



GOOD FOOD

WP7: Ambient Intelligence

Ambient Intelligence

TUTORIAL

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OUTLINE

- The Aml VISION
- The Implementation of the Aml Vision
- The GOODFOOD Aml GRID
- The GOODFOOD Aml Scenario



ISTAG (IST Programme Advisory Group) Vision in FP5

Start creating an **Ambient Intelligence landscape** (for seamless delivery of services and applications) in Europe relying also upon test-beds and open source software, develop user-friendliness, and develop and converge the networking infrastructure in Europe to world-class



Ambient Intelligence (Aml)

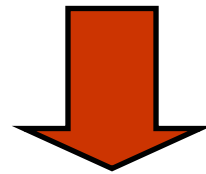
The focus of IST in FP6

- **Computers and networks will be integrated into the everyday environment** rendering accessible a multitude of services and applications through easy-to-use human interfaces. This vision of "ambient intelligence" places the user, the individual, at the centre of future developments for an inclusive knowledge based society for all
- **The Environment will be surrounded by intelligent interfaces supported by computing and networking technology** which is everywhere, embedded in everyday objects such as furniture, clothes, vehicles, roads and smart materials even particles of decorative substances like paint



Aml VISION

People are surrounded by **intelligent intuitive interfaces** that are embedded in **all kinds of objects** and an **environment** that is capable of recognising and responding to the presence of different individuals in a seamless, unobtrusive and often invisible way.



Aml implies a SEAMLESS ENVIRONMENT of computing, advanced networking technology and specific interfaces



This ENVIRONMENT should be:

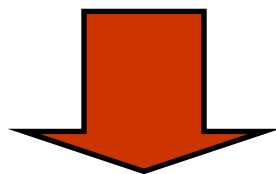
- Adaptive with respect to the user's needs
- Capable of responding intelligently to spoken or gestured indications of desire
- Configurable in systems that are capable to engaging in intelligent dialogue



Aml needs to be driven by humanistic concerns, not technologically determined ones

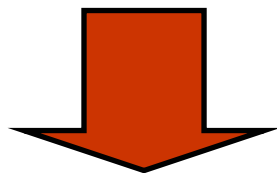


HOW AmI VISION CAN BE REALISED AND DEVELOPED?



Three Perspectives:

