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Information and Computer Systems in Automation

Manufacturing Systems – vertical integration and use of information in operations and maintenance

Tik-86.5141 Enterprise Systems Architecture - Lecture 28.9.2005

Kari Koskinen

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Contents of the lecture

- Vertical integration and use of information in production and maintenance related business processes
- Reference models of enterprise control system integration (ISA-95)
- Automation systems (DCS) in the factory floor
- MES, Manufacturing Execution System
- Vertical integration between ERP, MES and DCS – interface technologies
- OPC technology in systems integration
- System for field device configuration and condition monitoring (Metso FieldCare)
- Reference model for condition based maintenance (MIMOSA: OSA/CBM)
- Integration of Operations and Maintenance (O&M) related information, Condition Based Operations (MIMOSA: CBO) for Manufacturing
- Conclusions

Manufacturing Systems – vertical integration and use of information in production and maintenance

- **Customer order delivery process:**

  Use of automation system information can improve production and its control. This results to better management and profitability of the whole customer order delivery process.

- **Maintenance process:**

  Use of automation system and condition monitoring system information enables fault diagnosis and predictive maintenance.

  Predictive maintenance can reduce maintenance cost and improve the availability of the production system. The overall profitability of operations and maintenance can be increased.

Reference models

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ANSI/ISA-95.00.01-2000
Enterprise-Control System Integration
Part 1: Models and Terminology

Hierarchy models that describe the levels of functions and domains of control associated within manufacturing organizations are defined in clause 5. These models are based on The Purdue Reference Model for CIM, referenced as PRM;4 the MESA International Functional Model;5 and the equipment hierarchy model from the IEC 61512-1 (ANSI/ISA-88.01-1995) standard.

A data flow model that describes the functional and data flows within manufacturing organizations is defined in clause 6. This model is also based on The Purdue Reference Model for CIM.

An object model that describes the information that may cross the enterprise and control system boundary is defined in clause 7.

Why reference models ?

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Reference models are useful for establishing concepts and terminology in the field and they can help:

- End-users that manufacture products:
  - What functions can and must be required from commercial information systems.
- Equipment and system vendors:
  - What kind of systems, subsystems and components can be offered to the market and how to introduce their functions and benefits.
- Engineering companies and system integrators:
  - How to integrate customer specific solutions from systems and components that are in the market.

ANSI/ISA-95.00.01-2000 Enterprise-Control System Integration Part 1: Models and Terminology

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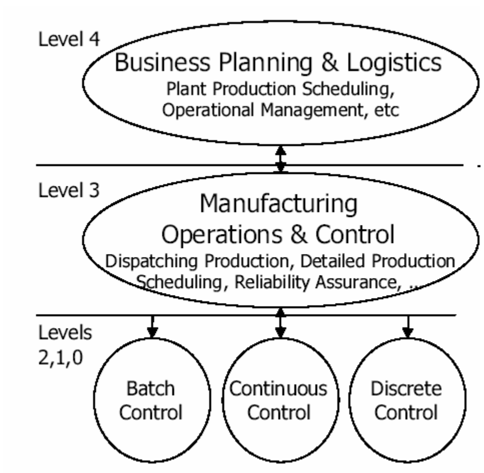
Contents

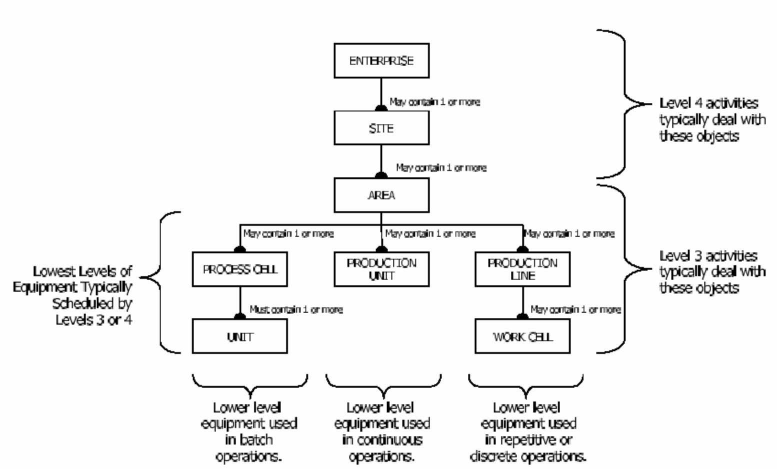
Functional hierarchy



Levels 2, 1, and 0 define the cell or line supervision functions, operations functions, and process control functions. There are several different models for the functions at these levels based on the actual production strategy used.

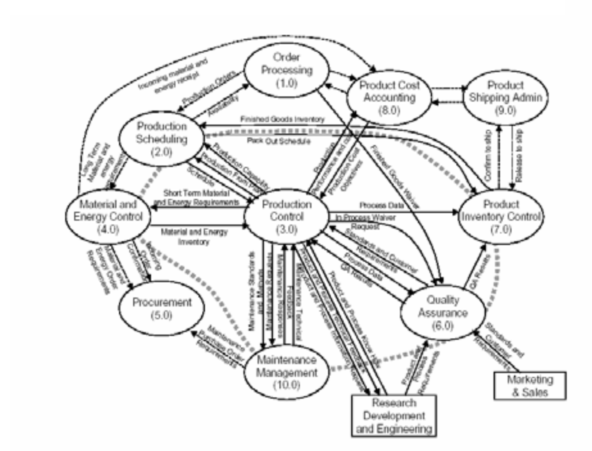
Source: Ansi/ISA-95.00.01-2000

Equipment hierarchy



Source: Ansi/ISA-95.00.01-2000

Functional enterprise-control model



The model is focused on operational activities in production.

The customer order delivery process is the central business process.

Functions as marketing or research and development are therefore described as external entities (rectangle symbol) in this context.

The model is essentially restricted to modelling of one enterprise. Not a network of enterprises nor a supply chain.

The model structure does not reflect an organizational structure within a company, but an organizational structure of functions. Different companies will place the functions in different organizational groups.

Source: Ansi/ISA-95.00.01-2000

Scope for Purdue Reference Model (PRM) for manufacturing

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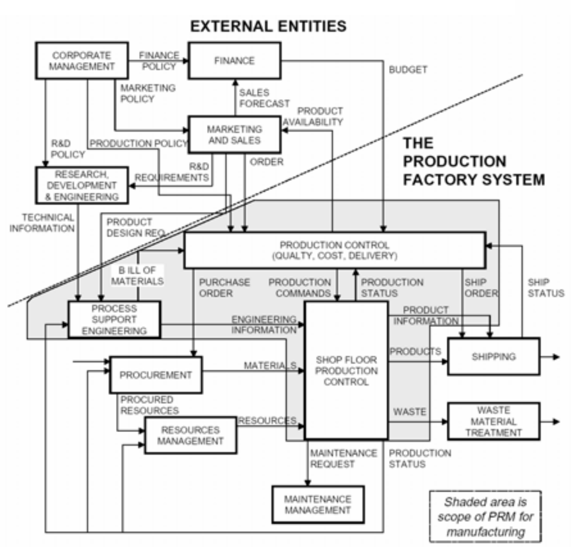

Source: Ansi/ISA-95.00.01-2000

PRM: Assumed hierarchical computer control structure for a large manufacturing complex (computer integrated manufacturing [CIM])

