PLUG INTO POWER

Model based soft-sensors based on OPC Unified Architecture

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POWER-GEN Europe 2010 Conference
June 10th, 2010
Amsterdam

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Presentation outline

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


The problem
Power Plant
by Grandwazoo

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
optimize
market
smart
unmanned operation
value
low-risk
customize
self-diagnostic


Old solution

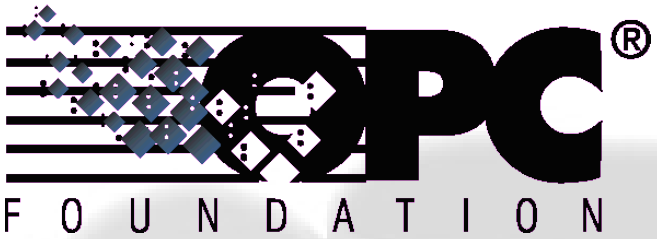
Protocols & interfaces

- 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

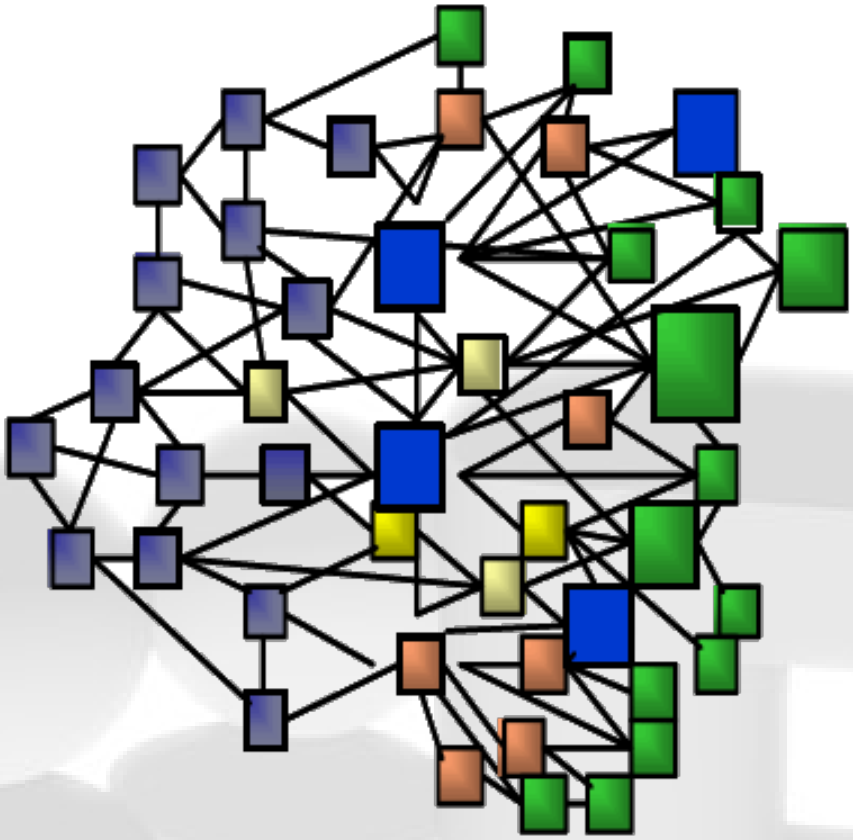
- Classic OPC is a set of de-facto standards

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

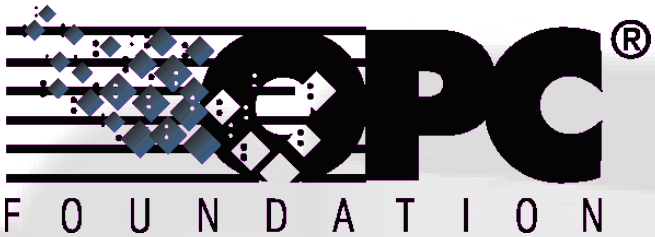


From an IBM whitepaper

OPC UA (Unified Architecture)