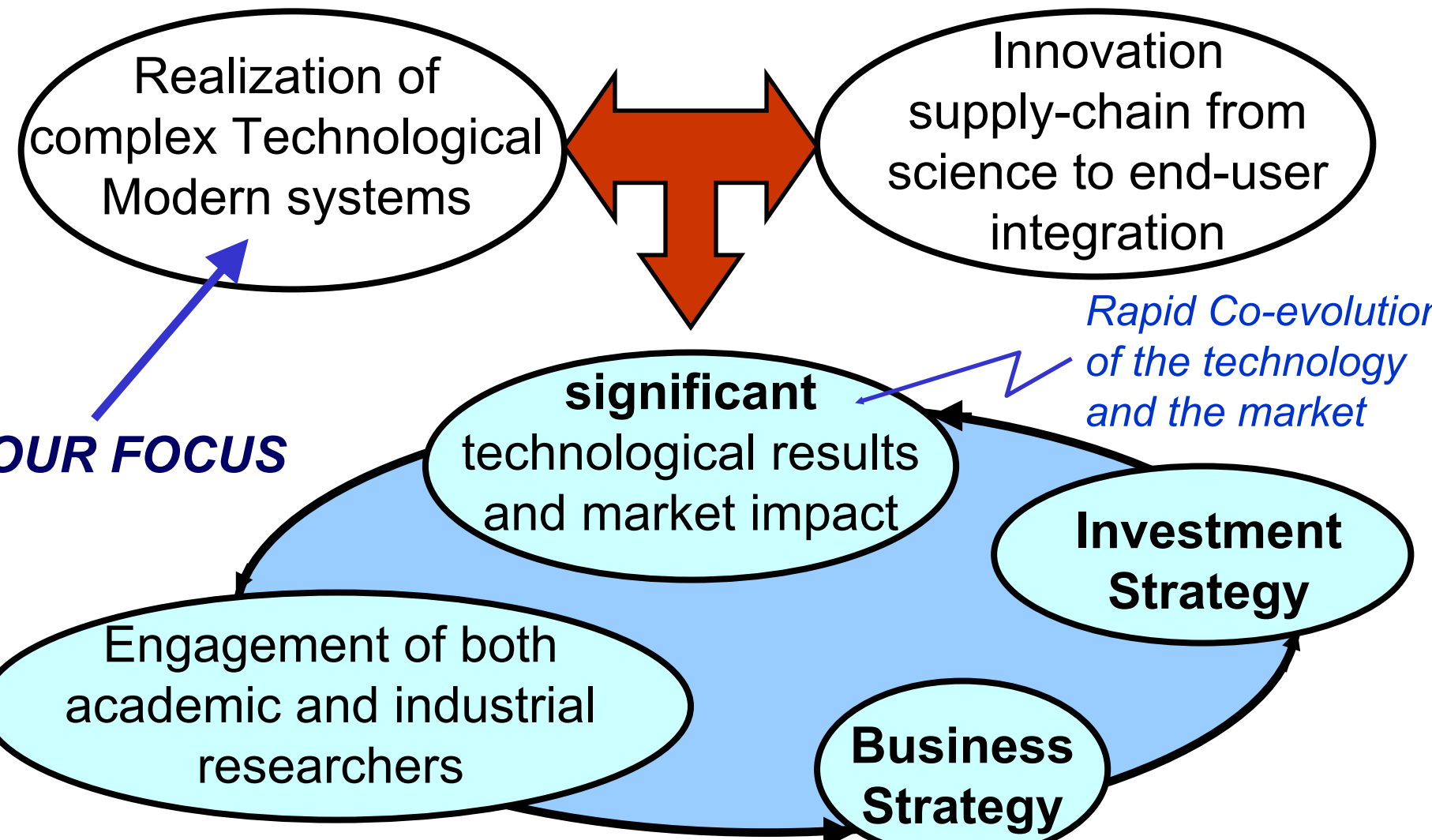
- Technological, Business, Resource



HOLISTIC VIEW OF AmI



WHY a HOLISTIC VIEW of Aml?





Ambient Intelligence stems from:

- Ubiquitous Computing
- Ubiquitous Communication
- Autonomous and intelligent systems.



Different technological Views



The Aml Technological View

- **Functional**
 - **The ambient:** systems/environment/background view
 - **The Intelligence:** user/person/foreground view
- **Systemic**
 - Components view
 - Integration view



Aml Components

- **For Ambient**

- Smart materials, MEMS and Sensor Technology, Embedded systems, Ubiquitous communication, I/O device technology, Adaptive software

- **For Intelligence**

- Media management and handling, Natural interaction, Computational intelligence (*KDD, DSS, AI, Intelligent Agents*), High performance computing



The very research challenge of Aml

- To define and develop mechanisms to ensure the successful, seamless **integration** of the components
- To converge them into a **Aml System**



New approaches for three key layers

- Platform Design
- Software and service architecture, design, engineering and integration
- Experience prototyping



Aml Platform Design requires:

- **Abstraction:** to easily integrate in the future different Aml platforms
- **Automatic Composition:** self-configuration of the platforms in term of interfaces, reusability and interconnectivity is a big challenge of Aml
- **Interaction Management:** between the Ambient and the intelligence
- **Computational Efficiency**
- **Scalability and Evolution**
- **Dependability:** consistency and trust are fundamental



Aml Software and Service Architecture will need:

- To deal with large, complex, heterogeneous and distributed systems
- To delivery innovative, functional and efficient services to the individual, to industry and to administrations
- To be intelligent, self-configuring, self-managed



Horizontal integration and
extensive cross layer interactions

that break open the interfaces between layers



Aml Experience Prototyping

- It is fundamental to understand how user needs can be translated into functional requirements
- System functionalities have to be determined in a **reliable** way from **feasible** prototypes providing proofs of concept.



Experience Prototyping is a form of prototyping that enables design team members, users and clients **to gain first-hand appreciation of existing or future conditions** through active engagement with prototypes



Aml Experience Prototyping

The challenges:

- To integrate prototypes with models-based user interfaces design
- To develop a lifecycle for prototypes supporting different abstraction levels and fidelities
- To annotate prototypes with metadata (*performances, user evaluation etc...*)
- To find ways properly to evaluate the user experience offered by prototypes of Aml applications and environments