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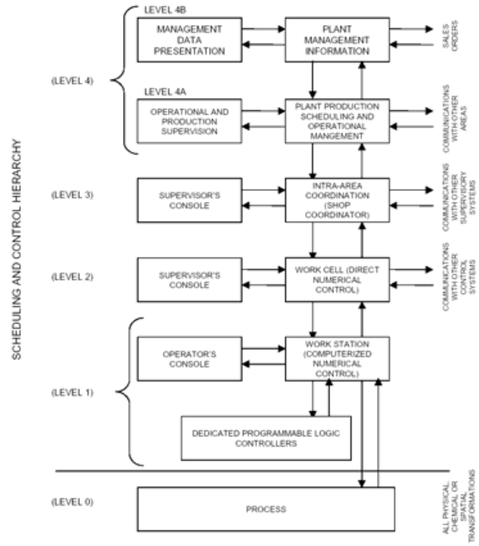

Source: Ansi/ISA-95.00.01-2000

PRM: Assumed hierarchical computer control system structure for an industrial plant (continuous process such as petrochemicals)

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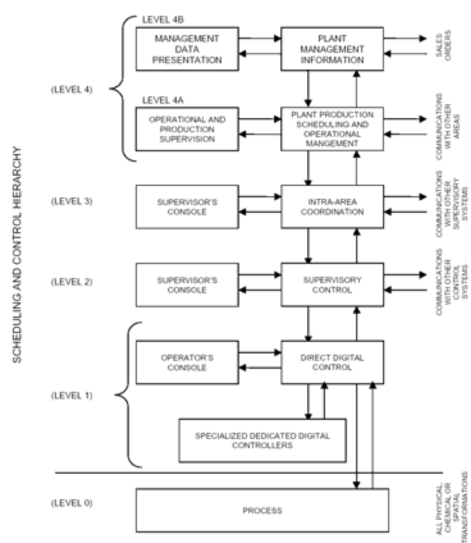
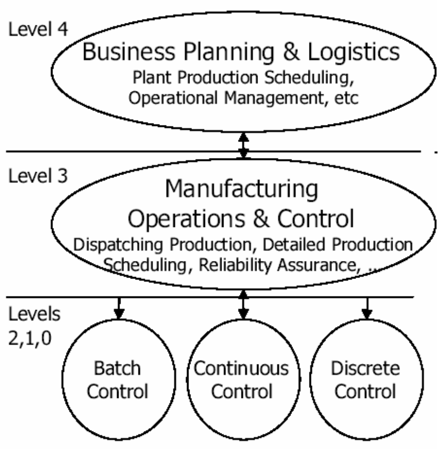


Source: Ansi/ISA-95.00.01-2000

Enterprise automation and information systems at different levels of the ISA-95 functional model



SCM systems (SCM, Supply Chain Management)

ERP systems (ERP, Enterprise Resource Planning)

MES (MES, Manufacturing Execution System)

SCADA systems (SCADA, Supervisory Control And Data Acquisition)

Automation systems
DCS (DCS, Distributed Control System)
PLC (Programmable Logic Controller)

Machines, Sensors, Actuators,

Enterprise automation and information systems at different levels of the ISA-95 functional model

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- Mapping of commercial systems to the different levels of the model is not unambiguous, because the functions of the systems tend to overlap.
- For example ERP system vendors have added functions for the supply chain management and for the detailed scheduling of production. ERP systems thus extend to SMC systems and also to MES systems on the other hand. At the same time MES systems extend to ERP systems and can include many functions that were previously typical to ERP systems only.
- Another example is that automation systems extend to include various functions typical to MES systems: acquisition and storing of data history from production and production equipment, supervisory control of production etc.

Horisontal and vertical integration in operational context

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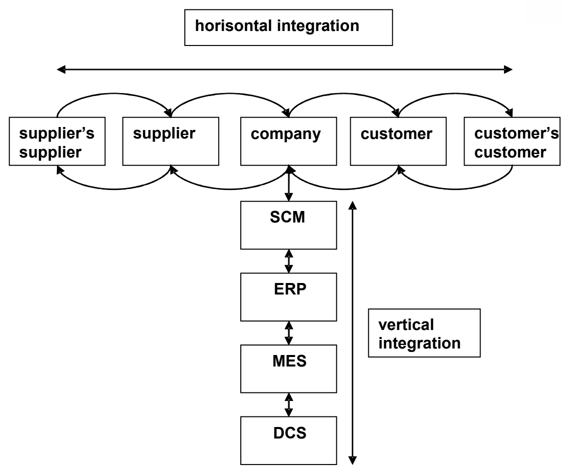

Automation hierarchy and function levels

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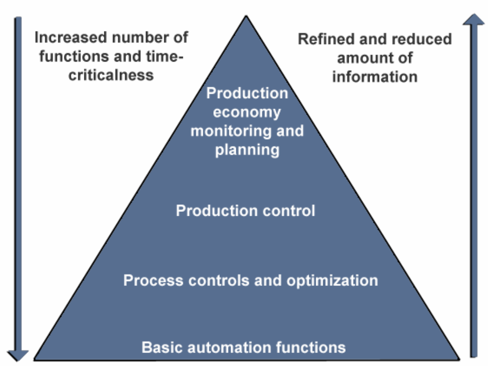

Total mill automation can be thought of as a process beginning with field equipment and ending with mill information systems. When moving down the pyramid from top to bottom, the number of functions and time-criticalness increases At the top of the pyramid, the time scale for process monitoring can range from days to months, while at its base the scale ranges from milliseconds to hours. When moving toward the top of the pyramid, information is refined and decreases in quantity.

Source: KnowPap - Learning Environment for Paper Making and Automation. www.knowpap.com

General structure of a process automation system

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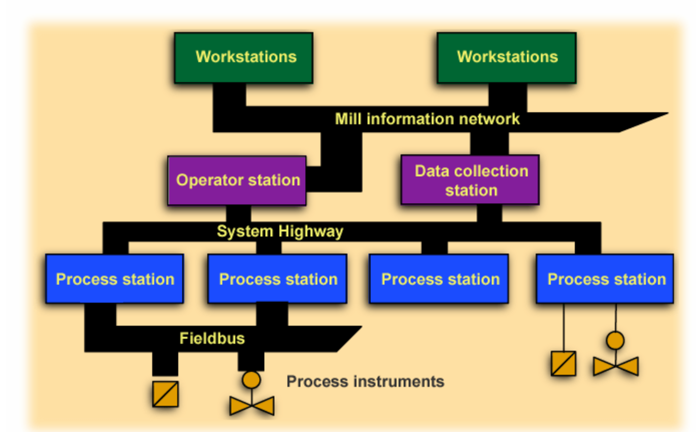

Source: KnowPap - Learning Environment for Paper Making and Automation. www.knowpap.com

