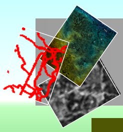
Dacus_Oleae: A Middleware for Building Location-aware Services



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Ambient Intelligence (AmI)

- Relies on the areas of:
  - ubiquitous computing
  - ubiquitous communication and
  - intelligent user interfaces
- Aiming:
  - seamless delivery of services and applications

Ambient Intelligence (AmI)

- Suggests:
  - an environment of a potentially large number of embedded mobile devices, or software components, interacting to support user goals and activities.
  - a component - oriented view, in which the components are independent and distributed.
  - an environment characterized by:
    - autonomy,
    - reactivity,
    - distribution,
    - collaboration and
    - adaptation of its artifacts

    (share the same characteristics as agents)
- Requires:
  - agents to be able to interact with other agents in the environment around them so as to achieve their goals.

Motivation of using Agents

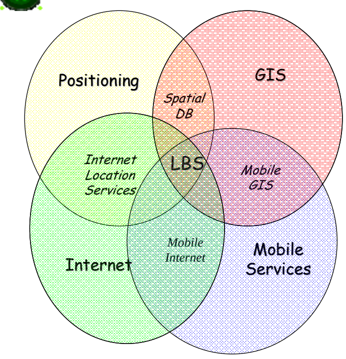
- Agent technology is an alternative for enhancing pervasive computing environments.
- Agent environment provides the infrastructure that enables AmI scenarios to be realized.
- Pervasiveness
  - Scalability of agents
  - Heterogeneity of agents and services
  - Agents learn how to adapt their decision to the context
- Requirements

  provide solutions to issues of:
  - context architecture,
  - operation,
  - integration and
  - visualization

  of distributed sensors, ad-hoc services, and network infrastructure.

Motivation of using LBSs

- LBSs integrate information related to geographic position of a mobile device with other information such as
  - mapping,
  - routing,
  - searching,
  - multimedia content and
  - address location functionalities
  - to provide added value to a user with specified profile and content.
- LBSs applications approaches are:
  - person/device oriented
  - push/pull services.



- Characteristics of LBSs:

  -Scalability:
  Ability of a location-aware server to provide real-time responses to a large number of continuous, concurrent spatio-temporal queries of different types.

  -Complexity:
  Spatial comparisons may require complex geometric algorithms.
  Efficient algorithms are required to avoid unnecessary complex computations.

Convergence of mobile technologies location aware technologies (positioning) with the Internet and GIS to create LBSs.

Enabling Technologies

- Considerable attention within LBS technology has been placed to its constituent technologies, like wireless Web, mobile Internet-enabled devices and mobile positioning.
- The heart of the whole system represents Internet-enabled GIS technology.
- LBSs will benefit from real-time information acquisition at the client side.
- Client will be equipped with sensors to collect information automatically and send it back to Server.

Capigi Conference, April 2008
InfoLab, Agricultural University of Athens

Sensors Everywhere - Applications

- Visions
  - Ubiquitous [pervasive | proactive] computing
  - Design space - Challenges
- **Applications**
  - Food Industry
  - Environmental monitoring (Crop yield, Cattle herding, Ocean water, fishing, power, construction, etc.)
  - Crop acreage (fertilization, harvest, contaminations, diseases, pests).
  - Water management
  - Precision agriculture
  - Chemical spraying
  - Livestock and wild animals tracking
  - Transportation of goods
  - Integrated electronic market
  - Management of Forest Industry
  - Surveillance
  - Emergency calls (E-112/E-911), finding – rescue of missing persons

Applications

Application	Description
Grape Monitoring • WSN, immobile • Sensor-gateway-BS, • Cable-Radio • Tree topology (two-tiered, multi-hop) • Sparse (20m apart), • Several hundreds (up to 65 deployed)	Monitor the conditions that influence plant growth across a vineyard in Oregon, USA. Support precision harvesting, precision plant care, frost protection, predicting insect, pest, fungi development. •Measure of temperature, soil, moisture, light and humidity.
Bathymetry • Self-organized, ad-hoc Homogeneous, • Radio, GPS, • Graph, sparse (0,5-1km) • 4-5 years life, • 6-50 hundreds	Monitor the impact on the surrounding environment of a wind farm off the coast of England (UK). •Formation of sand banks, tidal activities •Measure of pressure, temperature, conductivity, current, and turbidity.