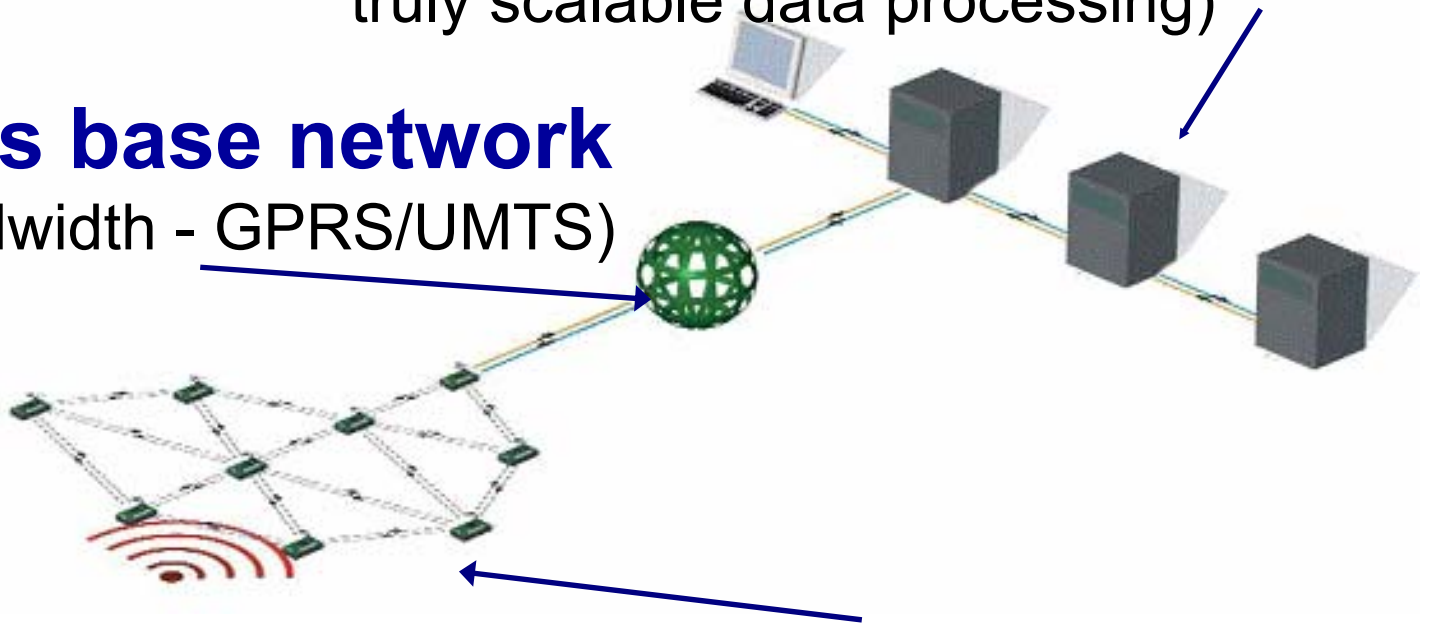


Aml Infrastructure requires:

Fixed base network (High performance computing platform to support truly scalable data processing)

Wireless base network

(High bandwidth - GPRS/UMTS)



High density sensors network (a Large number of low power, low bandwidth components that guarantees anywhere and any time aspects)

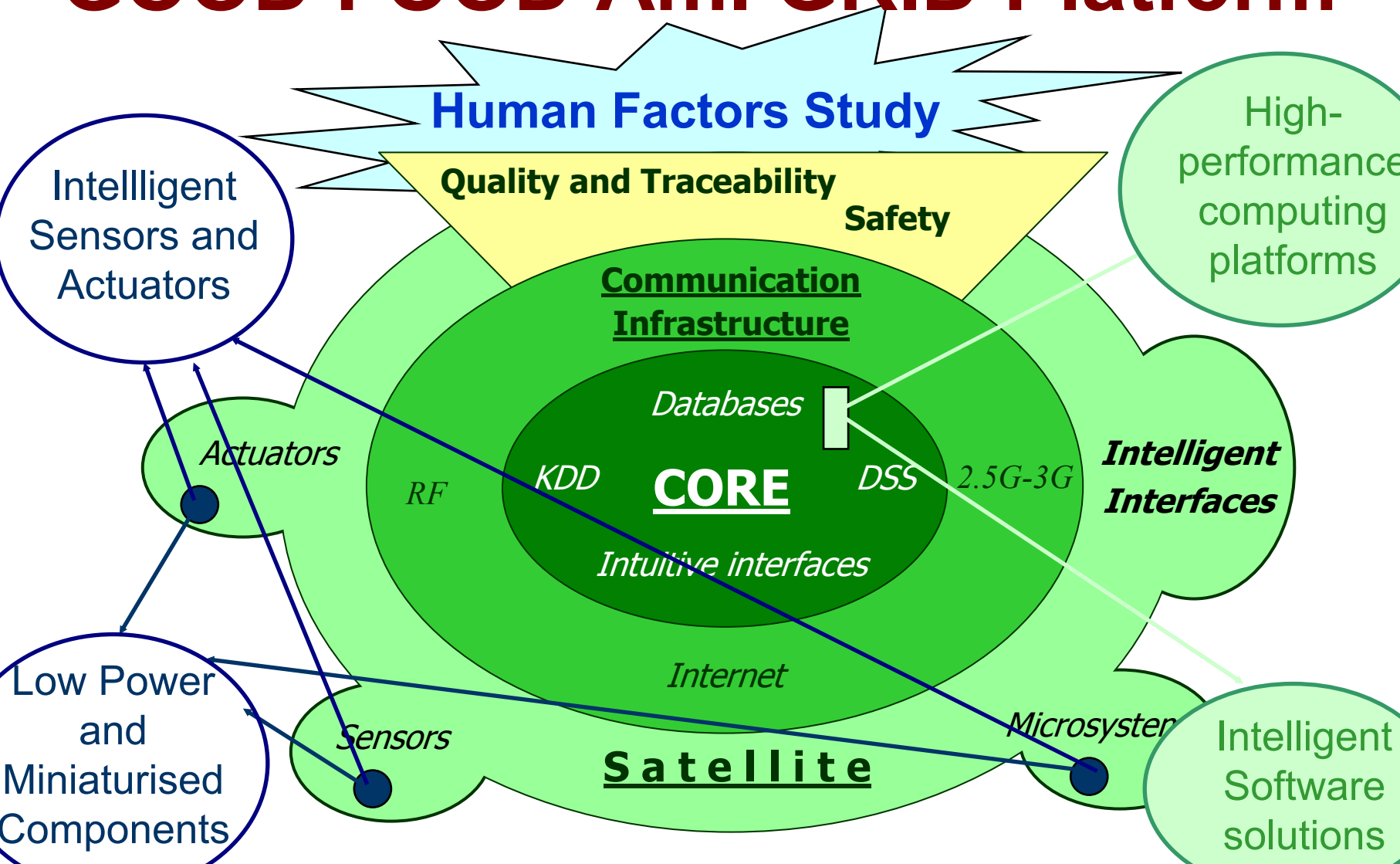


HOW GOODFOOD Aml-GRID does address the Aml Vision realization?



