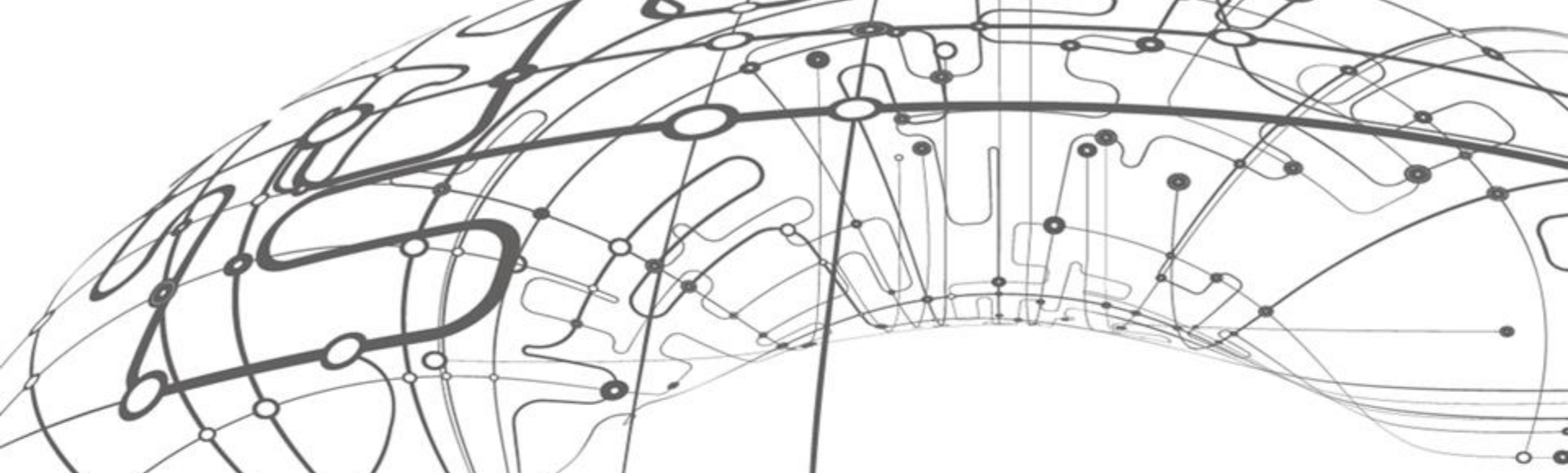

Smart Technologies for Large Control Systems

› 10th June 2015

CERN Open Day

Elisabeth Bakany, Siemens-ETM

Filippo Tilaro, CERN

CERN openlab

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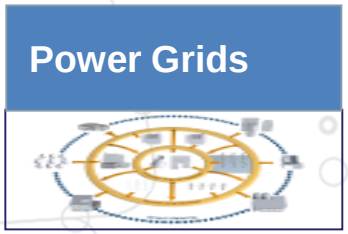
Siemens - Smart Data to Business



...

Customer Advantage

- Better Performance
- Lower Costs
- Saving Energy
- Reduce Risks
- New Business Models

Data from Products, Systems, Sensors, Processes ...

"Smart data to business"

Data → **Data analytics** → **Business Intelligence** → **Business Innovation** → **Value Generation**

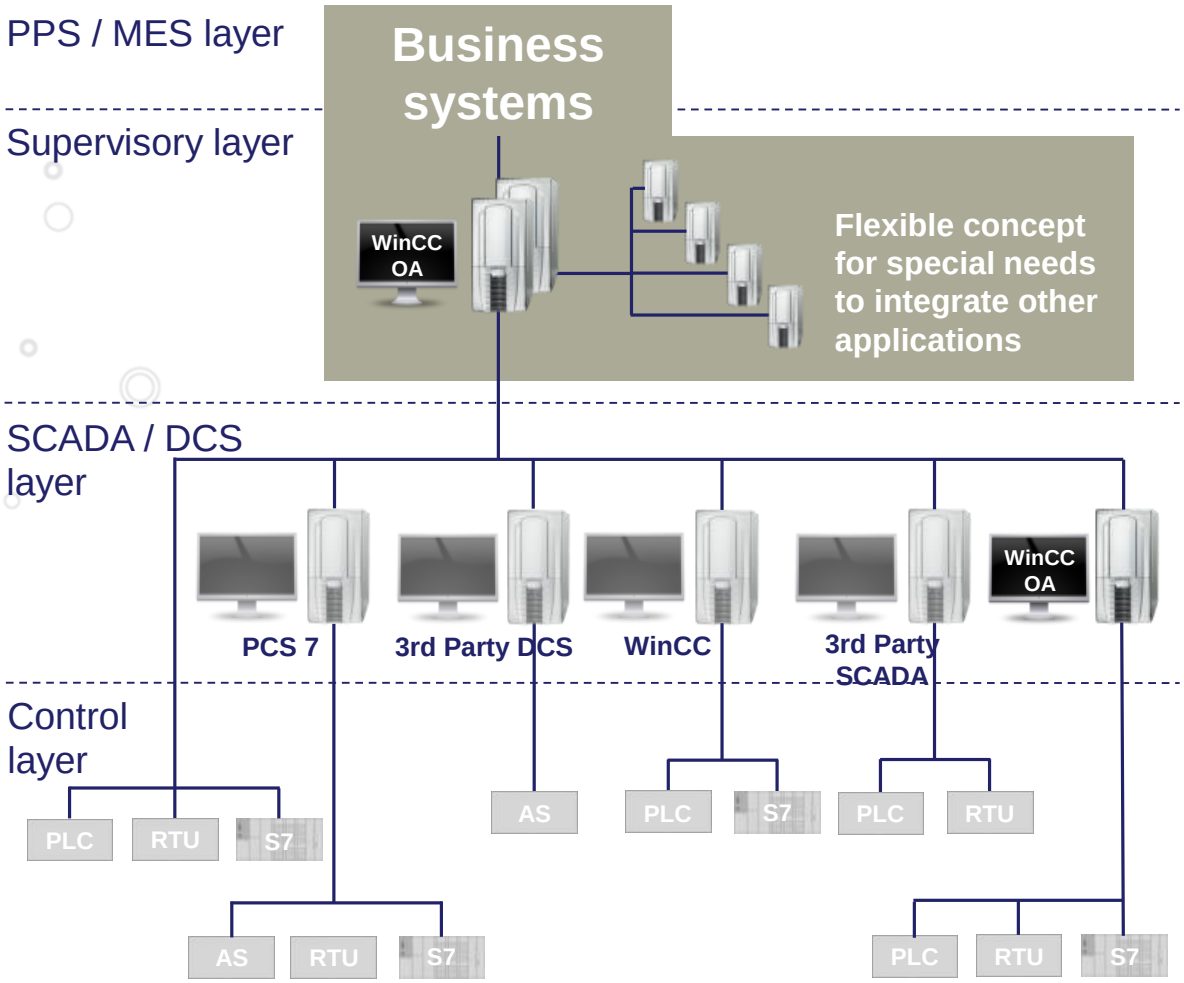
Domain know-how + **Device know-how** + **Analytics know-how** = **Smart Data**