Applications

Application	Description
Bird observation on Great Duck Island • WSN, immobile • Buttery, solar • Whether stations, burrow nodes, gateways • Radio –Infrared • Star of clusters • Dense (every burrow) • Tens of hundreds (~100 deployed) • 7 months breeding period	Observe the breeding behaviour of small bird (Leach's Storm Petrel) on Maine, USA. Biologists are interested in • Usage pattern of their nesting burrows, • Changes in the environmental conditions outside and inside the burrows during the breeding season, • Parameters of preferred breeding sites • Sensors measure pressure, temperature, humidity, and ambient light. • Borrow nodes are equipped with infrared sensors to detect the presence of the birds

Applications

Application	Description
Cattle Herding • WSN multi-hop, ad hoc • Homogeneous • Radio • BS-GPS, (BS transmits fence coordinates to the nodes) • Graph • Dense (every cow) • Up to hundreds (~10 deployed) • Days to weeks	Supports the implementation of virtual fences using acoustic stimulus being given to animals that cross a virtual fence line. A sensor is attached to the neck of the cows and consists of • PDA with GPS receiver, • WLAN card and • loud-speaker for providing acoustic stimuli to the cattle.

Applications

Application	Description
Cold Chain Management • WSN multi-hop, ad hoc • Sensors-relays-access boxes-BS (warehoue) • Radio • Relays, Access boxes • Tree (two-tired) • Sparse • Up to hundreds(55 sensors, 4 relays, deployed) • years	The commercial Securifood System monitors the temperature compliance of cold chains from production, via distribution centers and stores, to consumer. Clients receive an early warning of possible breaks in the cold chain. • Sensors are transported with the products and collect temperature data. • Relays collect and store temperature data from sensors. They also form a multi-hop network. • Access boxes act as gateways between the relay net and the Internet. There is one access box per production site. • Internet hosted data warehouse acts as a central server, collecting data from all the access boxes. It provides an on-line image of all the sensor data in he system and acts as a central repository for applications.

Applications

Application	Description
ZebraNet	Behavior of wild animals
Glacier Monitoring	Earth' s climate
Ocean Water Monitoring	Observe the temperature, salinity, and current profile of the upper ocean. ARGO progect:
Vital Sign Monitoring	Monitor vital signals of patients in a hospital environment.
Power Monitoring	Monitor power consumptions in large and dispersed office buildings.

Applications

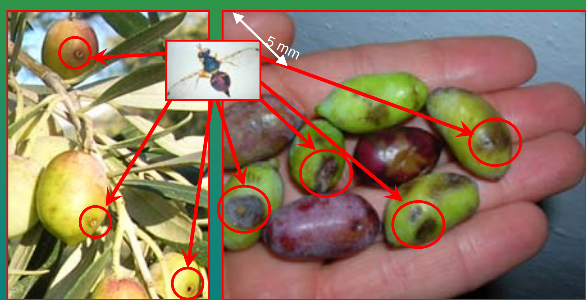
Application	Description
Rescue of Avalanche Victims	Assist rescue teams in saving people buried in avalanches. The goal is to better locate buried people and to limit the overall damage.
Parts Assembly	Assist people during the assembly of complex composite objects such as "do-it-yourself" constructions.
Tracking Military Vehicles	Track the path of military vehicle
Sniper Localization	Locate snipers and the trajectory of bullets providing valuable clues for low enforcement.

The FruitFlyNet application

- The OliveFlyNet project aims to develop a complete insect pest management system that provides real-time information to managers in order to monitor the olive fly population and control the spray application of olive trees.
- Extension includes other important species of the Tephritid fruit fly family:
  - **Mediterranean fruit fly**
  - **Cherry fruit fly**
  - **The Ethiopian fruit fly**

Olive fly

The olive fly (*Bactrocera* (*Dacus*) *oleae*) (Gmelin) (Diptera: Tephritidae)