Field buses – Profibus as an example

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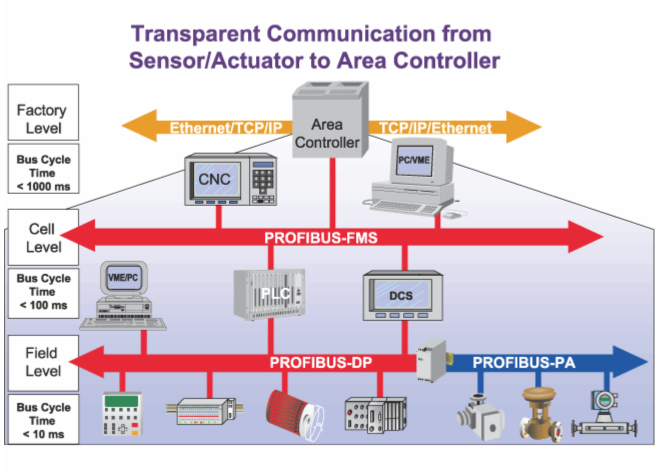

Communication protocol:

-master/slave stations
-token ring
-overall cycle time is user configurable

Source: KnowPap - Learning Environment for Paper Making and Automation. www.knowpap.com

Plant wide integrated automation and information system – a paper mill example

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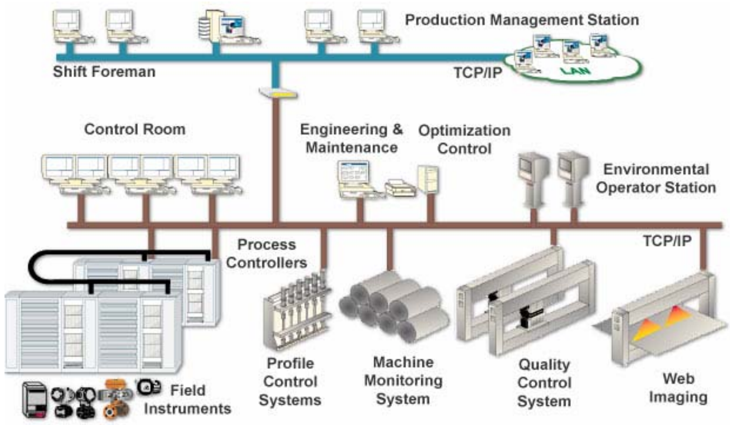

Source: KnowPap - Learning Environment for Paper Making and Automation. www.knowpap.com

Distributed automation in discrete manufacturing – an example

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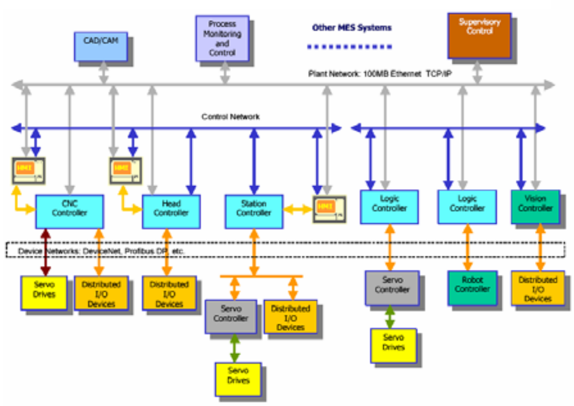


The general systems structure of bus networks and computing nodes has many similarities to distributed automation in process type of manufacturing as e.g. in a paper mill.

Many hardware and software modules can be used in both application areas.

Source: Tom Fortu: Vertical Information System Integration in Manufacturing Industry. Slide presentation. HUT Information and Computer Systems in Automation, 10/2003

MES, Manufacturing Execution System

- MES is a layer between the ERP system and the factory floor automation system
- Factory floor automation systems today are often based on PLCs (Programmable Logic Controller) and PC-based SCADA systems (Supervisory Control And Data Acquisition)
- DCS (Distributed Control Systems) are mainly used in process type of industries
- MES functionality is often a combination of manual and IT-system functions
- Some of the MES functionality can be included in ERP or SCADA or DCS systems.
- The following definitions of MES core and support functions represent a MES centered and broad view of MES.

MES Core Functions

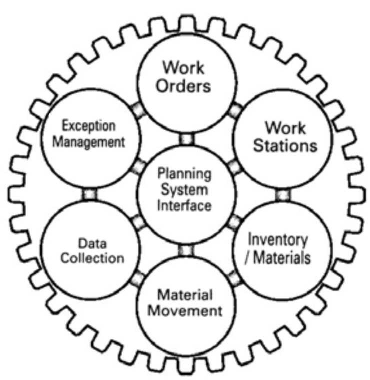
(From: Applying Manufacturing Execution Systems by Michael McClellan)

MES

Manufacturing Execution Systems (MES) deliver information that enables the optimization of production activities from order launch to finished goods. Using current and accurate data, MES guides, initiates, responds to and reports on plant activities as they occur.

MES Core Functions

Planning System Interface
Work Order Management
Workstation Management
Inventory Tracking and Management
Material Movement Management
Data Collection
Exception Management



Source: Tom Fortu: Vertical Information System Integration in Manufacturing Industry. Slide presentation. HUT Information and Computer Systems in Automation, 10/2003

Figure 4. MES Core Functions

MES Support Functions

(From: Applying Manufacturing Execution Systems by Michael McClellan)

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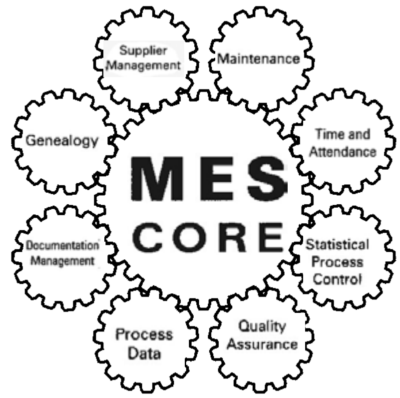
MES

Manufacturing Execution Systems (MES) deliver information that enables the optimization of production activities from order launch to finished goods. Using current and accurate data, MES guides, initiates, responds to and reports on plant activities as they occur.

MES Support Functions

Maintenance Management
Time and Attendance
Statistical Process Control
Quality Assurance
Process Data/Performance Analysis
Documentation / Product Data Management
Genealogy / Product Traceability
Supplier Management



Source: Tom Fortu: Vertical Information System Integration in Manufacturing Industry. Slide presentation. HUT Information and Computer Systems in Automation, 10/2003

Figure 5. MES Support Functions

MES is a layer and a link between ERP and automation system

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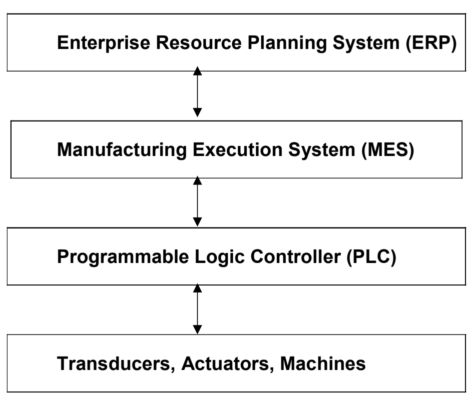

MES level functionality simplified: information processing and information exchange

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- ERP to MES : **production order** including product types, quantities and due dates
- MES **schedules** the use of production resources and **supervises** the automation system operation
- MES **monitors** the automation and production systems operation and **reports** to ERP

Vertical integration between ERP, MES and DCS – interface technologies

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- One possible class of technologies is based on **distributed object middleware solutions** as e.g. CORBA (Common Object Request and Broker Architecture), DCOM (Distributed Component Object Model) and Java RMI (Java Remote Method Invocation).
- CORBA is a specification by OMG (Object Management Group) while DCOM is a proprietary specification by Microsoft.
- CORBA has not been applied considerably at the automation system level or between the automation system and MES levels.
- Today DCOM and OPC (based on DCOM and later also on XML and Web Services) have gained a lot of ground in multivendor automation system environment and in communication with the MES level.

