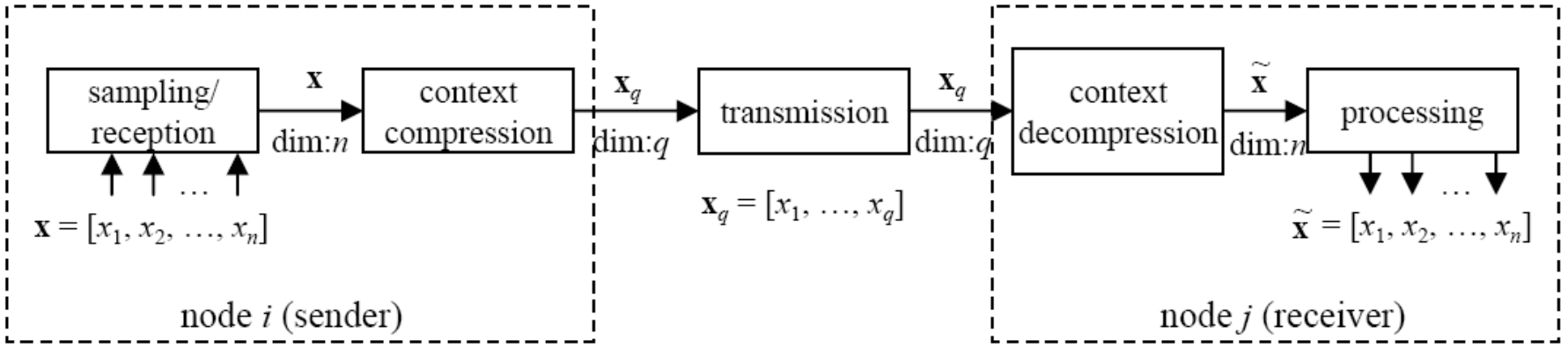
Context Compression 1/2

Objective:

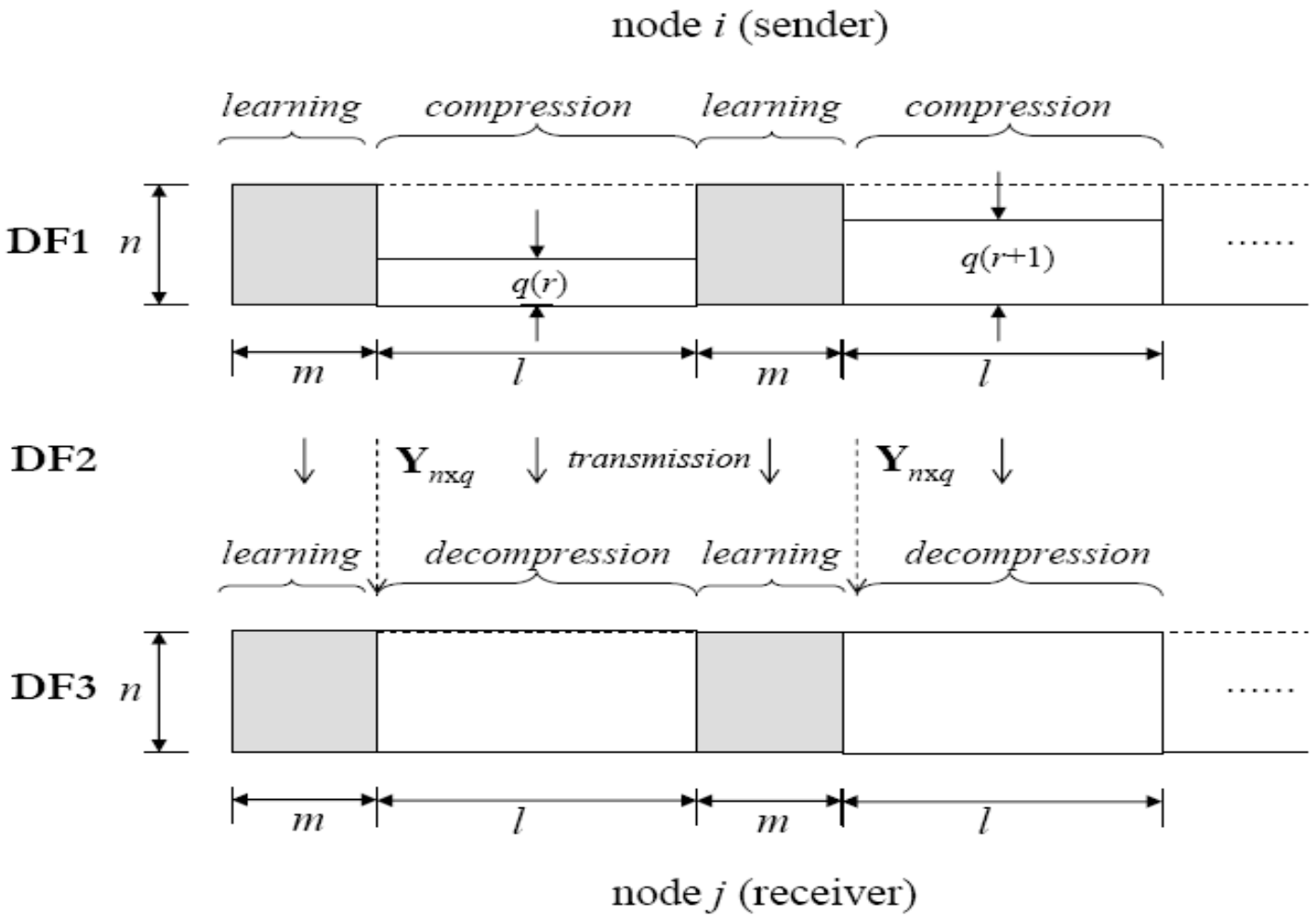
- ***Improve*** *energy efficiency in Wireless Sensor Networks, by …*
- ***Compressing*** *contextual information* ***prior*** *to transmission based on the current* ***Principal Components*** *of the sampled /transmitted/relayed data, and,*
- ***Exploit*** *the (inherent) interdependencies of contextual components*

