Model based soft-sensors based on OPC Unified Architecture

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Presentation outline

- The problem
- Old solution
- New solution
- An example
- Future outlook
The problem
3 stories

1) supplier of plants packages
2) automation supplier
3) operating company
Story 1: supplier of plants packages

• Provide fully-automated, self-diagnostic, self-optimizing, "intelligent" units

• Adapt and customize the package units to the ever-changing specifications with minimal effort and risks

• Make the package units easier to deploy by adapting to the customers' industrial information technology infrastructure
Story 2: automation supplier

- Flexible design: react to project changes
- Diverse environment: open standards
- Maintainability: follow seamlessly the changes during the operation phases
- Avoid risky reconfiguration or manual adaptation of custom interfaces
Story 3: operating company

- Adapt to load changes
- Handle day-night fluctuations in the electricity price
- Handle feedstock changes: variable-by-design feedstocks such as biomasses, but fossil fuels change quality continuously too
- Adjust the production mix the demand (cogeneration or trigeneration)
intelligent
integration adapt change
flexibility
smart
unmanned operation
low-risk
value
customize self-diagnostic
optimize market
change
Protocols & interfaces

- 4-20 mA
- SMART
- HART
- Ethernet
- Sattbus
- Modbus
- Profibus / Fieldbus
- EDAS
- CIP
- CIM-IO
- IEC 870-5-101/104
- http / https
- ODBC
- WCF
- Classic OPC
Classic OPC

- Classic OPC is a set of de-facto standards
  http://www.opcfoundation.org
- For interfacing between process automation (SCADA, PLC, DCS) and the rest of IT
- Time span: 1996 – 2005
- Based on COM technology (Microsoft, 1993)
Resulting industrial IT architecture
New solution
OPC UA (Unified Architecture)

- OPC UA (Unified Architecture) is a single de-facto standard, evolution of Classic OPC

  http://www.opcfoundation.org

- Time span: 2006 - ...
  - Based on SOA
  - Platform-independent (non-Microsoft specific)
  - Object-oriented
  - Semantic: domain-specific information models
SOA (Service Oriented Architecture)

From an IBM whitepaper
OPC UA: platform-independent

Profiles used to define subsets of functionality for different use cases

Multiple OPC APIs
- C/C++
- JAVA
- Microsoft .NET

Standard internet protocols allow cross-platform communication

From an OPC Foundation presentation
OPC UA object oriented: types

From an OPC Foundation presentation
OPC UA object oriented: instances

From an OPC Foundation presentation
OPC UA: architecture

Vendor Information Model

Domain-specific Information Model
- DA
- A&C
- HA
- Progs

OPC UA Base Services

From an OPC Foundation presentation
OPC UA: semantic

• Domain-specific information models for:
  • device information
  • analyser devices
  • plant operation and maintenance
  • batch control
  • PLC programming
  • process simulation capabilities?
An example
Soft sensors

Soft-sensors = replace real sensors with virtual, calculated results

- Model-driven - first principle models
- Data-driven - based on raw data manipulation
  - Principle Component Analysis (PCA)
  - Partial Least Squares (PLS)
  - Artificial Neural Networks (ANN).
The soft-sensor of the example

- gas-chromatograph measures the composition of a material stream composed of short-chain hydrocarbons

- Soft-sensor computes:
  - Lower / higher heating value and Wobbe-Index;
  - LEL / UEL (lower and upper explosive limits) and LOC (limiting oxygen content);
  - Density, compression factor and temperature / pressure dew-point and bubble-point with an equation of state specific for Natural Gas (GERG-2004)
LIBPF: LIBrary for Process Flowsheeting

• Modular Software Development Kit (SDK) for process flowsheeting

• Object-oriented C++ library:
  • Components, physical properties, phases, streams, unit operations and flowsheets
  • Tools: solvers, input/output, object persistency, communication interfaces
Classic OPC soft sensor

- OPC DA 2.0.4 client
- Placeholder tags have to be defined in the OPC server
- Configuration via XML file
- Start / stop as an operating system service
OPC UA process simulation information model

OPC UA node types from LIBPF objects

- BaseObjectType
- modelBase
- edgeBase
- vertexBase
- stream
- stream_VL
- stream_VL_eos<pengrobinson>
- stream_VL_eos<pcsaft>
- stream_VL_eos<gerg2004>
OPC UA soft sensor prototype

LIBPF objects are exposed as OPC UA nodes at runtime

- Flowsheet object instance
- Method can be actioned on the object
- Unit operation object instance
- Quantity with engineering unit object instance
OPC UA soft sensor features

- Runs on both Windows and Linux
- Could even be integrated directly into the device (gas-chromatograph, fiscal meter)
- No configuration files
- The configuration can be performed using any 3rd party OPC UA client, thanks to the discovery and browsing capabilities
Future outlook
Future work for us

• Complete the prototype, implementing additional OPC UA interfaces:
  • the **node creation** interface: clients can browse the hierarchy of available types known to the server, and request that one of them should be instantiated at run-time
  • the **state machine** information model: clients can configure the valid / invalid states and their triggers
  • the **program** interface: clients can start / stop soft sensors individually without starting / stopping the service / daemon
Future work for the community

- Agree on a domain-specific information model for on-line application of process models on top of OPC Unified Architecture stack:
  - Process modeling objects: Components, phases, streams, unit operations
  - On-line modeling applications: Soft sensors, process simulation, advanced control, model predictive control, plant-wide mass balance reconciliation, operator training
OPC Unified Architecture (UA): a new platform-independent standard for **interoperability** between enterprise information systems and **industrial automation**

OPC UA could reshape the automation industry and the business models in the *process simulation and optimization* and in the *real-time process optimisation and training* sectors