Socio-economic Motivation

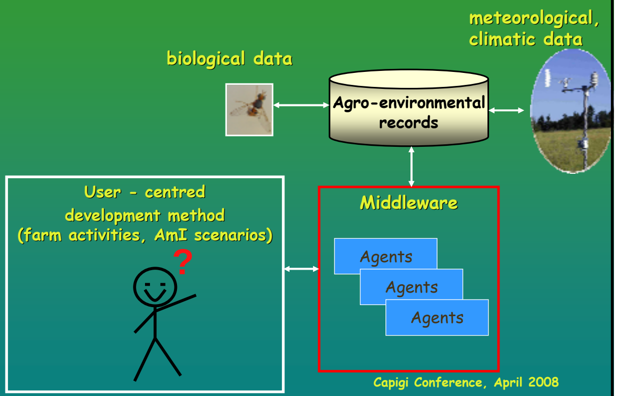
IOBC wprs Bulletin Vol. 25, 2002

- Mediterranean basin has 98% of the world's cultivated olive trees
- Number of olive trees: About 800 million
- Surface area: Approximately 10 million hectares.
- Production:
  - About 1.6 million metric tonnes per annum of olive oil
  - About 750,000 metric tonnes of table olives (about 9% of the area's production of olives).
- Losses (insect pests, fungi and weeds):
  - About 30% of production.
- Estimated damage caused to harvested fruits by insect pests is at least 15% of production.
  - This equates to 800 million US dollars per annum.
  - This comes despite the fact that olive growers spend annually more than 100 million US dollars combating these pests and of which 50% corresponds to pesticides.

Agro-environmental Information Systems

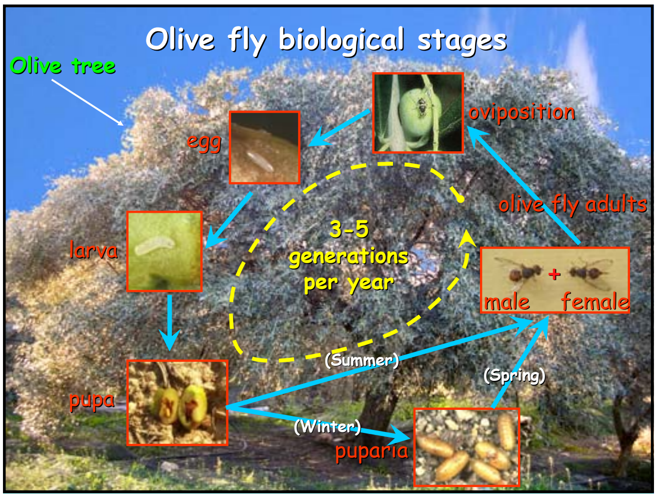
- Provide access to electronic agro - environmental (e.g biological, climatic, meteorological, etc.) records
- Provide accurate and timely information to farmers in support of decision - making.
- Autonomous agents can cope with the complexities associated with implementing AmI environments for precision farming settings.
- Farms are distinguished from
  - **the distributed nature of the information,**
  - **the intensive collaboration and mobility of their personnel,**
  - **the need to access agro - environmental information occasionally.**