SIEMENS

Background image: Shutterstock

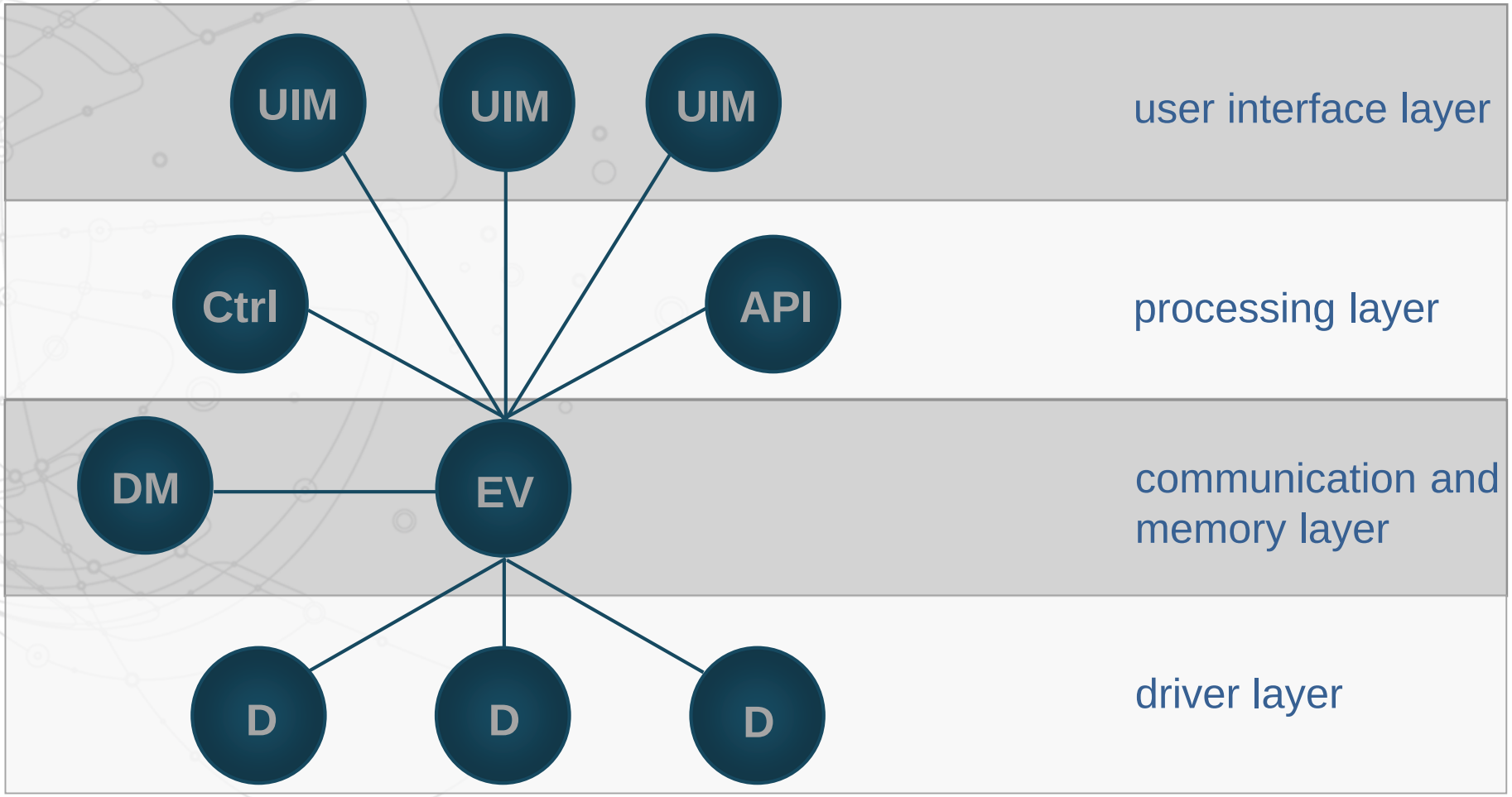
WinCC Open Architecture (OA)

- **Perfect for large scale applications**
  - for big and/or complex systems
  - for geographically wide distributed plants
  - freely scalable and expandable
  - for supervisory layer
  - supports redundancy
  - for the highest security requirements
  - the only SCADA system with SIL 3-certification
- **Supports > 10,000,000 data points**

