THE NEW APPLICATION ENVIRONMENT

- **A VERY LARGE NUMBER** of large data sources
- **GENERALLY** **HIGHLY VARIABLE AND VOLATILE** data (e.g., web)
- **HIGHLY HETEROGENEOUS** data sources
- **DIFFERENT** **DATA STRUCTURING LEVELS**
  - Databases with **DIFFERENT UNDERLYING MODELS** (relational, object oriented, legacy...)
  - **SEMI-STRUCTURED DATA** (XML, HTML, other tagging systems...)
  - **NON-STRUCTURED DATA** (text, image, sound, etc...)
- **DIFFERENT** **TERMINOLOGIES AND CONTEXTS**
AUTONOMIC PERVERSIVE SYSTEMS

– CONTEXT-AWARE

– REACTIVE

– SELF-ADAPTING

PERVASIVE IS: ADAPTIVITY

• HIGHLY DYNAMIC ENVIRONMENT
  – RESOURCE DISCOVERY
  – DATA SEMANTICS ACROSS HETEROGENEOUS SOURCES
  – DYNAMIC OPTIMIZATION
  – CHANGE OF CONTEXT

• CHANGING USER ROLES AND NEEDS
  – ASSESSING INSTANTANEOUS USER NEEDS/INTERESTS
    • USER PREFERENCES
  – MODELING AND EXPLOITING USER CHARACTERISTICS
    • USER PROFILE
PERVASIVE IS: METADATA

TO EXPLOIT THE AUTONOMIC FUNCTIONALITIES, THE SYSTEM USES METADATA

- **CONTEXT DATA**
  - STATIC FEATURES AND PROPERTIES
  - ISTITANTANEOUS SITUATIONS OF THE OPERATING ENVIRONMENT

- **PERSONALIZATION**
  - PERSONAL CHARACTERISTICS AND BEHAVIOUR
  - PREFERENCES OF INDIVIDUAL USERS (HIGHLY PRIVACY SENSITIVE)

PERVASIVE IS: DATA MANAGEMENT

CONTEXT-AWARENESS The six "W" questions

1. **What** is context?
2. **Who** might benefit from an awareness of their context; whose context is important to whom, or what?
3. **Where** can an awareness of context be exploited?
4. **When** is context-awareness useful?
5. **Why** are context-aware applications useful?

Answers to these five questions underpin the higher level, meta-question of:

6. **How** do we implement context-awareness so that we can develop context-aware applications?

CONTEXT AWARENESS

ABSTRACT SERVICES TO ASSIST THE PROGRAMMER IN IMPLEMENTING C-A APPLICATIONS

- **CONTEXT SUBSCRIPTION AND DELIVERY**
  - A SERVICE THAT CAN NOTIFY A COMPONENT WHEN AN EVENT OCCURS

- **CONTEXT QUERY**
  - A MECHANISM TO FIND A SUITABLE INFORMATION OR SERVICE

- **CONTEXT TRANSFORMATION**
  - CONVERSION OF LOW-LEVEL DATA INTO HIGH-LEVEL INFORMATION

- **CONTEXT SYNTHESIS**
  - AGGREGATION OF CONTEXT INFORMATION TO GENERATE A MORE PRECISE OR DETAILED CONTEXT

PERVASIVE IS: DATA MANAGEMENT

HETEROGENEOUS DATA SOURCES

- A LARGE NUMBER OF DATA SOURCES
- TIME-VARIANT DATA
- MOBILE, TRANSIENT DATA SOURCES
- MOBILE USERS
- DIFFERENT LEVELS OF DATA STRUCTURE
  - Databases (relational, OO…)
  - Semistructured datasources (XML, HTML, more markups …)
  - Unstructured data (sensors, text, multimedia etc…)
- DIFFERENT TERMINOLOGIES AND DIFFERENT OPERATION CONTEXTS
PERVASIVE DATA MANAGEMENT

PerLa
The PerLa system is basically composed of three components:

• The NODES
  - heterogeneous devices equipped with sensors (such as RFID tags or WSN nodes such as MOTES) or more complex devices (such as palms, portable computers or ad hoc boards).

