Process simulation as a domain-specific OPC UA information model

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Presentation outline

- Classic OPC
- OPC Unified Architecture
- Soft-sensor based on OPC UA
- OPC UA as a challenge to CAPE-OPEN ?

Where we are

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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**

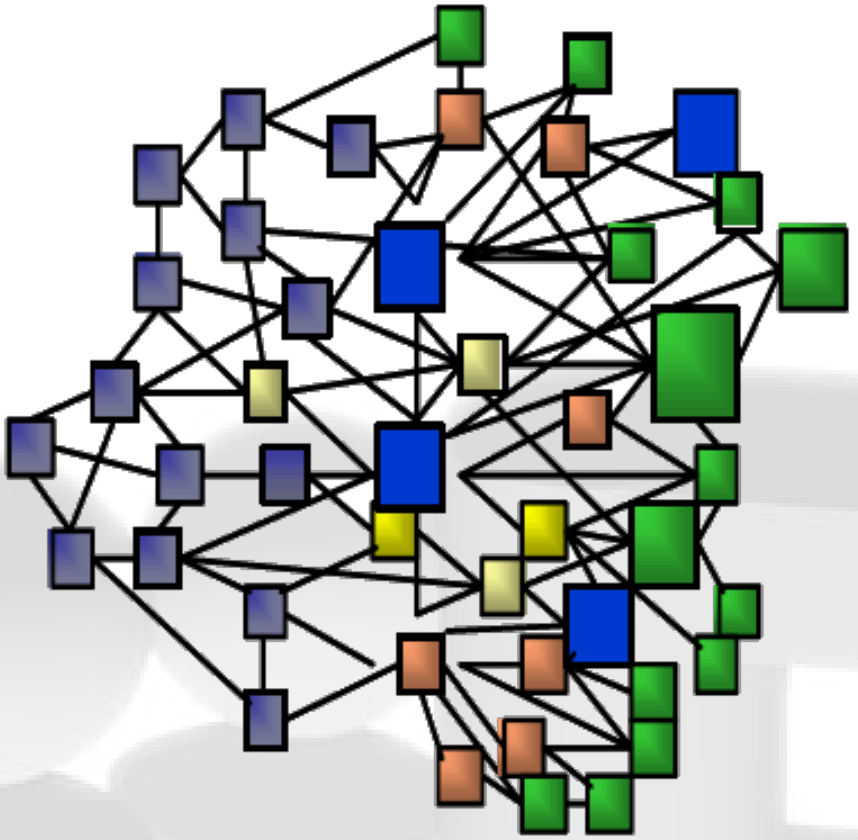
Classic OPC

- 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

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OPC UA (Unified Architecture)

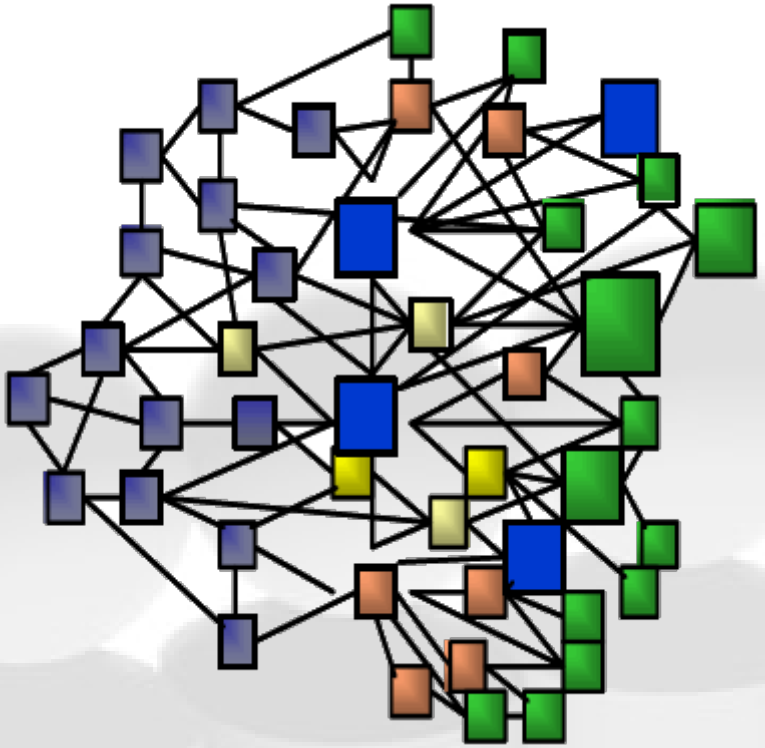
- OPC UA (Unified Architecture) is a single de-facto standard, evolution of Classic OPC

