PERLA:

A DATA LANGUAGE FOR PERVASIVE SYSTEMS

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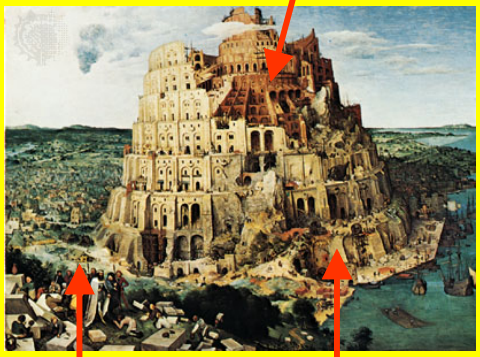
THE WINE PRODUCTION PROCESS



PREVIOUS SENSORS LANGUAGES

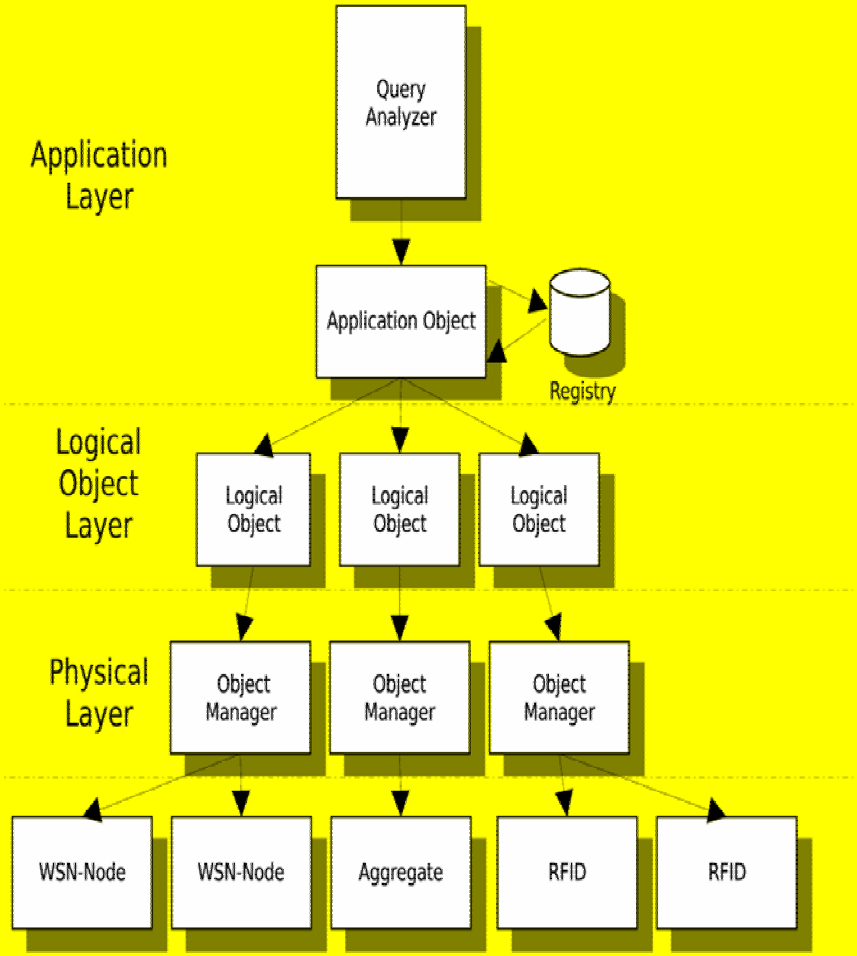
- **TinyDB (U. C. Berkeley)**
  - ONE OF THE FIRST AND MOST KNOWN PROJECTS
  - PORTABILITY BOUND TO TinyOS
- **GSN (EPFL Lausanne)**
  - SCALABLE, LIGHTWEIGHT, DYNAMICALLY ADAPTABLE TO SYSTEM CONFIGURATION
  - XML FOR NETWORK AND DATA SPECIFICATION
  - SQL FOR DATA MANIPULATION
- **DSN (U. C. Berkeley)**
  - THE WHOLE SYSTEM IS BUILT AND MANAGED IN Snlog (A DATALOG DIALECT)