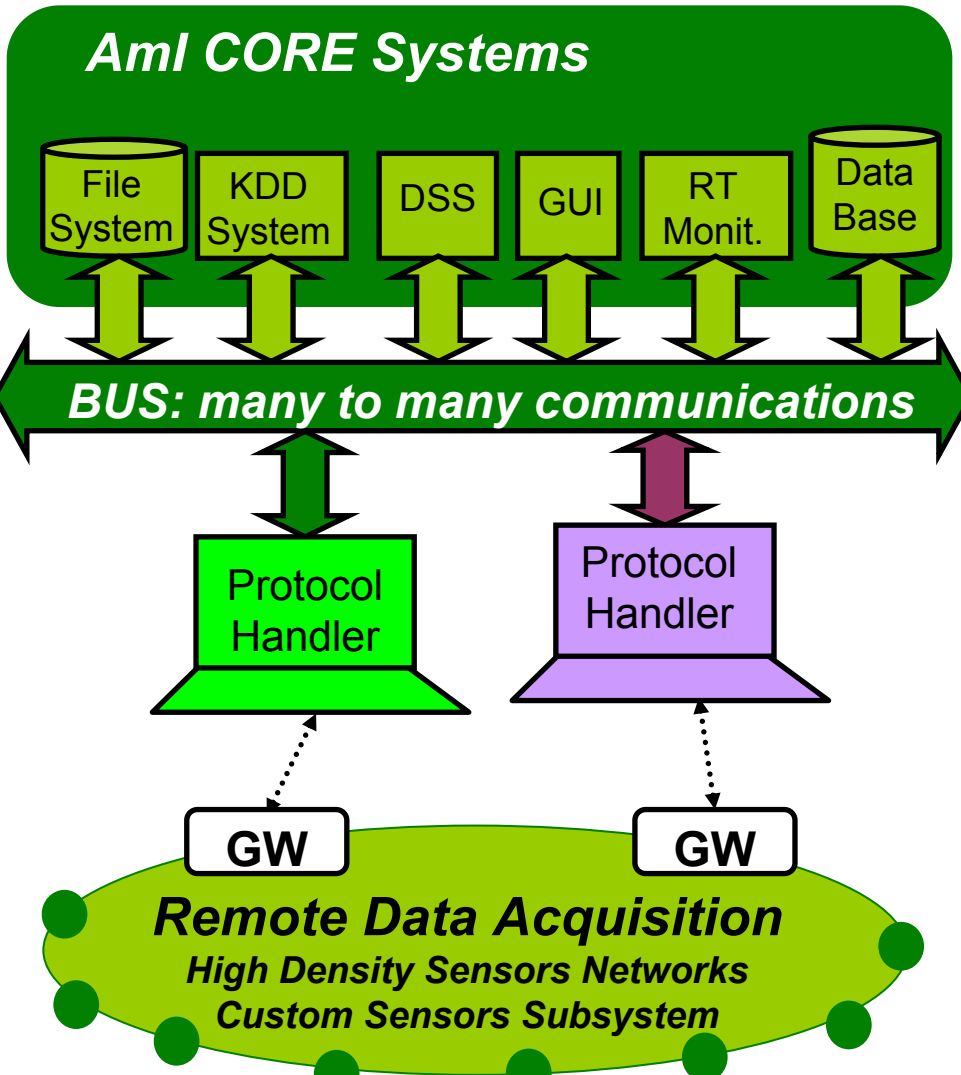


GOOD FOOD AmI GRID Platform





Aml GRID Infrastructure



The Gateway is connected to a **Protocol Handler** that wraps data coming from RDA into a structured stream of information for the Aml core Systems. The Aml Core is connected to the PH **through a bus** that contains the logic to distribute information to the systems.

(DB- KDD – DSS – GUI – File System – RT Monitoring)



Aml GRID Infrastructure

The PH permits the ***abstraction*** of the Aml application level and an ***interaction management*** between the ambient and the intelligence components