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

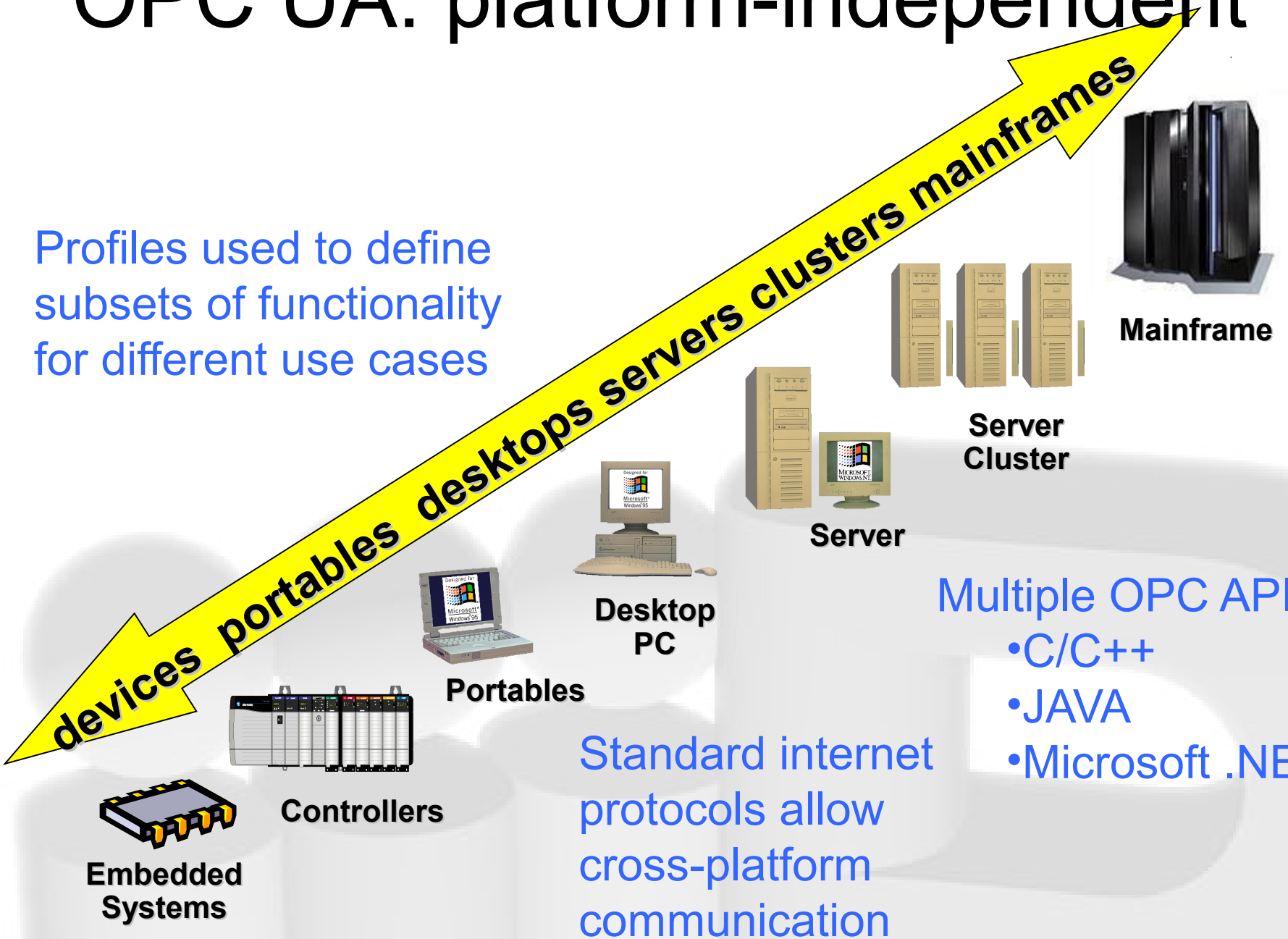


before SOA

after SOA

From an IBM whitepaper