Integration vision. Published with the first OPC specification (OPC DA 1.0) in 1997.

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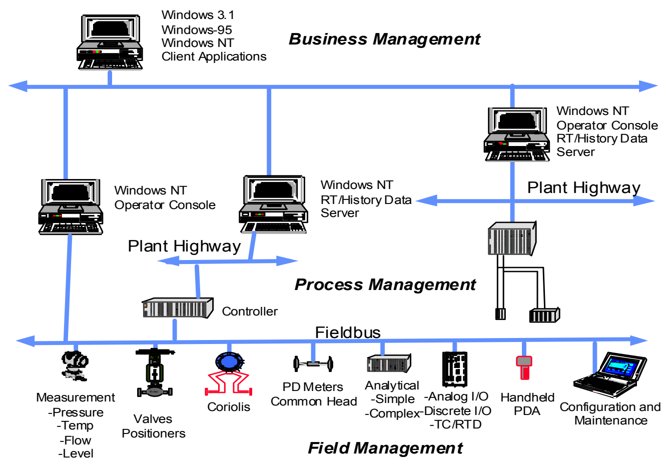

Source: **OPC Data Access Specification 1.0 (OPC = OLE for Process Control)**

Tik-86.5141 Enterprise Systems Architecture Kari Koskinen 28.9.2005 27

OPC Foundation
(OPC, OLE for Process Control was the original meaning of the OPC abbreviation)

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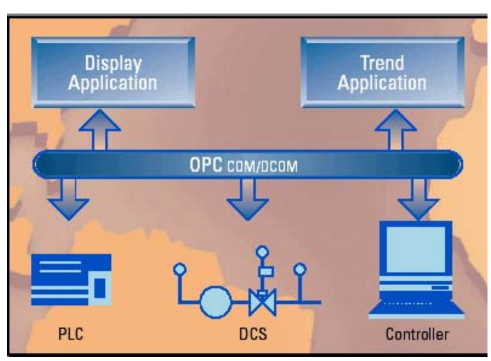
Goals

- **Develop an open and interoperable** interface standard **(specifications)**
- **based upon the OLE/COM and DCOM technology,**
- **that fosters greater** interoperability **between**
  - **business/office applications and**
  - **automation/control applications**
  - **field systems/devices**
- **easy to understand and use**
- **easy to implement**
- **open**



Source: Hans-Peter Otto: OPC Foundation. Goals, benefits and organisation. Slide presentation. SoftSympo'03, Helsinki

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OPC Foundation membership

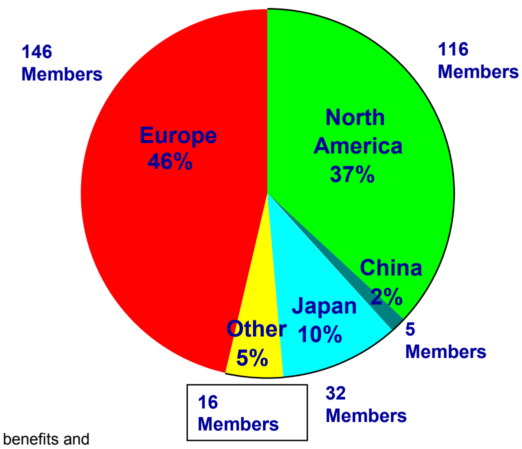
History:

1995 OPC task force

1996 1st Specification
OPC Foundation

2003 314 Members
>> products

Geographic Distribution 2003



Source: Hans-Peter Otto: OPC Foundation. Goals, benefits and organisation. Slide presentation. SoftSympo'03, Helsinki

OPC - what it is

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- standard software interface used in automation industry
- based on DCOM and Web Services
- provides interoperability on the application level
- Plug & Play
- follows Client / Server (DX: Server / Server) approach
- multiple Servers and multiple Clients at the same time
- remote access

Source: Jürgen Lange: OPC technical update on the latest extensions.
Slide presentation. SoftSympo'03, Helsinki

OPC - what it is (2)

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- a number of specifications for different areas
- different basic technologies
- vertical and horizontal integration
- OPC is organized by the OPC Foundation
- OPC Foundation is responsible for technical enhancement and marketing

Source: Jürgen Lange: OPC technical update on the latest extensions.
Slide presentation. SoftSympo'03, Helsinki

OPC Specifications

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• Version 1.0A Data Access Specification	09/97
• Version 2.0 Data Access Specification	11/98
• Version 3.0 Data Access Specification	03/03
• Version 1.0 OPC XML DA	07/03
• Version 1.0 OPC Data eXchange	03/03
• OPC Complex Data	ongoing
• Version 1.0/1.1 Alarms and Events Specification	01/99 and 10/02
• Version 1.0 Historical Data Access Specification	09/00
• Version 1.0 Security Specification	09/00
• Version 1.0 Batch Specification	04/00
• Version 2.0 Batch Specification	ongoing
• Version 1.0 Compliance Testing	09/00
• Version 2.0 Compliance Testing	ongoing

Source: Jürgen Lange: OPC technical update on the latest extensions.
Slide presentation. SoftSympo'03, Helsinki

OPC Basic Principles - DCOM the technological Basis of OPC

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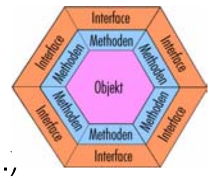
- object model for Client-Server applications
- access to services via interfaces
- specifications describe semantics
- IDL file describes syntax
- use of GUID for identification (CLSID, IID, CATID,...)
- the lifetime of the object is managed via reference counters



Source: Jürgen Lange: OPC technical update on the latest extensions.
Slide presentation. SoftSympo'03, Helsinki

Integration with OPC

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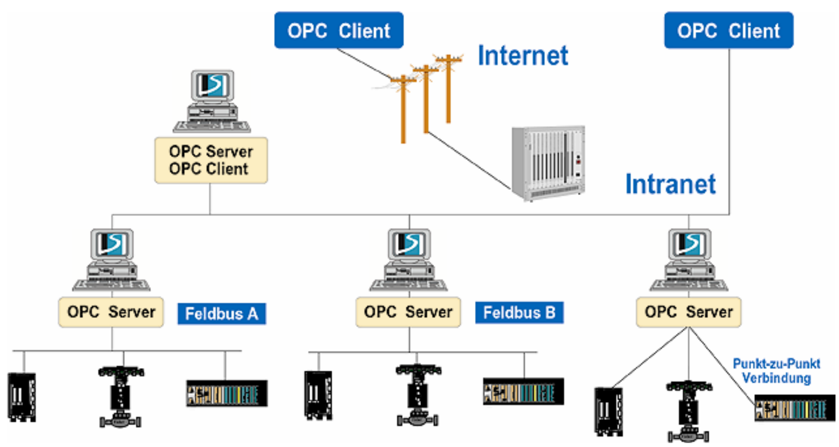

Source: Jürgen Lange: OPC technical update on the latest extensions.
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Vertical Integration with OPC

