Institut
National de la
Recherche
Agronomique

Use of Database in Automatic Control & Remote Monitoring

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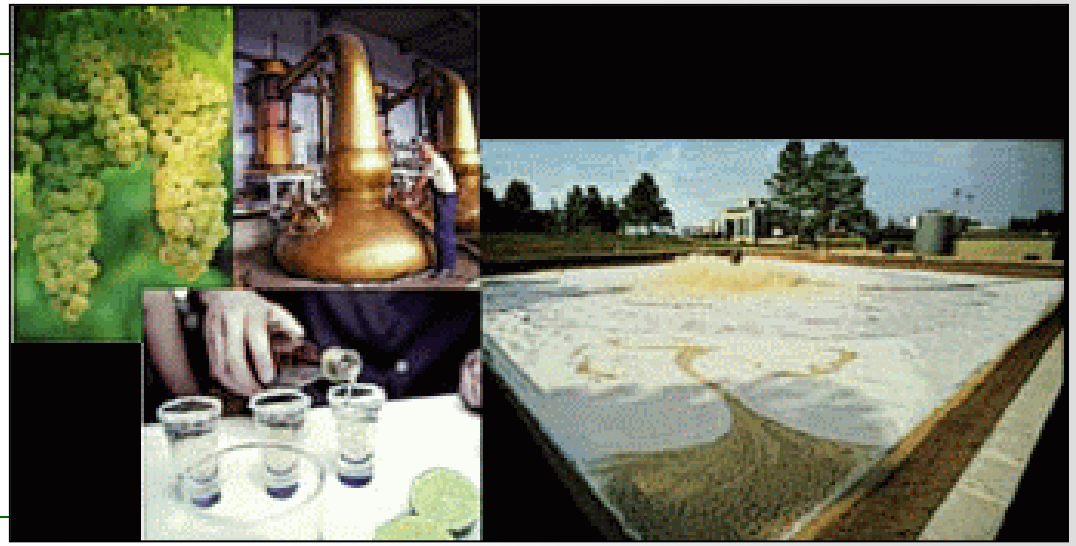


BioXHIT workshop, Grenoble, 4-5 May 2004

Summary

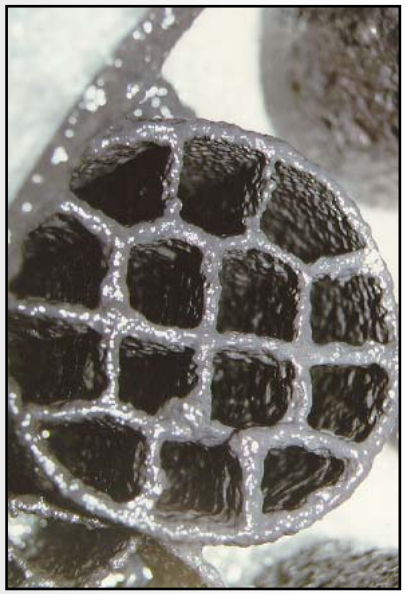
- Supervision and Information System
- Database : main ideas and implementation
- Integration of distributed applications
- Pratical Realisations (the TELEMAC project)
  - ✦ web interfaces
  - ✦ traceability

The Anaerobic Digestion Process

Influent : Distillery Wastewater (CODs ≈ 40 g/l)