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

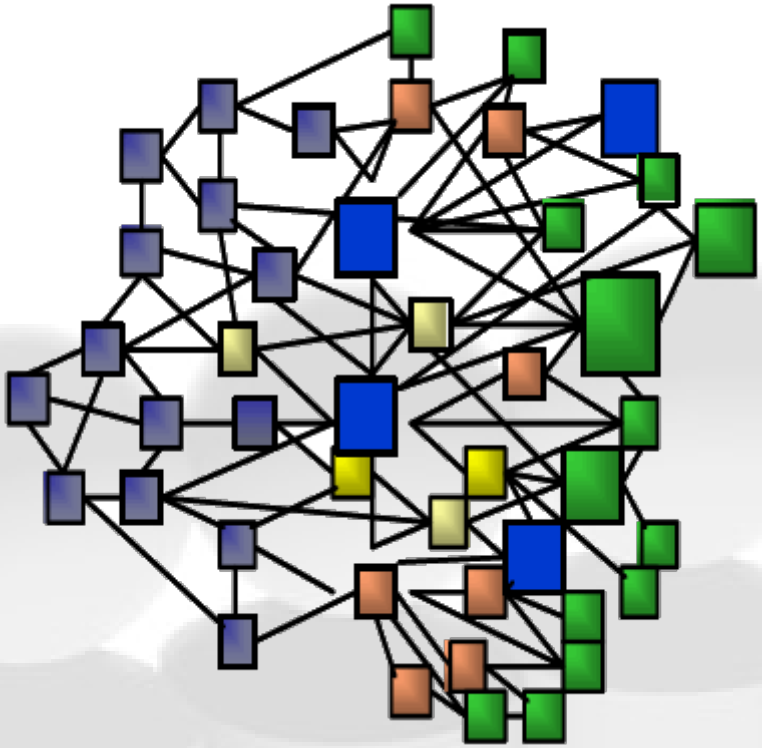
http://www.opcfoundation.org



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

SOA (Service Oriented Architecture)

