

Control System Data Analysis Current Issues and Solution

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CERN - Openlab Workshop

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- Current “production” state

- Use-cases under analysis
 - GAS alarms breakdown
 - Control System Health
 - Statistical Analysis of Alarms

- Issues and Current limitations



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Current “production” State

- Control and Monitoring system
- Alerting and reporting system
 - Manually configured
 - Based on threshold trespassing pattern
- Huge data volume:
 - OS logs, performances metrics, device status, Measurements, Alarms ...
 - but not efficiently exploited yet

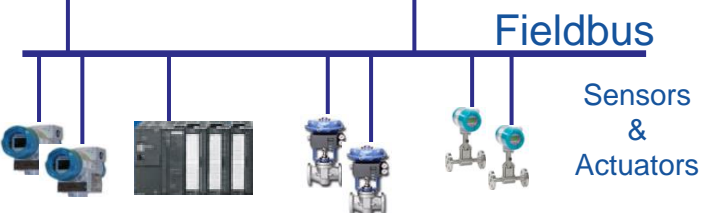
Supervision layer



Process layer



Field layer



- GAS system breakdown: system fault analysis and pattern extraction
 - Events sequence pattern matching
 - Post-mortem analysis so far
 - Fault prediction based on recognizable trails of events

- Control Systems Health
 - Pattern matching and correlations of multivariate time series
 - Structured (i.e. measurements) and unstructured (i.e. logs) data

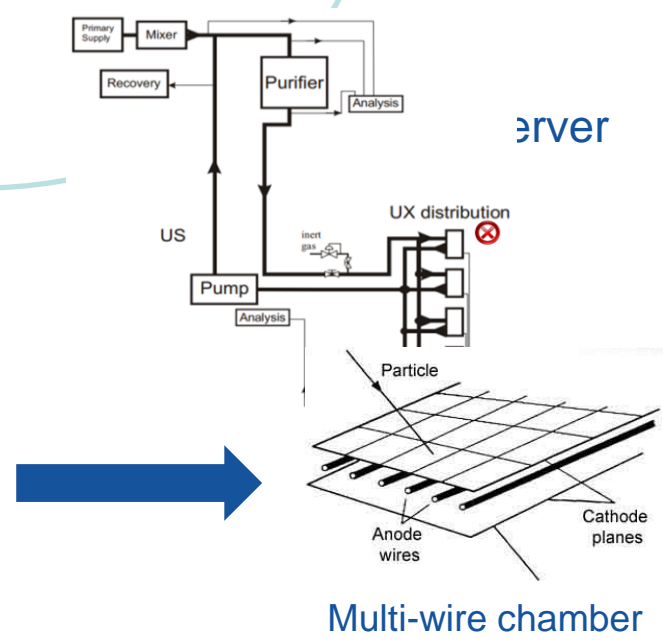
- Alarms statistical analysis
 - Extract statistical indexes from the list of raised alarms
 - Pragmatic approach: automatic threshold discovery and learning

- Strategy:
 - Use and extend the Siemens WatchCAT and other open-source analysis tools to extract possible patterns and discover new insights hidden in the control data
 - Take advantage of the huge amounts of control data produced by CERN facilities

Gas System use-case



6 Apps
1 Data Server





Extraction

Events List

XML
Conversion

Siemens
WatchCAT

Complex Diagnostic:

- Alarm flooding, “domino effect”
- A single fault can stop the whole process
- The 1st alarm is not necessarily the most relevant for the diagnosis
- The alarm list depends on the system status
- a knowledge-based model is not sufficient!

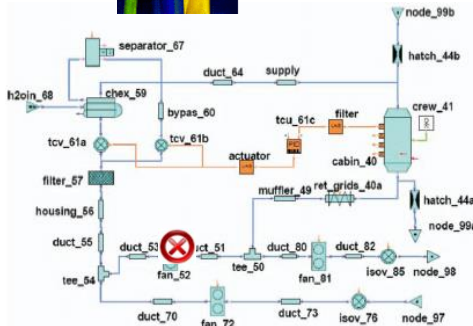
Pattern Extraction:

- Fault Signature
- Sequence Alignment

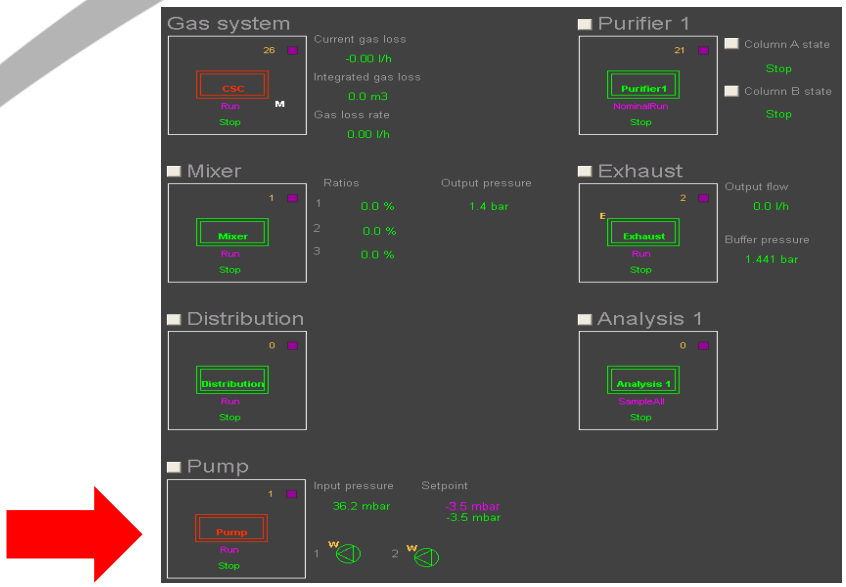
EcosimPro

Simulation of Physical Control System:

- Complex System: more than 9000 equations to model all the system
- Validated against the real system
- Includes **fault model!**



Example: Distribution fault



Bubbler (safety device broken) line 2:

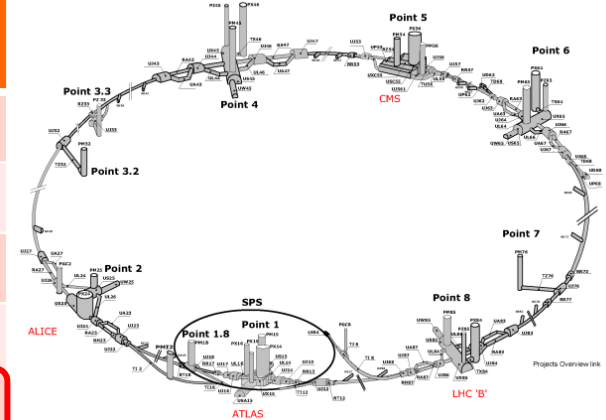
- Initial impact on the Pump module, then on the Distribution
- The Distribution seems to not have alarms yet
- The Entire Control Process collapses