OPC UA: platform-independent



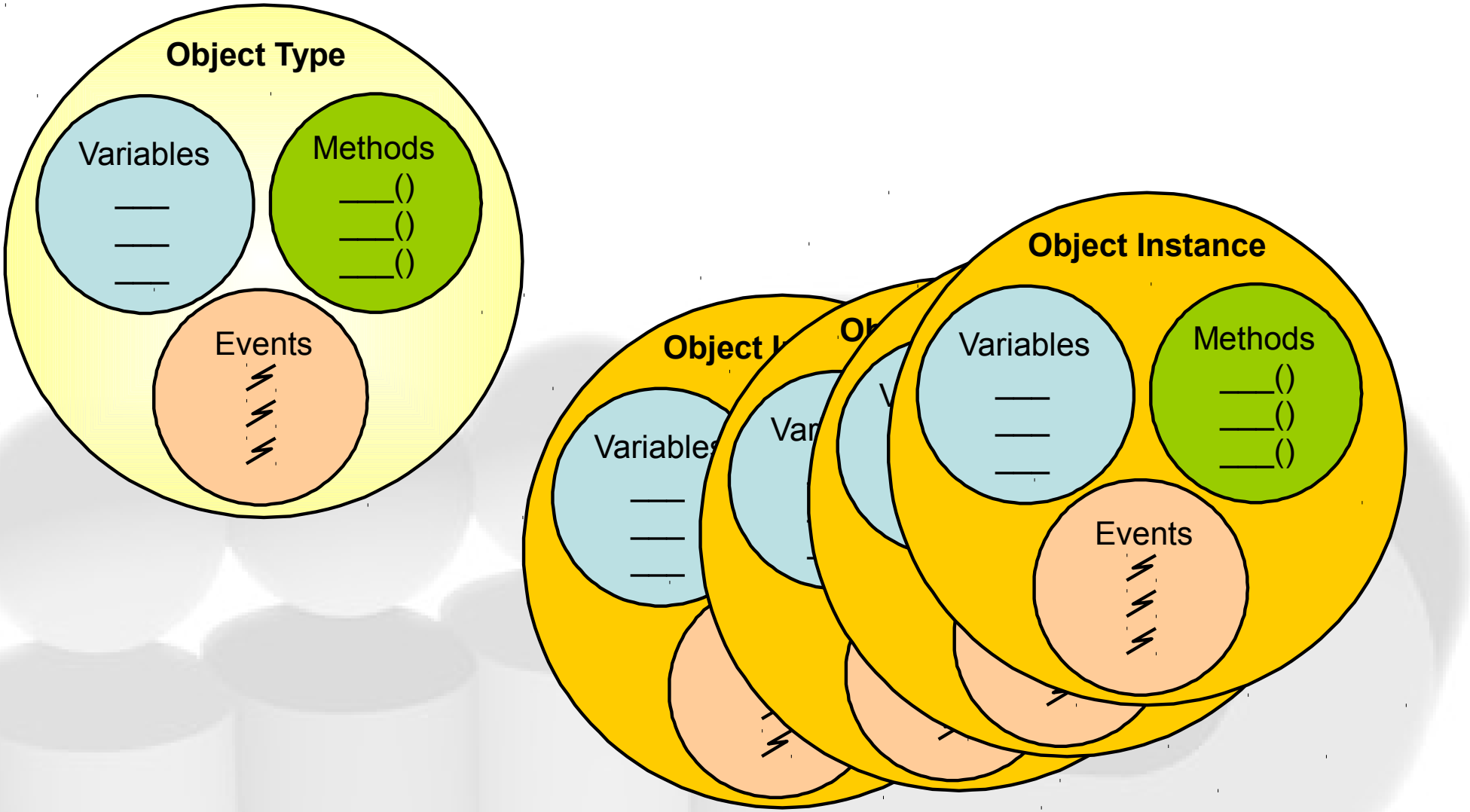
Profiles used to define subsets of functionality for different use cases