business process → service → interoperable software module

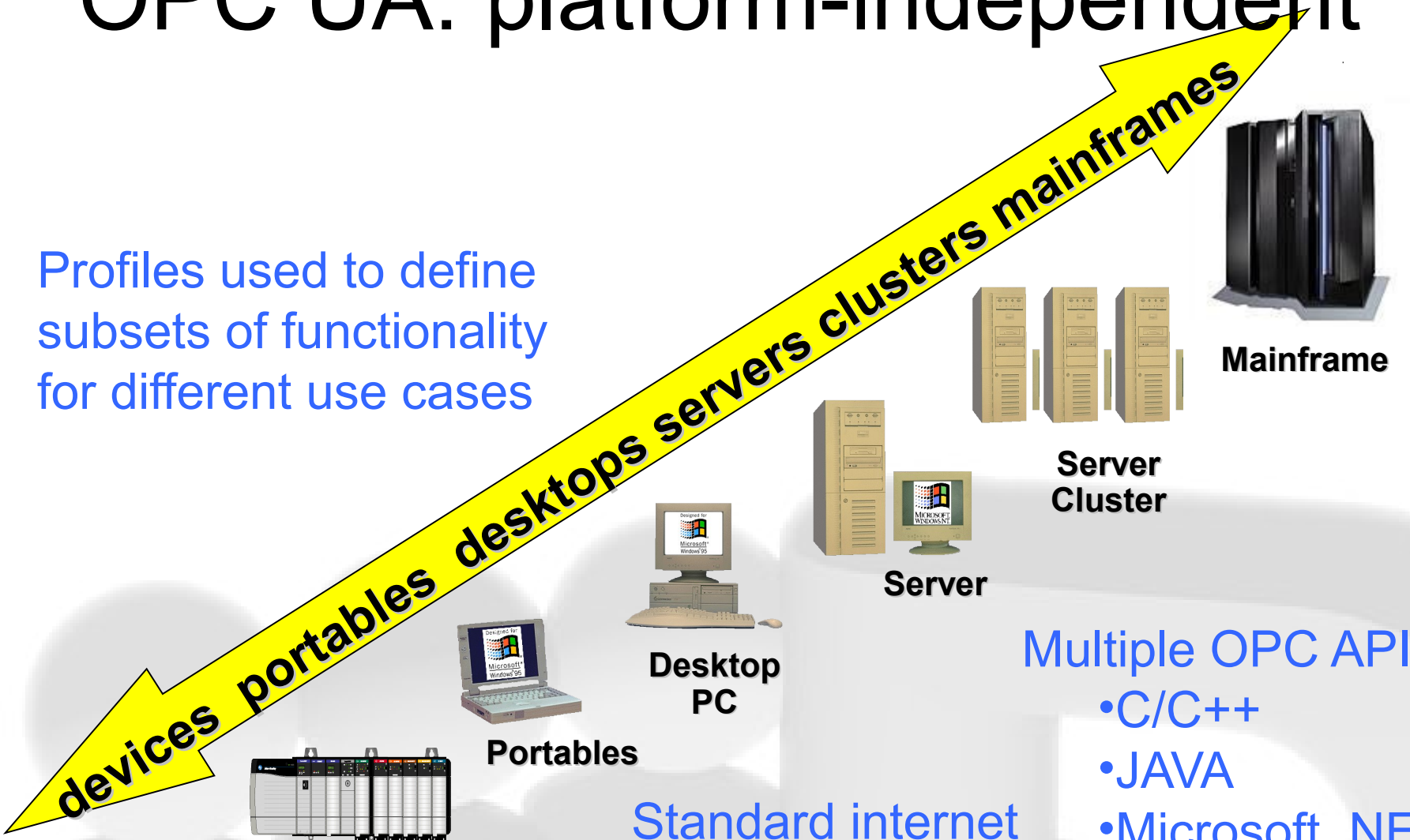


before SOA

after SOA

From an IBM whitepaper

OPC UA: platform-independent



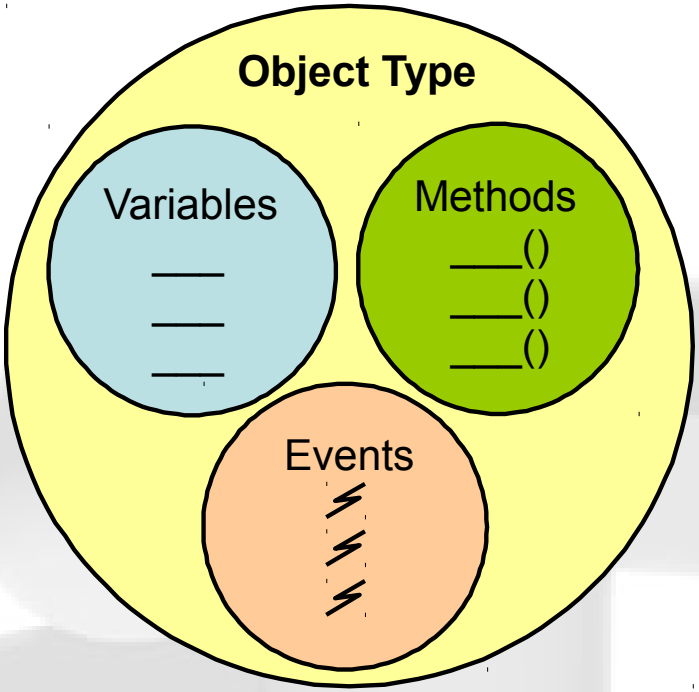
Profiles used to define subsets of functionality for different use cases