Context Compression 2/2

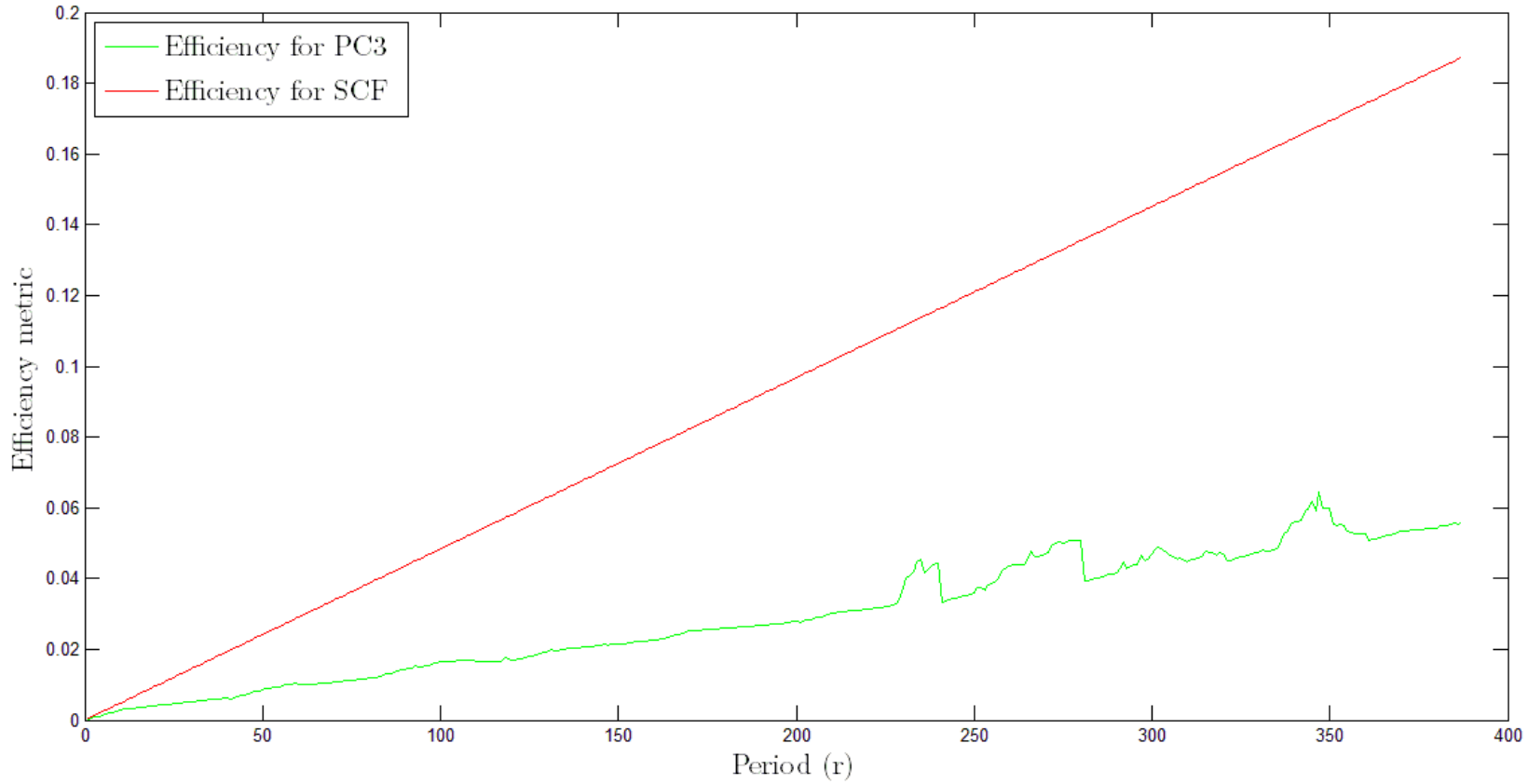
- Node *i* captures the *n*-dimensional context vector (CV) **x** ;
- Node *i* compresses **x** to a *q*-dimensional CV ($q < n$), $\mathbf{x}_q$ and forwards it to upstream node *j*.
- Node *j* reproduces the *n*-dimensional context vector **x′**, for further processing (or forwarding to upstream nodes).