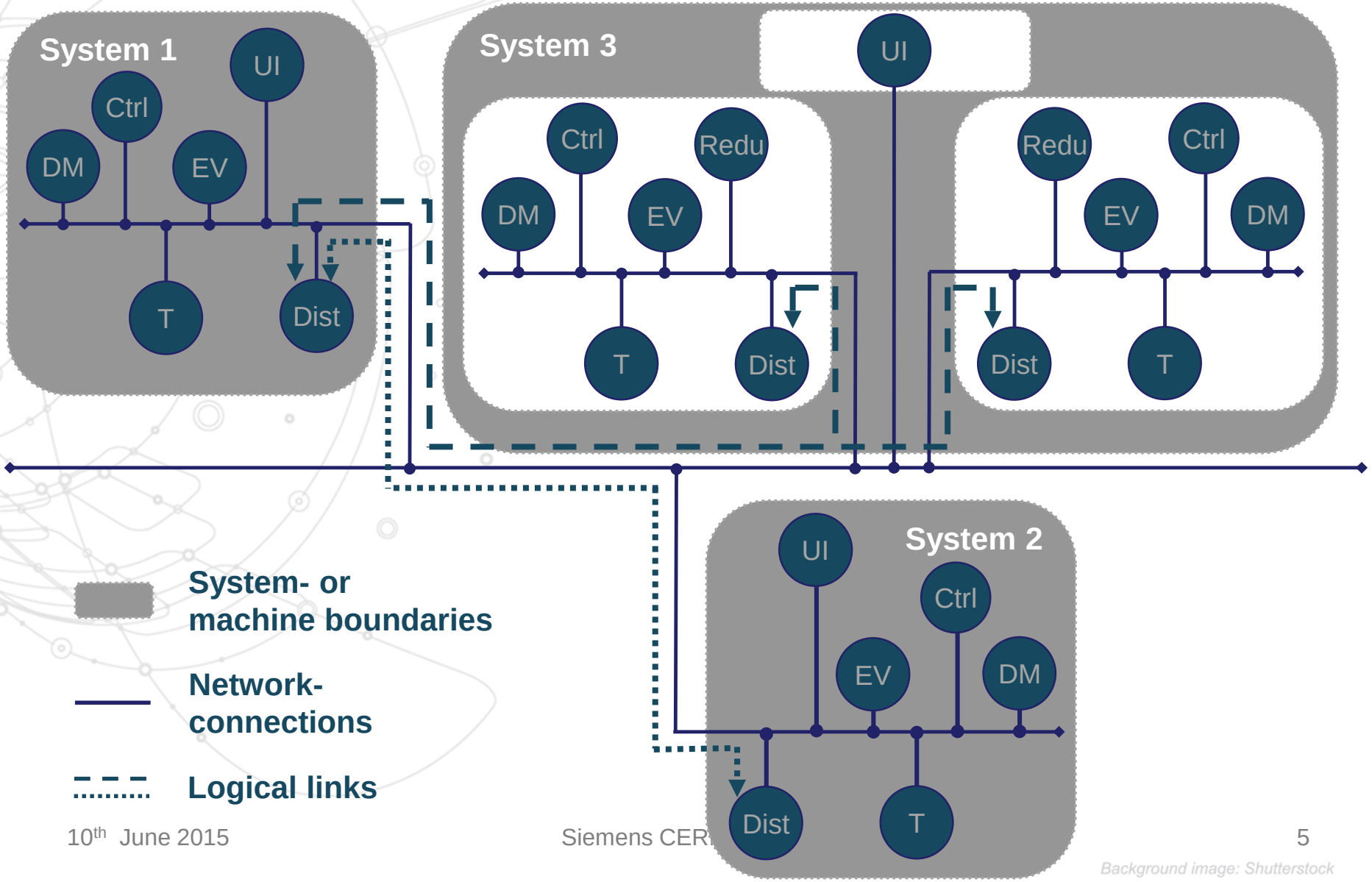


Background image: Shutterstock

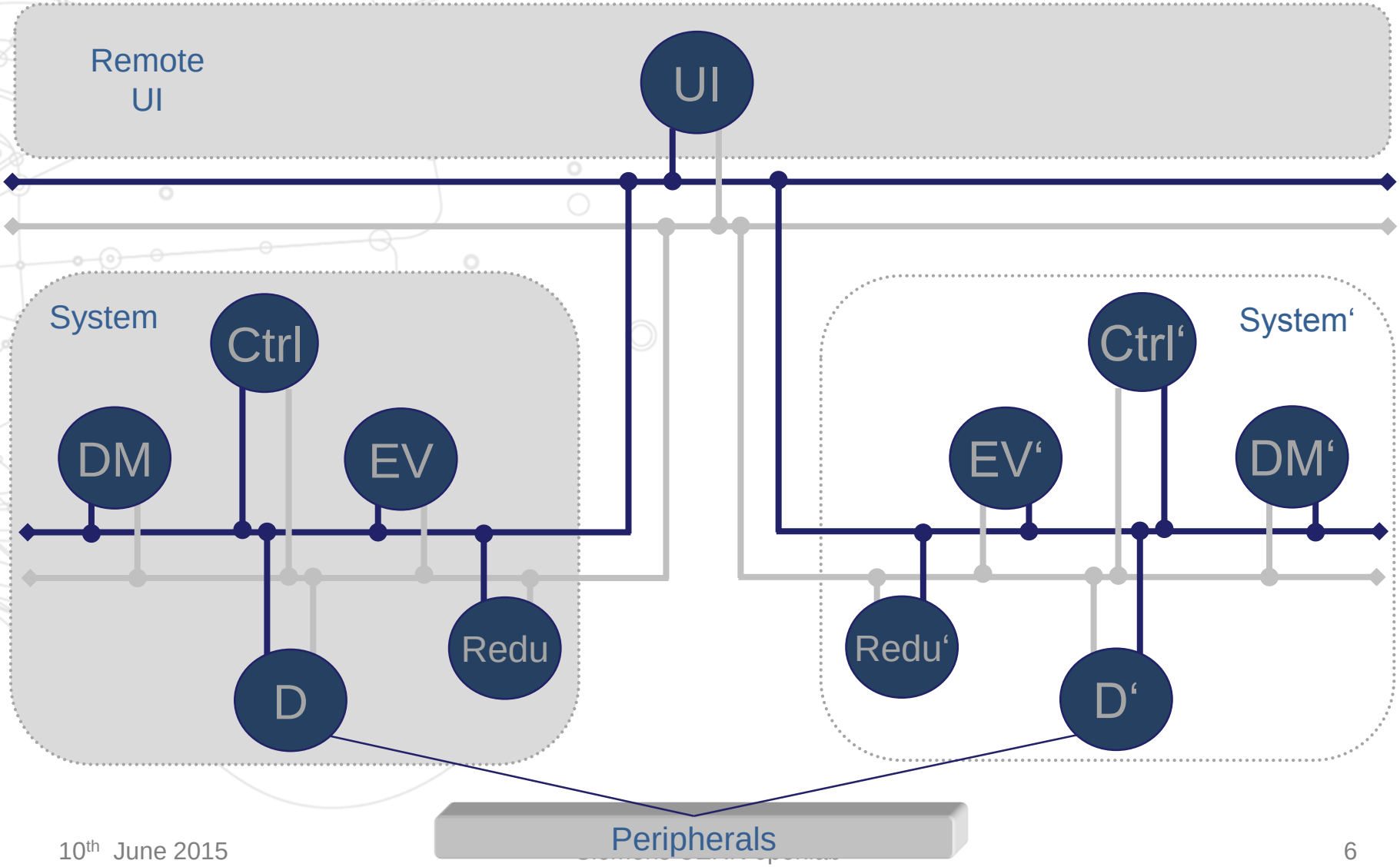
WinCC OA Manager Concept



WinCC OA as Distributed System



WinCC OA Redundancy



WinCC OA – flexible and open

- Fast adaptation of control and visualization of the plant to suit current market requirements
- Implement new processes quickly and easily also by in-house programming and developments enabling independence and know-how protection
- Standardized solutions enable continuous use
- SCADA Platform for OEMs
- Brand labeling is supported

- Platform independent (Windows, Linux, Solaris)
- Object orientation
- Open achitecture
- Platform in use in many industrial sectors
- Easy Integration with other SW
- Fast development time

WinCC OA within Siemens

SIEMENS

PG Power and Gas	WP Wind Power &Renewables	EM Energy management	BT Building technologies	MO Mobility	DF Digital factory	PD Process Industries and Drives	HC Healthcare
PG Power Generation Services							
DG	WP	LP	BT	MM	FA	LD	AU
SU		HP	CPS	TPE	PL	OM	CX
CP		MS		MLT	EC	PA	DX
ES		EA		UT	CP	MD	CP
IE		SG		CS	CS		IM
GT		TS			MC		
		TR					

17 products based on OA

A bit of history…

Long successful collaboration

- For more than 20 Years
- More than 600 Simatic control systems installed
- Partnership, Much more than a client-provider relationship

Large deployment of Siemens systems

- Supervision systems (WinCC OA, WinCC)
- Programmable Logic Controllers (PLC)
- Control modules
- Panels, …

Application	Systems installed
ALICE	~100
ATLAS	~130
CMS	~90
LHCb	~160
Accelerators	~200
Total	>600

Joined openlab in 2009

- Phase III (2009-12): Security, Large scale deployment
- Phase IV (2012-15): High performance archiving, Data Analysis
- Next phase V (2015-18): Data Analytics, WinCC OA enhancements

Typical Control System Architecture

Data Analytics

- Improve functionality, efficiency, and predictability of CERN control systems
- Support operators to take decisions, enhance the online monitoring systems