PERLA APPROACH

- **PERVASIVE SYSTEMS AS TARGET**
  - RUN-TIME SUPPORT OF HETEROGENEITY
  - SUPPORT OF NON INTELLIGENT DEVICES
  - EVENT- AND TIME-BASED SEMANTICS
- **SINGLE SYSTEM – SINGLE LANGUAGE**
  - **FUNCTIONAL** FEATURES
    - RAW DATA MANIPULATION → QUERY RESULTS
    - SET SAMPLING PARAMETERS
  - **NON FUNCTIONAL** FEATURES
    - CONSTRAINTS ON THE FUNCTIONALITY
    - QoS (MAINLY POWER MANAGEMENT)
    - DETERMINE THE PARTICIPATION OF A NODE TO A QUERY

MIDDLEWARE ARCHITECTURE

- **APPLICATION LAYER**
  - FRONT-END FOR DATA ACCESS
- **LOGICAL OBJECT LAYER**
  - ABSTRACTION FOR PHYSICAL DEVICES
- **DEVICE ACCESS LAYER**
  - SW INFRASTRUCTURE FOR DEVICE ACCESS



LOGICAL OBJECTS ATTRIBUTES

- **STATIC**
  - **NODE CHARACTERISTIC (type, max. sampling rate, …)**
- **DYNAMIC PROBING**
  - **VARIABLES READ FROM PHYSICAL DEVICES (sensor measurements)**
- **DYNAMIC NON-PROBING**
  - **LOCALLY CACHED VALUES**

LANGUAGE FEATURES

- DATA REPRESENTATION
- FUNCTIONAL CHARACTERISTICS
- PHYSICAL DEVICE MANAGEMENT
- NON-FUNCTIONAL CHARACTERISTICS

PHYSICAL DEVICE MANAGEMENT

- DEFINITION OF THE SAMPLING SEMANTICS FOR EACH CLASS OF DEVICES
  - READING OF A LOGICAL OBJECT ATTRIBUTE
  - PERIODIC SAMPLING
  - EVENT BASED SAMPLING

- EXAMPLE: RFID ABSTRACTION
  - RFID TAG AS A SENSOR
    - *SAMPLED DATA* → ID OF THE LAST READER WHICH SENSED THE TAG
  - READER AS A SENSOR
    - *SAMPLED DATA* → ID OF THE LAST TAG SENSED BY THE READER
  - EVENT BASED SAMPLING
    - WHEN THE CORRESPONDING LOGICAL OBJECT SENSES THE *READER FIRING*

NON-FUNCTIONAL CHARACTERISTICS

- NON FUNCTIONAL FIELDS EXPOSED BY LOGICAL OBJECTS ARE EXPRESSED IN AN ABSTRACT WAY AND TRANSLATED IN CONCRETE VALUES HANDLED BY PHYSICAL DEVICES

- EXAMPLE: A DEVICE PERCENTAGE POWER LEVEL
  - VOLTAGE VALUE
  - PREDICTED FROM THE NUMBER OF PERFORMED OPERATIONS
  - SET TO 100% FOR A.C. POWERED DEVICES

LOGICAL OBJECTS INTERFACE

- **RETRIEVE ATTRIBUTES VALUES**
  - DATA
  - POLICIES
- **FIRE NOTIFICATION EVENTS**
  - EVENT BASED SAMPLING
  - ACTIVATE QUERY SELECTION
- **GET THE LIST OF SUPPORTED ATTRIBUTES AND THEIR PROPERTIES**

DATA STRUCTURES

- **STREAM TABLES**
  - **UNBOUNDED LISTS OF RECORDS. QUERIES CAN PERFORM**
    - INSERT (GENERATES AN INSERTION EVENT)
    - READ (EXTRACTS A DATA *WINDOW[ts, size]*)

- **SNAPSHOT TABLES**
  - **SET OF RECORDS PRODUCED BY A QUERY IN A GIVEN PERIOD**

EVERY RECORD IS TIME-STAMPED

LANGUAGE LEVELS

- **LOW LEVEL**
  - **DEFINES THE BEHAVIOUR OF A SINGLE OR OF A GROUP OF DEVICES ABSTRACTED BY A SINGLE LOGICAL OBJECT**
    - **PRECISE DEFINITION OF SAMPLING OPERATIONS**
      - **READ ATTRIBUTES FROM A LOGICAL OBJECT**
      - **INSERT VALUES IN THE LOCAL BUFFER**
    - **PERFORM SIMPLE *SQL* OPERATIONS (filtering, grouping, …)**
      - **ON DATA IN THE LOCAL BUFFER**
      - **INSERT RECORDS IN A DATA STRUCTURE**
  - **PERIODIC OR EVENT BASED**
  - **CONDITIONAL EXECUTION**