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

Standard internet protocols allow cross-platform communication

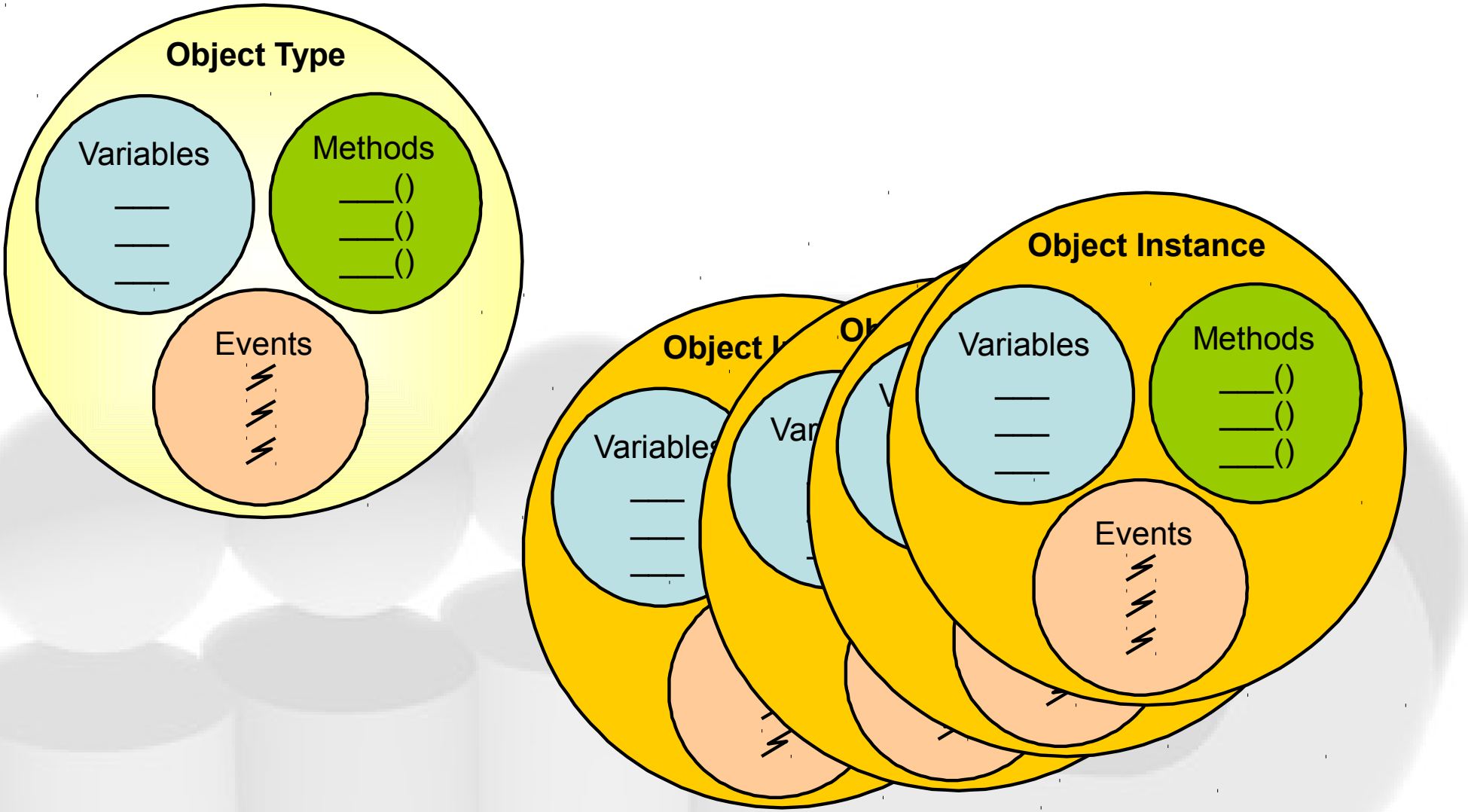
From an OPC Foundation presentation

OPC UA object oriented: types



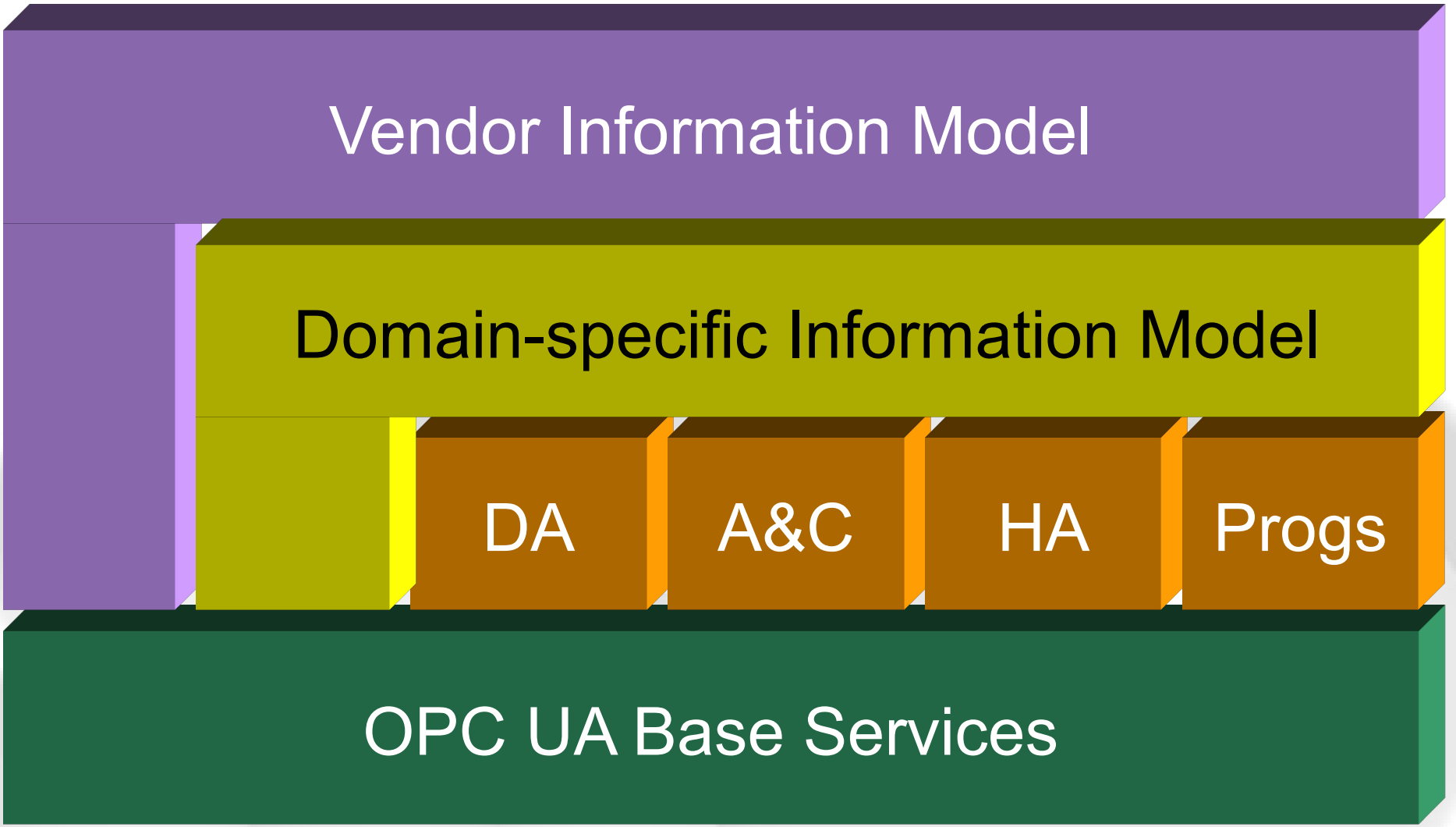