Supervision layer

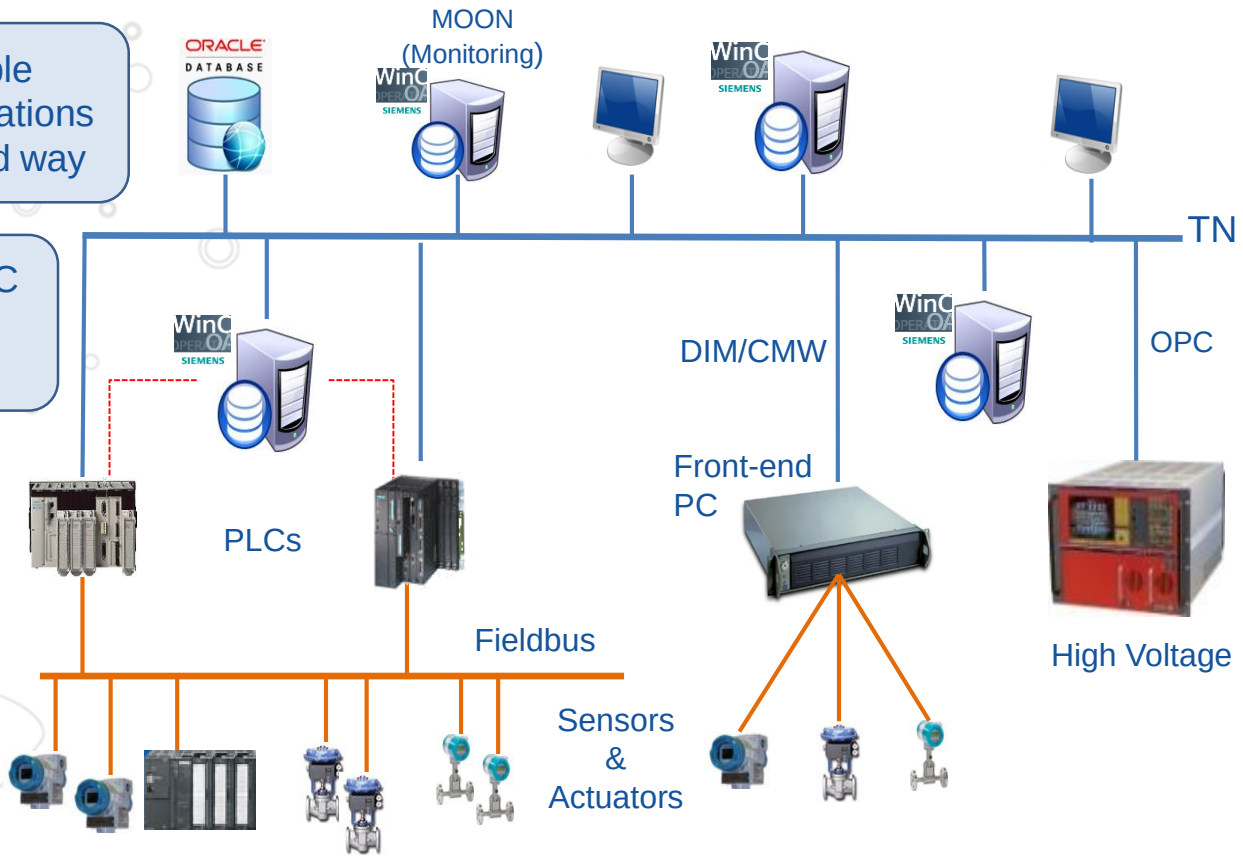
WinCC OA:
- **Deployment tool**
- **RDB Archiver**

Manage multiple SCADA applications in a centralized way

Improve WinCC OA archiving capabilities

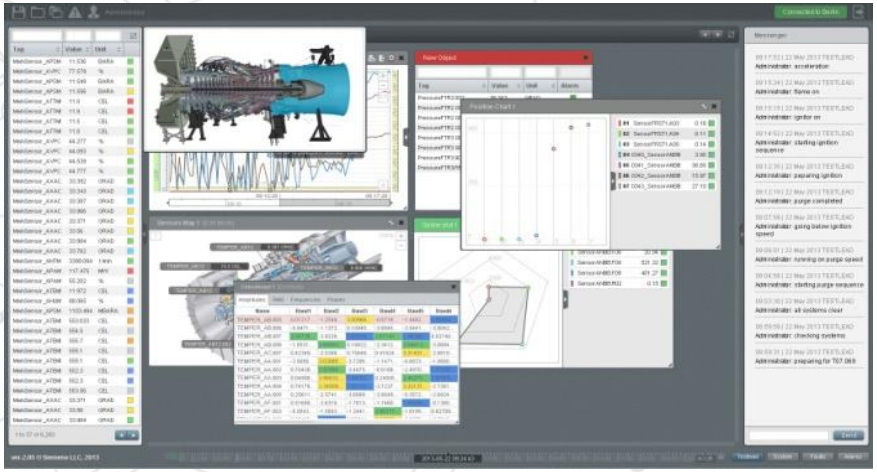
Process layer

Field layer



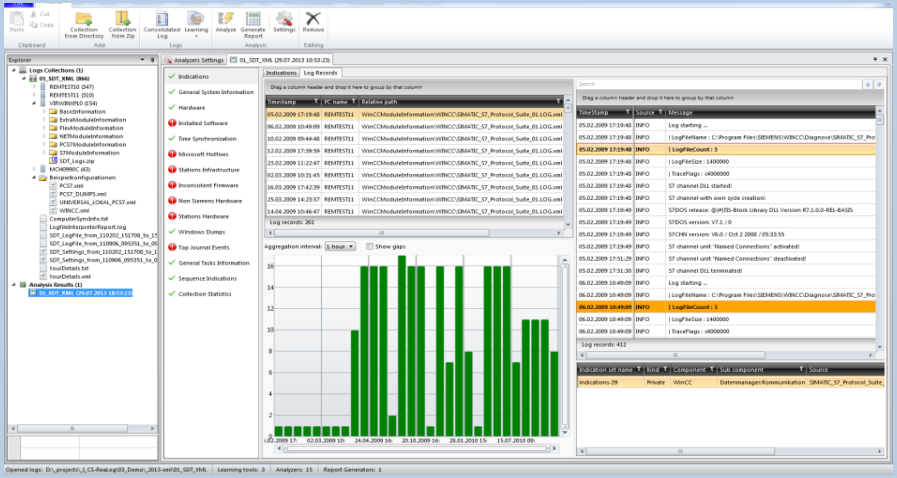
Siemens' Smart Data Technologies @ CERN

Code name "ELVis"



- Cloud-based BIG Data Analytics for Time Series Sensor Data
- Real-Time Stream Processing at customizable KHz-Rates
- High Performance Online Visualization in Rich Web-based UI
- Intelligence for Sensor Data Validation
- Job-based Offline Data Analysis

Code name "WatchCAT"



- Data Fusion of events & sensors
- Complex Event Processing
- Automated Learning of fault patterns
- Logical Reasoning for Fault Detection & Isolation
- Fault prediction based on recognizable patterns

Siemens' Smart Data Technologies:

