Openlab Workshop on Data Analytics 16th of November 2012

Axel Voitier – CERN EN-ICE

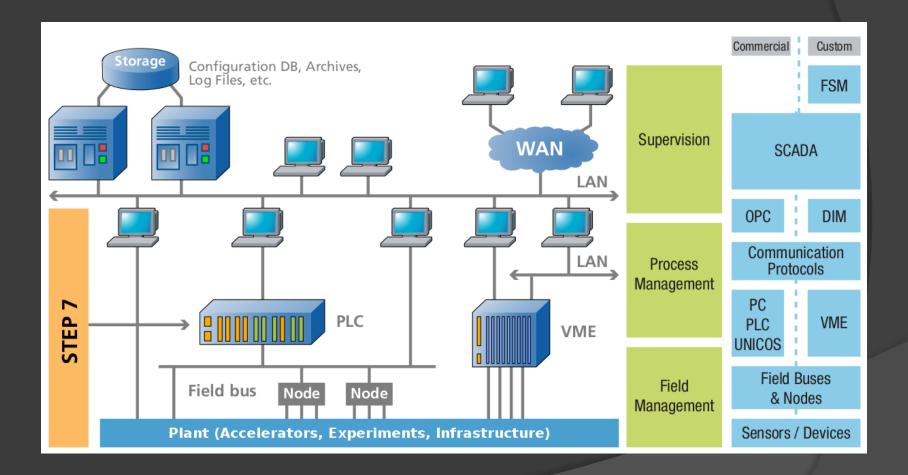
INDUSTRIAL CONTROLS DATA ANALYTICS USE CASES

Outline

- Industrial Control Systems at CERN
- Oata Sources for Analysis
- Possible Use of Data Analytics:
 - Online Monitoring
 - Fault Diagnosis
 - Engineering Design

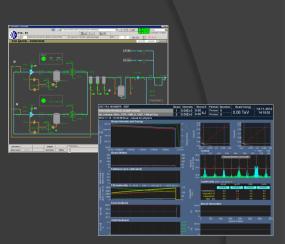
Where to go with our tons of data?

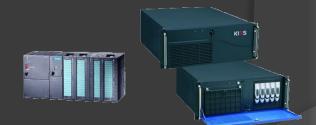
Typical Industrial Control System



Technologies

- Supervision layer
 - Siemens WinCC Open Architecture
 - National Instrument LabView
- Control layer
 - Programmable Logic Controllers
 - Front End Computers
 - VME modules, PXI controllers, etc.





- Field layer
 - Sensors, devices

Some examples

- Accelerators
 - Cryogenics
 - Vacuum
 - Machine Protection
- Experiments
 - Detector Control
 - Detector Safety
 - Gas
- Technical Infrastructure
 - Cooling and Ventilation
 - Electricity











Particularities of Control Systems

They are stables most of the time.
Relatively few incidents to learn from.

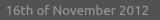
 But a single system failure can lead to a complete stop of the accelerator(s).

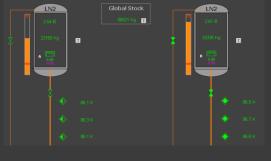
- Beam dump!
- Unavailability time (repair + recovering).
- => High global cost.

Data sources for analysis

- Online values
 - Single value, instantaneous.
- Archives
 - LHC Logging + PVSS archives.
 - +100 Tbytes, extensible.
 - Data and alarms.
- Log files
 Almost never used.

Configuration data







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Use case 1: Online Monitoring

Detect issues and inform operators before they affect the process under control.

Possible applications:

- Control systems health.
- Electrical power quality of service.
- Looking for heat in superconducting magnets.
- Oscillation of cryogenic valves.
- Discharge of superconducting magnets heaters.

Inputs/Outputs

- Inputs
 - Operating system information.
 - Network load.
 - PLCs status information.
 - Process measurements.
 - Layout database.
 - Log messages.