Reactor : Fixed Bed Reactor

- Height : 3.5 m
- Diameter : 0.6 m,
- Total Volume : 982 liters

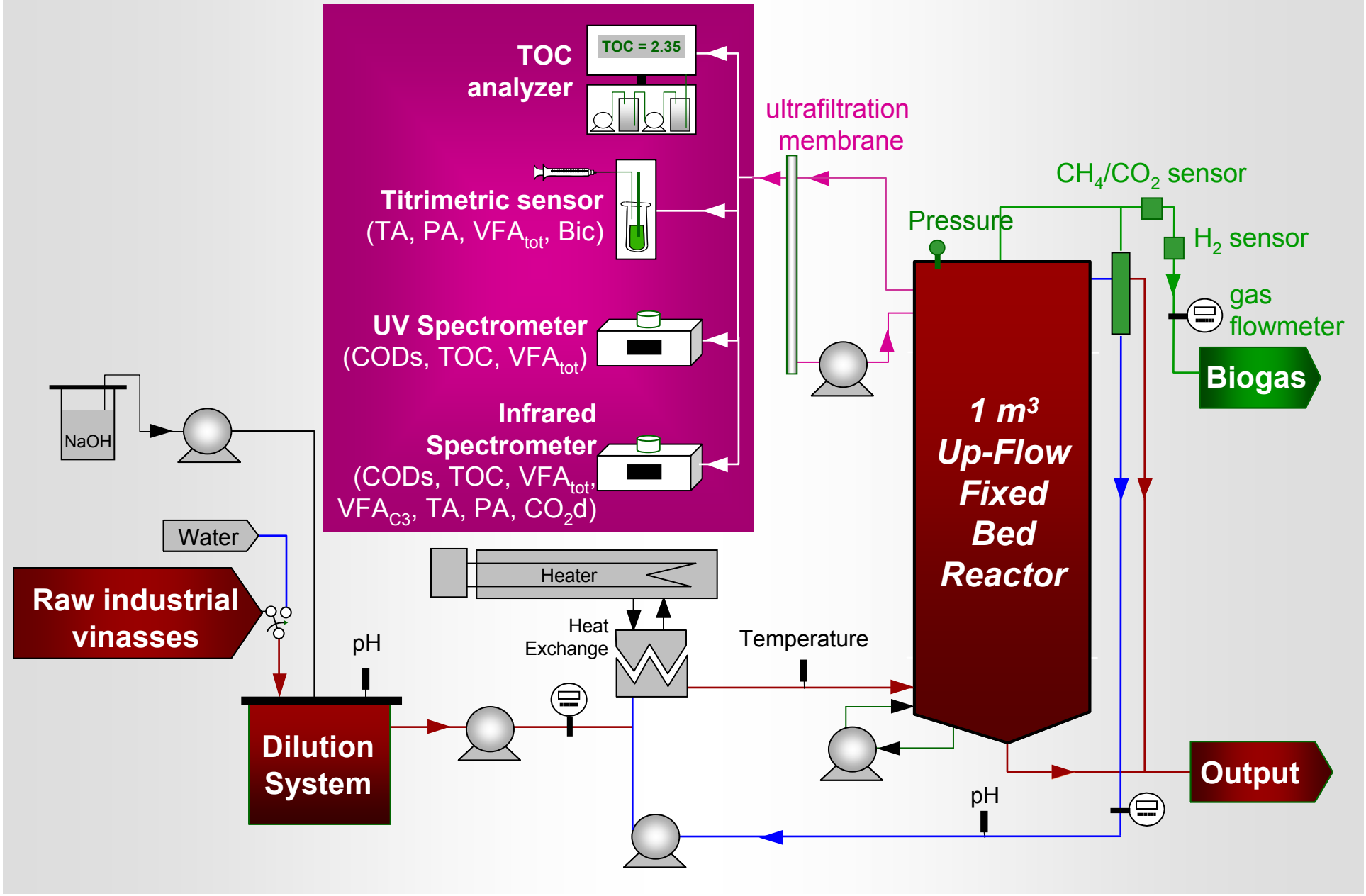


The Anaerobic Digestion Process

In 1997

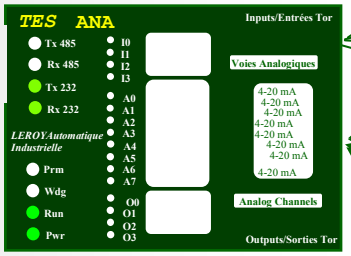
Since 1999

Schematic layout of the plant



Software Architecture

I/O Board + PLC



To the actuators (4-20 mA, 0-10 V, ...)

From the sensors (4-20 mA, 0-10 V, ..)

RS 232/485

gwbasic

Matlab®

Serial link

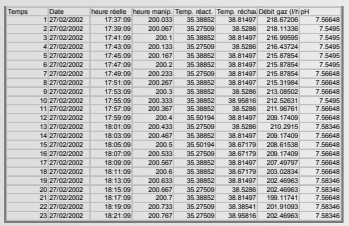
Omnic®

Serial link

MSPC
(Visual Basic)

Excel® files
(2000 lines / files)

Quant®



Temps	Date	heure réelle	heure manip.	Temp. réact.	Temp. réchau	Débit gaz (l/h)	pH	
1	27/02/2002	17:37:09	200.033	35.38852	38.81497	218.67206	7.56648	
2	27/02/2002	17:39:09	200.067	35.27509	38.5286	218.11336	7.5495	
3	27/02/2002	17:41:09	200.1	35.38852	38.81497	216.99595	7.5495	
4	27/02/2002	17:43:09	200.133	35.27509	38.5286	216.43724	7.5495	
5	27/02/2002	17:45:09	200.167	35.38852	38.81497	215.87854	7.5495	
6	27/02/2002	17:47:09	200.2	35.38852	38.81497	215.87854	7.5495	
7	27/02/2002	17:49:09	200.233	35.27509	38.81497	215.87854	7.56648	
8	27/02/2002	17:51:09	200.267	35.38852	38.81497	215.31984	7.56648	
9	27/02/2002	17:53:09	200.3	35.38852	38.5286	213.08502	7.56648	
10	27/02/2002	17:55:09	200.333	35.38852	38.95816	212.52631	7.5495	
11	27/02/2002	17:57:09	200.367	35.38852	38.5286	211.96761	7.56648	
12	27/02/2002	17:59:09	200.4	35.50194	38.81497	209.17409	7.56648	
13	27/02/2002	18:01:09	200.433	35.27509	38.5286	210.2915	7.58346	
14	27/02/2002	18:03:09	200.467	35.38852	38.81497	209.17409	7.56648	
15	27/02/2002	18:05:09	200.5	35.50194	38.67179	208.61538	7.56648	
16	27/02/2002	18:07:09	200.533	35.27509	38.67179	209.17409	7.56648	
17	27/02/2002	18:09:09	200.567	35.38852	38.81497	207.49797	7.56648	
18	27/02/2002	18:11:09	200.6	35.38852	38.67179	203.02834	7.56648	
19	27/02/2002	18:13:09	200.633	35.38852	38.81497	202.46963	7.58346	
20	27/02/2002	18:15:09	200.667	35.27509	38.5286	202.46963	7.58346	
21	27/02/2002	18:17:09	200.7	35.38852	38.81497	199.11741	7.56648	
22	27/02/2002	18:19:09	200.733	35.27509	38.38541	201.91093	7.58346	
23	27/02/2002	18:21:09	200.767	35.27509	38.95816	202.46963	7.58346	

Software Architecture

☺ **It works**

☹ **It is quite complex**

↳ **Evolution on the long term ?**

(*i.e.,* from "data poor, information rich" to "data rich information poor")