LANGUAGE LEVELS

- **HIGH LEVEL**
  - **PERFORMS COMPLEX *SQL* QUERIES ON WINDOWS EXTRACTED FROM ONE OR MORE INPUT STREAMS**
    - **TIME DRIVEN**
    - **EVENT DRIVEN**

THE PILOT JOIN OPERATION

MONITOR THE TEMPERATURE OF ALL THE WINE PALLETS IN TRUCKS WHOSE CURRENT POSITION IS IN A GIVEN PARKING AREA

- **TEMPERATURE SENSORS ON PALLETS**
- **POSITION SENSORS ON TRUCKS**

THE PILOT JOIN OPERATION ACTIVATES THE EXECUTION OF A LOW LEVEL QUERY ON LOGICAL OBJECTS CONDITIONED BY VALUES SAMPLED ON OTHER NODES

THE PILOT JOIN OPERATION

- **EVENT BASED PILOT JOIN**
  - **WHEN AN EVENT HAPPENS, A GIVEN SET OF NODES ARE FIRED TO SAMPLE (e.g. sense pallet temperature for 15 minutes every time a truck enters parking area *B*)**
- **CONDITION BASED PILOT JOIN**
  - **CONTINUOUS SAMPLING IS PERFORMED ON NODES CONNECTED TO A GIVEN BASE STATION (e.g. start samplig every 15 minutes the temperature of pallets whose last sensed position was in parking area *B*)**

COMPLEX QUERY EXAMPLE

LIST PALLETS *ID*'S WHOSE TEMPERATURE EXCEEDED A GIVEN THRESHOLD WHILE TRAVELLING THROUGH A CRITICAL ZONE

```
DEFINE SNAPSHOT
  TrucksPositions (ID baseStationId) AS
WITH DURATION 1 hour
SELECT baseStationId
SAMPLING EVERY 1 hour
WHERE is_in(location, CRITICALZONE)
EXECUTE IF deviceType = "GPS"


DEFINE OUTPUT STREAM
  OutOfTemperatureRangePallets (ID palletId)
EVERY 10 min
SELECT id
SAMPLING
    EVERY 10 min
    WHERE temperature > threshold
PILOT JOIN TrucksPositions ON
    currentBaseStationId =
    TrucksPositions.baseStationId
EXECUTE IF EXISTS (ALL)
```