Control System Analysis

Control Systems

~200 systems

~300PLCs
~100 FECs

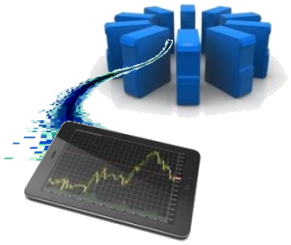
~5*10^7 I/Os

Data

Analyze

Identify and detect fault / abnormal pattern for Diagnosis and Prognostics based on domain knowledge

Learn



Provide experts with Root-cause and Gap Analysis using Rules and Patterns Mining

Diagnose

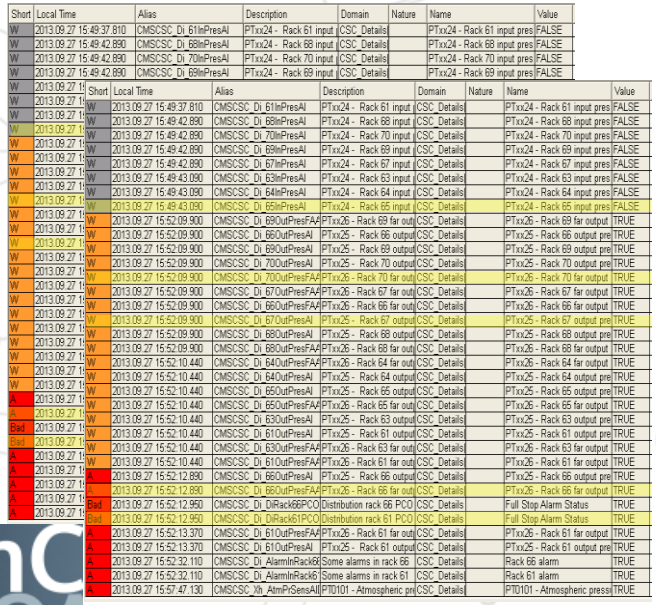
Forecasts, Trends and Early-Warnings to increase Operating Hours

Pattern AA B A A B → **Alarm**

X T C D F A A E D N D B K D F A A B K D

Understanding the GAS system behaviour with Smart Data:

Identifying a root-cause



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W	2013.09.27 15:49:42.890	CMSCSC_Di_68InPresAl	PTxx24 - Rack 68 input	CSC_Details		PTxx24 - Rack 68 input pres	FALSE
W	2013.09.27 15:49:42.890	CMSCSC_Di_70InPresAl	PTxx24 - Rack 70 input	CSC_Details		PTxx24 - Rack 70 input pres	FALSE
W	2013.09.27 15:49:42.890	CMSCSC_Di_69InPresAl	PTxx24 - Rack 69 input	CSC_Details		PTxx24 - Rack 69 input pres	FALSE
W	2013.09.27 15:49:42.890	CMSCSC_Di_67InPresAl	PTxx24 - Rack 67 input	CSC_Details		PTxx24 - Rack 67 input pres	FALSE
W	2013.09.27 15:49:43.090	CMSCSC_Di_63InPresAl	PTxx24 - Rack 63 input	CSC_Details		PTxx24 - Rack 63 input pres	FALSE
W	2013.09.27 15:49:43.090	CMSCSC_Di_64InPresAl	PTxx24 - Rack 64 input	CSC_Details		PTxx24 - Rack 64 input pres	FALSE
W	2013.09.27 15:49:43.090	CMSCSC_Di_65InPresAl	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_66OutPresAl	PTxx25 - Rack 66 output	CSC_Details		PTxx25 - Rack 66 output pre	TRUE
W	2013.09.27 15:52:09.900	CMSCSC_Di_69OutPresAl	PTxx25 - Rack 69 output	CSC_Details		PTxx25 - Rack 69 output pre	TRUE
W	2013.09.27 15:52:09.900	CMSCSC_Di_70OutPresAl	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_67OutPresAl	PTxx25 - Rack 67 output	CSC_Details		PTxx25 - Rack 67 output pre	TRUE
W	2013.09.27 15:52:09.900	CMSCSC_Di_68OutPresAl	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_64OutPresAl	PTxx25 - Rack 64 output	CSC_Details		PTxx25 - Rack 64 output pre	TRUE
W	2013.09.27 15:52:10.440	CMSCSC_Di_65OutPresAl	PTxx25 - Rack 65 output	CSC_Details		PTxx25 - Rack 65 output pre	TRUE
A	2013.09.27 15:52:10.440	CMSCSC_Di_65OutPresFAA	PTxx26 - Rack 65 far out	CSC_Details		PTxx26 - Rack 65 far output	TRUE
A	2013.09.27 15:52:10.440	CMSCSC_Di_63OutPresAl	PTxx25 - Rack 63 output	CSC_Details		PTxx25 - Rack 63 output pre	TRUE
Bad	2013.09.27 15:52:10.440	CMSCSC_Di_61OutPresAl	PTxx25 - Rack 61 output	CSC_Details		PTxx25 - Rack 61 output pre	TRUE
Bad	2013.09.27 15:52:10.440	CMSCSC_Di_63OutPresFAA	PTxx26 - Rack 63 far out	CSC_Details		PTxx26 - Rack 63 far output	TRUE
A	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_66OutPresAl	PTxx25 - Rack 66 output	CSC_Details		PTxx25 - 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 15:52:12.950	CMSCSC_Di_DiRack66PCO	Distribution rack 66 PCO	CSC_Details		Full Stop Alarm Status	TRUE
Bad	2013.09.27 15:52:12.950	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_61OutPresAl	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_AtmPrSensAll	PT0101 - Atmospheric pre	CSC_Details		PT0101 - Atmospheric press	TRUE