From Supervision to Information System

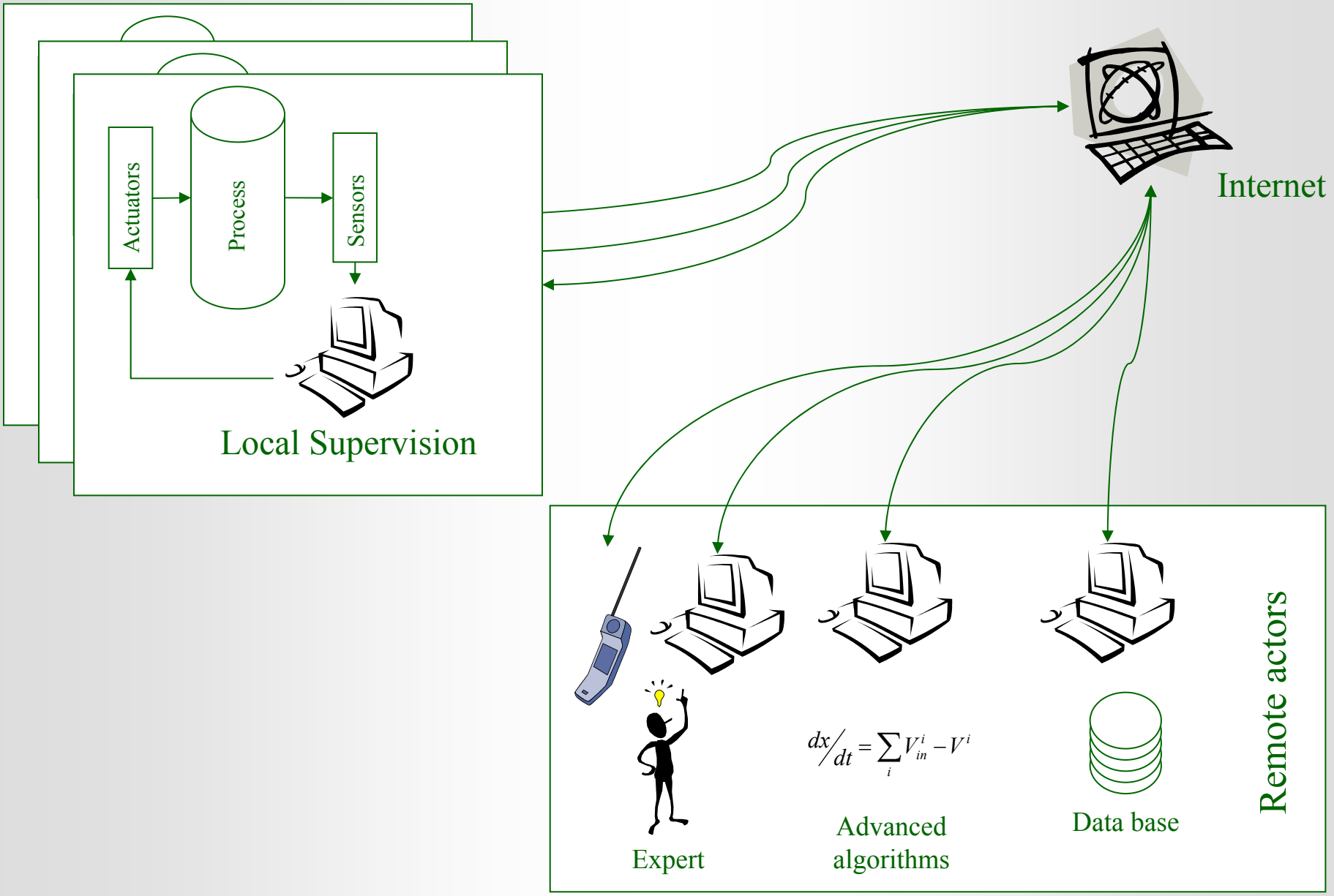
Evolution of requirements

- Richer infomation to be managed: development of sensors and regulation loops, delocated inputs
- More actors can interact: remote decisions, external constraints

Evolution of technical tools

- Computer : from client-server architecture to a virtual network of independant computers
- Connection : availability of local network and Internet connection

Distributed management of information



Information System

A supervision task can be considered as an Information System

Spatial and temporal Distribution of monitoring functions: no hypothesis on the location and the treatment of each part of the supervision task.

- ✓ data aquisition,
- ✓ data display,
- ✓ data storage,
- ✓ data validation,
- ✓ process control,
- ✓ decision support system.

→ Higher robustness and modularity are achieved iif:

- ✓ Collected data are structured
- ✓ Each message is validated
- ✓ Treatment by autonomous modules
- ✓ Storage shared by different modules

Summary

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- Integration of distributed applications
- Pratical Realisations (the TELEMAC project)
  - ✦ web interfaces
  - ✦ traceability

Data storage

Main constraints for storage

- **Rationality :** minimal redundancy of data with a good availability of information
- **Completeness :** all necessary information (to understand data) is collected and stored (traceability)
- **Coherency :** to guarantee the integrity of inserted data
- **Evolutivity :** to be able to adapt data storage to data evolution

Data access

- **Multi-actor :** monitoring, data-mining, web-services,…

- **Standardised :** universal querying language independant of database evolution
- **Secured :** control of access, confidentiality
- **Performant :** keep good performances although accumulation of data

DataBase Management System

Functions of a Data Base Management System (DBMS)

A Database is a set of ***structured*** data so that several users can access and select data with satisfying performances.

A DBMS provides :

- ✓ Storage and verification functions
- ✓ Data research tools
- ✓ Administration tools
- ✓ Access control
- ✓ Communication tools

A Database is a logical intermediate between files and users.
A Database is a server of data, users are clients sending request to the server.

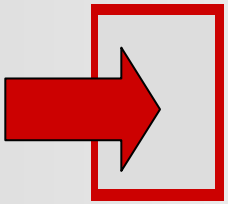
DBMS

To build a DBMS, modelling of information is mandatory !!!

