1. Industry 4.0, some aspects

http://www.gipsa-lab.grenoble-inp.fr/~jean-marc.thiriet/asean/asean.html

Asean-Factori 4.0 project

Grenoble, 21st March, 1st April 2022

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Condensed CV

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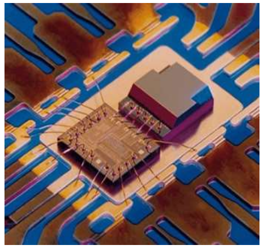
Docteur (Ph.D.) Université Henri Poincaré Nancy 1: February 1993
* Associate Pr. Université Henri Poincaré Nancy 1 1993-2005
* Habilitation à Diriger des Recherches UHP-Nancy 1: December 2004
  DEPENDABILITY OF INTELLIGENT DISTRIBUTED CONTROL SYSTEMS
* Full Professor Univ. Grenoble Alpes since 2005
  Head of the GIPSA-Lab Research Lab (April 2011-December 2015)
  Research in the dependability of automation systems which integrates communication networks (Networked Control Systems) and cyber-security of cyber-physical systems (smart grids, drones)
  Teaching in networks, network security, signal processing, automatic control
  Education projects
  - Asean-Factori 4.0
  - SALEIE: Strategic ALignment of Electrical and Information Engineering in European Higher Education Institutions

At the heart of Europe

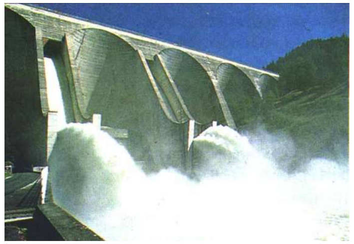
Grenoble
3h by train from Paris
1h40 by car from Geneva

Dynamic environment
Population: 680,000
60,000 students,
15% of which foreigners

Some Fields of research in Grenoble (70 Research Centres)



Smart systems
Nano-techno
Energy
Water
Environment
Transportation



5 International laboratories and instruments

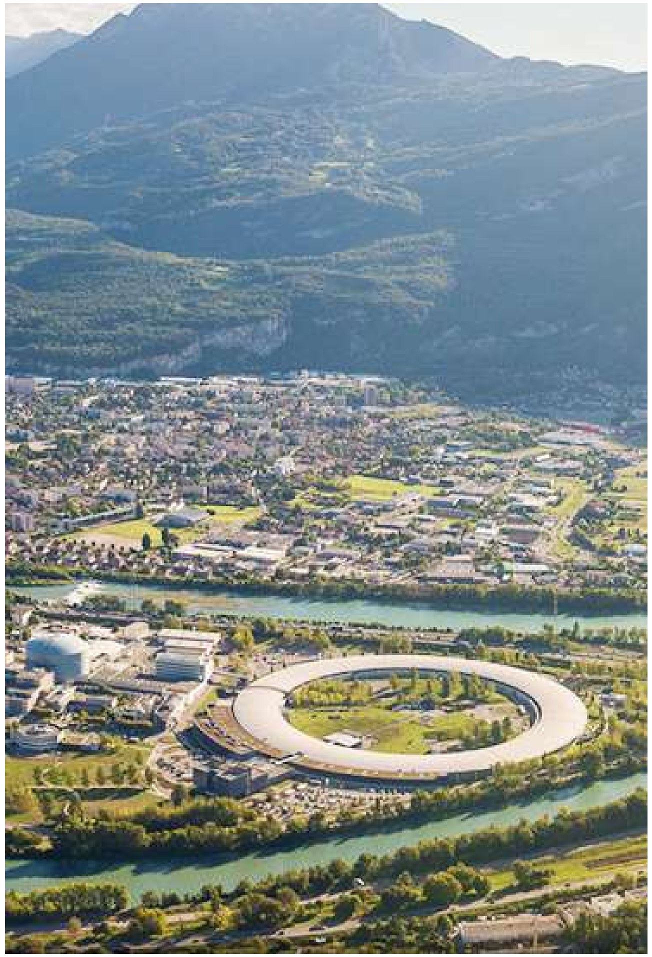
- ESRF, ILL, EMBL, GHMFL, IRAM

8 National research organizations

- CNRS, CEA, Inria, Inserm, INRAE, CRSSA, IRD, CHU Grenoble Alpes

Major companies

- Sun Microsystems, HP, Orange, STMicroelectronics, Schneider Electric, Alstom, Xerox, Thales…



UGA facts and figures

- **60,000** students
- **3,400** PhD students (45% international)
- **7,500** employees, of which
  - **5,500** academic
  - **2,000** staff
- **€ 512m** budget per year
- **82** laboratories
- **100+** research centers
- **1** teaching hospital
- **175** hectares of campus

From Industry 1.0 to Industry 4.0…

Industry 1.0 : mechanization, mechanical energy (water, steam), ex: agriculture , XIXth century

Industry 2.0 : mass production, electricity, ex: car factory ~from 1920s to 1970s

Industry 3.0 : automation (robots) => First PLCs (Programmable Logic Controllers)
computer, ex: pharmacy, food, 1980

Industry 4.0 : Cyber-physical systems, communication (virtual tools: Cloud), ex: smart cities, Nowadays

From Industry 1.0 to Industry 4.0...

Purposes: Production, minimal cost

- Production strategy => to product
- Maintenance strategy => to take care of the production tools
- Logistics and organization strategy => to organize production, transport and maintenance in the best way

Industry 4.0: some challenges

PARCE QUE CERTAINS SYSTÈMES SONT CRITIQUES
NOS SERVICES DATACENTER AFFICHENT 100% DE DISPONIBILITÉ DEPUIS 10 ANS

Certification ISO 27001 pour les services Datacenter, Cloud, hébergement, supervision NOC/SOC, administration, innovation, commercialisation

Certification Hébergeur de données de santé sur les 6 périmètres

Certification

Organisation

L'usine du futur devrait faire la part belle à la 5G plutôt qu'aux réseaux LPWAN.
Ces derniers pourront servir cependant à l'optimisation des bâtiments.