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

Standard internet protocols allow cross-platform communication

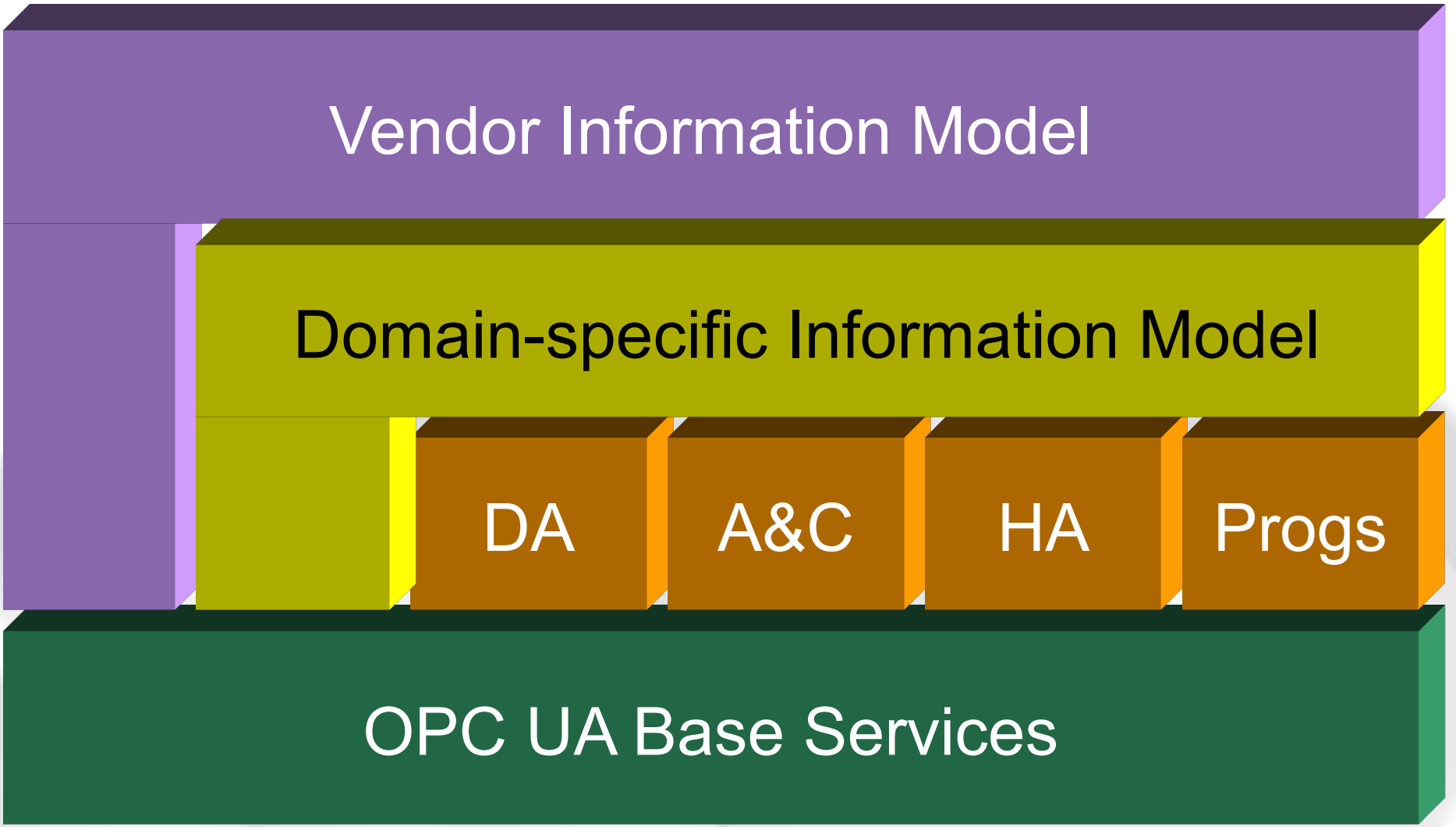
From an OPC Foundation presentation

OPC UA object oriented: types and instances



From an OPC Foundation presentation

OPC UA: architecture



From an OPC Foundation presentation

OPC UA: semantic

Domain-specific information models for:

1. device information
2. analyser devices
3. plant operation and maintenance
4. batch control
5. PLC programming

- **process simulation capabilities ?**

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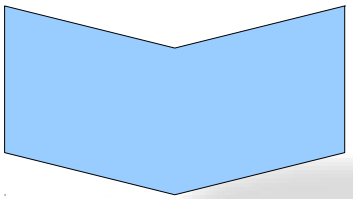
Soft sensors