Outputs

- Alerts, sent to our stand by service by SMS.
- Periodic summary reports.

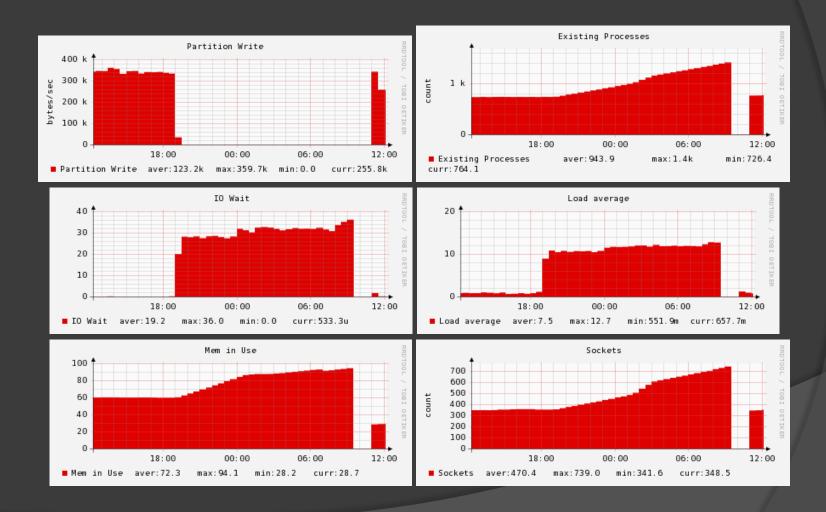
Type of analysis

- Analysis Processes
 - Thresholds learning.
 - Correlations.
 - Classifications.
 - Formalisation of temporal relations (eg. Markov chain, Wavelet, FFT).
 - Pattern recognitions.

• Time span:

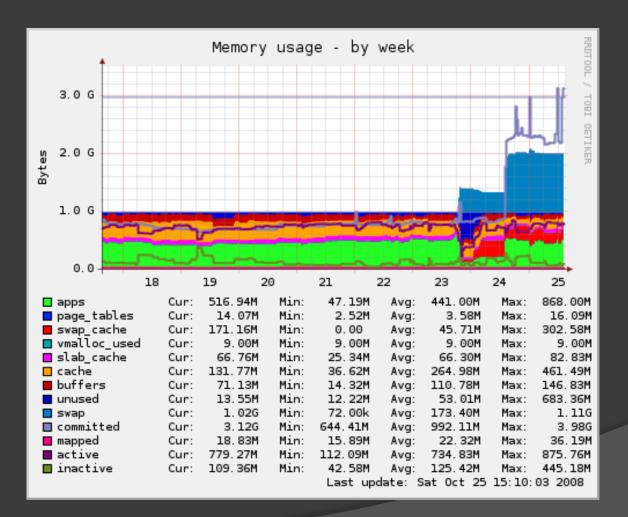
- Learning over relatively long periods.
- Detection periods: "immediate", 1 week, 1 month, 1 year.

Example 1: Hard drive failure



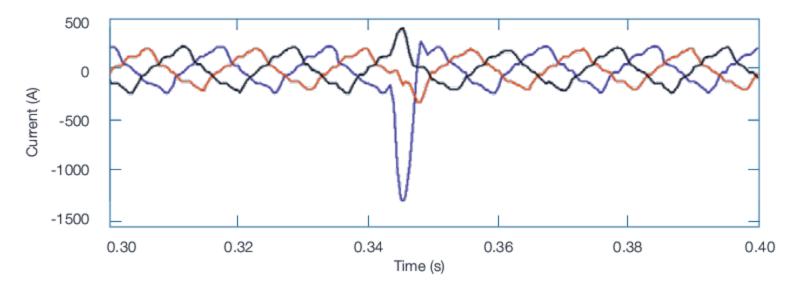
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Example 2: Memory disturbance



Example 3: Incipient fault on electrical network

Example recording of an incipient failure. This was a self-clearing fault that did not result in any immediate outage.