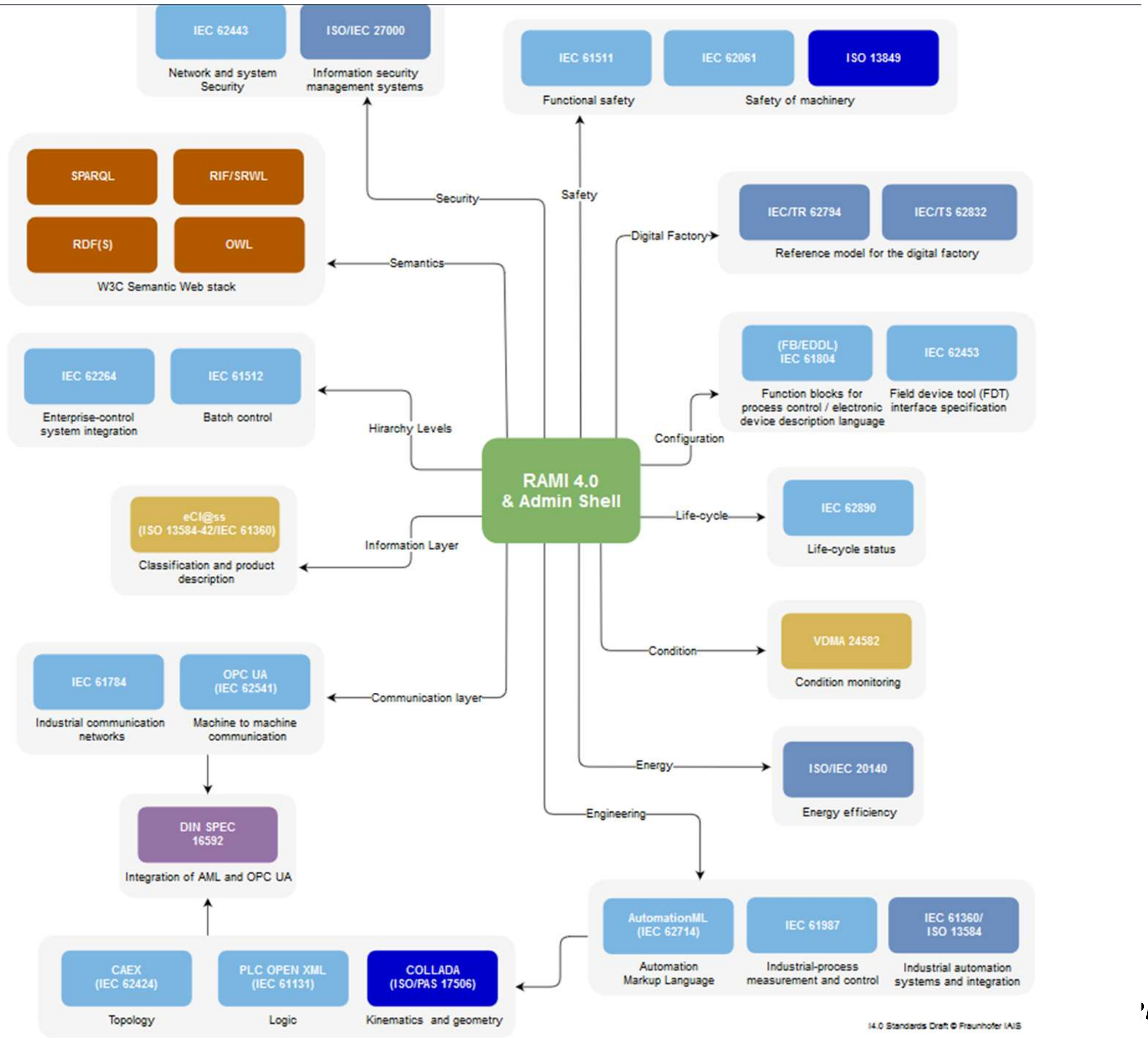
« New » networks: 5G

Certification

Standards…

State of the Art
Best practises
In security

Quality
Assurance
processes



PLC (Programmable Logic Controller)

Digital Inputs (0/1) Digital Outputs (0/1)

Analog Inputs and Outputs
(from ex: Vmin to Vmax)

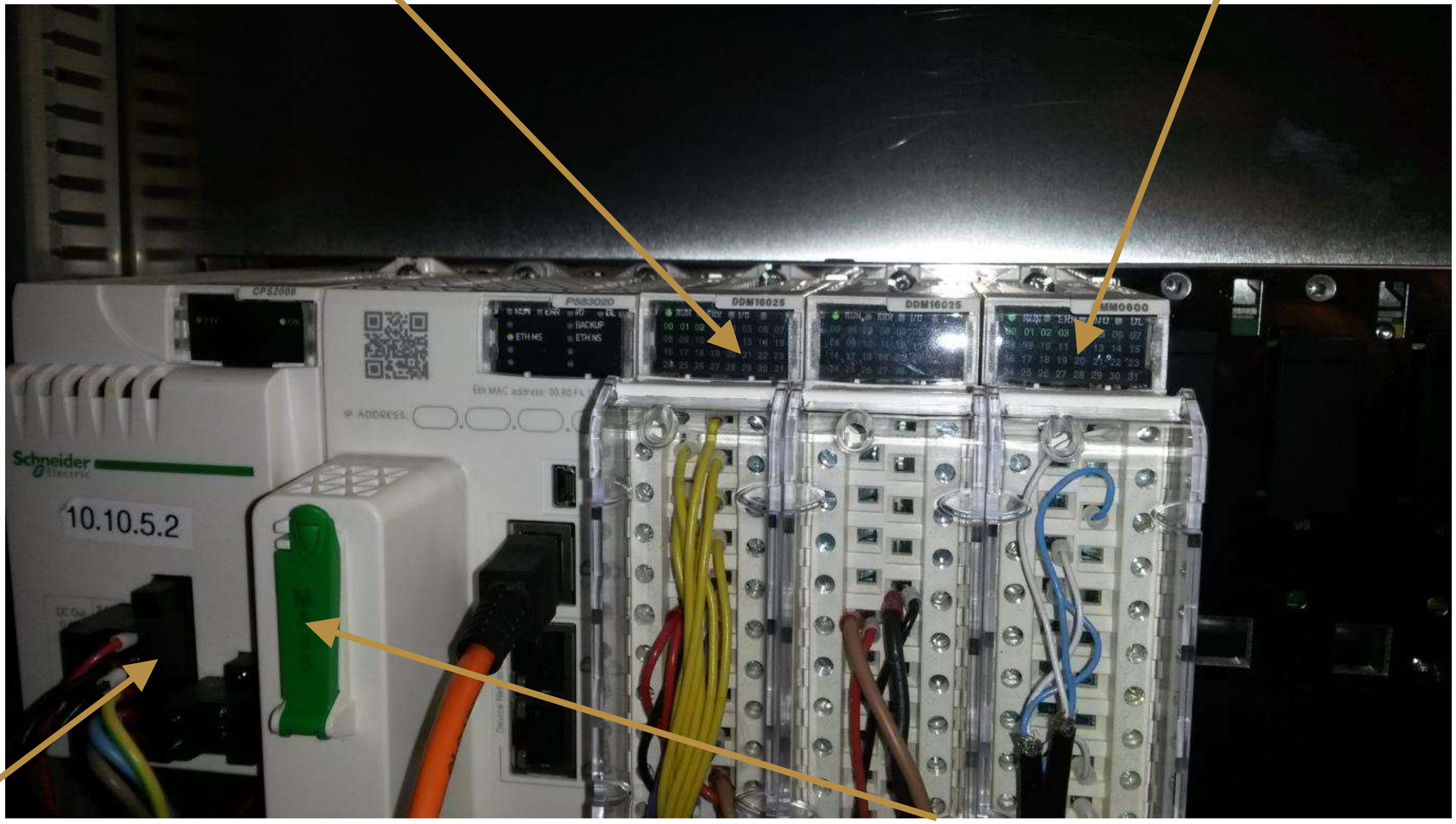
Free slots

Power Unit

Central Unit + Communication Interfaces
(Ethernet and CAN (fieldbus))