Fundamental and sometimes antagonist properties like evolutivity, exhaustivity and performances rely on the modelling of the information to store

Several types of databases corresponding to different models :

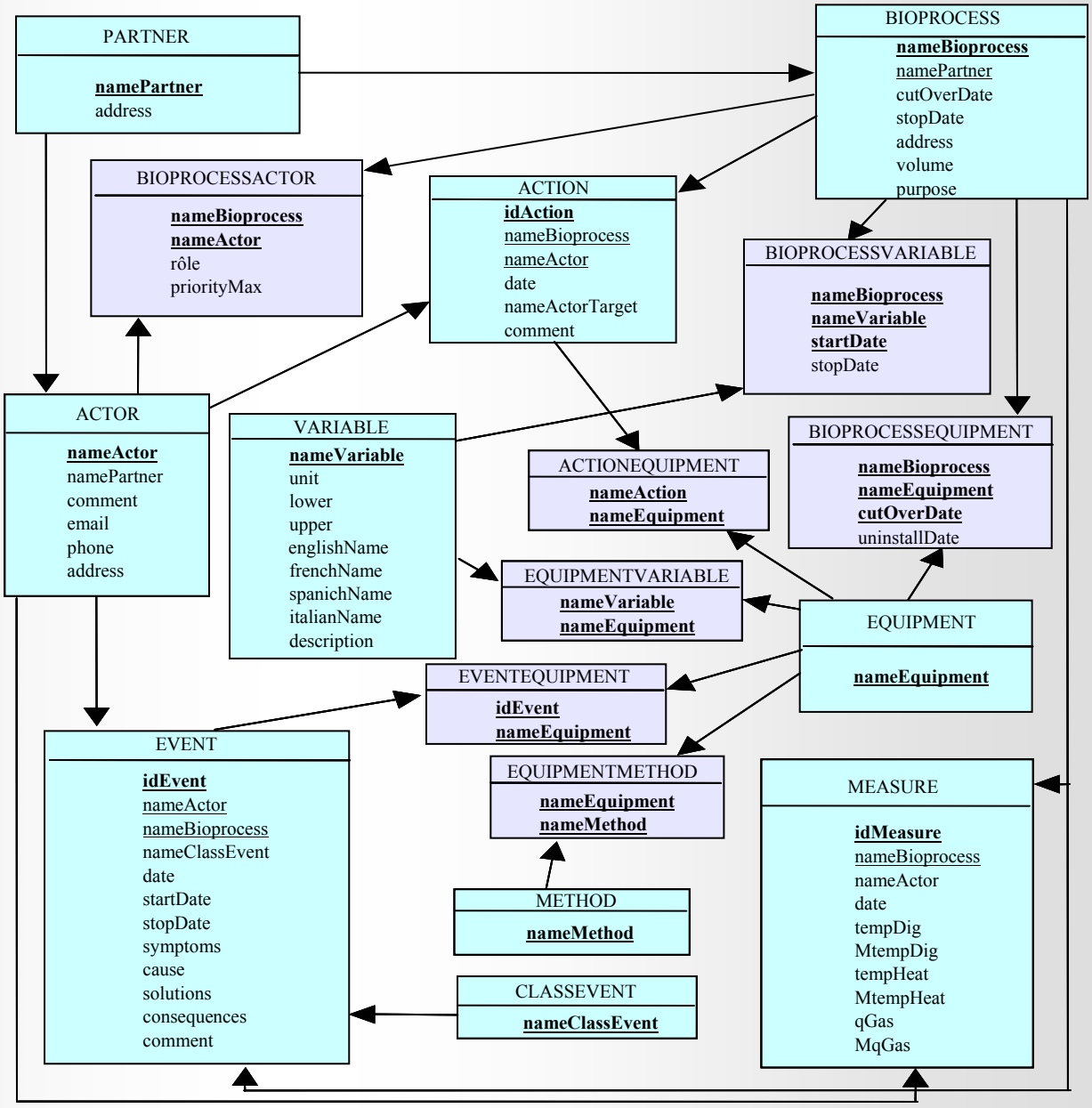
- ✓ Hierarchic : tree organisation of data
- ✓ Relational : organisation in tables and relations between tables (the most frequent model)
- ✓ Objects : data are hierarchised instances of objects



Focus on relational databases because they are efficient, widely used and have a universal request language (SQL for Standard Query language)

Data Base Modelling

Relational model of the database



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Distributed Application

Which functions to guaranty ?

Several interconnected modules

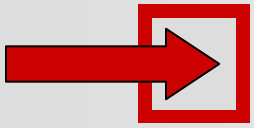
Modularity, interoperability — heterogeneous actors, different technologic tools

Evolutivity: — evolution of descriptions should not invalidate previous software developments.

Message control: — intégrity, authenticity, confidentiality

Several and simultaneous access

Need of an *ad hoc* language to formulate and validate messages, independent from sending authors and addressed actors but open enough to support evolutions



Developpment of an XML language

XML languages

Definitions

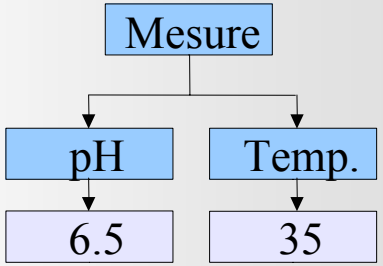
XML : eXtensible Markup Language

Language dedicated to formalization, storage and dynamic exchange of information

Explicit Separation of content and form

Description by tree of mark-ups

XML : meta language to define a language (*i.e.,* vocabulary *and* grammar)




```
<measurement>
    <ph>6.5</ph>
    <temp>35</temp>
</measurement>
```