From an OPC Foundation presentation

OPC UA object oriented: instances



From an OPC Foundation presentation

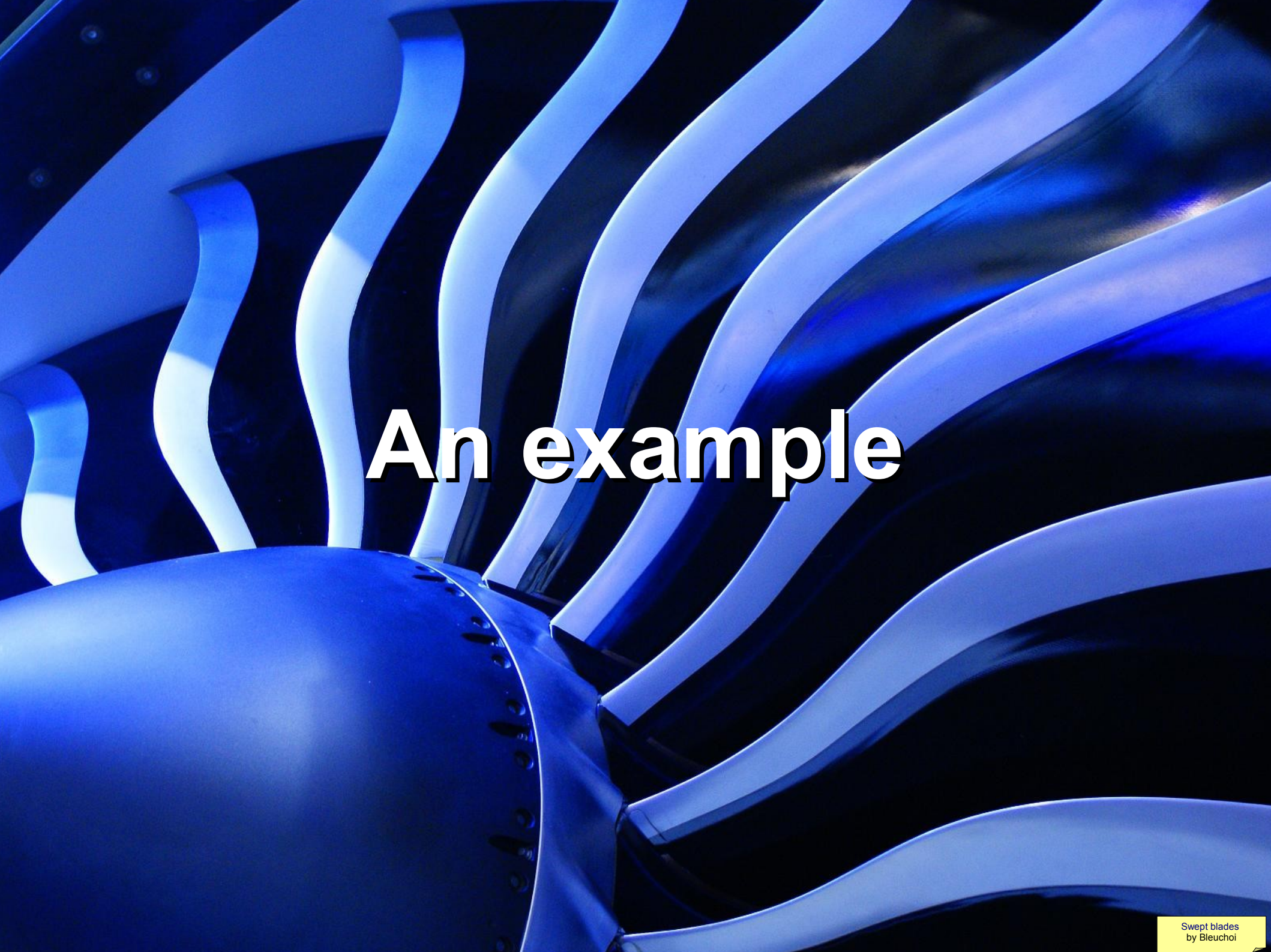
OPC UA: architecture



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
Swept blades
by Bleuchoi