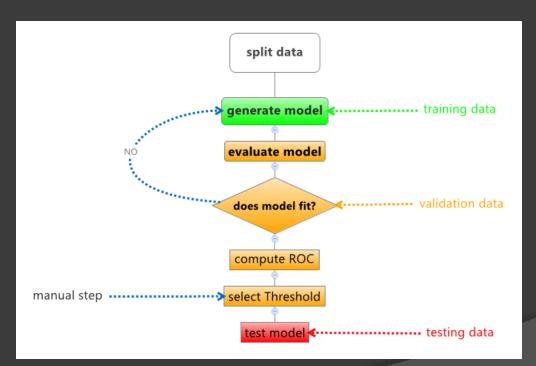


Subsequent monitoring recorded 140 additional cases of similar incipient failures until the catastrophic failure nine months later that blew a 65A fuse

Mirrasoul et Al., "Real-time automated distribution event detection and notification for grid control", ABB Review 3/2009, p.38-44

Current developments

 Exploring machine learning techniques for control systems health monitoring.



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Use case 2: Fault Diagnosis

Helping operators to find the root event in an avalanche of alarms.



Possible applications:

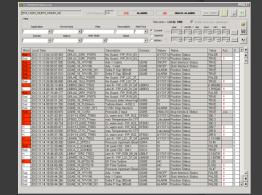
- Analysis of electrical power cuts.
- Cryogenic system breakdowns.

Inputs/Outputs

Inputs

- Hundreds of Analog/Digital Inputs/Outputs.
- Event list.
- Alarm list.

👂 EventList							
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Outputs

- Incident report for the operator.
- An identified/classified result.

Type of analysis

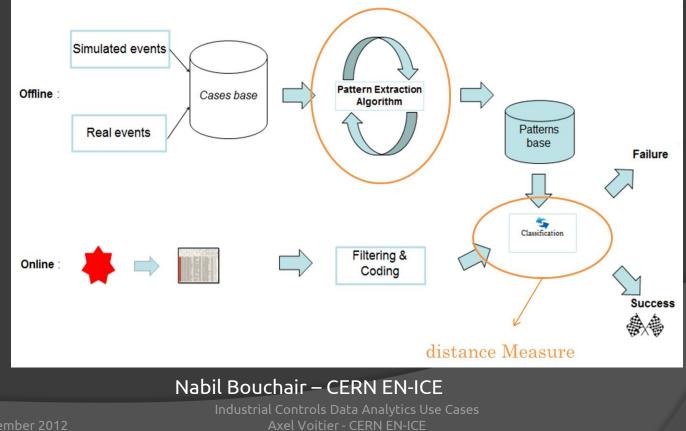
- Analysis processes
 - Pattern classification.
 - Model based methods (process simulation).
 - Knowledge based methods (interlocks are known).

Time span

- An avalanche of alarm is short. But...
- ... The root cause can happen hours/days before.

Current developments

Research on cryogenic systems breakdown diagnostic



Use case 3: Engineering design

Analyse historical data to draw conclusions about the behaviour of a system.

Possible applications:

- Electrical consumption forecast.
- Predictive maintenance of control systems elements.
- Vibration analysis.

Inputs/Outputs

Inputs

• Any kind of process data.

Outputs

- Detailed status reports.
- Previsions.

Type of analysis

- Analysis processes
 - Multivariate interpolations.
 - Correlations.
 - Inferences based on knowledge or model.
 - Unsupervised classifications.

Time span

As long as the system has existed and will exist.

Where to go with our tons of data?

- We have a lot of data!
 - Very few are used though.
 - But we have some ideas...
- Currently doing preliminary studies
 - Prospect and researches.
 - Many techniques to explore.
- Challenges ahead
 - Suitability of state of the art techniques to our domains.
 - Integration within our tools and environment.
 - Hard to reuse a development, every use case seems unique.