Some examples

XML is a W3C Norm

- MathML, ChemML, XHTML, SMIL, WML …

Structure of an XML document

```
<?xml version="1.0" encoding="UTF-8"?>
<!DOCTYPE plantML SYSTEM "PlantML.dtd">
<plantML>
    <acquisition plantID="33.11100.200" date="2003-01-20 14:00:00">
        <sensor>
            <value label="vfaDig" unit="g/L" from="1">1.4</value>
            <value label="vfaDig" unit="mg/L" from="2">1450</value>
            <value label="pCH4" unit="%">68</value>
        </sensor>
    </acquisition>
</plantML>
```

Header :
This is an XML file, following the model called *PlantML.dtd*

Elements :
Textual data between a couple of markup opening <> and closing </>.
A mark-up can be completed by some arguments

Verification :

Well-formed : syntax and tree are correct

Valid : mark-ups are conform to the document model

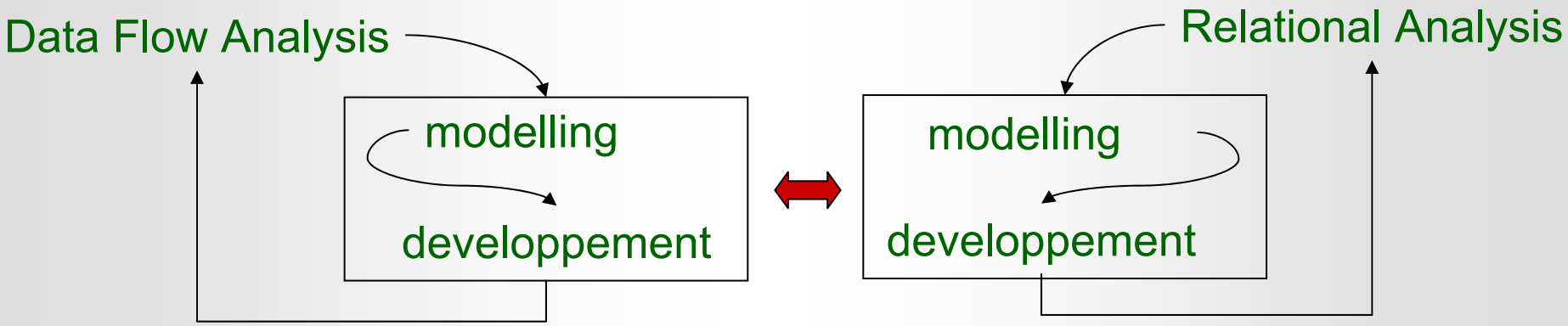
XML language modelling

Strategy

Compared to relational database elaboration :
Strong analogy between entity and eléments, and between relations and hierarchy

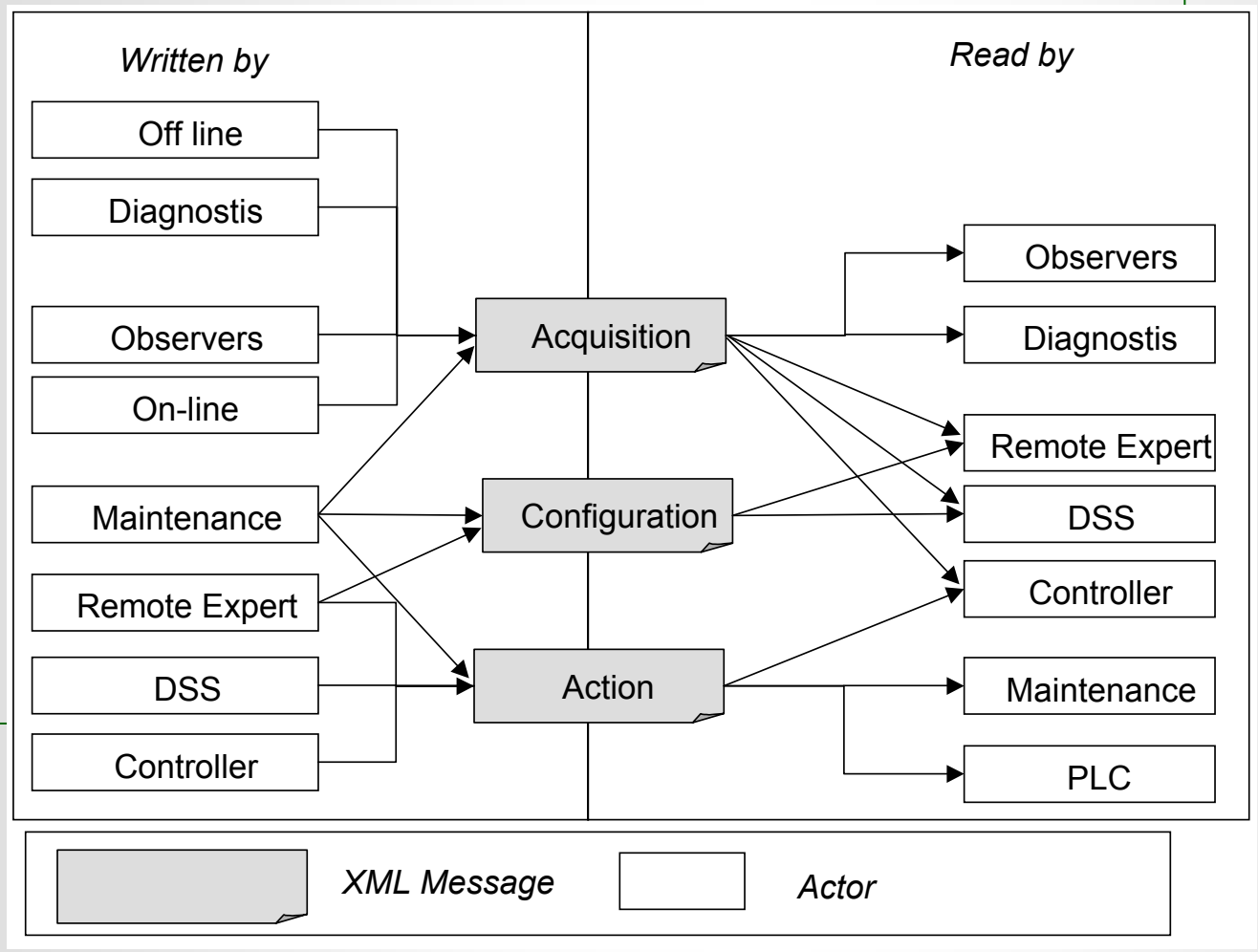
Treatment and flow diagram : identification of all senders and receivers, determine minimal knowledge needed to correctly understand each message