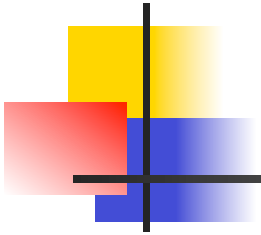
Learning – Compression Phases



Performance Improvements

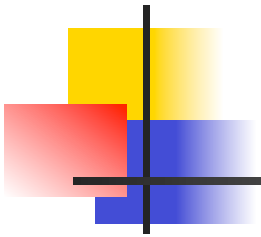


Optimal scheduling of data reporting/ consumption (1/2)



- Applications define a time horizon N>0 in which a consumer node delivers the received data to the application.
- A low value of N indicates that the application is in need of data.
- During the time horizon, the consumer delivers data y to the application with QI x(y).
- $x_k(y)$ is the QI value for y observed at time k, $1 \leq k \leq N$.
- TSTB strategy: schedules information consumption right after delivery (i.e., k=1).

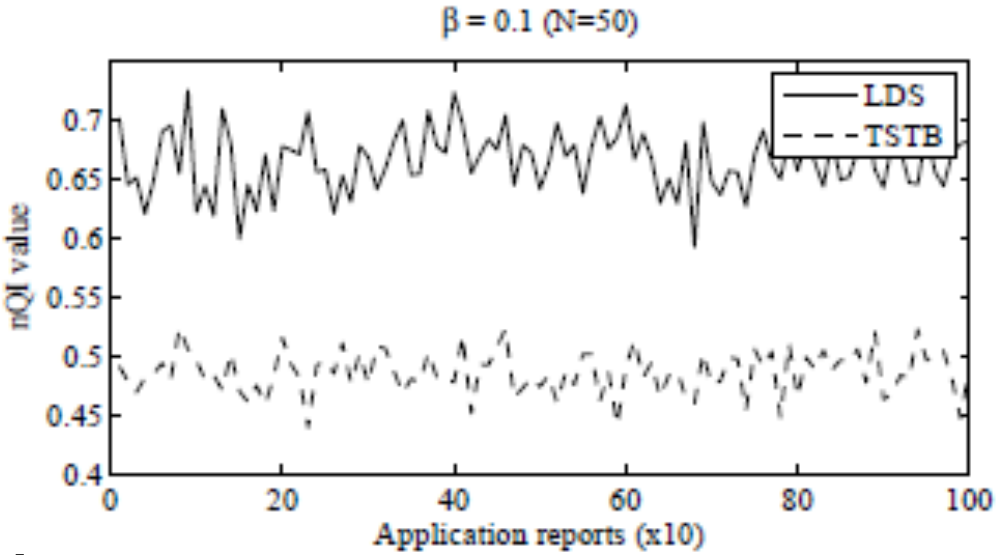
Optimal scheduling of data reporting/ consumption (2/2)