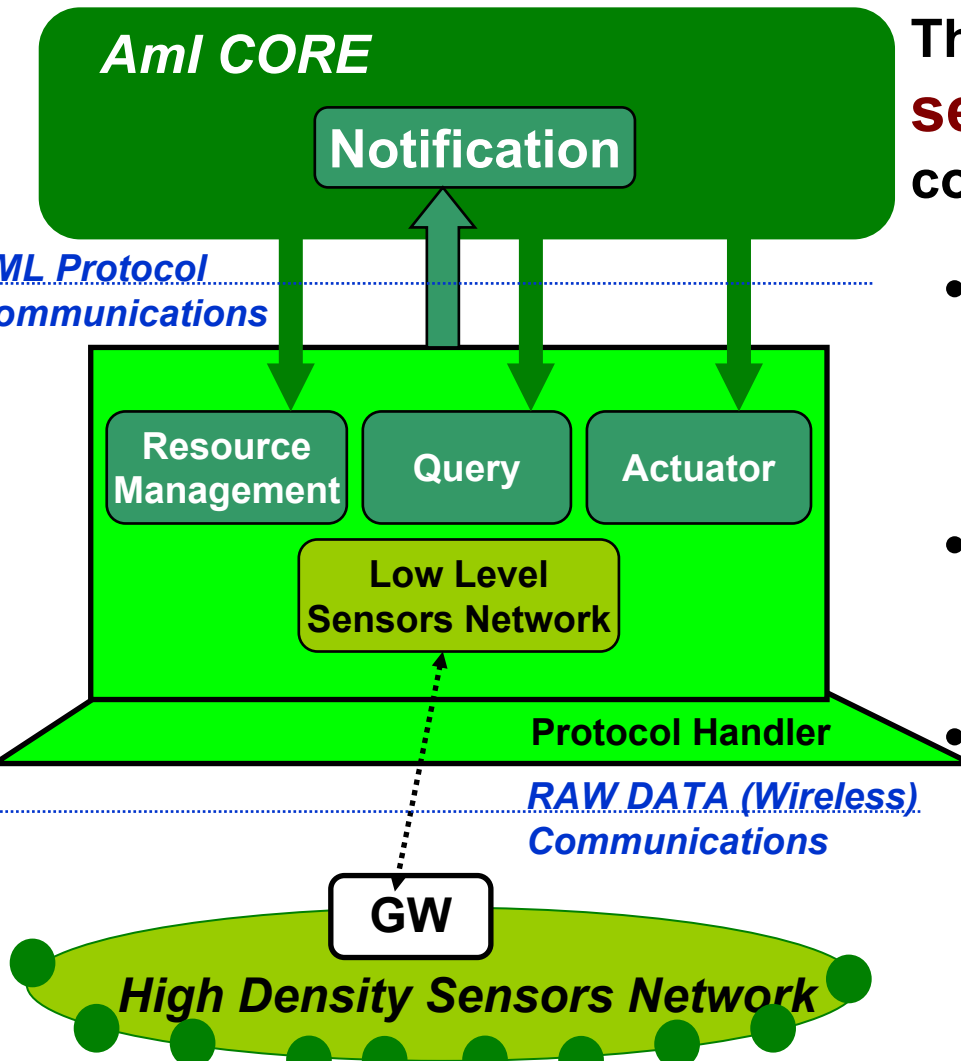
- Use of a modelling language for targeting explicitly sensor networks (*tinyML*)
- Based on XML protocol

The BUS addresses the concepts of ***horizontal integration*** and ***extensive cross layer interactions***

KDD and Decision Support Systems address the need of intelligent computing



Aml GRID Interfaces



The PH and the Aml Core expose a **set of interfaces** for communicating between each other

- The **Resource Management** interface, used to query or change the configuration of the sensor subsystem.
- The **Query** interface, used for sending queries on the data of the sensor system environment.
- The **Notification** interface, to receive the notification of events occurring in the sensor subsystem.



The Aml Core Systems

- A **database** for storing and retrieving data in a more structured way according to the sensors modelling language and the database model.
- A **Real Time Monitoring System**
- A **Display System**, for the Graphic User Interface
- A **KDD (Knowledge Discovery in Database) system** for analyzing the information with data mining techniques to find some interesting correlations.
- A **DSS (Decision Support System)** that helps the Aml framework in taking any sort of decisions according to the knowledge acquired with the analysis of the stored information.
- The **file system** for storing data structured in files.



The GOODFOOD Aml-GRID SCENARIO

Monitoring a vineyard during the entire vegetative cycle plants

- The **wine chain** has been selected as a case-study for the demonstration of the Aml concept into the agro-food chains
- The Montepaldi farm is an exclusive property of the University of Florence and it is in use by Agriculture Faculty for educational, trial and research activities. Therefore, it has been chosen as an ideal location for the **Good Food WP7 pilot site**.



Aml Scenario: User's needs Analysis

A Careful user's needs Analysis has been performed

- Several meetings with the agronomists produced a detailed description of the wine food-chain, with special regards to the vineyard and the cellar: a lot of measurable parameters have been identified and described
- Appropriate features for each of the identified sensors have been identified and described in what has been called "Sensor Matrix", which identifies and describes a number of relevant characteristics for each sensor



Aml Scenario: The Requirements

Detailed System's and functional Requirements has been collected

System's requirements: identification of possible solutions at the state of the art, suitable for the physical implementation of the Aml infrastructure's subsystems in the pilot-site, namely the distributed network of sensors and the software platforms

Functional Requirements: identification of the required functionalities of the Data Storage System, the Real Time Monitoring System and of the Analysis System (identification of *Alert* and *Alarm* parameters)



The Architectural choices

- For the implementation of the distributed network of sensors the **Sensor Web** architecture has been chosen
- **The Aml Application Level Architecture is transparent to the chosen WSN and to the chosen scenario**
 - Use of the Protocol Handler and of a data modelling language faces this problem



Sensor Web

An example of high density sensors network

A macro-instrument for the spatio-temporal understanding of an environment

Large number of wireless transducer elements (**mote**), distributed in an environment, not connected to any energy source and capable of:

- sensing it (by integrating a lot of sensors),
- computing and communicating the measured data.