Digital Inputs and Outputs

Analog Inputs and Outputs



Central Unit + Communication Interfaces
(Ethernet and CAN (fieldbus))

Power Unit

The first PLC, model 084, was invented by Dick Morley in 1969

The "084" - Details

The **"084"** consisted of three major components mounted on two vertical rails, one of which was hinged to allow for service access to the front and back.

Ladder Logic:

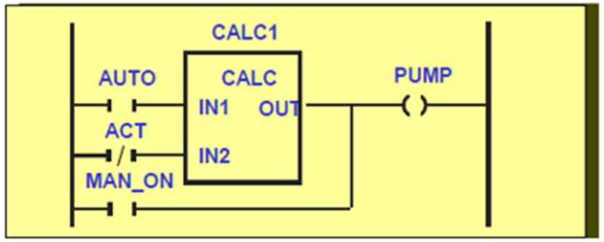
The use of **Ladder Logic** was significant in the rapid acceptance of the **"084"** because the very same engineers and electricians who designed and maintained Factory Automation Systems could also program an **"084"**. Ladder Logic was simply an electronic version of the elementary electrical diagram that they already used -- not the case for other types of control systems being designed at the time.

PLC Languages: IEC 61131

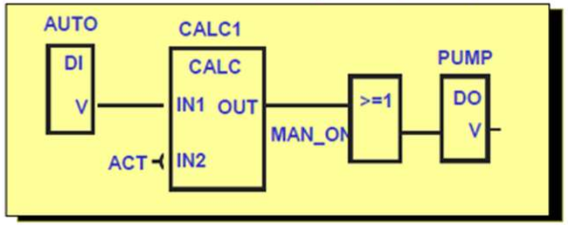
Instruction List (IL)

```
A: LD   %IX1  (* PUSH BUTTON *)
   ANDN %MX5  (* NOT INHIBITED *)
   ST   %QX2  (* FAN ON *)
```

Ladder Diagram (LD)



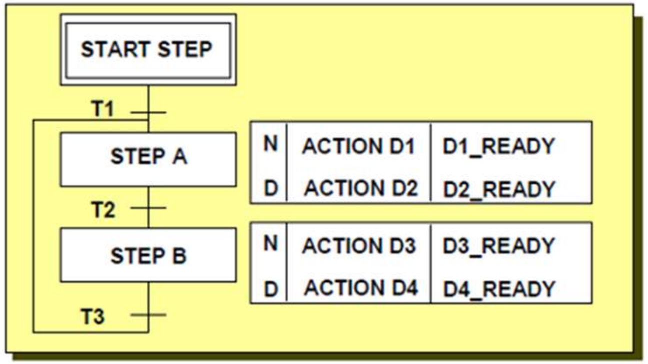
Function Block Diagram (FBD)



Structured Text (ST)

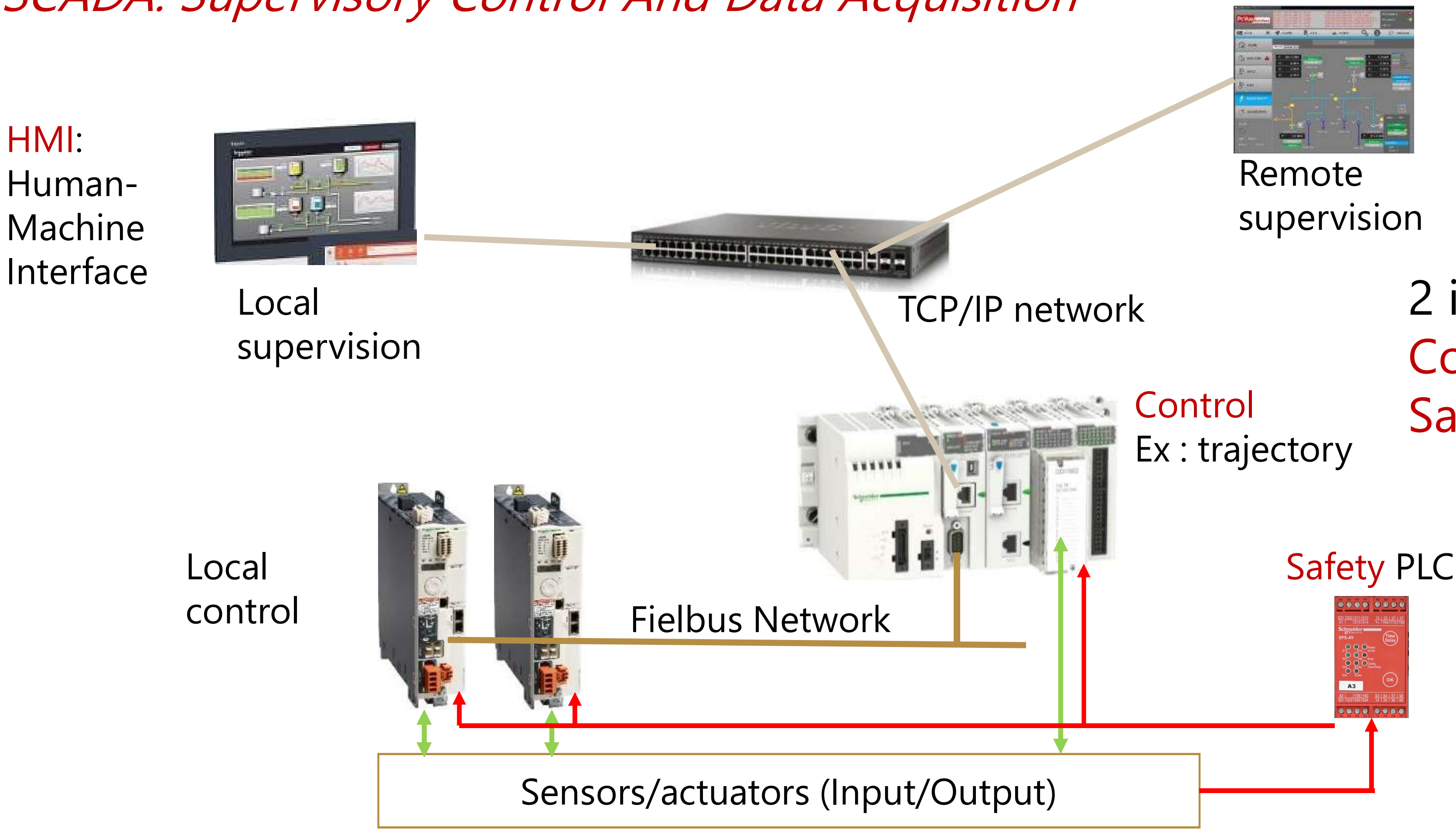
```
VAR CONSTANT X : REAL := 53.8 ;
Z : REAL; END_VAR
VAR aFB, bFB :  FB_type; END_VAR

bFB(A:=1, B:='OK');
Z := X - INT_TO_REAL (bFB.OUT1);
IF Z>57.0 THEN aFB(A:=0, B:="ERR");
ELSE  aFB(A:=1, B:="Z is OK");
END_IF
```