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

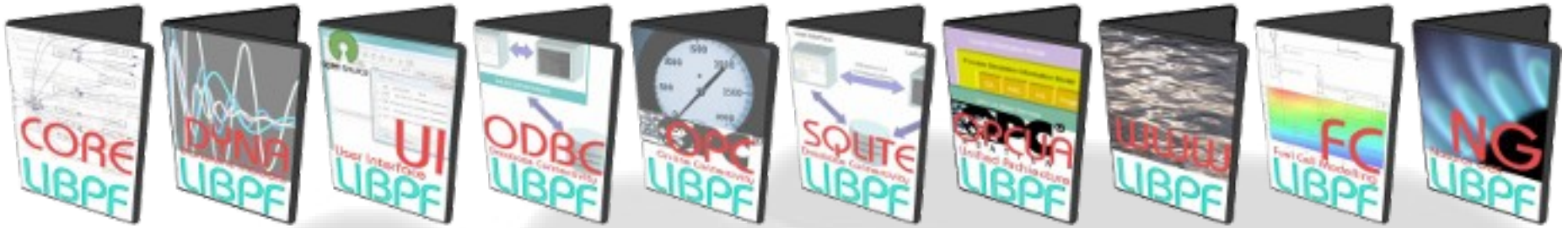
- Gas-chromatograph measures the composition of a a material stream composed of short-chain hydrocarbons



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

LIBPF: **LIB**rary for **P**rocess **F**lowsheeting

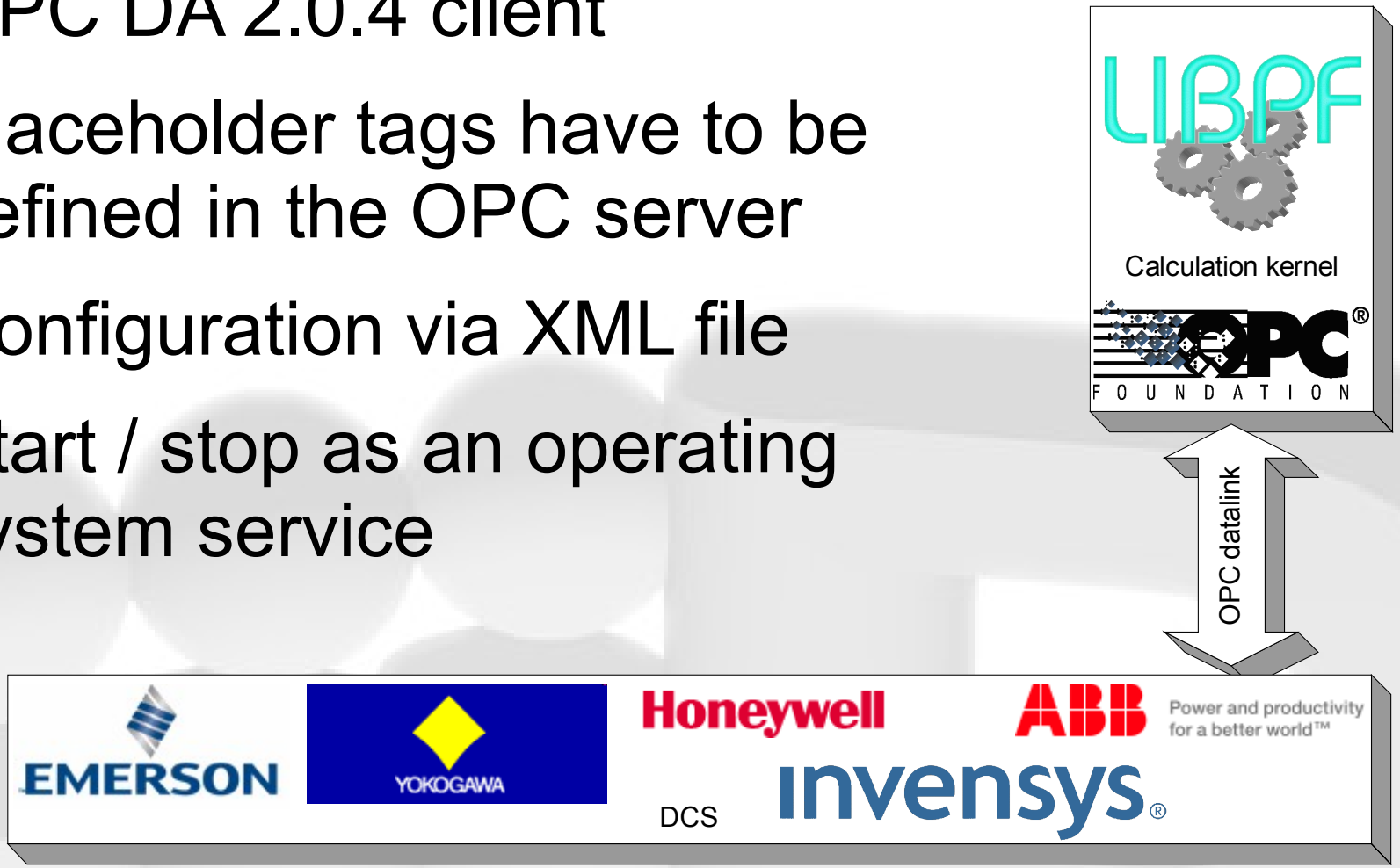
- Modular Software Development Kit (SDK) for process flowsheeting