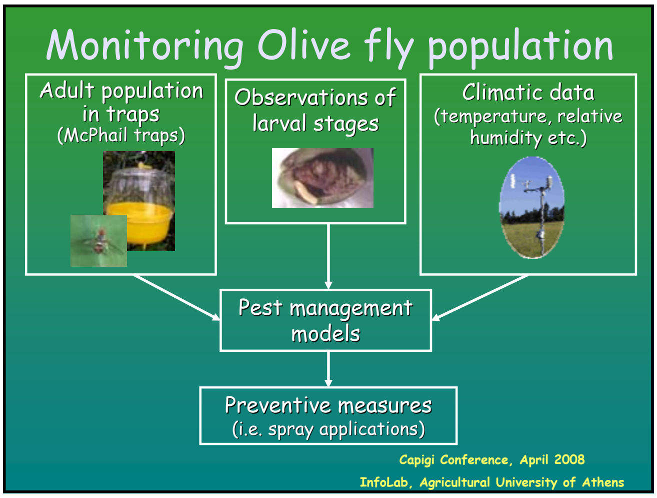
Agro-environmental Information Systems

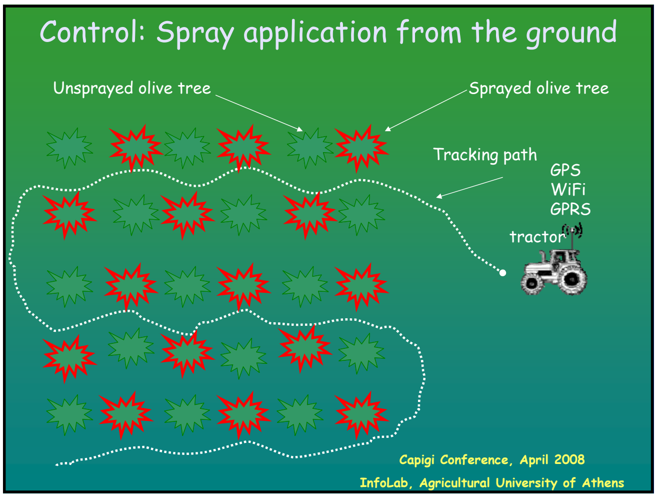


Agro-environmental Information Systems

- An AmI scenarios in PFarming - The olive fly case
  - The Dacus_oleae middleware for spray control of olive trees is based on:
    - ✓ an envisioned scenarios and
    - ✓ the easy integration of components represented by autonomous agents.
  - Building Blocks used for sensory information management
    - ✓ Data gather
    - ✓ Event handler
    - ✓ Communications module
  - The communication aspects of the middleware architecture, allows different context-aware applications to query, retrieve and use sensor data in a way that will be decoupled from the mechanisms used for acquiring the raw sensor data.







Spray application from the ground

- To avoid failures in the spray treatment, there is a need to ensure that:
  - The experimental plants of olive trees are large enough.
  - The population of olive flies tend to increase significantly.
  - The olives must be in an advanced stage.
  - The female to male insect ratio should be greater than one.
  - The female insects must be in a mature stage
  - The temperature and the humidity levels should exceed a threshold.

Spray application from the ground – Environmental aspects(*)

The proposed middleware ensureς that the farmer:

- is carrying out spray operations on approved cultivations only
- use pesticides at the correct dosage levels (taking into account the coverage of olive trees of the spraying area; the olive fruit fly population of the spraying area)
- leaving adequate buffer zones so that the pesticide does not enter water courses, domestic or environmentally protected areas, biological crops, etc..

- (*)According to: Council Directive 91/414/EEC of 15 July 1991 concerning the placing of plant protection products on the market.

Agricultural Information Systems (AIS)

- The olive fruit fly case
  - The Dacus_oleae middleware for spray control of olive trees is based on:
    - an envisioned scenarios and
    - the easy integration of components represented by autonomous agents.
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    - Data gather
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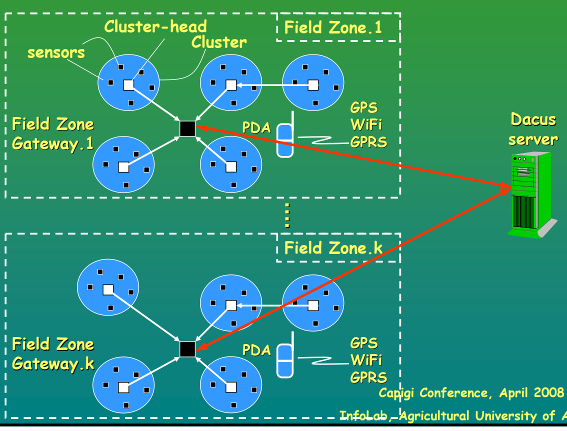
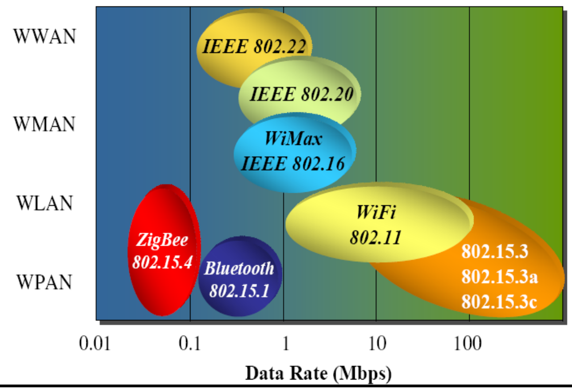
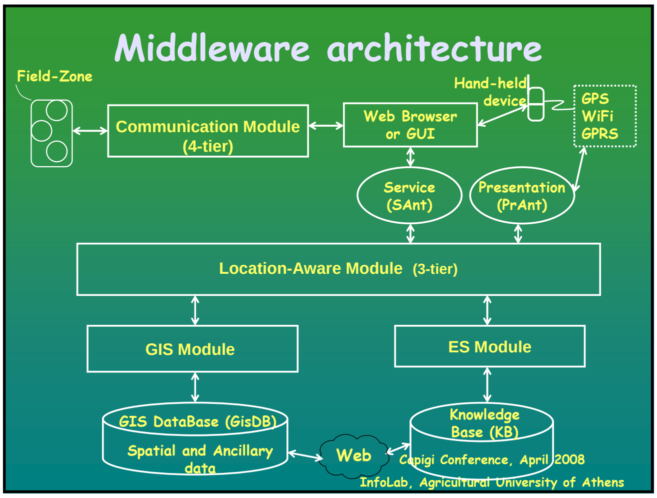
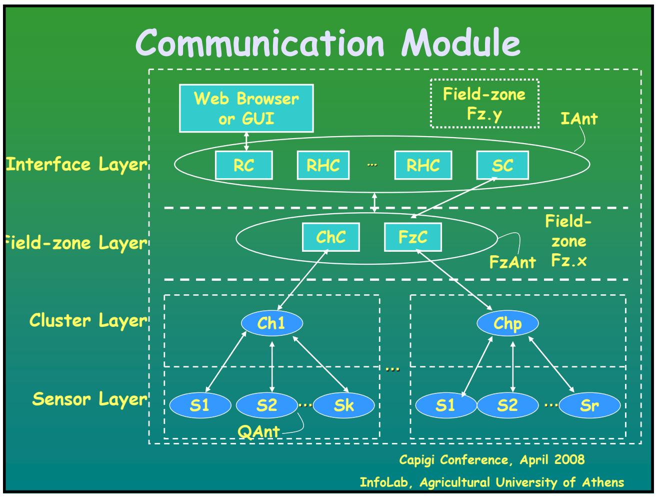
The *Dacus oleae* Wireless Sensor Network

