WAO 2018
Operator-made Tools and Software

Yannick Le Borgne
CERN – SPS / LHC Operator
Outline

• Introduction

• **Front-End Software Architecture**

• **LHC Software Architecture**

• Tools use case

• Conclusion
Introduction to CERN complex

CERN was founded 1954: 12 European States
"Science for Peace"

Today: 22 Member States

~ 2600 staff
~ 1280 other paid personnel
~ 11000 users
Budget (2016) ~1000 MCHF
CERN Accelerator Complex

Large Hadron-Collider (LHC)
SuperProton Synchrotron (SPS)
Proton Synchrotron (PS)
CERN Accelerator Complex
Operational tools

CERN control infrastructure is composed of:

- A large number of **Front-End computers** > 800
- A huge **equipment diversity** > 500
- A big number of **physical devices** to control ~45000

Operator is not expert, he should diagnose faults, if the problem persist an equipment specialist will intervene and hopefully solve the problem.

Efficient operation tools are extremely helpful for operators and are essential for machine reliability.
Front-End Software Architecture

Control Middleware: Front-End Software Architecture

Presentation Layer

Server Layer

Front End (Back End) Layer
Front-End Software Architecture

Control Middleware: Front-End Software Architecture

- Object oriented framework
- Common equipment software across all accelerators
- Easier communication with equipment
- Use a standardized language for front end software development
- Support all primitive data types
- Provide an interface for clients

Presentation Layer

- Server Layer

- Front End (Back End) Layer

- FESA:
  - ✔ Object oriented framework
  - ✔ Common equipment software across all accelerators
  - ✔ Easier communication with equipment
  - ✔ Use a standardized language for front end software development
  - ● Support all primitive data types
  - ● Provide an interface for clients

Network:
- ETHERNET NETWORK
- VME Front Ends
- RT Lynx/OS
- WORLDIP

Server Layer
- RT Lynx/OS
- VME Front Ends
- WORLDIP Front Ends
- SCADA SERVERS
- OPCAL

Presentation Layer
- OPERATOR CONSOLES
- FIXED DISPLAYS
- OPERATOR CONSOLES
- SCADA SERVERS
- WORLDIP

Communication
- CERN GIGABIT ETHERNET NETWORK
- CERN VME FRONT END NETWORK

Front End (Back End) Layer
- OPTICAL FIBERS
- WORLDIP SEGMENT
- PROFIBUS
- FIPIO

Equipment
- ACTUATORS AND SENSORS
- CRYOGENICS, VACUUM, ETC.
- QUENCH PROTECTION AGENTS,
- POWER CONVERTERS
- FUNCTIONS GENERATORS, ...
- RF SYSTEMS, ETC.
- BEAM POSITION MONITORS
- BEAM LOSS MONITORS
- BEAM INTERLOCKS
- RF SYSTEMS, ETC.

TCP/IP communication services
Client interface

<table>
<thead>
<tr>
<th>Target</th>
<th>I/E11</th>
<th>MUL</th>
<th>%SYM</th>
<th>Experiment</th>
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<tbody>
<tr>
<td>T2</td>
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<td>16</td>
<td>93 a</td>
<td>H2/H4</td>
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Phone: 77500 or 70475  
Comments (22-Sep-2018 16:17:26)
### Client interface

**Magnetic Field**

**Beam Intensity**

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Equipment state and control

Equipment Selection

Cycle Selection

Status and Control property selection

SPS 200 MHz cavities
Equipment state and control
LSA (LHC Software Architecture)

- Around the ring, we have thousands of different devices
- In order to work they need to be given settings
  - They need to know what to do

LSA does it: manage settings
LSA (LHC Software Architecture)

LSA is a database:

- Every change is registered.
- Allow **reloading** of previous settings **at any time**.
- Provide **physics model-based** controls for operation.
  - MBI/IREF - **hardware** level parameter
  - TUNE/QH - high level **physical** parameter
- Parameters organized by **hierarchies**.
Hierarchy and calculation

How to calculate main magnets current in SPS from a momentum function?

Machine design:
Machine run energy: 400 Gev
Dipole magnet field: 1.8 T
Calibration factor is specific to dipole magnets

\[ B = \frac{\text{MOMENTUM} \times 1.8}{400} \]

Example with a LHC beam:
\[ B = \frac{450 \times 1.8}{400} = 2.025 \text{ T} \]
Hierarchy and calculation

LHC Horizontal Tune Hierarchy
Hierarchy and calculation

LHC Collimator aperture Hierarchy
Tools use-case
Conclusion

Front-End Software Architecture and LHC Software Architecture are two essential tools for operation at CERN:

- Adapted to a huge number of devices to control
- Provide high level accelerator machine parameters
- Optimized for expert and operator work

These powerful tools combined with good operation skills contributed to achieve high performance and reliable operation.
Thanks to CERN BE/CO group, and specially to the FESA team, LSA / INCA team and G. Kruk

Thanks for your attention!