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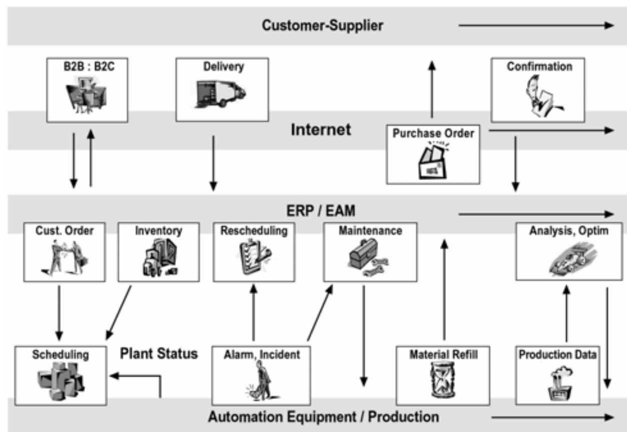
- Integration of business-/ IT- and industrial application

- continous data flow from the customer to the device



Source: Jürgen Lange: OPC technical update on the latest extensions.
Slide presentation. SoftSympo'03, Helsinki

OPC Specifications

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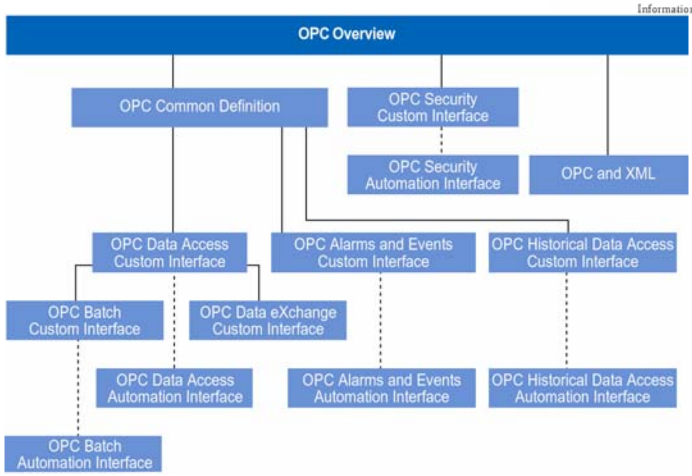

Custom interface: clients can written in C/C++
Automation interface: clients can be written in Visual Basic

J.Lange: OPC Technical Survey, OPC Roadshow Finland, 21.5.2002, Helsinki University of Technology

Data Access Specification
Object Hierarchy and Name Space

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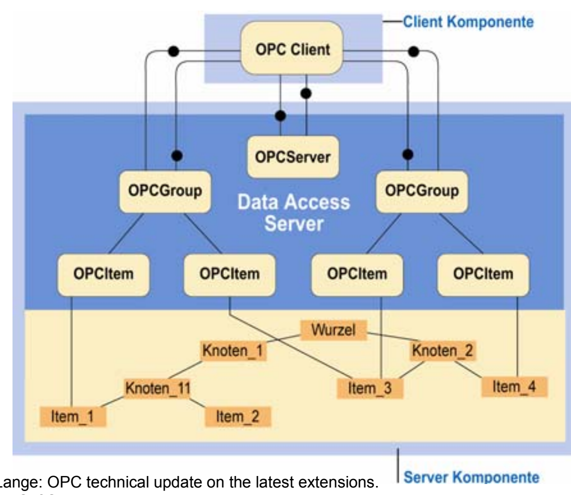

Source: Jürgen Lange: OPC technical update on the latest extensions. Slide presentation. SoftSympo'03, Helsinki

Data Access Specification
Data Format

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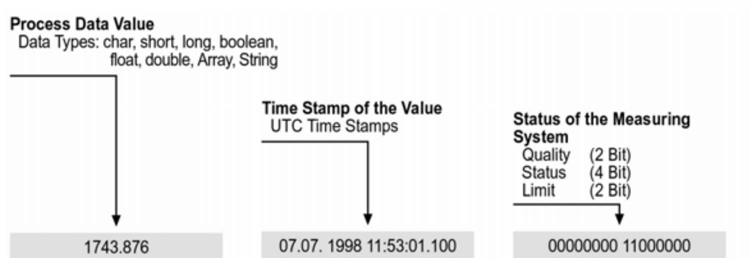

- quality
  - good, bad, uncertain
- status
  - not connected, ...; last usable value, ...
- limit (diagnostic information)
  - The value is located at a limit.

Source: Jürgen Lange: OPC technical update on the latest extensions. Slide presentation. SoftSympo'03, Helsinki

OPC Complex Data

- Defining possibilities of structure description
  - Type descriptions defined within the OPC Specification
  - Type descriptions defined outside the OPC Foundation (e.g. in fieldbus organizations)
- Information on complex data is mapped to defined properties.
- Defining the procedure if values are written to structures

Source: Jürgen Lange: OPC technical update on the latest extensions.
Slide presentation. SoftSympo'03, Helsinki

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Data eXchange (DX)
Scope of Application and Model

- Configurable interactions between servers
  - No use of clients or proprietary bridges is necessary
  - Data exchange between sections of a plant
- What is not included in the specification?
  - Replacement of fieldbus systems
  - Deterministic real-time control
- Vision
  - Direct data exchange between fieldbuses
  - OPC DX Servers in field devices

Source: Jürgen Lange: OPC technical update on the latest extensions.
Slide presentation. SoftSympo'03, Helsinki

Data eXchange
OPC DX

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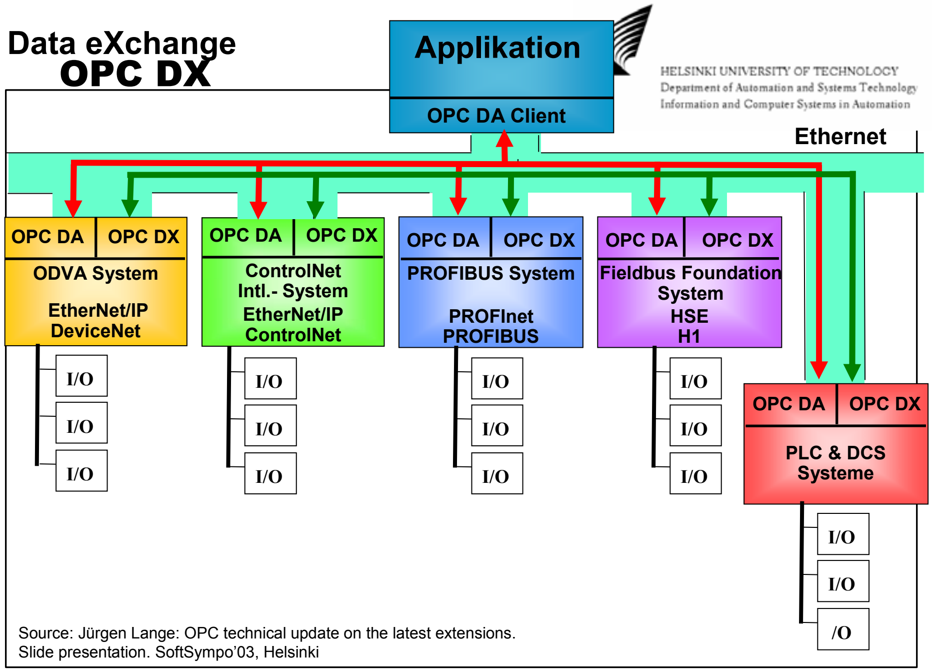