Short	Local Time	Alias	Description	Domain	Nature	Name	Value
W	2013.09.27 15:49:37.810	CMSCSC_Di_61InPresAI	PTxx24 - Rack 61 input	CSC_Details		PTxx24 - Rack 61 input pres	FALSE
W	2013.09.27 15:49:42.890	CMSCSC_Di_68InPresAI	PTxx24 - Rack 68 input	CSC_Details		PTxx24 - Rack 68 input pres	FALSE
W	2013.09.27 15:49:42.890	CMSCSC_Di_70InPresAI	PTxx24 - Rack 70 input	CSC_Details		PTxx24 - Rack 70 input pres	FALSE
W	2013.09.27 15:49:42.890	CMSCSC_Di_69InPresAI	PTxx24 - Rack 69 input	CSC_Details		PTxx24 - Rack 69 input pres	FALSE
W	2013.09.27 15:49:42.890	CMSCSC_Di_67InPresAI	PTxx24 - Rack 67 input	CSC_Details		PTxx24 - Rack 67 input pres	FALSE
W	2013.09.27 15:49:43.090	CMSCSC_Di_63InPresAI	PTxx24 - Rack 63 input	CSC_Details		PTxx24 - Rack 63 input pres	FALSE
W	2013.09.27 15:49:43.090	CMSCSC_Di_64InPresAI	PTxx24 - Rack 64 input	CSC_Details		PTxx24 - Rack 64 input pres	FALSE
W	2013.09.27 15:49:43.090	CMSCSC_Di_65InPresAI	PTxx24 - Rack 65 input	CSC_Details		PTxx24 - Rack 65 input pres	FALSE
W	2013.09.27 15:52:09.900	CMSCSC_Di_69OutPresFAA	PTxx26 - Rack 69 far out	CSC_Details		PTxx26 - Rack 69 far output	TRUE
W	2013.09.27 15:52:09.900	CMSCSC_Di_66OutPresAI	PTxx25 - Rack 66 output	CSC_Details		PTxx25 - Rack 66 output pre	TRUE
W	2013.09.27 15:52:09.900	CMSCSC_Di_69OutPresAI	PTxx25 - Rack 69 output	CSC_Details		PTxx25 - Rack 69 output pre	TRUE
W	2013.09.27 15:52:09.900	CMSCSC_Di_70OutPresAI	PTxx25 - Rack 70 output	CSC_Details		PTxx25 - Rack 70 output pre	TRUE
W	2013.09.27 15:52:09.900	CMSCSC_Di_70OutPresFAA	PTxx26 - Rack 70 far out	CSC_Details		PTxx26 - Rack 70 far output	TRUE
W	2013.09.27 15:52:09.900	CMSCSC_Di_67OutPresFAA	PTxx26 - Rack 67 far out	CSC_Details		PTxx26 - Rack 67 far output	TRUE
W	2013.09.27 15:52:09.900	CMSCSC_Di_66OutPresFAA	PTxx26 - Rack 66 far out	CSC_Details		PTxx26 - Rack 66 far output	TRUE
W	2013.09.27 15:52:09.900	CMSCSC_Di_67OutPresAI	PTxx25 - Rack 67 output	CSC_Details		PTxx25 - Rack 67 output pre	TRUE
W	2013.09.27 15:52:09.900	CMSCSC_Di_68OutPresAI	PTxx25 - Rack 68 output	CSC_Details		PTxx25 - Rack 68 output pre	TRUE
W	2013.09.27 15:52:09.900	CMSCSC_Di_68OutPresFAA	PTxx26 - Rack 68 far out	CSC_Details		PTxx26 - Rack 68 far output	TRUE
W	2013.09.27 15:52:10.440	CMSCSC_Di_64OutPresFAA	PTxx26 - Rack 64 far out	CSC_Details		PTxx26 - Rack 64 far output	TRUE
W	2013.09.27 15:52:10.440	CMSCSC_Di_64OutPresAI	PTxx25 - Rack 64 output	CSC_Details		PTxx25 - Rack 64 output pre	TRUE
W	2013.09.27 15:52:10.440	CMSCSC_Di_65OutPresAI	PTxx25 - Rack 65 output	CSC_Details		PTxx25 - Rack 65 output pre	TRUE
W	2013.09.27 15:52:10.440	CMSCSC_Di_65OutPresFAA	PTxx26 - Rack 65 far out	CSC_Details		PTxx26 - Rack 65 far output	TRUE
W	2013.09.27 15:52:10.440	CMSCSC_Di_63OutPresAI	PTxx25 - Rack 63 output	CSC_Details		PTxx25 - Rack 63 output pre	TRUE
W	2013.09.27 15:52:10.440	CMSCSC_Di_61OutPresAI	PTxx25 - Rack 61 output	CSC_Details		PTxx25 - Rack 61 output pre	TRUE
W	2013.09.27 15:52:10.440	CMSCSC_Di_63OutPresFAA	PTxx26 - Rack 63 far out	CSC_Details		PTxx26 - Rack 63 far output	TRUE
W	2013.09.27 15:52:10.440	CMSCSC_Di_61OutPresFAA	PTxx26 - Rack 61 far out	CSC_Details		PTxx26 - Rack 61 far output	TRUE
A	2013.09.27 15:52:12.890	CMSCSC_Di_66OutPresAI	PTxx26 - Rack 66 output	CSC_Details		PTxx26 - Rack 66 output pre	TRUE
A	2013.09.27 15:52:12.890	CMSCSC_Di_66OutPresFAA	PTxx26 - Rack 66 far out	CSC_Details		PTxx26 - Rack 66 far output	TRUE
Bad	2013.09.27 15:52:12.990	CMSCSC_Di_DiRack66PCO	Distribution rack 66 PCO	CSC_Details		Full Stop Alarm Status	TRUE
Bad	2013.09.27 15:52:12.990	CMSCSC_Di_DiRack61PCO	Distribution rack 61 PCO	CSC_Details		Full Stop Alarm Status	TRUE
A	2013.09.27 15:52:13.370	CMSCSC_Di_61OutPresFAA	PTxx26 - Rack 61 far out	CSC_Details		PTxx26 - Rack 61 far output	TRUE
A	2013.09.27 15:52:13.370	CMSCSC_Di_61OutPresAI	PTxx25 - Rack 61 output	CSC_Details		PTxx25 - Rack 61 output pre	TRUE
A	2013.09.27 15:52:32.110	CMSCSC_Di_AlarmInRack66	Some alarms in rack 66	CSC_Details		Rack 66 alarm	TRUE
A	2013.09.27 15:52:32.110	CMSCSC_Di_AlarmInRack61	Some alarms in rack 61	CSC_Details		Rack 61 alarm	TRUE
A	2013.09.27 15:57:47.130	CMSCSC_Yh_AtmoPrSensAI	PT0101 - Atmospheric pres	CSC_Details		PT0101 - Atmospheric pres	TRUE