• The MIDDLEWARE
  - is a stack of software layers providing a high level abstraction of each node (called LOGICAL OBJECT).
  - implements a set of functionalities to allow communications among logical objects and to manage devices that enter and leave the system (following a “Plug and Play” behaviour).

• The LANGUAGE
  - a full declarative high level language that allows to query a pervasive system, hiding the difficulties related to the need of handling different technologies.
  - provides a database like abstraction of the whole network in order to hide the high complexity of low level programming and allows users to retrieve data from the system in a fast and easy way.

http://perla.dei.polimi.it/index.php
PERVASIVE DATA MANAGEMENT

THE MoGATU FRAMEWORK (Perich et Al. 2004) ABSTRACTS ALL DEVICES IN TERMS OF
– INFORMATION PROVIDERS
  HOLD (HETEROGENEOUS) FRAGMENTS OF DATA ANNOTATED IN A SEMANTIC LANGUAGE
– INFORMATION CONSUMERS
  HUMAN OR AUTONOMOUS SW AGENTS WHO QUERY AND UPDATE DATA
– INFORMATION MANAGERS (ONE PER DEVICE)
  RESPONSIBLE OF THE NETWORK COMMUNICATIONS AND MOST DATA MANAGEMENT FUNCTIONS
WHICH ARE EQUAL SEMIAUTONOMOUS PEERS GUIDED IN THEIR INTERACTION BY CONTEXT AND PROFILES

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OTHER PERVERSIVE DATA MANAGEMENT SYSTEMS

• AURA

• CoolTown

• DSN

• GAIA

• GSN

• SECAS

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HOMEWORK DEEPENING TOPICS 4

- ABOUT CONTEXT AWARENESS (Prof. Tanca)
- ABOUT DATA INTEGRATION (Prof. Tanca)
- IN-DEPTH DESCRIPTION OF A PERVERSIVE DATA MANAGEMENT SYSTEM

AUTONOMY

- AUTOMATIC CONTROL SYSTEMS
**PERVASIVE INFORMATION SYSTEM MODEL**

![Diagram of Pervasive Information System Model]

**SOME R&D OPEN PROBLEMS (1)**

- A pervasive information system is a *dynamic* system possibly composed of *hundreds or thousands of nodes* and multiple feedback paths exist between the field (sensors) and the control logic (context and middleware).

  It is impossible to test a real prototype of the system at design time.

- **Scalability** thus becomes an important issue when designing system control algorithms.

- System **stability** also is affected by many factors and must be checked and controlled.
SOME R&D OPEN PROBLEMS (2)

ALGORITHM COMPLEXITY (SCALABILITY)

THE MEMORY AND TIME BEHAVIOUR OF ALGORITHMS CANNOT BE INFERRED BY TESTING SYSTEMS COMPOSED OF ONLY A BOUNCE OF NODES: CONSTANTS MATTER!

\[
y = 2^n, \quad y = n, \quad y = n^2
\]

SOME R&D OPEN PROBLEMS (3)

SYSTEM STABILITY

NO GENERAL METHOD EXISTS COMPARABLE TO WHAT IS DONE IN CONTINUOUS SYSTEMS DESCRIBED BY DIFFERENTIAL EQUATIONS (root locus plot, phase plan analysis, catastrophe theory, …)

– NOISE IN THE SENSORS OUTPUT
  • CLEANING AND FILTERING

– TIME CONSTANTS IN THE FEEDBACK PATHS
  • RELATIVE COMPATIBILITY CHECKS???

– ERRORS IN THE RULES DEFINING THE CONTEXT (AND THE CONTEXT CHANGES)
  • MODEL CHECKING???
SOME R&D OPEN PROBLEMS (3)
SIMULATION Vs. TESTBEDS

- **SIMULATION** OFTEN PROVIDES IMPRECISE RESULTS OWING TO MANY PARAMETERS OF THE SYSTEM WHICH ARE NOT ACCOUNTED FOR BY THE SIMULATION PROGRAMS
- **TESTBEDS** WITH A VERY LARGE NUMBER OF COMPONENTS ARE VERY DIFFICULT, IF NOT IMPOSSIBLE, TO ORGANIZE

• USE TESTBEDS TO TUNE AND CALIBRATE SIMULATION PROGRAMS???

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