Source: Jürgen Lange: OPC technical update on the latest extensions.
Slide presentation. SoftSympo'03, Helsinki

OPC Data eXchange

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- Scope of application
  - Horizontal data exchange between (DA/DX) Servers
- Model
  - DX Server implements:
    - » DA Server functionality
    - » DA Client functionality for interaction with other servers
    - » Configuration and monitoring functionality
  - Support of DCOM DA and XML DA

Source: Jürgen Lange: OPC technical update on the latest extensions.
Slide presentation. SoftSympo'03, Helsinki

OPC Data eXchange

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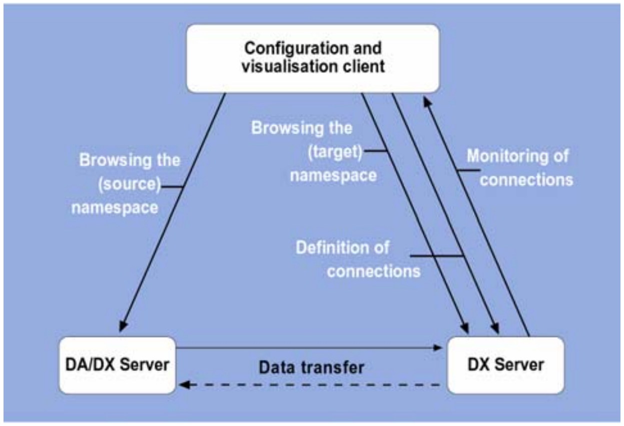

Source: Jürgen Lange: OPC technical update on the latest extensions.
Slide presentation. SoftSympo'03, Helsinki

OPC XML DA
Motivation

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- OPC DCOM is widely used in PC based SCADA, DCS and Visualization systems, but:
  - OPC DCOM Servers can not be accessed from Non-MS-Systems
  - OPC DCOM Clients can not interact with Non-MS-Systems
  - OPC DCOM interactions over the internet are not possible
- XML technology can be used to close these gaps, since
  - XML support is available on any platform
  - XML is used in a lot of application areas

Source: Jürgen Lange: OPC technical update on the latest extensions.
Slide presentation. SoftSympo'03, Helsinki

OPC XML DA

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- Application area
  - Access to data over the Internet
  - OPC applications in non-Microsoft environments
- Model
  - Corresponds to OPC DCOM DA
  - Use of Web Services = XML + HTTP
  - Great freedom of implementation
  - Parameters on request, list and item levels
  - Monitoring of the connection between client and server and vice versa

Source: Jürgen Lange: OPC technical update on the latest extensions.
Slide presentation. SoftSympo'03, Helsinki

OPC XML DA
Technologies

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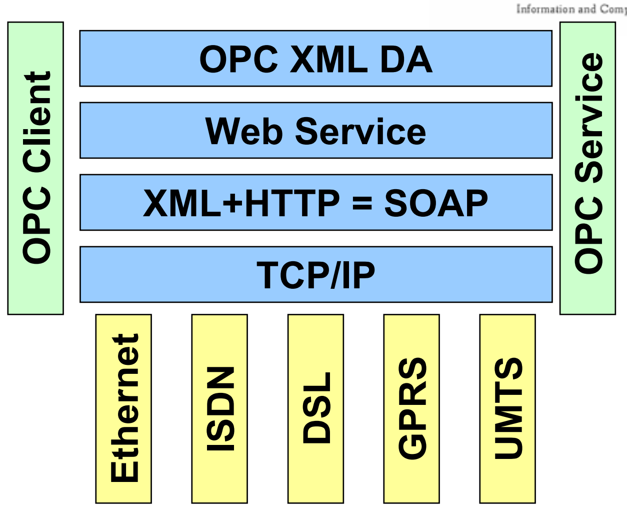

Source: Jürgen Lange: OPC technical update on the latest extensions.
Slide presentation. SoftSympo'03, Helsinki

OPC - development

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- New specifications increase scope of application
- Vertical integration with DA, horizontal integration with DX
- OPC connectivity via Internet with XML-DA
- OPC becomes standard bridge between different OS with XML-DA
- Vision of interoperablity on device level becomes reality with OPC XML-DX
- New development of OPC Unified Architecture (OPC UA) will combine all OPC interfaces (DA, Alarms&Events, Batch, Historical Data, DX etc.) to one server interface.

Source: Jürgen Lange: OPC technical update on the latest extensions.
Slide presentation. SoftSympo'03, Helsinki

Conclusions – enhancement of the customer order delivery process

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- Real-time information from the factory floor can greatly help in achieving better management of the production process that is one key part of the whole **customer order delivery process.**
- New technologies like OPC and XML will ease systems integration in multivendor environment.
- DCOM based OPC is mainly used for tight integration within a process plant and its systems while XML and Web Services based OPC is better suited for more loose integration in heterogenous networks.

Maintenance paradigms

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- **Reactive maintenance**
  Equipment is repaired after breakdown.

- **Preventive maintenance**
  Maintenance is based on a preplanned schedule.

- **Predictive maintenance**
  Maintenance is based on real-time information of the equipment condition. This is provided by a condition monitoring system.

Maintenance paradigms

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- Reactive and preventive maintenance or their proper combination are mainly used as maintenance paradigms today.

- Predictive maintenance is an interesting new paradigm. However, implementing condition measurements and condition monitoring increases investment cost.

- The most cost-effective maintenance solution can be a combination of the three maintenance paradigms depending on the nature and characteristics of the production system. The primary application targets of the predictive maintenance are the most critical equipment or sub-processes in the production system.

Acquisition and processing of condition, diagnostic and performance information in a production plant

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”Service center” - level	•Expert analysis and service provision •Knowledge accumulation and management
Communication networks (Internet, etc.)	
Plant management and operating level	•Plant history DB •Plant performance factors •Maintenance DB •Operative actions •Knowledge accumulation and management
Plant level LAN (wired, wireless)	
Process level	•Process history DB •Equipment history DB •Control loop performance factors •Process performance factors
Fieldbus systems (wired, wireless)	
Equipment level: Eq1 ..... EqN	•Self-diagnosis (equipment, embedded IT) •Data preprocessing (trends, histograms, performance factors) •Test procedures •Communication of operational •Raw data acquisition, local DB and control parameters and data

Example of remote expert services

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System for field device configuration and condition monitoring (Metso FieldCare)

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- FieldCare from Metso Automation is a new, universal FDT-based software for the operation and monitoring of intelligent field devices.
- FDT (Field Device Tool) is an open software specification supported by major instrument and control system suppliers. FieldCare can be used within a process control system or as a device management tool.
- It consists of an FDT frame application and DTMs (Device Type Managers). It is independent of communication protocol. A DTM is a user interface for device operation that is developed by the device vendor and can be used in any frame application.