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

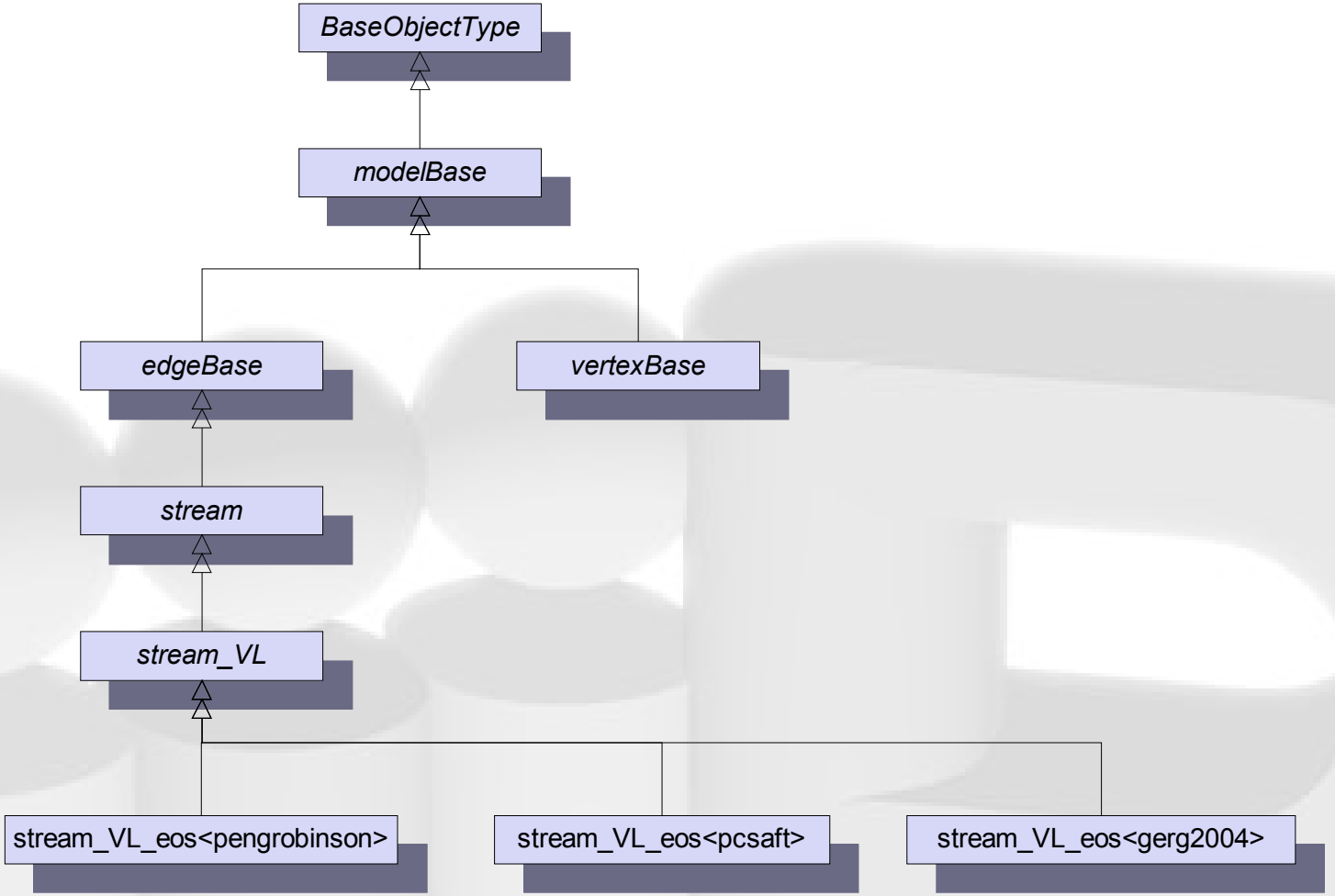
Classic OPC soft sensor

- 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



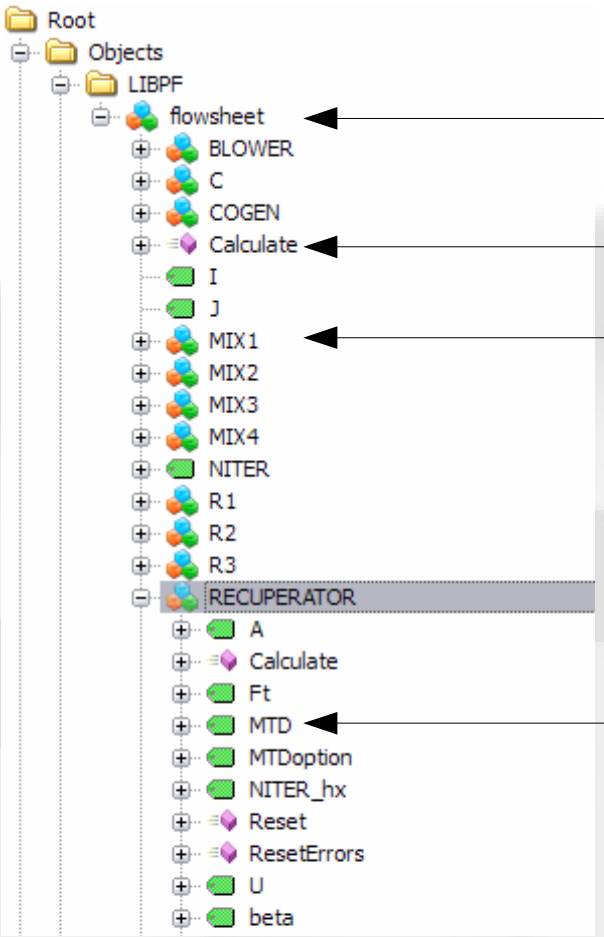
OPC UA process simulation information model

OPC UA node types from LIBPF objects



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

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CAPE-OPEN vs. OPC UA

Item	CAPE-OPEN	OPC UA
Definition	Standards for interfacing process modelling software components developed specifically for the design and operation of chemical processes	secure and reliable cross platform framework for access to real time and historical data and events
Embedding	in-process	out-of-process
Protocol scope	Local, LAN	Local, LAN, WAN
Supported operating systems	Windows	Windows, Embedded Windows XP, QNX, Linux
Typical use	Unit operation interfacing	Flowsheet or whole-model interfacing
Typical application	Interoperability between different process simulators	On-line modeling applications

Applicability of OPC UA to CAPE

- OK to transfer 10000 variables that require an out-of-process computation of 500 ms in one batch: communication overhead < 10%
- The function call grouping should be implemented in the host (feasible for simultaneous solution algorithms):
  - Simulation executive groups calls to individual unit operation models
  - Unit operation model groups calls to physical property subroutines

This slide incorporates comments from Jasper van Baten and William M. Barrett Jr.

Preferred OPC UA on-line modeling applications

- Soft-sensors
- Advanced Process Control (APC)
- model predictive control (MPC)
- Plant-wide mass balance reconciliation
- Operator Training (OTS)

Future work for the community

- Agree on a domain-specific information model for process modeling on top of OPC Unified Architecture stack:
  - Process modeling objects: Components, phases, streams, unit operations
  - CAPE applications
  - On-line modeling applications

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