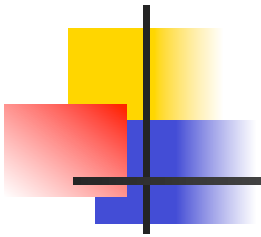


- The consumer refrains from delivering data to the application instantly.
- The consumer bypasses received y values in order to deliver another y' value of better QI.
- The waiting period implies that it is uncertain whether a better piece of information will arrive.
- A consumer caches a QI-tagged y value until it turns unusable.

Optimal Scheduling

- Objective: applications should receive disseminated data with high QI value (increased quality).
- Find a stopping rule (time) $0 \leq k \leq N$: the consumer delivers the pair $(y, x^*_k(y))$ that maximizes the average QI value of the data managed until N.





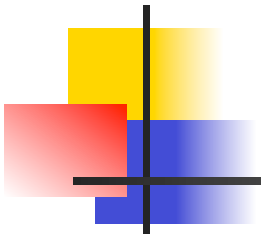
Context Discovery (1/3)

Objective:

• to sense environmental parameters and accurately capture the evolution of a certain phenomenon (e.g., fire, air contamination), and,

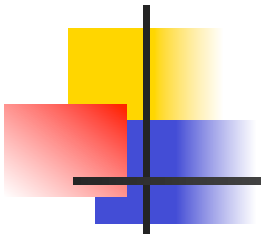
• to fully automate the deployment process by letting nodes relocate, self-organize (and self-reorganize), and,

• optimally cover the focus area.



Context Discovery (2/3)

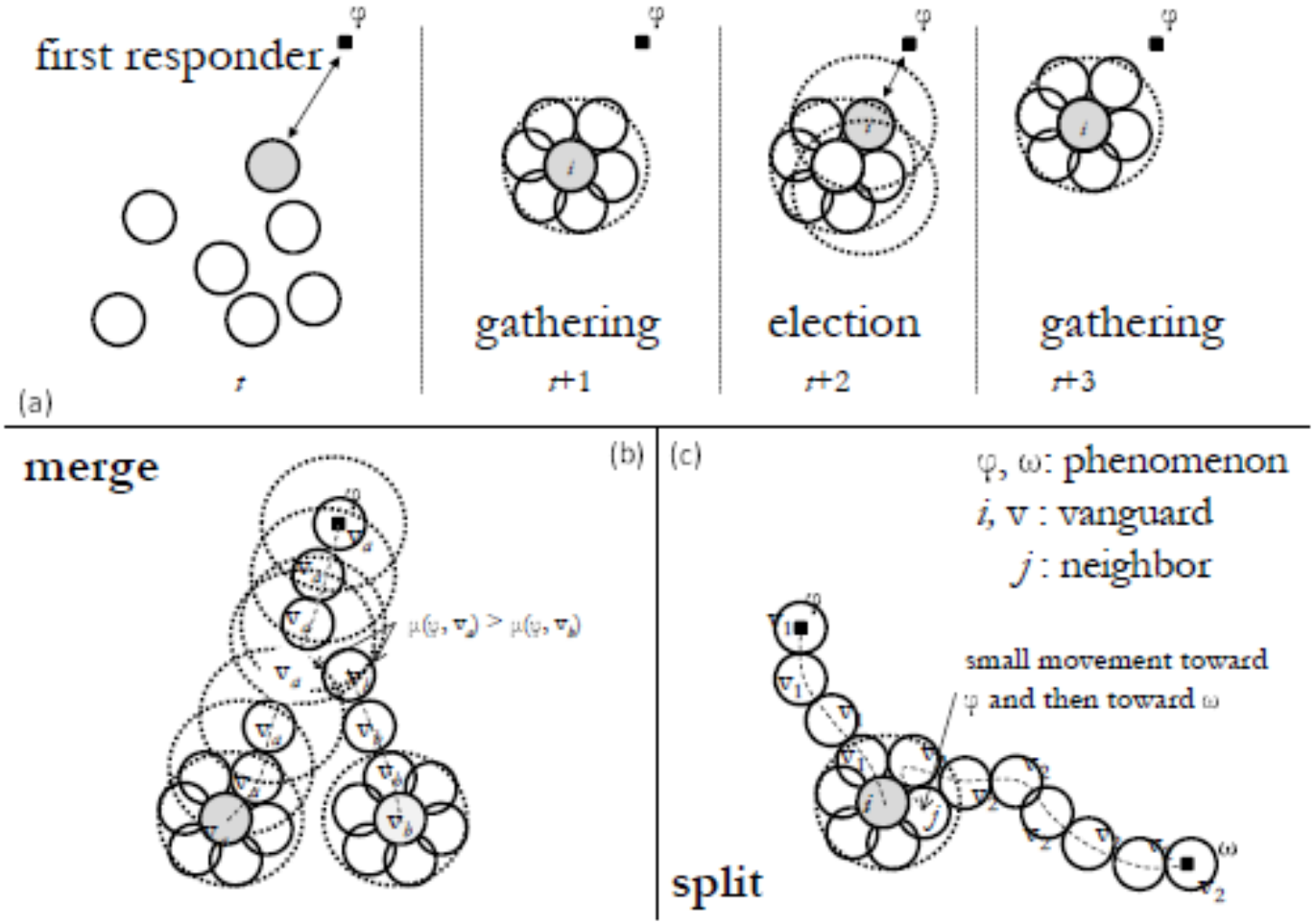
- Node measurement of a physical quantity and local evaluation.
- Based on measurements a group of nodes locates an incident by exchanging relocation directives among neighbors.
- If, at some time, another incident occurs then the group of nodes autonomously splits and different subsets of the initial group are self-deployed in order to cover the extra cases.
- Once groups of nodes target to the same phenomenon then they merge to one group.