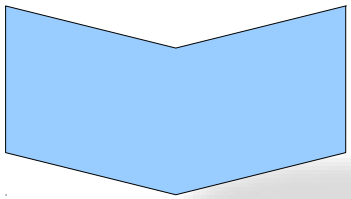
Soft sensors

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

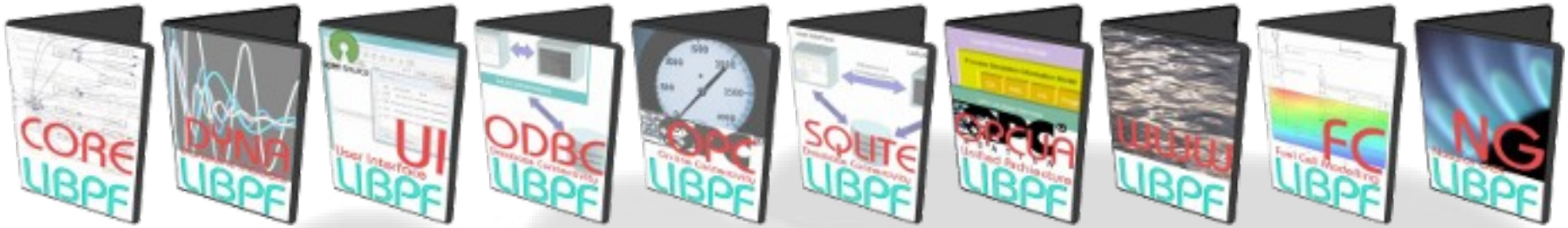
- gas-chromatograph measures the composition of a a material stream composed of short-chain hydrocarbons



