Using an Expert System for Accelerators Tuning and Automation of Operation Failure Checks

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- Motivations
- SOLEIL Expert System Building Blocks
  - Passerelle
  - Drools
  - CDMA
- Use Case
In daily operation an operator has to perform many manual checks:

- Are the control system services working fine (i.e. is the archiving system really logging data?)
- Is the alarm detected by a supervision application linked to a control system sub module or is it an equipment problem?
- Is beam correctly delivered to beamlines?

- Same kind of problems analysis to do again and again
- Many different applications to interact with
- Diagnose quality is operator knowledge dependent
- Very error-prone

Why not automate all these tasks?
In case of abnormal operation (beam loss)

- Collect data for analysis (extract archived data, post-mortem data, …)
- Check the elog book or an accelerator expert to see what is the relevant recovery process to apply
- Perform in sequence the advised operation/rules for the given situation

- No uniform way to **collect data** from different sources
- Lack of centralization accelerator operation **expertise**
- Non automated repetitive **sequences** of operations
- Very **error-prone**

Why not use an expert system?
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Automation of an analysis/diagnosis process workflow takes care of:

- Collecting and consulting the available data for analysis
- Formulating decisions/diagnosis rules
- Preparing advised actions to repair the problematic situation

Need for a workflow modeling environment: Passerelle
Need for a uniform data access layer: CDMA
Need for a rules based environment: Drools
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PASSERELLE allows to graphically design complex workflows and execute them.

- PASSERELLE is provided by a company called ISENCIA
  - Specialized in process driving for industrial companies.
- PASSERELLE is based on an environment for scientific modelisation and simulation: PTOLEMY (developed by the Berkeley University)

http://ptolemy.eecs.berkeley.edu/ptolemyII/
Workflows are developed by connecting « boxes » and « wires »:

- The « boxes » are called **ACTORS**: they execute an action.
- The « wires » are called **MESSAGES**: they transfer data.

The graphic language for editing sequences provides all functionalities to build complex logics:

- Loops
- Comparison
- Error Management
- Parameterization
Full-featured remote access via standard web technology

- Allows workflows design, execution, monitoring etc on a secure and robust server-based platform
- Automated scheduling of workflows executions
- Monitoring and diagnostics of workflows execution
- A relational DB stores:
  - Workflows definitions
  - their configuration
  - the analysis rules
  - the execution traces
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**Drools: The inference system principle**

- **Jboss Drools is an inference system**
  - It can be seen as an advanced “if-then” programming language interpreter

- **Rules engine**
  - Is based on a declarative (“what to do”) programming model
  - *instead of the usual imperative (“how to do it”) programming*
  - It evaluates a collection of registered “facts” in a “knowledge base”
  - New facts can be derived by the rules, and added to the knowledge base
  - This can trigger (other) rules again
Drools is an easy-to-use Java API which can be integrated in a “normal” Java program in 2 different ways:

- Using the standard Java Rules API (JSR 94)
- Or using a proprietary Drools API (more feature-rich)

Rules can be defined in different ways

- Using the usual Java programming mixed with “when/then” Drools syntax (which allow complex and powerful rules to be defined))
- Using Domain specific languages (user-friendly)
- Using Decision tables (spreadsheet definition)
We developed a library of Passerelle actors for

- **Data collection**
  - Adaptation of existing Tango actors (AttributeReader etc)
  - SQL-Database-Reader (CDMA plugin)
  - HDF files reader (CDMA plugin)

- **Analysis**
  - Drools Expert actors which bridges the Passerelle and Drools worlds

- **Diagnosis**
  - Report generator (based on the eclipse BIRT package)
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CDMA API: An abstraction to access data

- CDMA is an API providing a unified data layer
  - independently of the kind of the data source (database, HDF5 files)

- CDMA key points are:
  - An abstract interface to navigate in a uniformed way through data sources using a unique data model
  - A plugin system to cope concretely with the real kind of data source (database, HDF5 files)
  - A dictionary mechanism to cope with data organization in the data sources

- CDMA is an open source collaboration project:
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Use Case: Beam Stability in the storage ring

The Simplified prototype we developed for this scenario does:

- **Data collection phase**
  - Gets from a database the “Reference storage beam orbit”
  - Compare it to last 10 seconds “Archived Beam Positions”

- **Data analysis/diagnosis**
  - If these 2 orbits differ see if any of the insertion devices gap positions has changed during the last 100 seconds
  - Store all these collected data thanks to CDMA layer

- **Diagnosis report**
  - Done through the BIRT reporting package
Simple Beam Stability Scenario
Passerelle Workflow

Beam position analysis
Gap position analysis
Storing Results
List Of Beam Positions Deviating from their reference

<table>
<thead>
<tr>
<th>Beam Position</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>ANX-CDUG/CDU-EDB-POSITION-AXIS1EnergieX</td>
<td>0.39861860823683326</td>
</tr>
<tr>
<td>ANS-CDUG/CDU-EDB-POSITION-AXIS1EnergieX</td>
<td>5.498003273116112</td>
</tr>
<tr>
<td>ANX-CDUG/CDU-EDB-POSITION-AXIS1EnergieX</td>
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<tr>
<td>ANX-CDUG/CDU-EDB-POSITION-AXIS1EnergieX</td>
<td>58.75166587054227</td>
</tr>
</tbody>
</table>
An example of a possible Reason:
Deviation of an Insertion device Gap Positions

One Insertion Gap Position has changed
An expert system is a promising environment to cope with the problem of automating diagnosis of abnormal accelerator operation

- **Foreseen**
  - To perform a complete beam stability diagnosis workflow
  - To develop a beam Post mortem diagnosis workflow which integrate knowledge from all accelerator experts

- **The most challenging will be to**
  - Convince our operators and physicists to put (part of) their knowledge in an expert system
  - But the very high requirements in term of beam stability and beam availability will be an important driver
Thanks for your attention
CDMA API: Accessing data through keywords thanks to its dictionary mechanism

```
<data-def name="Experiment name">
    <!-- ex: EXAFS, SAXS,... -->
    <item key="mono_energy">
    <item key="mono_type">
    </data-def>

<map-def name="Experiment name">
    <!-- ex: EXAFS, SAXS,... -->
    <item key="mono_energy">
        <path>path/to/user/mono/energy</path>
    </item>
    <item key="mono_type">
        <path>path/to/user/mono/type</path>
    </item>
    ...
</map-def>
```