Source: http://www.metsoautomation.com/

Preventive Maintenance Costs

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Real life example

- Over 500 valves taken off line during shut down for maintenance
- Over 400 did not need maintenance
- About 100 needed maintenance and were properly serviced
- TOTAL COST $1.000.000 of which 70 % spent on valves that did NOT need any maintenance

With automatic condition monitoring installed the figures would have been totally different

Source: Metso Field Systems presentation material 3/2001

Condition and performance monitoring can improve process quality

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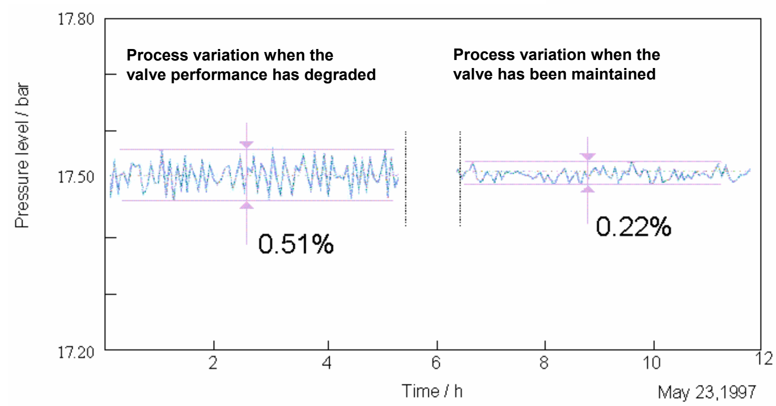

Even a small improvement in process variation may result to considerable cost savings in terms of energy and materials during the life cycle of the process.

Modified from: Ismo Niemelä, Metso Automation Inc. 25.9.2003

FDT and DTM

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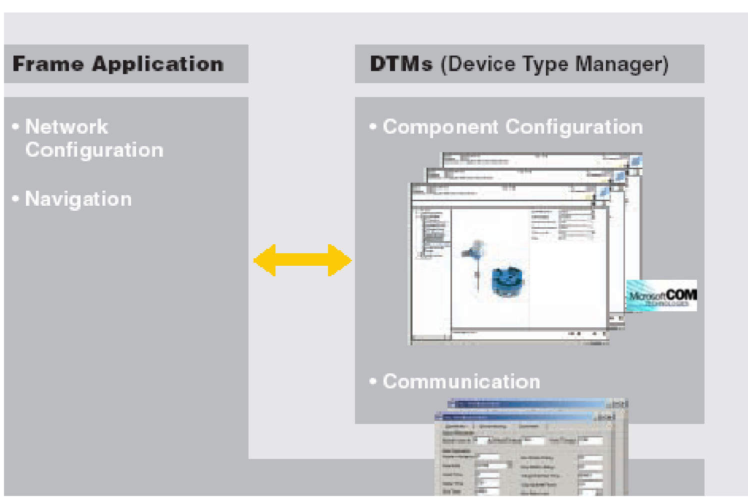

Source: Ismo Niemelä, Metso Automation Inc. 25.9.2003

Each device has its own DTM in the factory network

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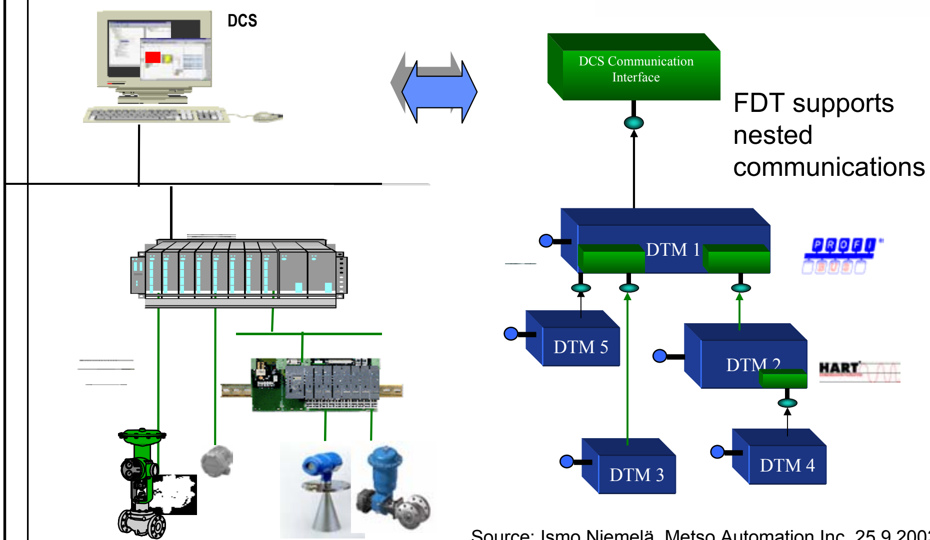

FDT supports nested communications

Source: Ismo Niemelä, Metso Automation Inc. 25.9.2003

An example of DTM – a digital valve controller ND9000

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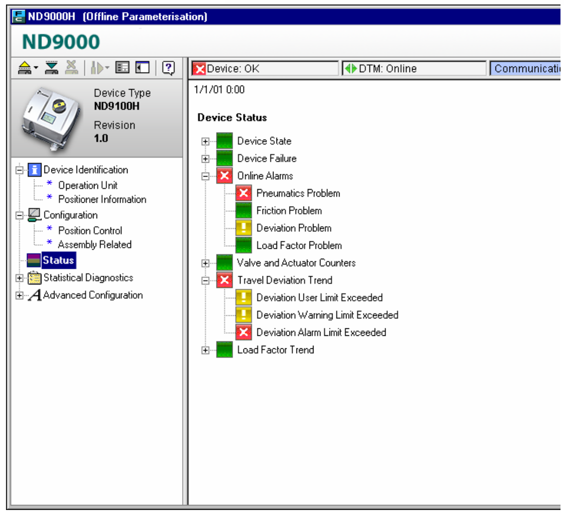
Source: Ismo Niemelä, Metso Automation Inc. 25.9.2003

Simple fault diagnostics at a glance

- **Three level Device Status for simplified information OK - Warning - Alarm**
- **Unambiguous valve package diagnostics on:**
  - Positioner internal alerts
  - Communication alerts
  - Valve on-line alarms
  - Trend based warnings
  - Inadequate supply pressure



Source: Ismo Niemelä, Metso Automation Inc. 25.9.2003

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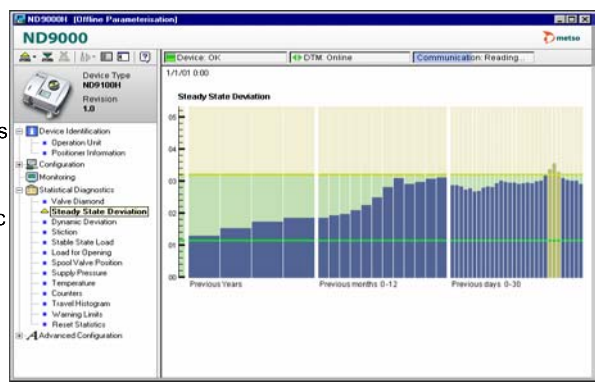
Collected Trends

- **Deviation**
  - For determining valve accuracy
  - Steady and dynamic states separately
- **Stiction (static friction)**
  - For determining pneumatic load of valve operation
  - Open direction, closed direction and stable state cases separately



Source: Ismo Niemelä, Metso Automation Inc. 25.9.2003

Collected histograms

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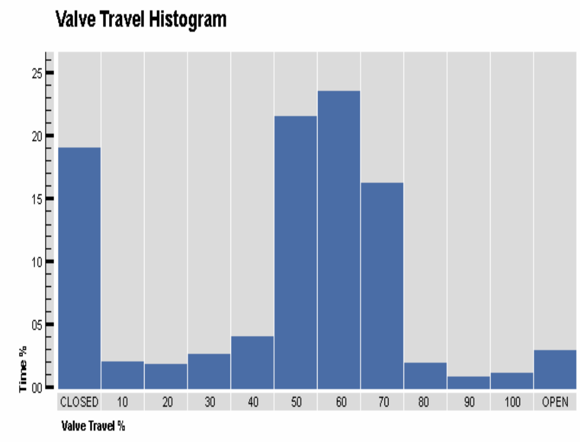
Benefit:

- Quick analysis of application suitability, e.g. valve operation and sizing can be verified.