Sequential Flow Chart (SFC)



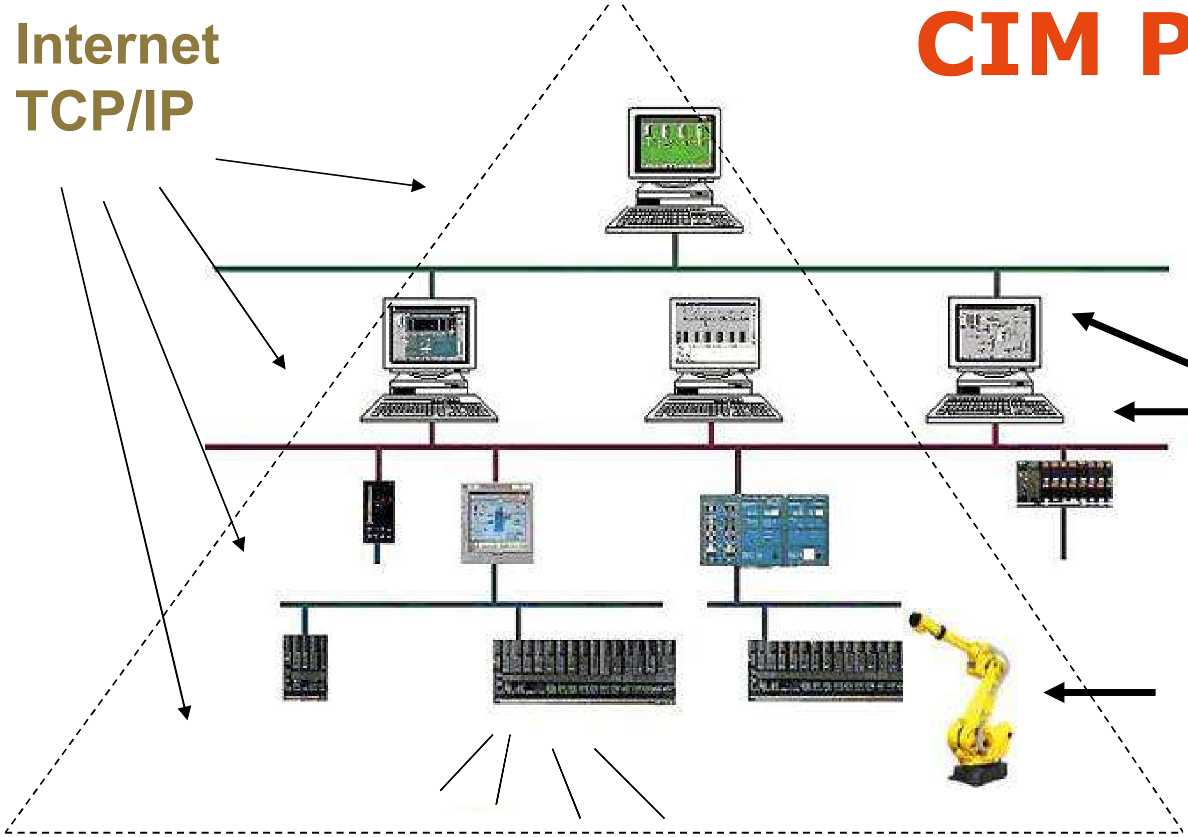
An example

SCADA: Supervisory Control And Data Acquisition



2 important aspects:
Control
Safety

CIM Pyramid



Computer-integrated manufacturing (**CIM**)
Describe the complete automation of manufacturing processes
Several network layers