- Sequence:** Confidence: 100.0 % / Appearance count: 6
- CMSCSC_Di_62PRegAI | Alarm Unacknowledged | Rising
 - CMSCSC_Di_62PRegAI | Position Status (HH-LL) | Rising
 - CMSCSC_Di_YC60995 | Auto Off/Close Request Status | Falling
 - CMSCSC_Di_YC60995 | Auto On/Open Request Status | Rising
 - CMSCSC_Di_YC60995 | Off/Closed Status | Falling
 - CMSCSC_Di_YC60995 | On/Opened Status | Rising
 - CMSCSC_Di_YC60995 | Output Order Value Status | Rising
- Sequence:** Confidence: 83.3 % / Appearance count: 5
- CMSCSC_Di_62PRegAI | Alarm Unacknowledged | Rising
 - CMSCSC_Di_62PRegAI | Position Status (H-L) | Rising
 - CMSCSC_Di_62PRegAI | Position Status (HH-LL) | Rising
 - CMSCSC_Di_AlarmInRack62 | Alarm Unacknowledged | Rising
 - CMSCSC_Di_AlarmInRack62 | Position Status | Rising
 - CMSCSC_Di_YC60995 | Auto Off/Close Request Status | Falling
 - CMSCSC_Di_YC60995 | Auto On/Open Request Status | Rising
 - CMSCSC_Di_YC60995 | Off/Closed Status | Falling
 - CMSCSC_Di_YC60995 | On/Opened Status | Rising
 - CMSCSC_Di_YC60995 | Output Order Value Status | Rising