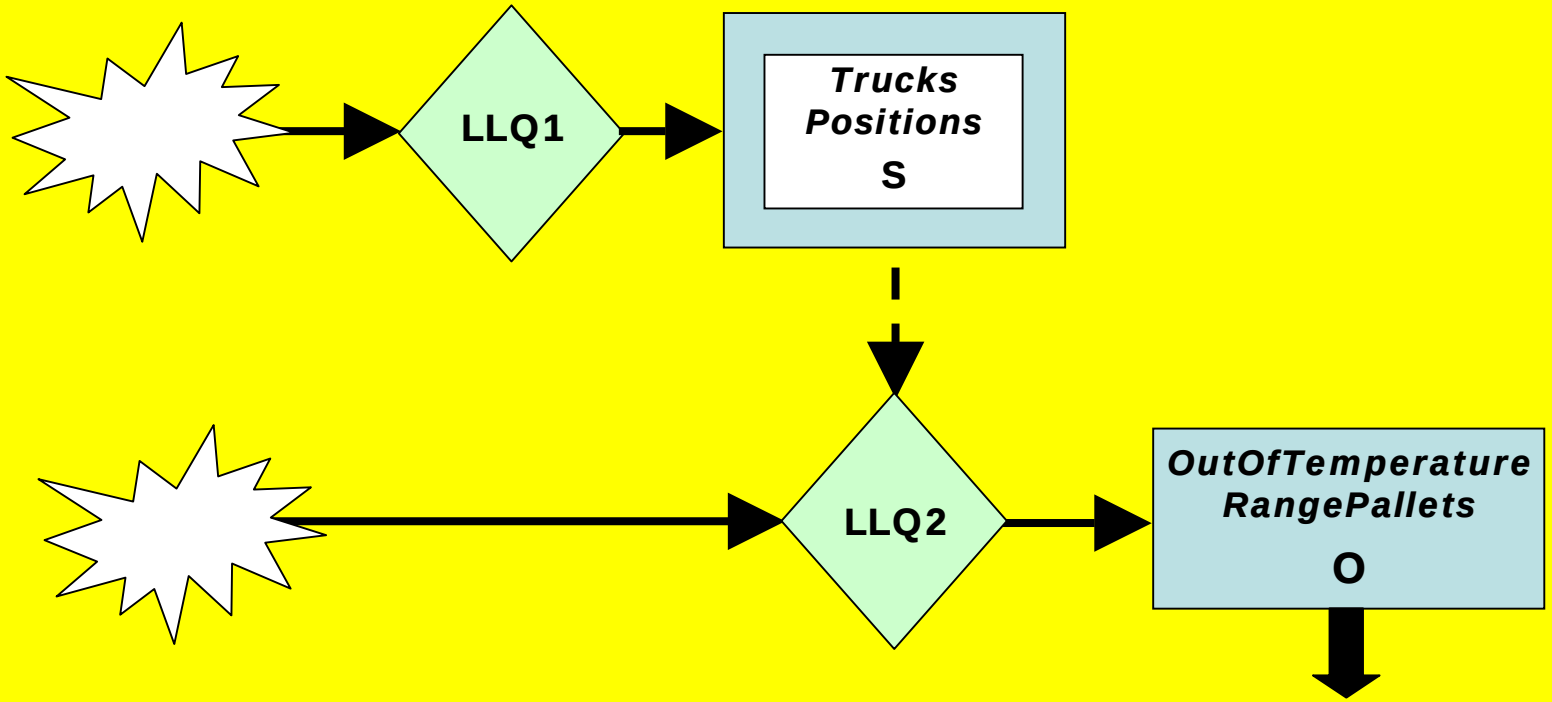
COMPLEX QUERY EXAMPLE

LOGICAL OBJECT ATTRIBUTES

GPS		
• **id**	**ID**	**(static)**
• **location**	**COORDS**	**(dynamic probing)**
(current truck position sensed by GPS)		
• **baseStationId**	**ID**	**(static)**
(id of the base station mounted on the truck)		
• **deviceType**	**STRING**	**(static)**