Example of a SCADA

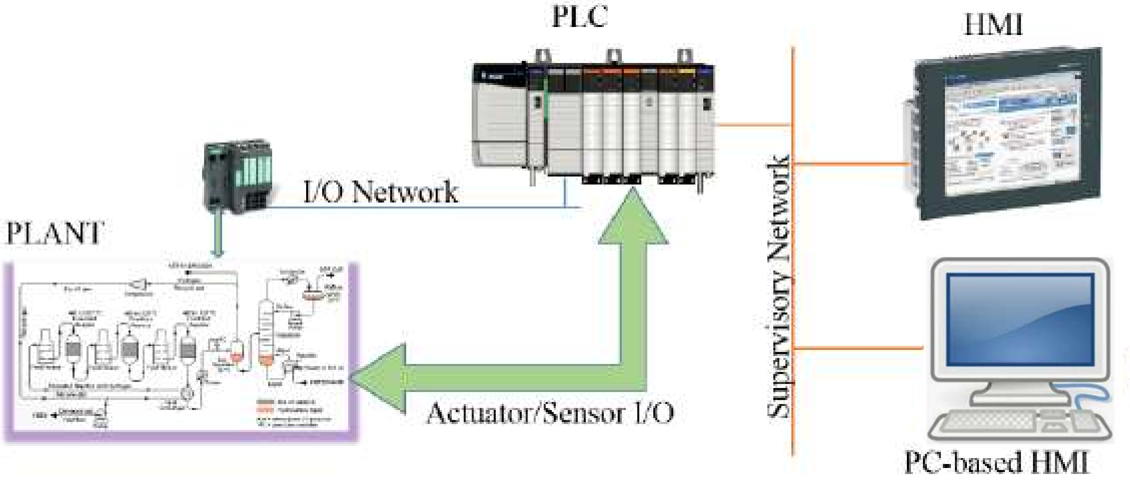
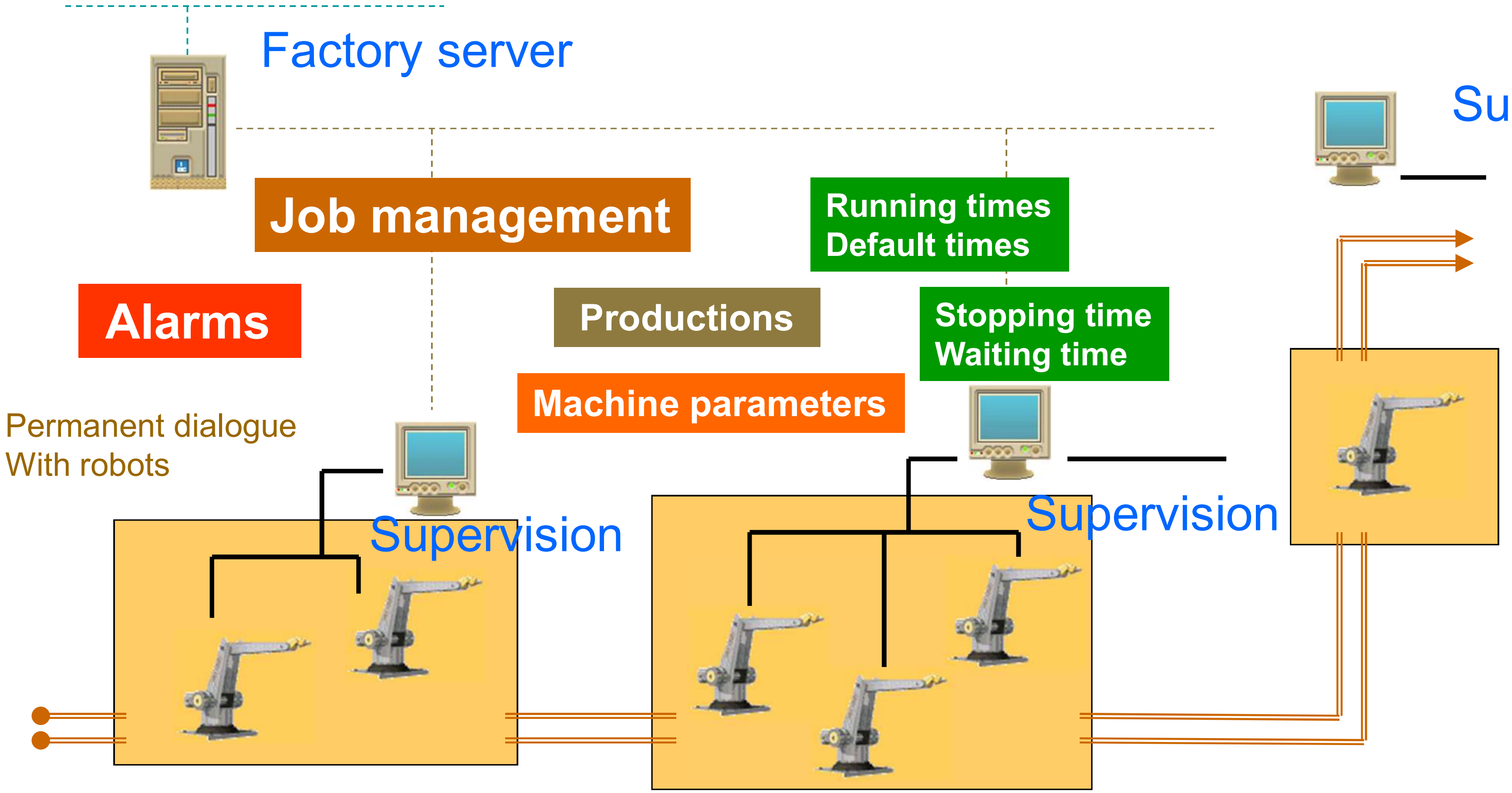


Figure 1. The simple SCADA system

Supervisory Control And Data Acquisition

Supervision : computerized monitoring and control of automated manufacturing processes
- Data acquisition
- Manual or automatic modification of process control parameters
- Use of PLCs, special machines, robots...

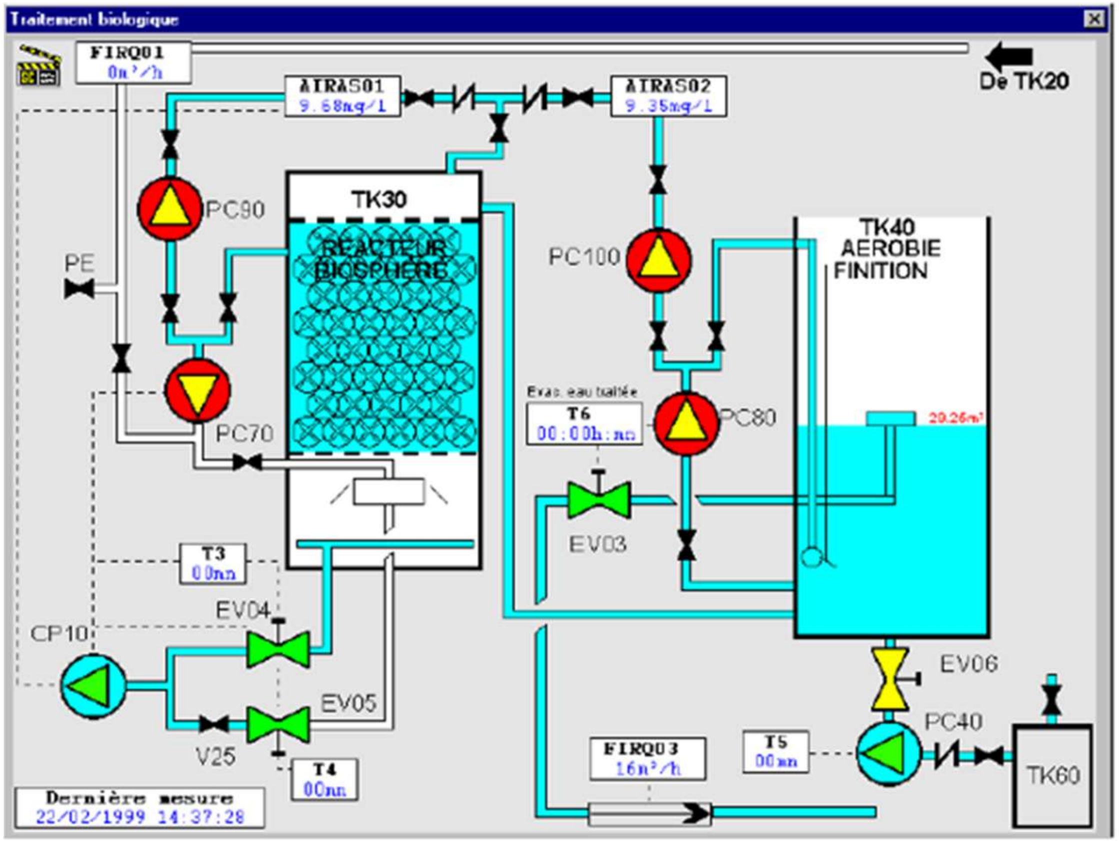
Supervision



Supervisors
Collect and process information from the robots
Basis of the factory's information system