Simultaneous conception of the XML model and the SQL model :
Models are validated when same information is concisely and correctly represented under the both formalisms



XML language modelling

Example of a treatment diagram for a supervision task



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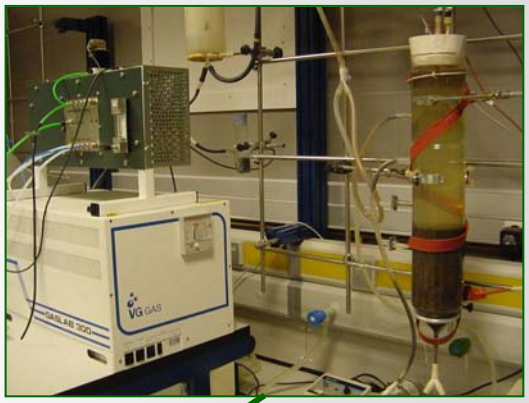
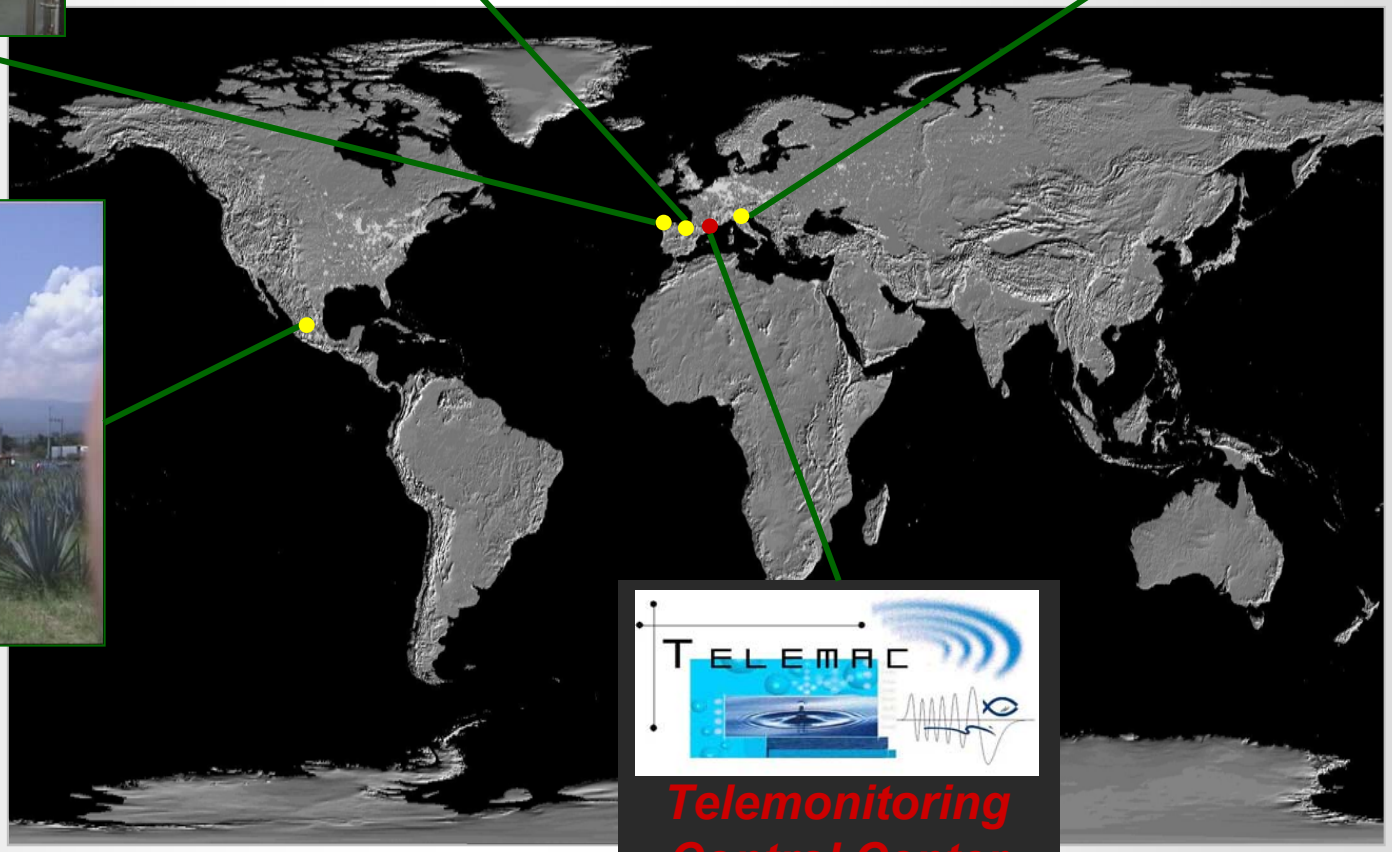
The European Project TELEMAC