- 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

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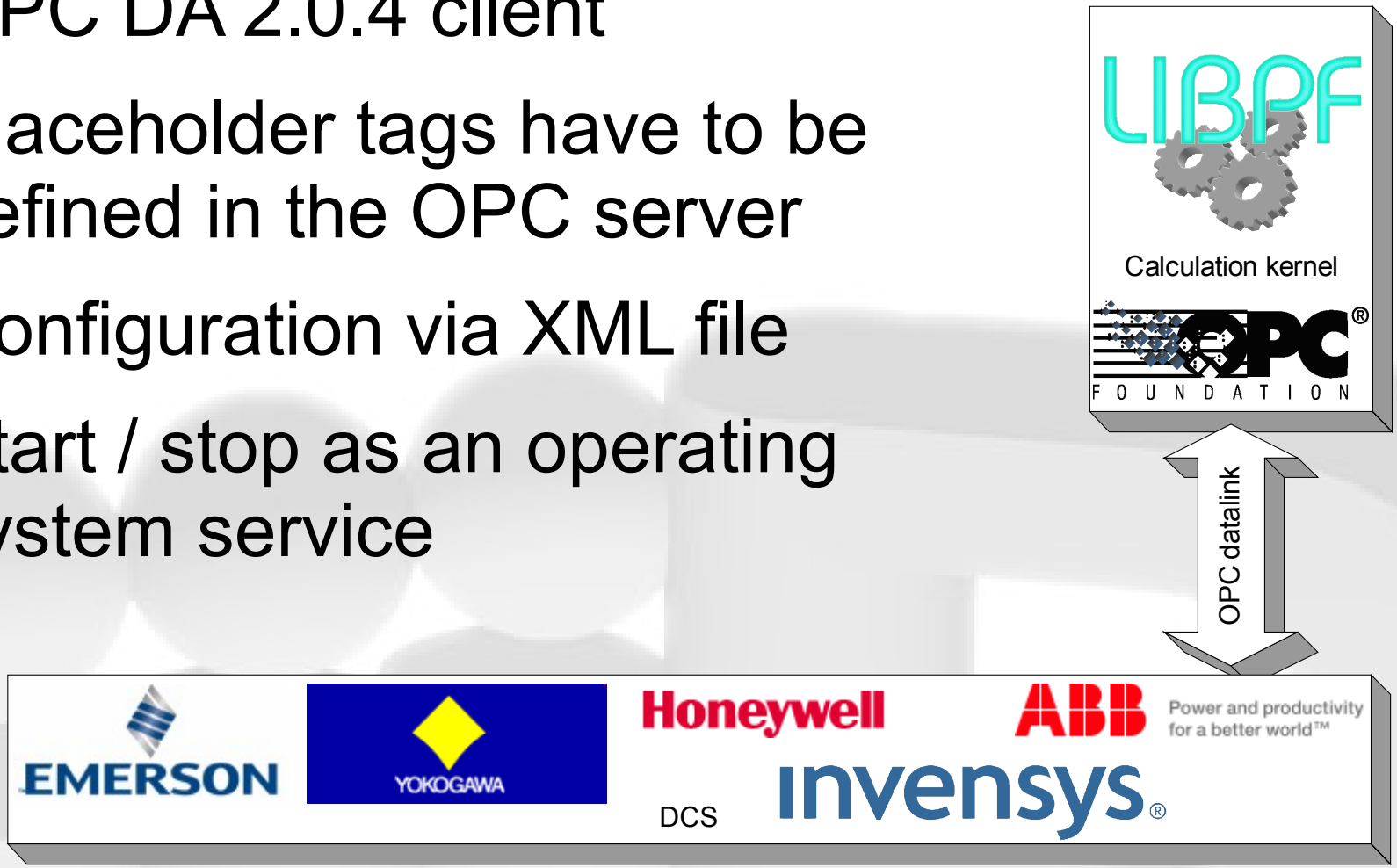
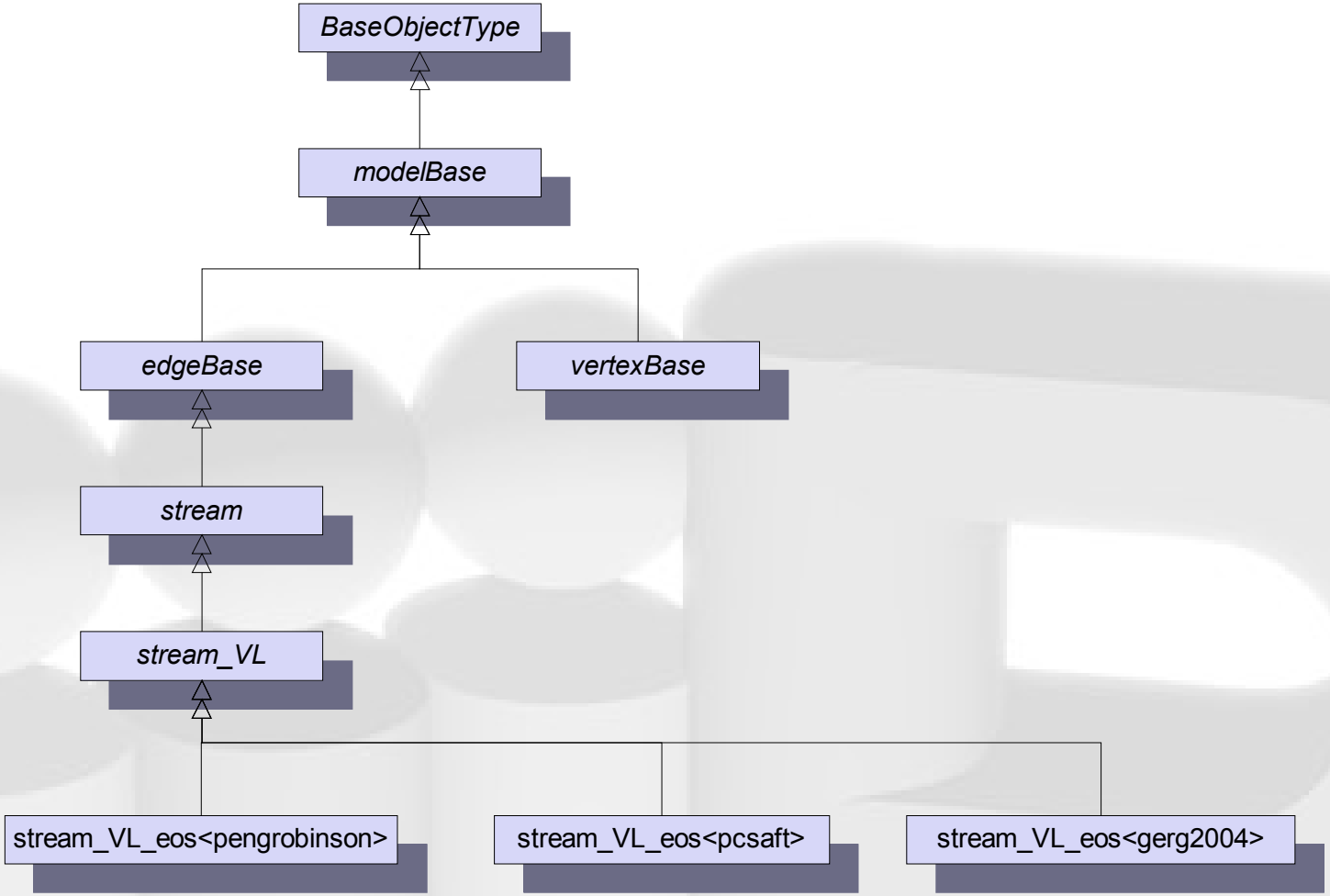
Classic OPC soft sensor