Supervision functions

Synoptic: essential function of the supervision, provides a synthetic, dynamic and instantaneous representation of all the means of production of the unit

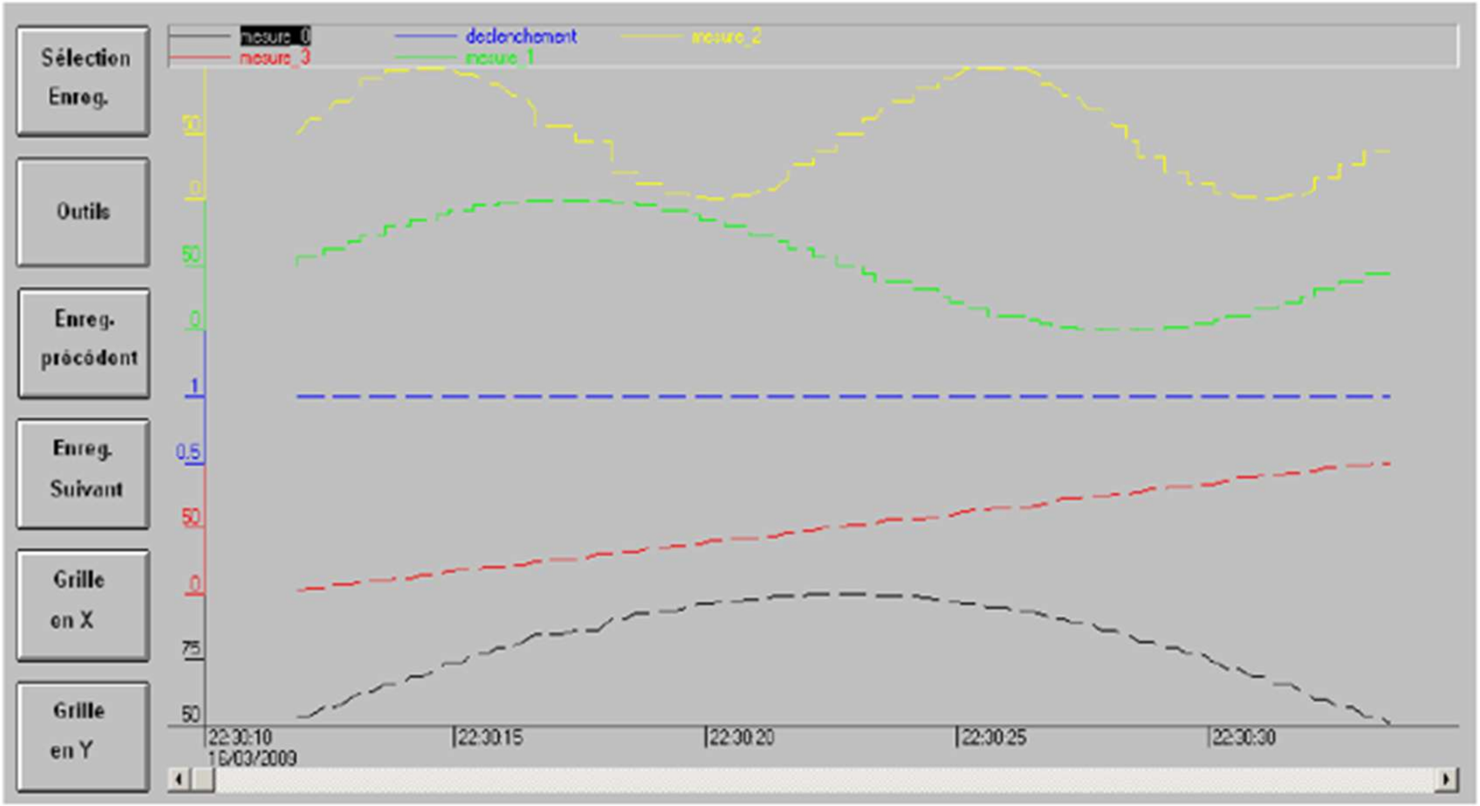


Supervision functions

Curves:

- gives a graphical representation of different process data

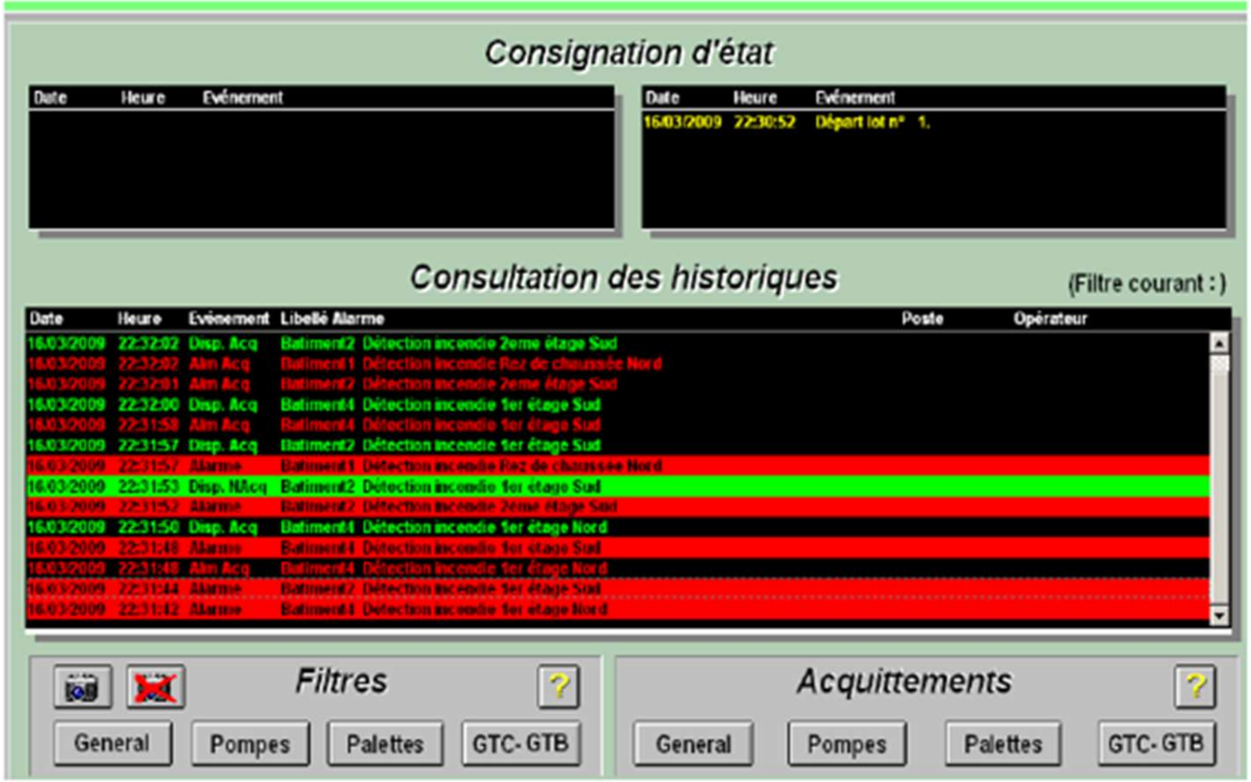
- gives the tools to analyze the historical variables