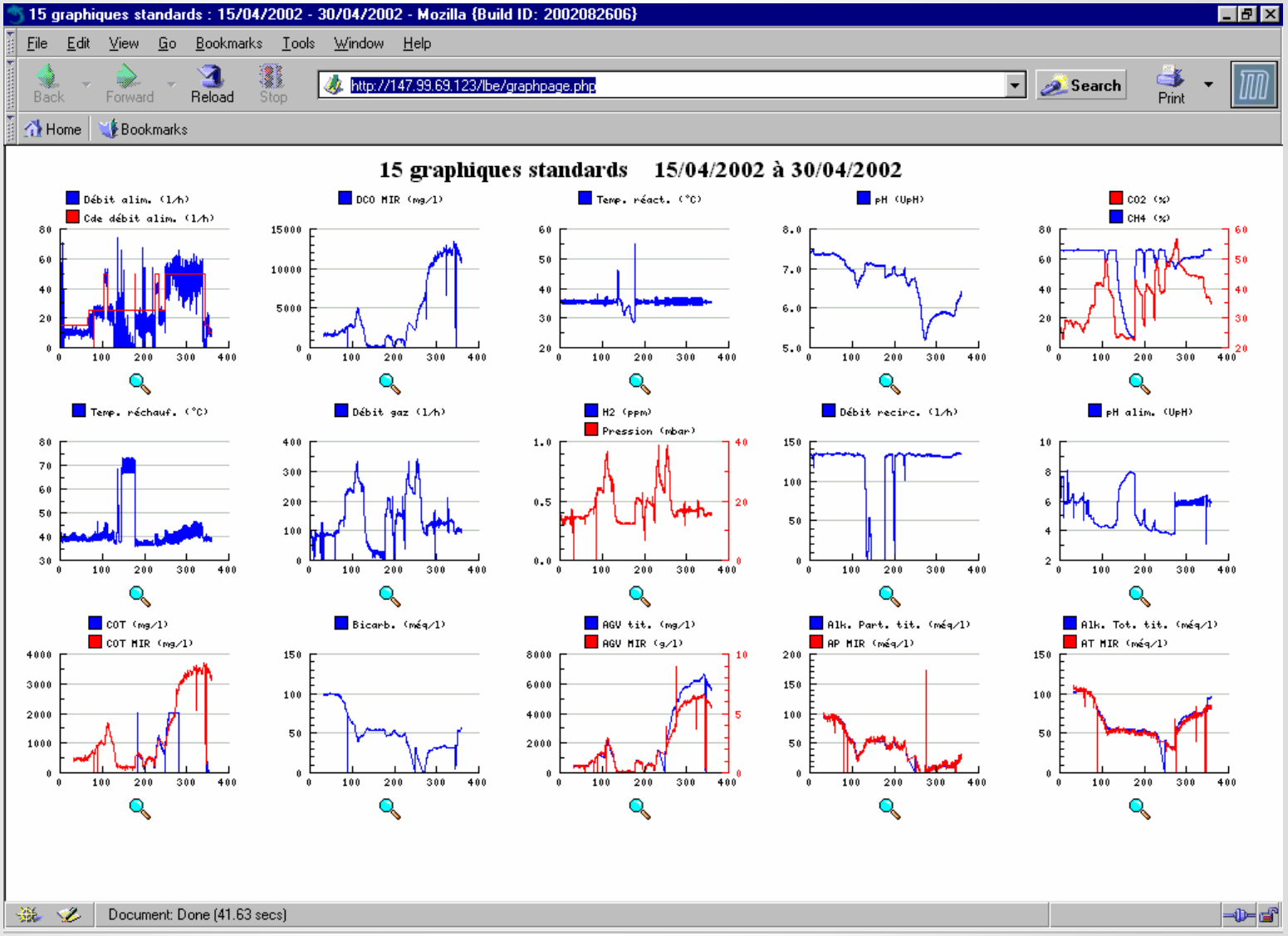


TELEMAC

Telemonitoring Control Center

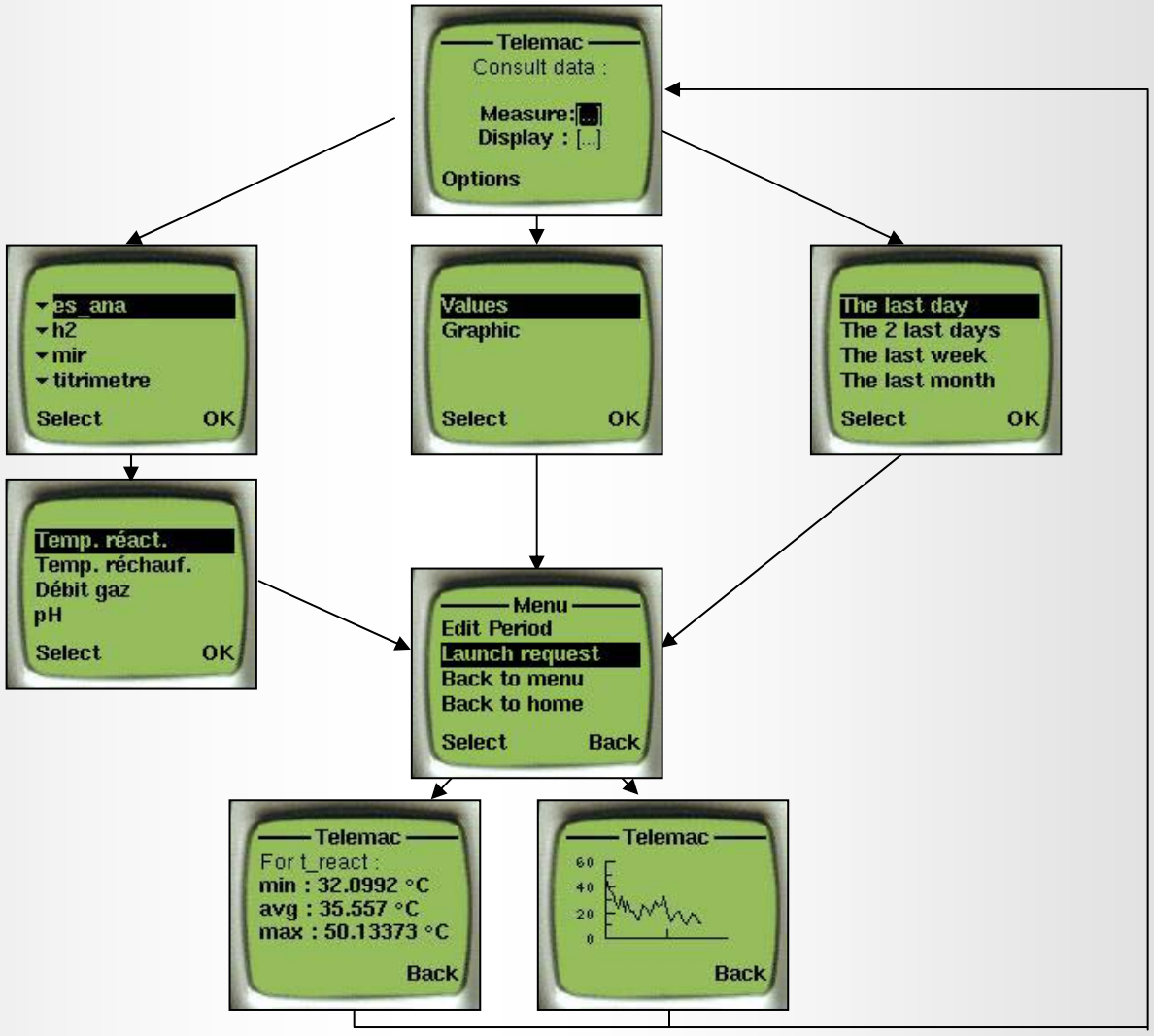
Web access to the database

PlantML:
- ✓ Multi-language graphical display and closed loop control,
- ✓ Web interface for expert comments, off-line measurements, ...



Wap access to the database

Easy acces to the last data from a mobile phone