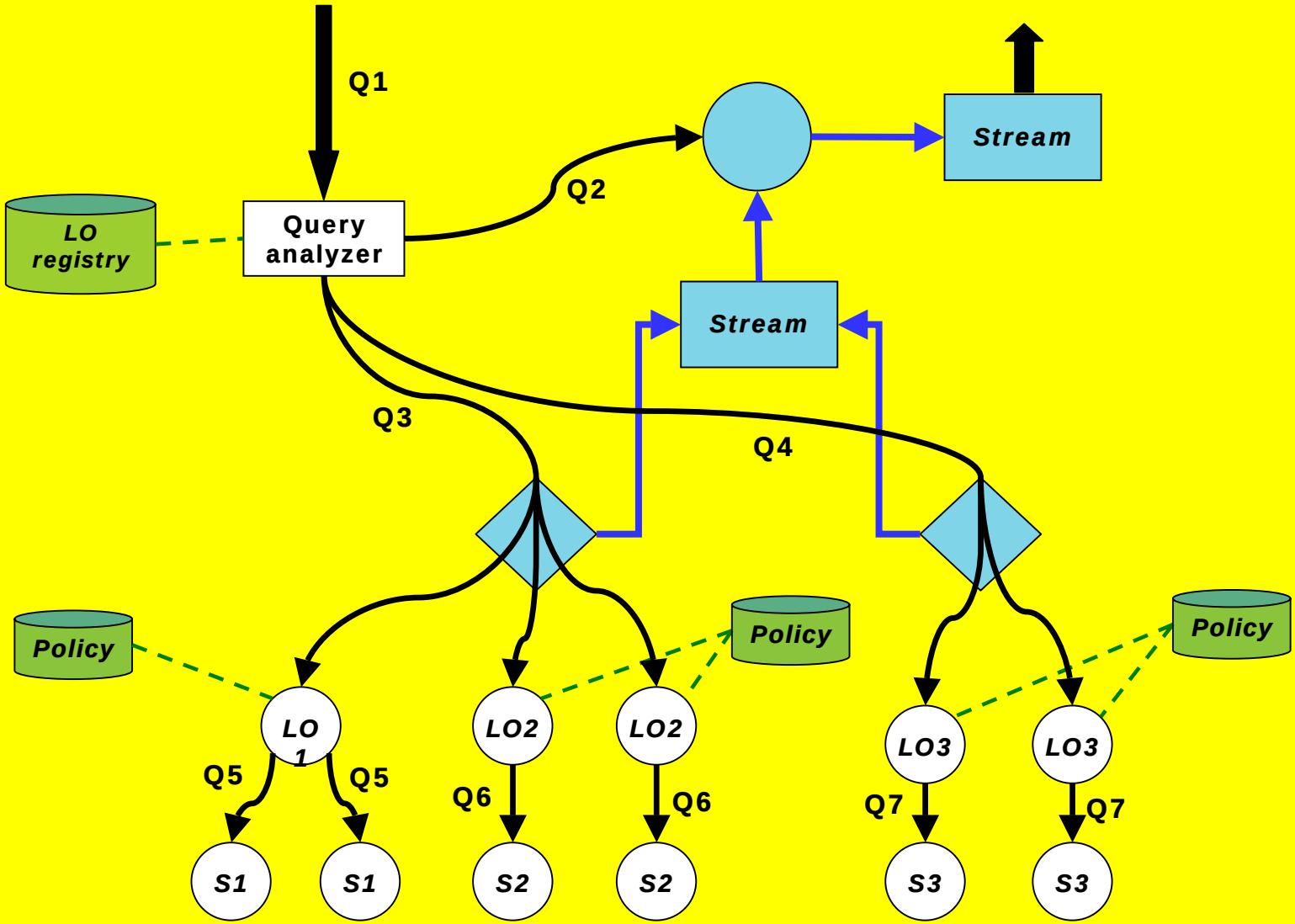
TEMPERATURE NODE		
• **id**	**ID**	**(static)**
• **temperature**	**DOUBLE**	**(dynamic probing)**
(current pallet temperature)		
• **currentBaseStationId**	**ID**	**(dynamic non probing)**
(id of the base station the node is currently connected to)		
• **deviceType**	**STRING**	**(static)**

QUERY PROCESSING



LLQ1, LLQ2	low level query	O	output stream
→	data flow	S	snapshot
- - →	pilot join		

QUERY DECOMPOSITION



STATE OF THE PROJECT

• LANGUAGE GRAMMAR AND SEMANTICS DEFINITION	• COMPLETED
• PARSER AND QUERY ANALYZER IMPLEMENTATION	• COMPLETED
• LOW LEVEL AND HIGH LEVEL QUERY ENGINES	• IN COURSE
• LOGICAL OBJECTS DESIGN AND IMPLEMENTATION	• UNDER DESIGN (Technological choices)
• SENSORS SIMULATOR	• COMPLETED
• NEW LANGUAGE FEATURES (Actuators, Data Mining, …)	• FUTURE WORK