Global sharing of information → mote synergism

- (the whole of their activity being greater than sum of their parts)



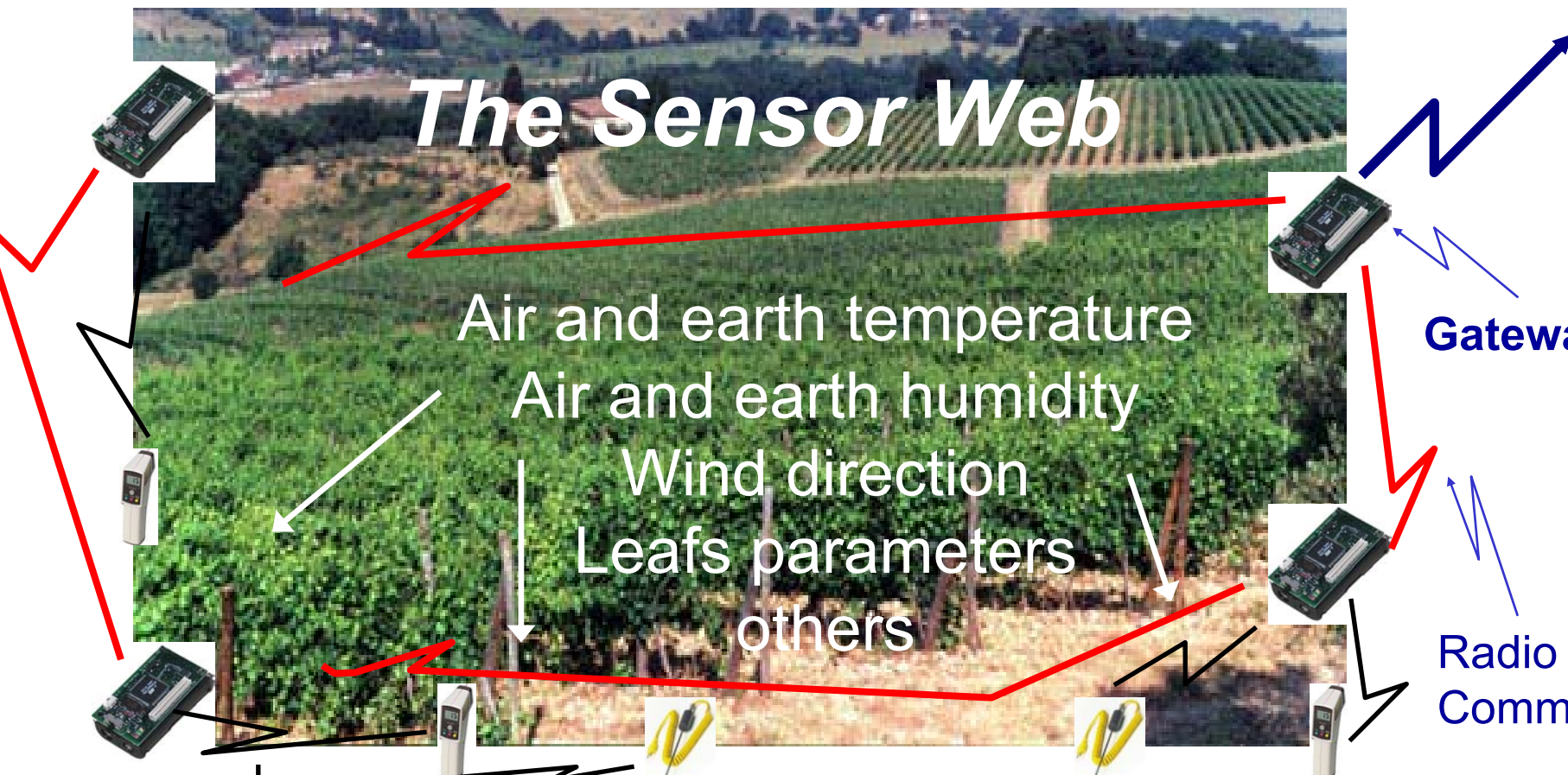
Aml GRID Scenario

Monitoring the vineyard during the entire vegetative cycle plants

Ip-based Comm

The Sensor Web

Air and earth temperature
 Air and earth humidity
 Wind direction
 Leafs parameters
 others



Gateways

Radio Comm



Aml GRID Scenario

Monitoring the vineyard during the entire vegetative cycle plants

- The mote components will be installed in the cellar too, to monitor:
 - Cellar environmental parameters
 - Wine parameters (e.g. the Fermentation)
 - Wine ageing (barrel) parameters

By means of
the Data modelling language and the PH layer,
new VIRTUAL SENSORS can be defined.