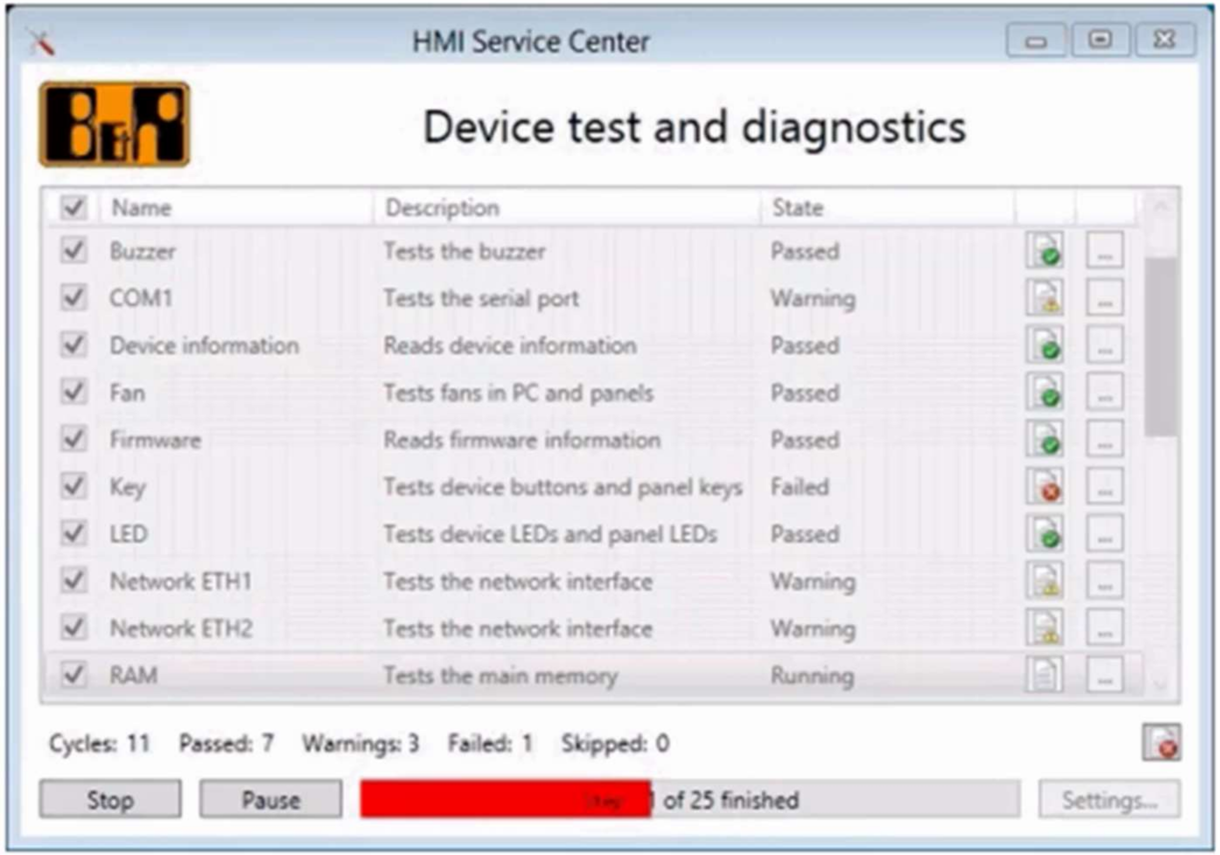
Supervision functions

Alarms

- Calculates in real time the conditions for triggering alarms
- Displays all alarms according to priority rules
- gives management tools
- ensures the recording of all the steps of the alarm processing



Supervision functions



Alarms

Circumscribe the cause of the feared event (cause of the incident)
Limit the impact of the event, protect (consequences)
Be able to assess the system after the incident: repair, reconfigure (total and partial redundancies)
Reconstruct, recover the system: time required for it to be operational again, what happens and what are the recovery steps? (Activity Return Plan)

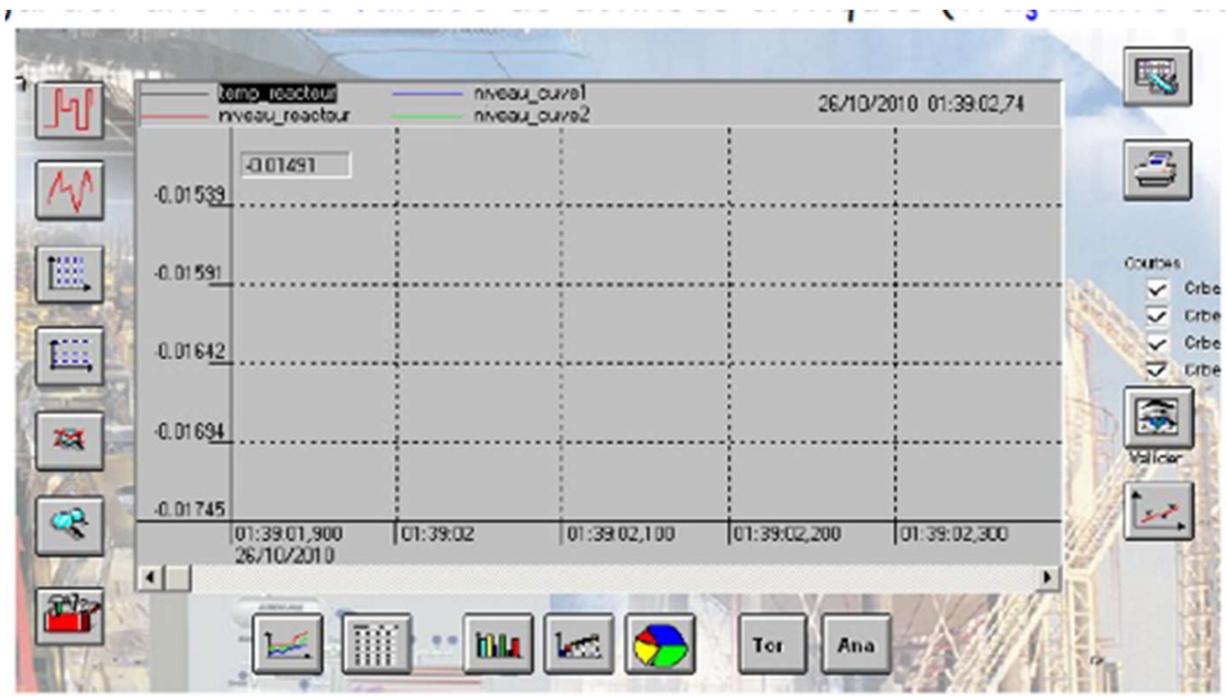
Other related aspects: robustness, resilience (ability to maintain the system as well as possible in a situation of "attacks")