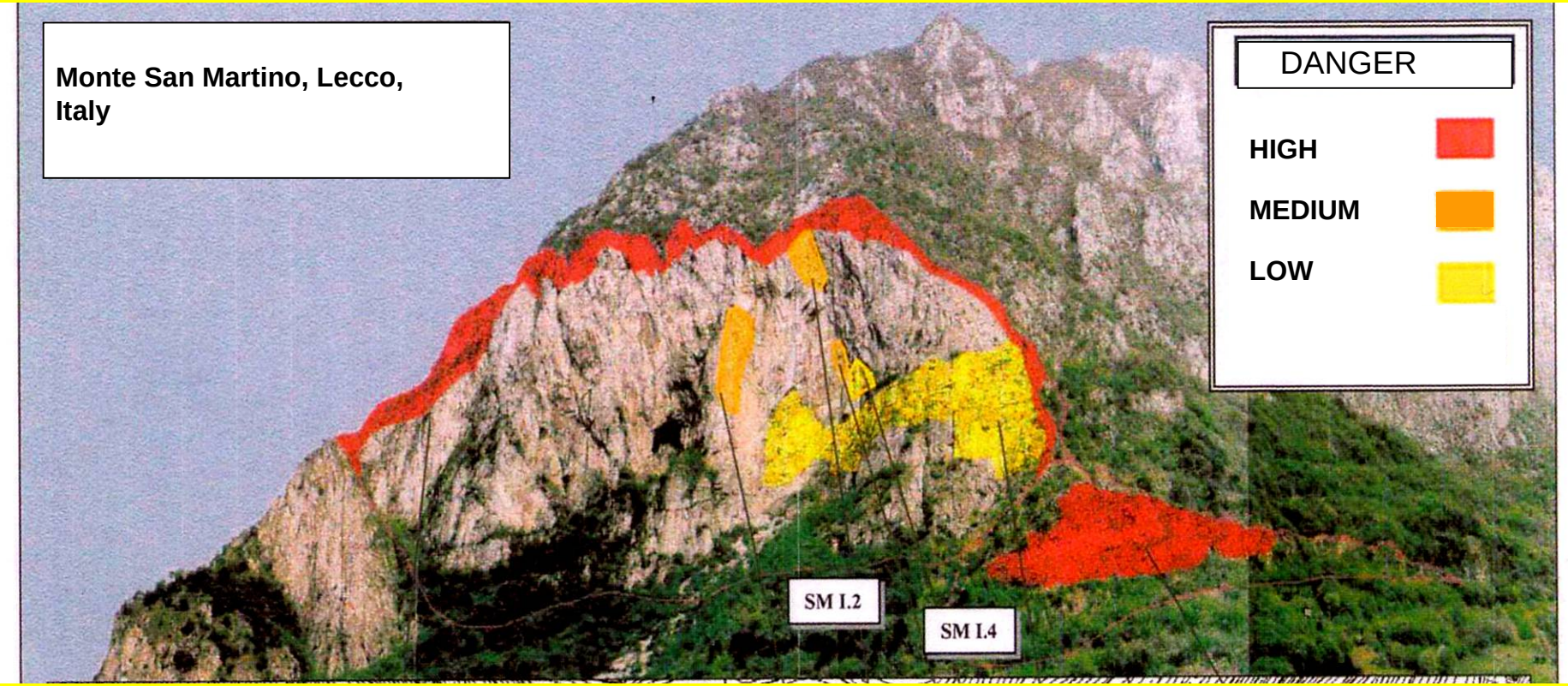
A REAL WORLD TESTBED

WE USED THE WINE AND TRANSPORT EXAMPLE AS THE MAIN CASE STUDY DURING THE LANGUAGE DEFINITION PHASE

ROCKFALL MONITORING

- **THE FIRST RELEASE OF PERLA WILL BE ADOPTED IN A ROCKFALL MONITORING PROJECT (PROMETEO)**
  - **CONCRETE AND MISSION CRITICAL APPLICATION**
  - **SENSORS ARE AD-HOC BOARDS:**
    - **GEOPHONES**
    - **ACCELEROMETERS**
    - **TEMPERATURE SENSORS**
  - **EXPLOITS EVENT BASED MONITORING FEATURES**
  - **ALLOWS THE TESTING OF THE SYSTEM BEFORE THE IMPLEMENTATION OF ALL THE LANGUAGE FEATURES**