Event lists generated
⊗ by the same fault

Sequence: Confidence: 100.0 % / Appearance count: 6

CMSCSC_Di_62PRegAl | Alarm Unacknowledged | Rising
CMSCSC_Di_62PRegAl | 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_62PRegAl | Alarm Unacknowledged | Rising
CMSCSC_Di_62PRegAl | Position Status (H-L) | Rising
CMSCSC_Di_62PRegAl | 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

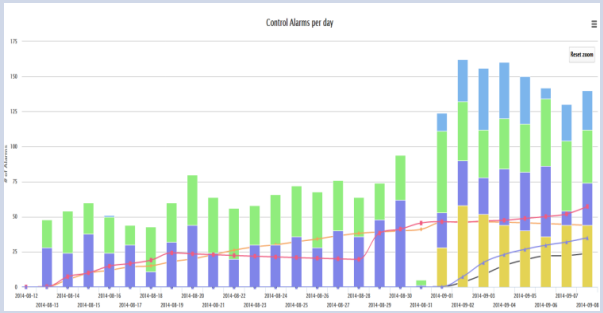
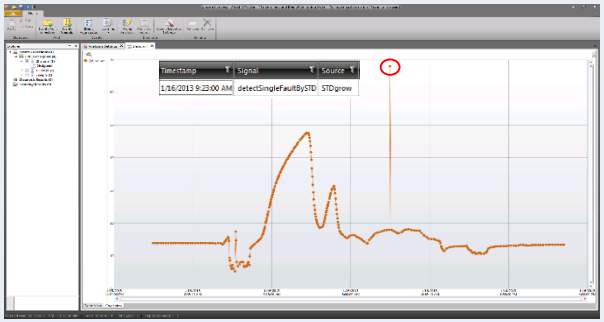
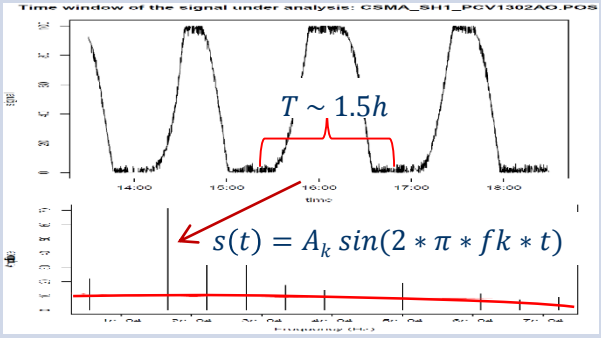
Extracted fault signatures

WinCC OA OPERATION
SIEMENS

› **Objective: Support the operator during diagnostic activities shortening the analysis time and avoiding or shorting the downtimes**

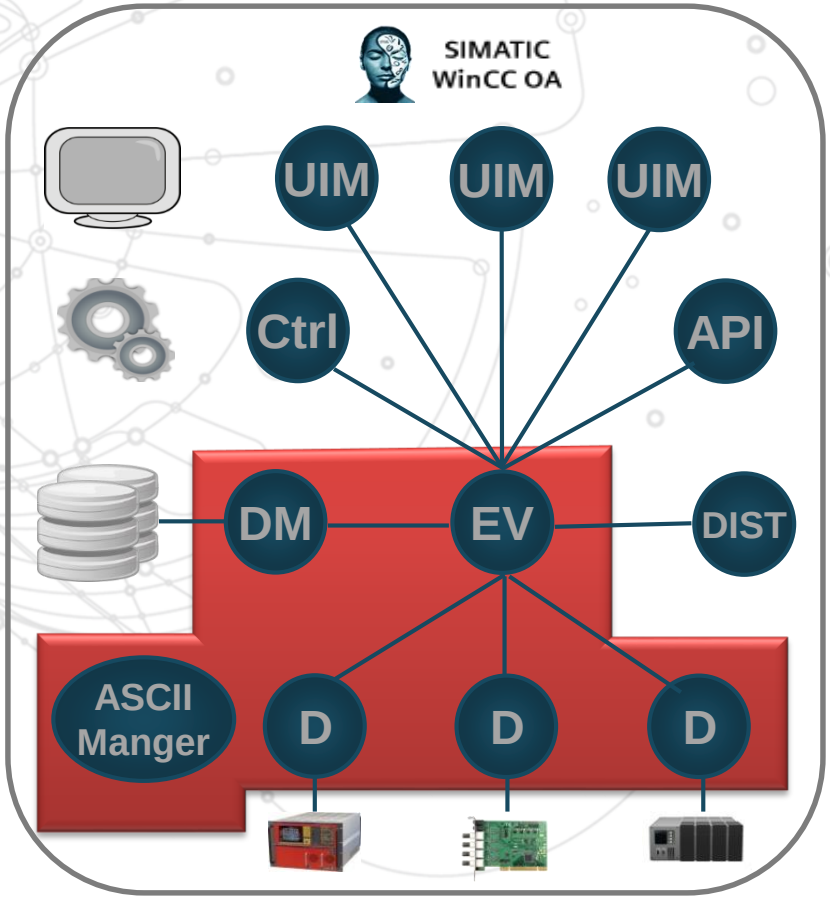
- 1st Phase: learning system behaviour by extracting fault signatures
- 2nd Phase: automatic fault classification by comparing the current events and alarm with the previously extracted signatures

Data Analytics use-cases:
few examples, but many more!