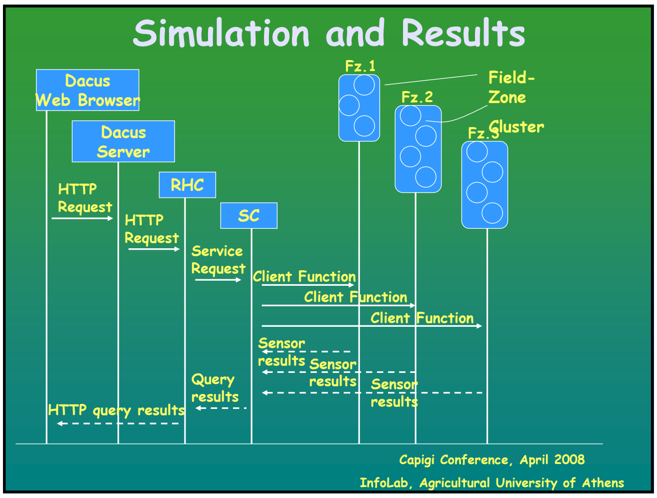


Wireless Standards









Problems solved (1)

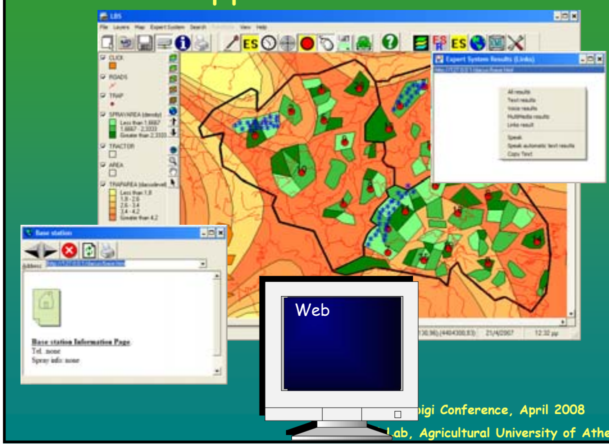
- the air temperature and air speed values are unknown to the spraying attendant. In this case, the spraying could continue even when the meteorological conditions have been violated.
- the spraying areas cannot be memorized by the attendant and, therefore, over or under spraying may occur.
- the spray volume is dependent on the coverage of olive trees and, as a result, the spraying attendant cannot easily determine if the number of the olive trees per area unit is low, medium, or high.