GEOLOGICAL INVESTIGATION OF THE TESBED

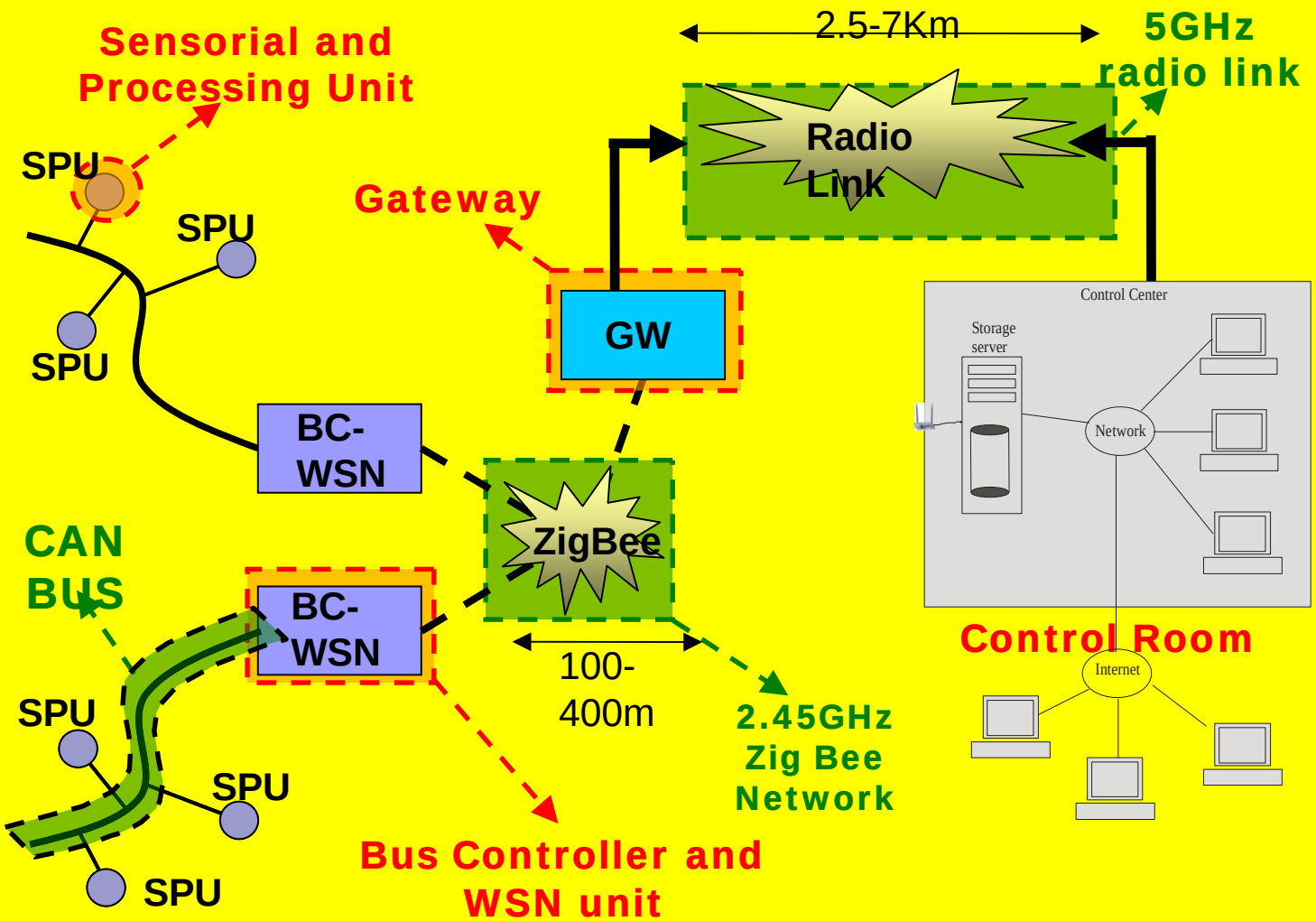


COURTESY OF C. Alippi et Al.

A POSSIBLE DEPLOYMENT

COURTESY OF C. Alippi et Al.

AN OVERVIEW OF THE HW INFRASTRUCTURE



CONCLUSIONS

- ***PERLA* FEATURES**
  - ***PERLA* IS ENTIRELY SQL-LIKE**
  - ***PERLA* GIVES AN IMPORTANT ROLE TO THE SAMPLING OPERATION**
  - ***PERLA* ALLOWS THE SAMPLING ACTIVATION ON A NODE BASED ON DATA SAMPLED FROM ANOTHER NODE (PILOT JOIN OPERATION)**
  - **METADATA AND DATA HOMOGENEOUSLY MANAGED (e.g.: Power levels, …)**

CONCLUSIONS

	PERLA	GSN
FULLY DECLARATIVE LANGUAGE		
HETEROGENEOUS SYSTEMS SUPPORT		
EVENT BASED AND TIME BASED QUERIES		
PILOT JOIN OPERATION SUPPORT		
FULL SAMPLING AND SENSOR PARAMETERS CONTROL		
POLICY MANAGEMENT		

CHEERS!