Context Discovery (3/3)

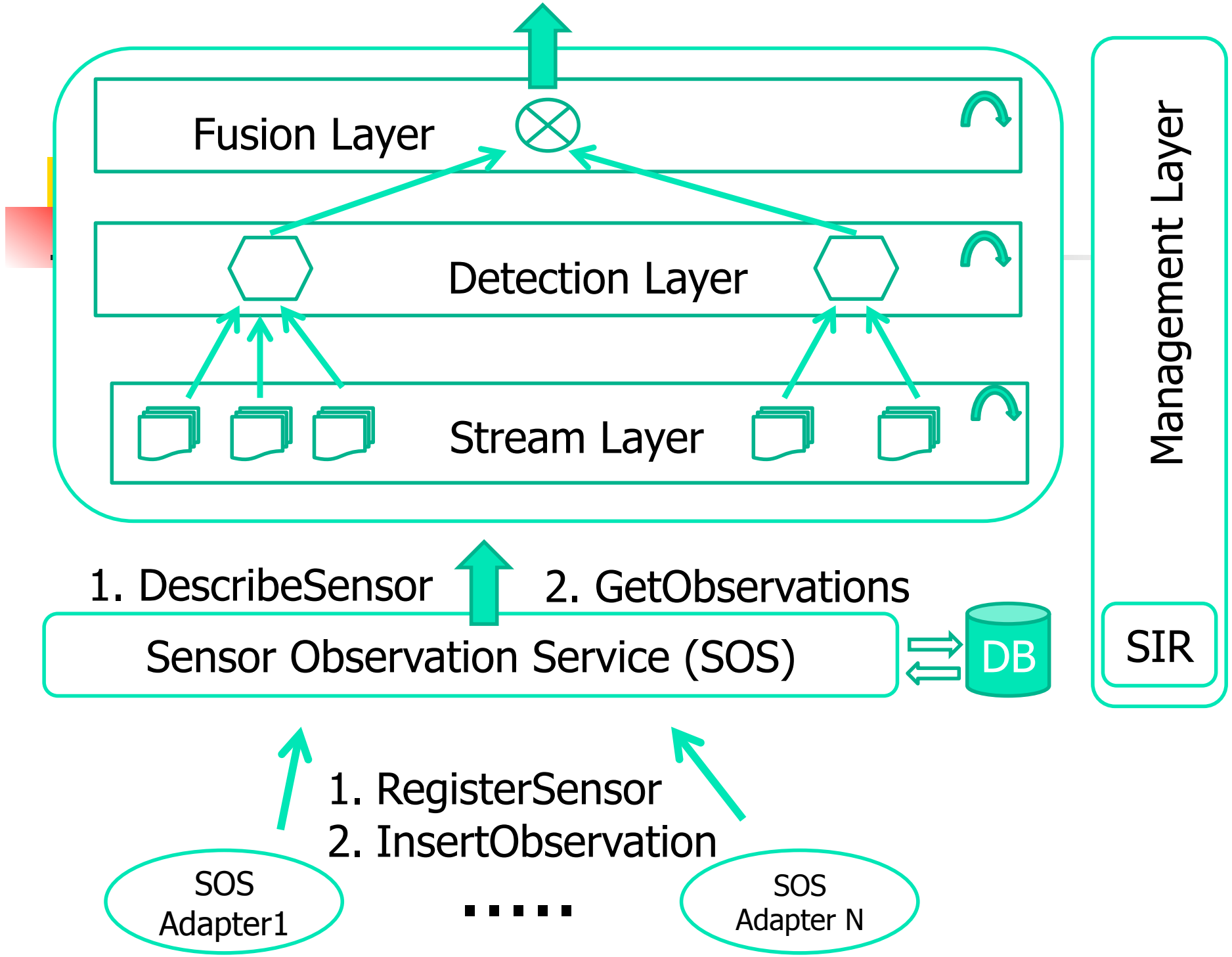
- Particle Swarm Optimization algorithm for local, optimal coverage of certain areas close to the "vanguards"
- Fully distributed, self-deployment and relocation algorithm for optimal coverage of unknown POIs in a ROI
- Low energy expenditure as node relocation is optimized