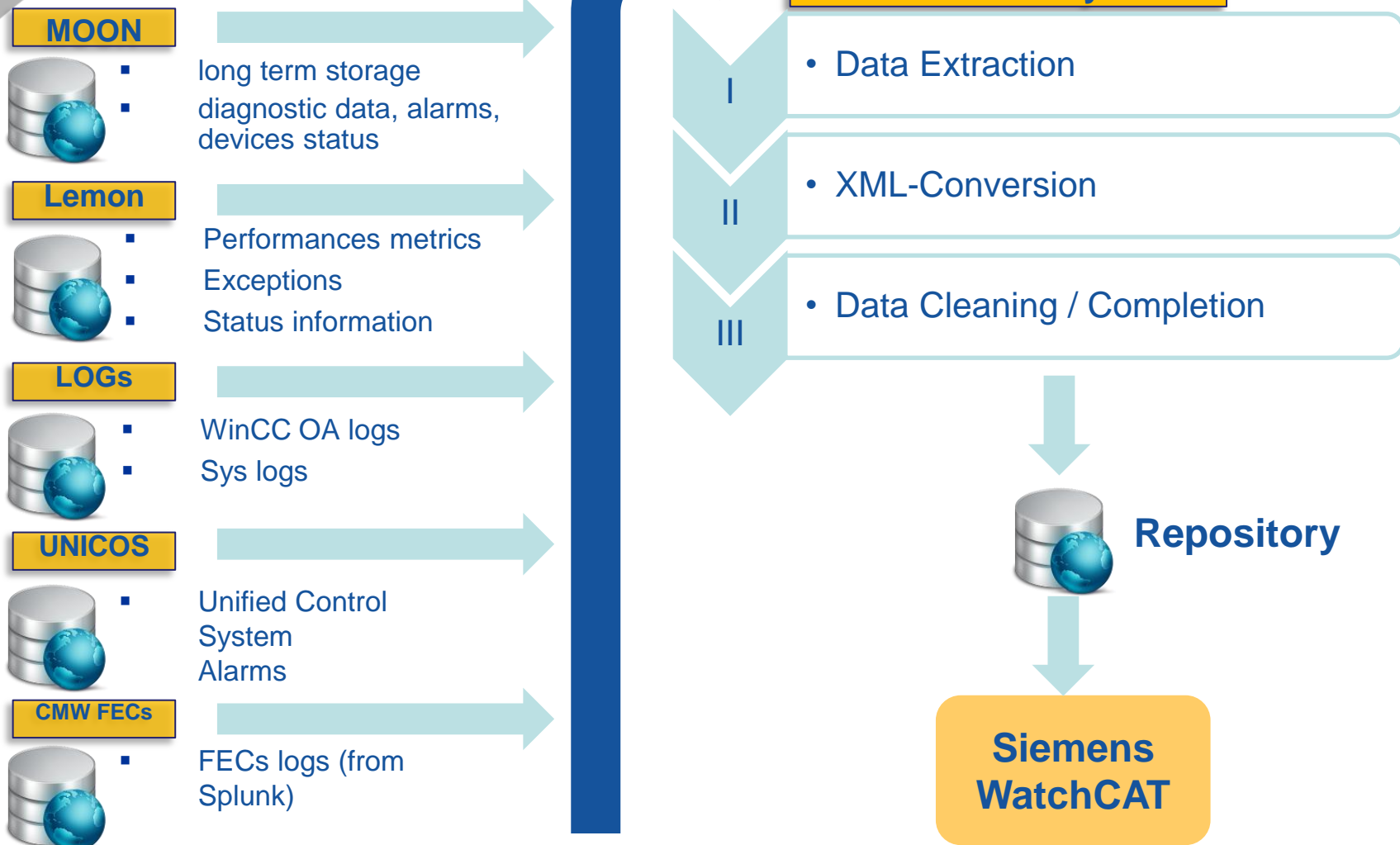
- Goal: control system faults/anomalies detection and diagnosis

Application	WinCC OA Systems	Parameters (Million dpes)
ALICE	100	3
ATLAS	130	12
CMS	90	10
LHCb	160	10
Accelerator Complex	120	10



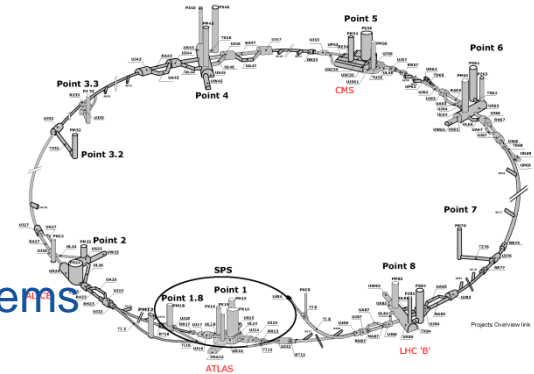
- System architecture under analysis:
 - 16 Control Applications
 - QPS, nQPS, CRYO, CIET, CIS, PIC, WIC, LHC-CIRCUIT, PSEN ...
 - Linux control PCs : ~120
 - PLCs: ~300
 - FECs: ~100