Problems solved (2)

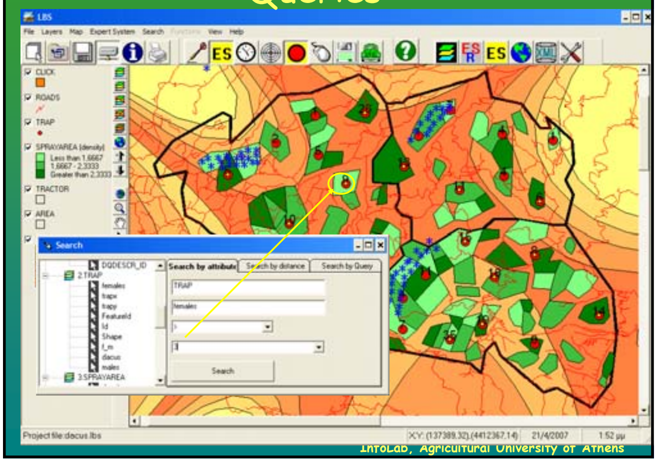
- the existing areas inside the spraying area which must not be sprayed for some reason (i.e. domestic areas).
- the olive fly population of the spraying area is not known to the attendant and therefore the spray volume per area cannot be determined at all.
- the lack of communication between the supervisor and the attendants.

The *Dacus oleae* application

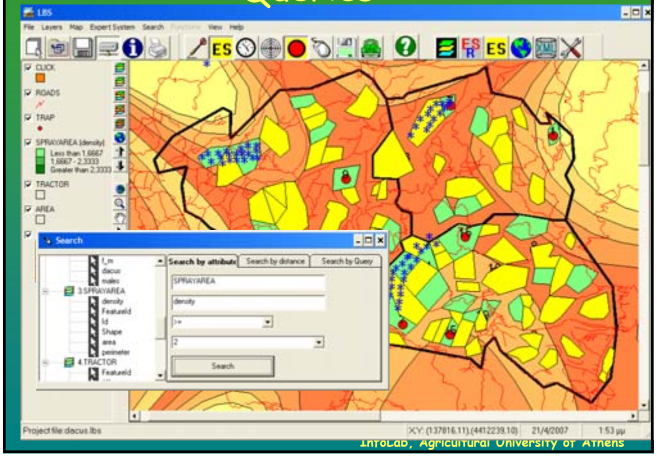
An application scenario



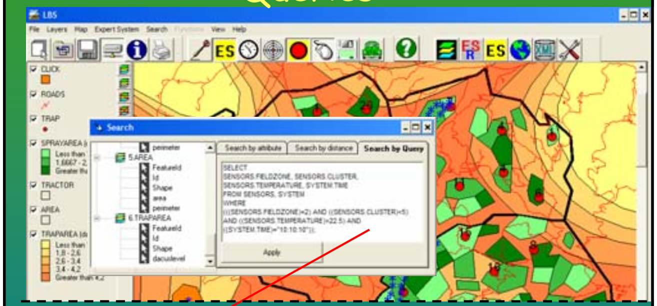
Queries (1)



Queries (2)



Queries (3)



FIELDZONE	CLUSTER	TEMPERATURE
2	1	23.2
2	2	24.5
2	3	26.7
2	4	24.1

Testing and Evaluation (1)

- Critical questions
  - Testing and evaluating the proposed application in its target environment with a suitable infrastructure and a volunteer user community is costly and usually does not scale well to large number of users or applications.
  - To proceed with a different approach we created a test environment that supports the evaluation of key aspects of the Dacus oleae application, without extensive resource investments necessary for a full application implementation and deployment.

Testing and Evaluation (2)

- A complete evaluation requires many different aspects to be examined, such as:
  - user interface issues,
  - system and network related issues,
  - physical device considerations,
  - new embedded sensing devices
- Our concern here is:
  - to improve the test environment
  - to use it as part of the test and evaluation process for this and other, similar applications.

Conclusions (1)

- We proposed the design of a multi-agent middleware to support a novel application for spray control and treatment of the olive fly pest problem.
- The multi-agent design architecture allows agents to cooperate and communicate among themselves, disseminating and/or gathering the sensory data on the WSN.
- The architecture consists of four layers with different types of functionalities. It is open and may adapt future technologies, encapsulating and integrating various modules as agents, by means of communication, with a clearly defined XML schema.

Conclusions (2)

- The application integrates many interesting characteristics, such as:
  - the independence of the positioning system,
  - the location model support,
  - the capability of the decision support system,
  - the user friendly environment with multimedia capabilities of the GUI,
  - the flexibility in the development of a new location aware application and services.
- The system provides efficient data dissemination, in cases where sensors are deployed in large areas with limited power.

See you all in Athens, Greece

Call for papers

4th HAICTA Conference on ICT in Bio and Earth Sciences

September 18-20, 2008.

Paper submission deadline: April 21, 2008

http://infolab.aua.gr/haicta

Bio-geo-sensing

Agricultural University of Athens

Thank you for your attention!!