Self-deployment and POI coverage

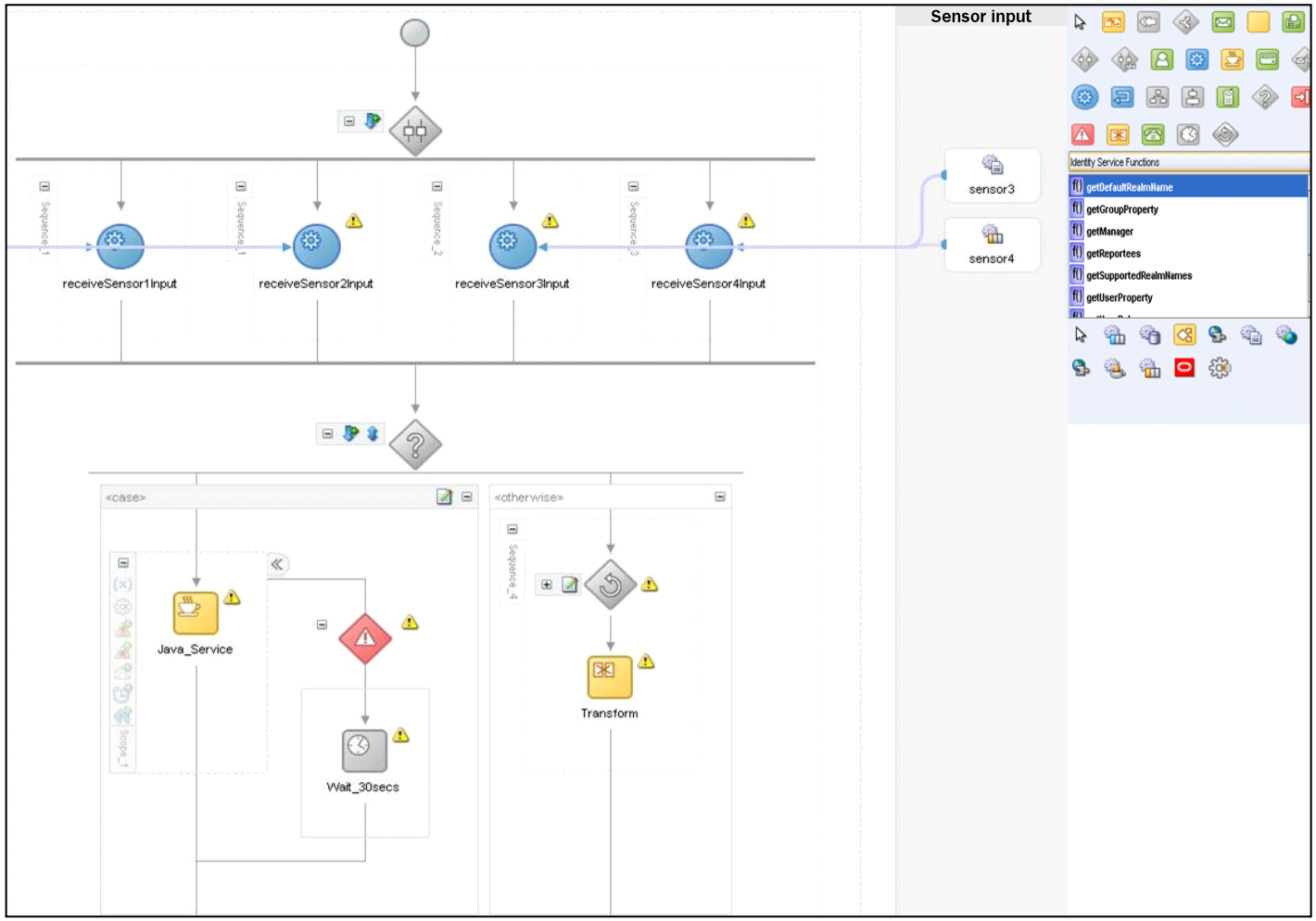


Prototype Development

- Optical Sensor for Ball Velocity
- Generic Fusion Box
- Domain Specific Languages and Tools

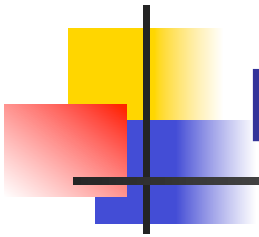

Fusion Layer
Detection Layer
Stream Layer
Management Layer
SIR
1. DescribeSensor
2. GetObservations
Sensor Observation Service (SOS)
DB
1. RegisterSensor
2. InsertObservation
SOS Adapter1
SOS Adapter N

Domain Specific Languages and Tools



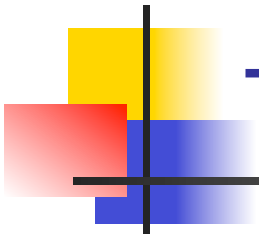
Indicative publications…

- C. Anagnostopoulos, S. Hadjiefthymiades, P. Georgas, **"PC3: Principal Component-based Context Compression - Improving Energy Efficiency in Wireless Sensor Networks"**, *Journal of Parallel and Distributed Computing,* Elsevier, October, 2011
- Christos Anagnostopoulos, Stathes Hadjiefthymiades, Evangelos Zervas, **"Information Dissemination between Mobile Nodes for Collaborative Context Awareness"**, *IEEE Transactions on Mobile Computing (vol. 99)*, IEEE , August, 2011
- Christos Anagnostopoulos, Odysseas Sekkas, Stathes Hadjiefthymiades, **"An Adaptive Epidemic Information Dissemination Model for Wireless Sensor Networks"**, *Elsevier, Pervasive and Mobile Computing Journal, Elsevier (to appear)*, Elsevier, August, 2011
- G. Alyfantis, S. Hadjiefthyiades, and L. Merakos, **"Exploiting User Location for Load Balancing WLANs and Improving Wireless QoS"**, *ACM Transactions on Autonomous and Adaptive Systems (TAAS), 4(2)*, , May, 2009
- C. Anagnostopoulos and S. Hadjiefthymiades, "**Enhancing Situation Aware Systems through Imprecise Reasoning**", in the IEEE Transactions on Mobile Computing (TMC), vol. 7, no. 9, September 2008.



Lab Equipment

- Short Range Communication platforms
- High- and low-frame rate cameras/vision sensors , PTZ cameras
- Weather stations
- Sunspots, Xbox Motes, CSEM WiseNodes
- mini DSP units
- RFID readers & IRDA Beacons
- DVB-T distribution server and STB middleware platform



Thank you !

Questions?