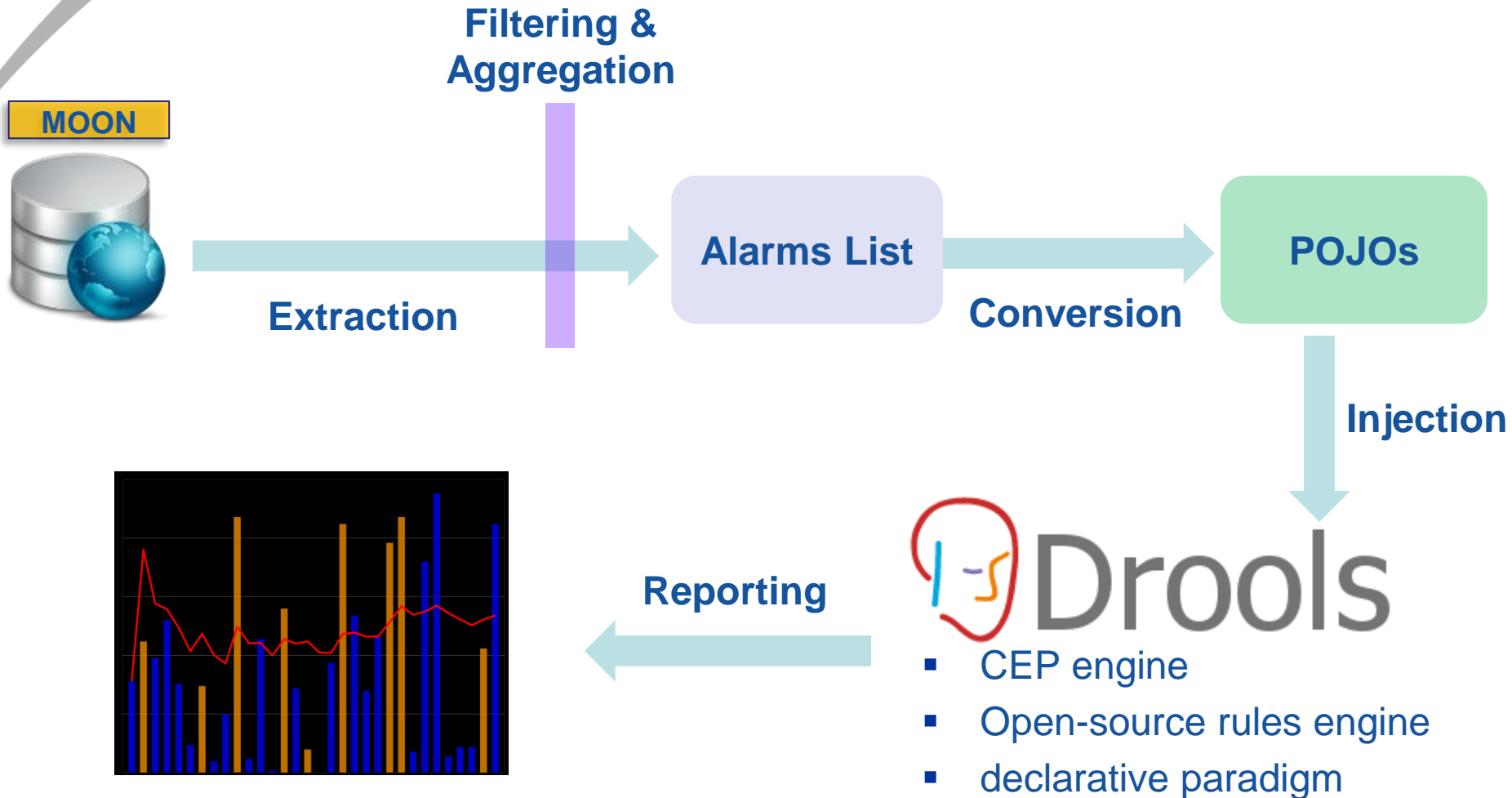
Offline Control System Health Analysis



Offline Control System Health: Status

- Issues:
 - Huge amount of data [$\sim 130\text{GB} + \text{LHC}$]
 - Different data types:
 - Structured/Not Structured
 - Numerical / Boolean / Plain-text
 - Gaps, missing some metadata
 - Unsynchronized data sources
 - Different relationships among the subsystems
 - ...
- Initial conclusions
 - no single framework out of the box to analyze numerical data and not (next version of WatchCAT)
 - Necessary a combination of tools for a complete data analysis (log processing, statistical analysis, pattern recognition...)
 - Split this use-case into smaller ones:
 - signal analysis use-case (next version of WatchCAT will provide predictive trending capabilities)
 - automatic extraction of statistical metrics and thresholds





Necessary actions:

- Access to the data (i.e. sensible or protected information)
- Deal with data heterogeneity: file formats, units of measure, date formats, data structures
- Data synchronization
- Several different data sources
- Data enhancement: data classification, data completeness, improve time resolution ...
- Data selection / filtering
- Data input/output representations
- ...

Any Questions



Thank you for attending!