- 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



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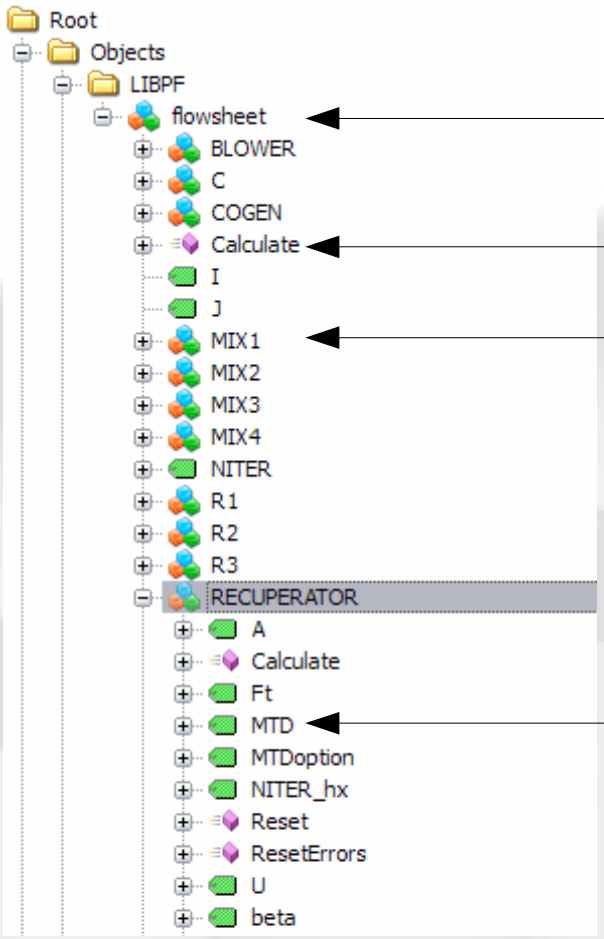
OPC UA soft sensor prototype

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
RWE Weisweiler
by glasseyes view

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