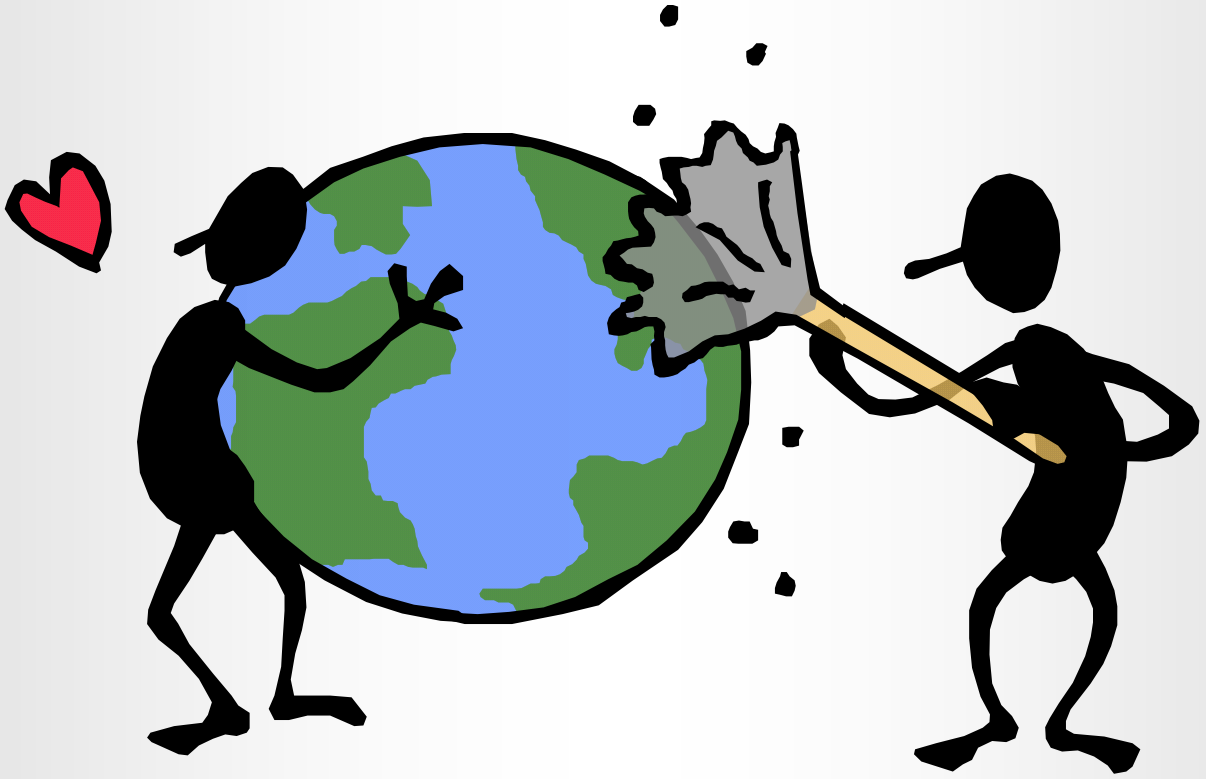
Conclusion

Data Base (+ XML)

- ✓ **Traceability** (☺ for understanding)
- ✓ **Data validation** (☺ for on-line control)
- ✓ **Generalization** over several locations (1+1>2)

↳ Need of **information modeling** !

Many thanks to you for your interest !



And I will be happy

to answer your questions...