Alarms detection

- TP (true positive) corresponds to correctly identified alarms
- FP (false positive) corresponds to authentic behavior identified as faulty
- TN (True Negative) corresponds to the correct rejection of authentic behavior
- FN (False Negative) corresponds to undetected failures
- Two metrics are used to evaluate the performance of alarm detection
  - True Positive Rate TPR=TP/(TP+FN)
    => 1 if no False Negative
  - False Positive Rate FPR=FP/(FP+TN)
    => 0 if no False Positive

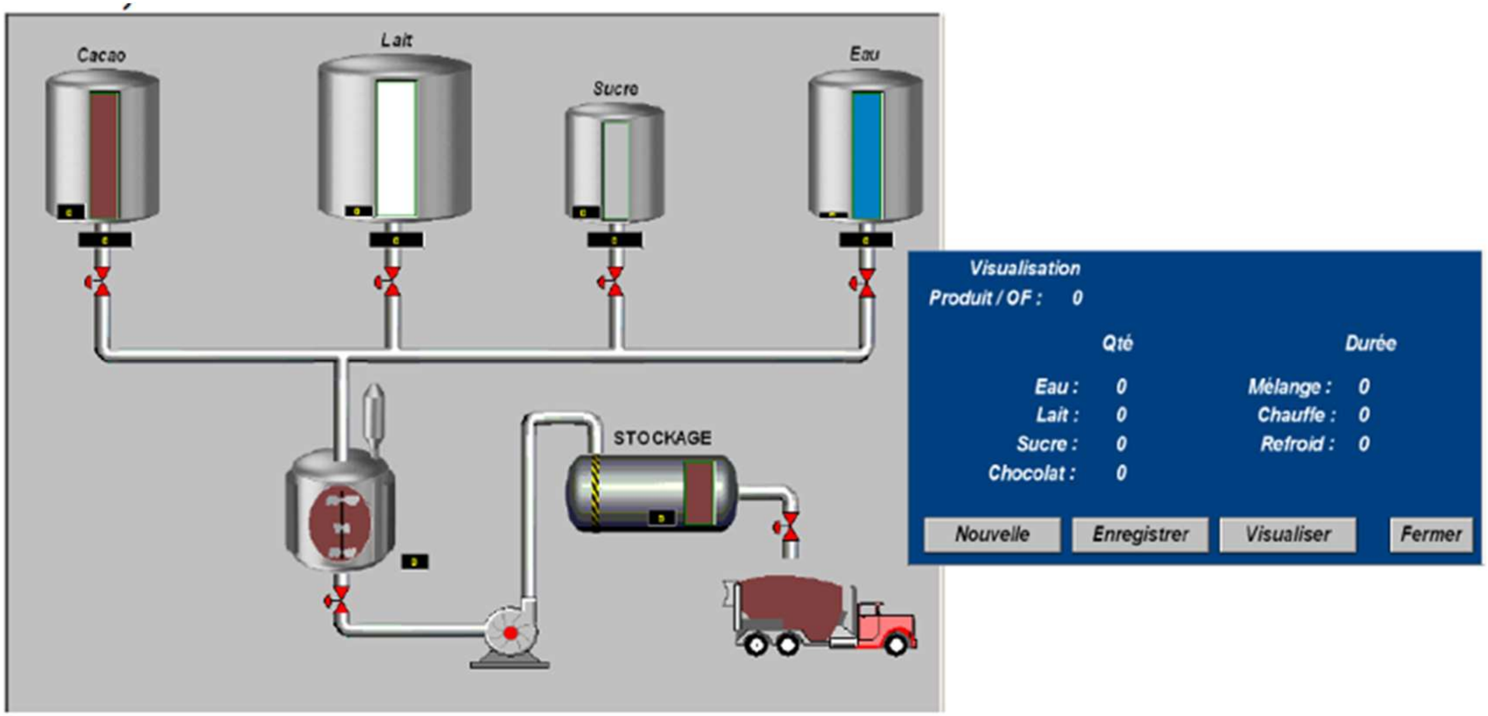
Supervision functions

Historicization of the process:
- Allows the saving of time-stamped events (selective archiving)
- provides search tools in the archived years
- provides the possibility to run the synoptic again with archived data (replay function)
- allows to keep a validated trace of critical data (traceability of production data)



Supervision functions

Management of production lines and recipes:
- Provides a tool for managing production batches
- Manages the parameters of the machines for each batch (recipes)



Other aspects of Industry 4.0 (from Seminar spring 2021)

1. Description of the Main Industrial sector using PLC - Industry 4.0
2. Challenges: Safety & Cyber-security
3. **Maintenance**
4. **Logistics & Organisation**
5. **Production**
6. **Supervision**
7. **Robotics in Industry**
8. Conclusion
9. References

Conclusions

- Industry 4.0
  - Concept around Information Systems (from the « field » (sensors, actuators) to the higher levels of management in the companies)
  - Various functionalities: Production, but also Maintenance, Logistics, Transport
  - Robotics is an important aspect (for Production, Maintenance, Transport…)
- PLC, Programmable Logic Controller
  - « Industrial » computer
  - Inputs/outputs to be connected to physical processes
  - Communication networks
    - Fieldbus networks, « Industrial networks », for interactions between PLC (ex: Master/slave), I/O interactions with PLC
    - Classical networks for supervision
    - More and more in the Cloud (virtual devices) => Cyber-security challenges
- « Integration » IT (Information Technology)/ICS (Industrial Control Systems)
- Challenges in Dependability/Safety and in « Cyber-Security » => Convergence between these concepts
  - Risk Analysis, risk management

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Merci pour votre attention

Merci pour votre attention

UGA Université Grenoble Alpes

FACTORI 4.0 Erasmus +

សូមអរគុណចំពោះការយកចិត្តទុកដាក់របស់អ្នក។ (KH)

ຂອບໃຈຫຼາຍໆ ສຳ ລັບຄວາມສົນໃຈຂອງທ່ານ (LAO)

ขอบคุณมากสำหรับความสนใจของคุณ (TH)

Merci pour votre attention

Thank you for your attention