Title	Description	Analysis Results
On-line analysis of control alarms	Alarms analysis to detect anomalies or abnormal behaviours at the single device level	
Fault sensor measurements detection for the cryogenic system	Design and implementation of algorithm to detect faults in sensors measurements	
Cryogenic valves oscillation	Optimize the regulation of control valves by spotting oscillator behaviours	

Centralized Deployment Tool (CDT)

- Large control applications @CERN:
  - +150 interconnected WinCC OA systems
- Upgrade sets of WinCC OA applications in a centralized fashion



ASCII Manager is a key component of the CDT

- Projects DB imports/exports from/to files
- Hardware equipment configuration

Goal

- Introduce XML based file format for export/import
- XML is easier to validate and integrate with external tools than current ASCII files

ASCII Manager

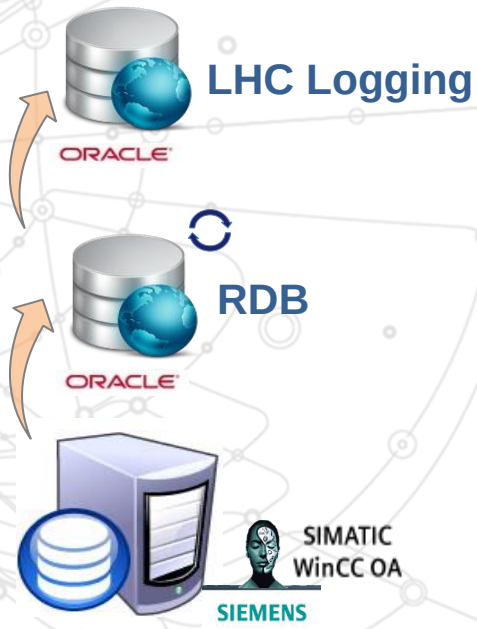
WinCC OA 3.X

- XML schema defined
- First implementation of XML export functionality
- Code and schema currently under review at ETM

IOWA-based SCADA system

- Completely new platform (including data model)
- New way to interact with the runtime
- CERN involvement since an early stage
- Influence the requirements and technology selection
- Pioneering the usage of the new SDK
- Valuable feedback sent to ETM on SDK and tutorials
- Prototype available

RDB Archiver for WinCC OA 3.11
Performance, robustness and stability



- **Successful collaboration**
  - Improvements implemented and tested at CERN
  - Code transferred to ETM
  - New functionality made available to all ETM customers
- **Success story: migration to Oracle Archiver**
  - 200 LHC-related applications
  - Required to run the LHC at 13 TeV (QPS)
  - 200 000 values/s steady state, 10^6 values/s in peak
- **Essential also for CERN experiments**
  - Oracle archiver used since 2007
- **Unified archiving technology CERN-wide**
  - ~500 CERN production systems and ~10 databases
  - Deployed on time for the LHC Run II

More on Data Processing

Reporting Manager

- **Significant performance improvements**
  - parallel request processing
  - redesign of architecture for Oracle queries
- **Already available in WinCC OA 3.13**

R&D: Big data and NoSQL

- **Research on technology for future archiving system**
  - Prepare future run of LHC: throughput/size increase by a 10x factor
- **Hadoop**
  - Workshop to transfer knowledge to ETM
- **Initial investigation of other technologies**
  - Elasticsearch, IMPALA
- **Synergy with Data Analytics**
  - Archiving subsystem is essential

CERN openlab
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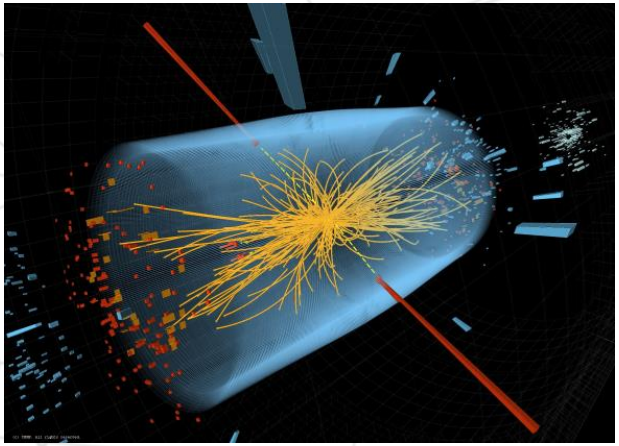
CERN & Siemens collaboration:

Benefits for CERN



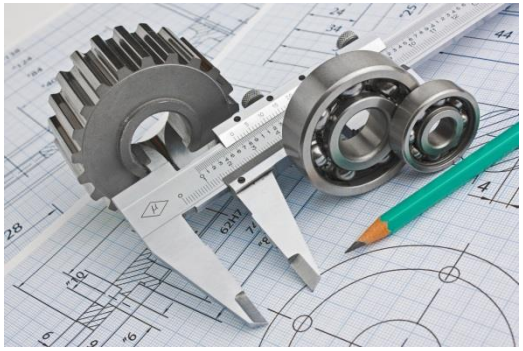
- **Increased System Reliability**
  - Minimized forced outages
- **Complete data analysis**
  - Reduced service effort: weeks → hours
- **24/7 Expert Knowledge Availability**
  - One central knowledge base

Operation support

- Forecast system status and take proper actions in time
- Prevent possible faults and system downtime
- Identify hidden patterns

Diagnosis support

- Identify root causes
- More accurate analysis
- Accelerate analysis
  From weeks to hours



Engineering support

- Improve operational performance
- Increase reliability and efficiency by design
- Lead control system decisions

Background image: Shutterstock

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CERN & Siemens collaboration :

Next Steps

Data Analytics

- Innovative Siemens' Smart Data technologies suited for the analysis of many CERN control systems
- Integration of CERN specific extensions & data analysis algorithms

Q3/2015 — Q1/2016 — *Q2/2016* — *Q1/2017* — *2018*

WinCC OA

- Continue the work on the open fronts: RDB and CDT
- Broaden the spectrum of activities to other areas like:
  - Visualization: Web, widgets enhancements
  - Secure Remote Access
  - Alarms: Screen and alarm hierarchies
  - Enhanced Reporting / Data Analytics integration
  - Prototype of NoSQL-based archiver system
  - Development tools

Any Questions

Thank you for your attention!