The Virtual Sensors

The VS can be defined to:

- create aggregate observations from basic sensors
- create functional approximations of non existing sensors
- automatically monitor correlations among different (possibly heterogeneous) sensors

The OPERATIONS

- The requests of creation/configuration of VS are presented to the Resource Management (in the PH), from the higher level applications.
- The PH has to transform them into sequences of commands to be sent to the RDA.



Aml GRID Scenario

The agronomists suggested a set of interesting virtual sensors for the wine-chain scenario:

- Temporal and spatial aggregation of environmental and cellar parameters
- New measurements for approximating non-existing sensors, according to the following table:

Virtual Sensors	temperature	air rel. humidity	rain fall	wind speed
Downy mildew	X	X	X	
Powdery mildew	X	X		
Grey mould	X	X		
Evapotranspiration	X			X

+ *Functional Specifications*



Aml GRID Scenario

Monitoring the vineyard during the entire vegetative cycle plants

The agronomists suggested a set of **ALERT** and **ALARM** situations too, according to the values and the combinations of the measured parameters:

- Vineyard
 - Drought stress
 - Pathogen attack
- Cellar
 - Fermentation parameters
- Ageing
 - SO₂
 - Acetic Acid

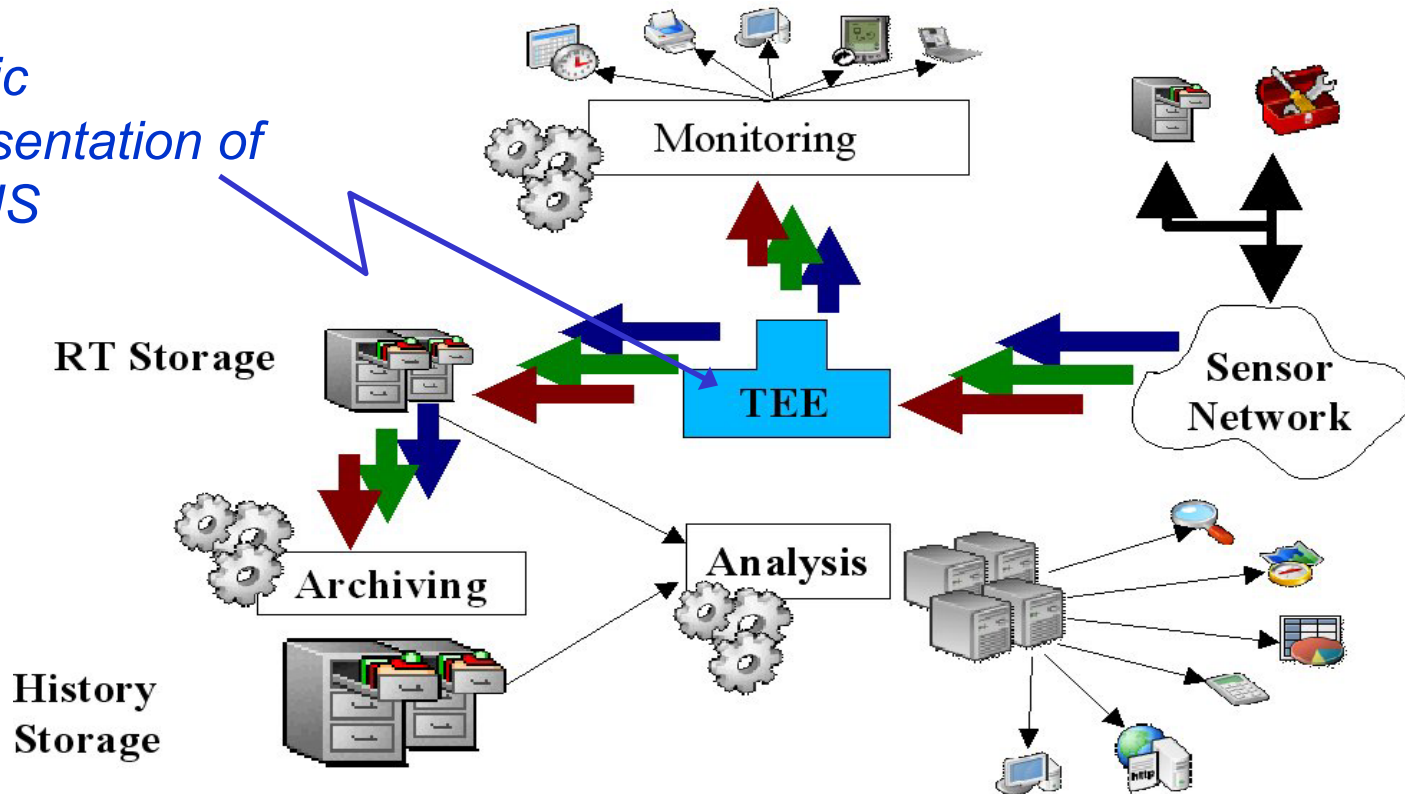
Required variables
The Formula
Alert/alarm rules



Aml GRID Data Workflow

The data produced by a Sensor Network is streamed into the Aml layer according to the following schema:

Graphic Representation of the BUS



NB: This is a GENERAL PURPOSE Schema



Aml GRID Data Workflow

The **Real Time (RT) Monitoring** process is able to visualize the data coming from a sensor (BASIC or VIRTUAL) or simple combinations of that data that are produced by operations who aggregate the data in both ways intra sensor or inter sensors.

The data is then streamed into a **Real-time Storage** that makes it persistent.

Archiving is a complex operation that might involve the functional transformation of the data along with a timing policy that drives the operation.

Analysis involves both the storage systems (real-time and historical) and is intended to model the study of the acquired data to obtain cross comparisons among long time periods, decision and planning support, find new patterns in natural phenomena, economically exploit the results and quality assurance (**Use of KDD and DSS methodologies**)

Finally all this information can be publicated using the **GUI Systems**



Aml GRID User Interfaces

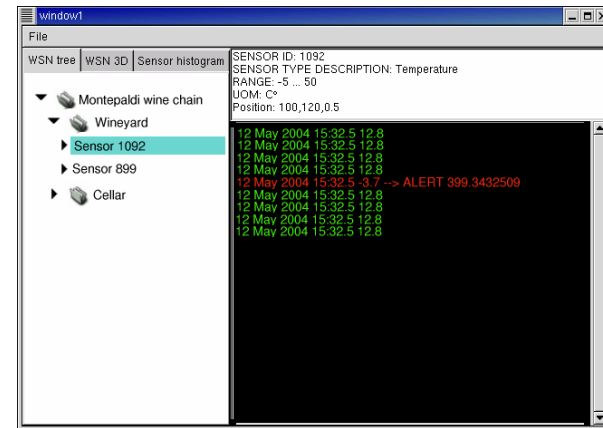
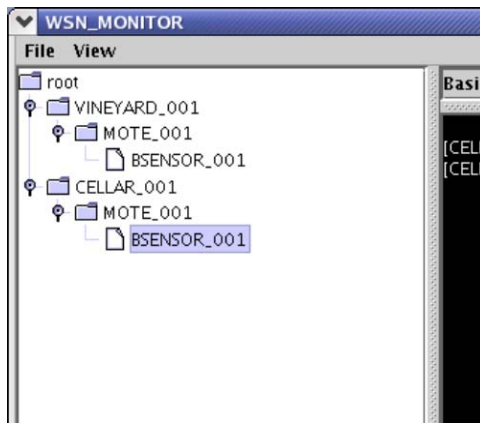
- UI are required to enable the human operators to interact with the Remote Data Acquisition (RDA) level both in terms of resource and observational data management.
- Observational data is presented to the user during two specific activities:
 - **Monitoring** is a mainly automatic activity that is used to control some attributes that influence the life of the specific food chain.
 - **Analysis** activity is a computer aided Decision Support System designed as a management tool to assist the domain experts in the different food-chains to achieve their target levels of efficiency, yield and fruit quality, while reducing the risk of crop loss and minimising the use of chemicals and other input
- The User Interface functionalities design depends on the chosen Scenario



Aml GRID Scenario

A Preliminary User Interface for RT Monitoring

- Based on a tree widget: it shows a schematic view of the RDA level
- A text (or graphic) panel describes the sensor characteristics (higher) and displays the monitored values (lower).



With this preliminary UI design, used for a early mock-up, we intend to address the

Aml Experience Prototyping issue



Aml GRID Scenario: Examples

REAL TIME MONITORING (Use of simple DSS)

- Monitoring of the **drought stress**
 - the **drought stress** is monitored in real time by the system, measuring the soil moisture
 - a **ALARM** is activated if soil water content < 30% of soil available water
 - The **ALARM Rule** depends on the growing state of the plants. The actions are: **TO IRRIGATE** or **NOT TO Irrigate**.
 - If the plants have to be IRRIGATED, the RTM System computes the Potential Evapotranspiration (as VIRTUAL SENSOR) and suggests the type and the location of the irrigation
- **Other Example:**
 - With the last values of cellar temperature, must temperature and the presence of CO₂, the RT Monitoring System sends an alert because the must fermentation could be interrupted



Aml GRID Scenario: Examples

ANALYSIS SYSTEM

- **Prediction of the Toxigenic Fungi**
 - The agronomist queries the Analysis System (AS) to obtain the **aggregation** of air temperature, soil humidity and wind intensity in the last 30 days and **to correlate** this data with one of the last years **to foresee the presence of toxigenic fungi**
 - The AS activates a KDD process to correlate the aggregated data of the last 30 days and the historical data of the vineyard.
 - The results of the KDD process are elaborated by a wine –chain Decisions Support System to provide a forecast of the fungi attack and to suggest to the agronomist the better initiative to take.



The proposed Process for a Aml Compliant food-chain

- User's needs analysis (Use of Sensor Matrix)
- Definition of the System's and functional requirements (use of Synapsis Questionnaire)
 - Temporal and spatial aggregation of the measurements
 - Definition of Virtual Sensors
 - Identification of Alarm/alert situations
- Definition of preliminary User Interfaces
- Design and developing of early mock-ups