Features:

- Valve Travel Histogram



Source: Ismo Niemelä, Metso Automation Inc. 25.9.2003

Innovative Valve Diamond as diagnostics visualisation

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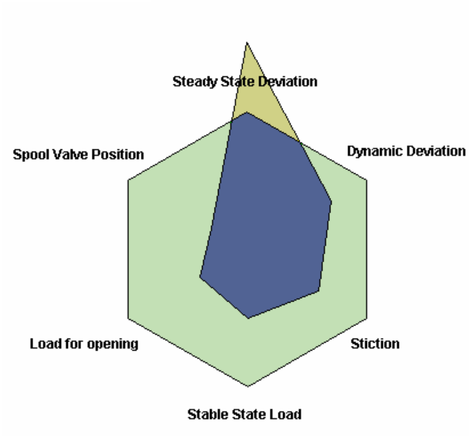
Benefit:

- Valve Diamond as a visualizer for the total control valve package performance.

Features:

- Shows at a glance the problem areas in a valve performance
- Areas for improvement easily defined
- Fast and easy maintenance planning



Source: Ismo Niemelä, Metso Automation Inc. 25.9.2003

Multi-variable monitoring

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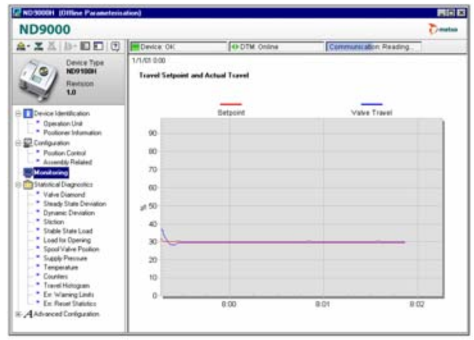
Benefit:

- Easier problem solving using multi-variable monitoring

Features:

- Instant on-line measurement on:
  - Supply pressure and actuator pressure difference
  - Temperature
  - Deviation from setpoint and valve position
- Multi-variable monitoring enables to analyze valve package performance and behaviour in control duty on-line



Source: Ismo Niemelä, Metso Automation Inc. 25.9.2003

FieldCare integration with Metso DNA, Profibus

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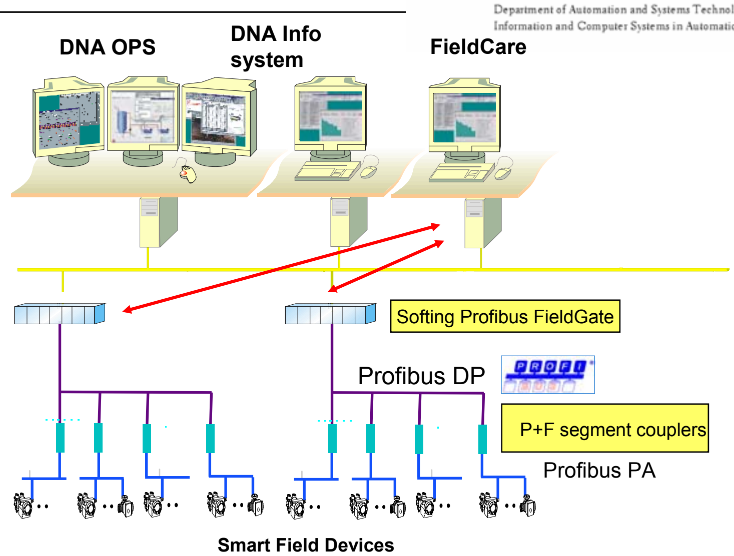

Source: Ismo Niemelä, Metso Automation Inc. 25.9.2003

Example of information logistics from production plants to corporate level systems

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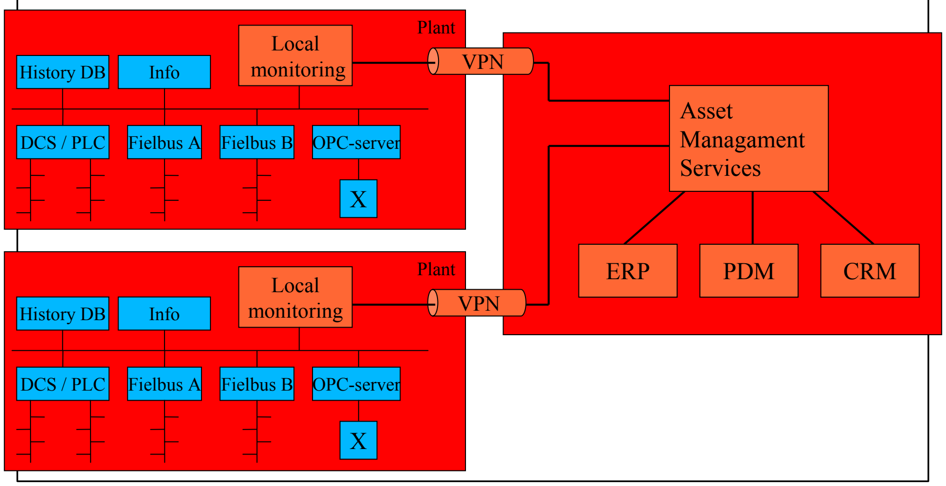

WHAT IS MIMOSA?

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MIMOSA is an Operations and Maintenance Information Open Systems Alliance
Organized as a Non-profit Trade Association
- Vendors
- Integrators & Service Providers
- End-Users

Collaboratively Develops and Promotes Open Standards for Operations and Maintenance (OpenO&M™)
- Fleets
- Plants
- Facilities

Produces Vendor-Neutral Open Information Exchange Standards
- Open Systems Architecture for Enterprise Application Integration (OSA-EAI™)
- Open Systems Architecture for Conditioned-Based Maintenance (OSA-CBM™)
- Finalized standards are publicly available at: http://www.mimosa.org

Source: MIMOSA and OpenO&M™ Executive Overview, August 2004

MIMOSA Strategy

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- **Enable a win/win O&M Solutions Environment for end-users & solutions providers**
- Enable Condition Based Operations (CBO) through Asset Capabilities Management (ACM)
- Enable Collaborative Asset Lifecycle Management (CALM) through use of OSA-EAI and OSA-CBM open asset management information standards
- Strongly brand and leverage OpenO&M™ Open Information Standards
  - A single branded “Language” for Operations and Maintenance integration
  - Enable Solutions that are Open & Interoperable
- Achieve critical mass standards consensus both through organic efforts and through collaboration with other key industry and public sector associations. Avoid standards proliferation.
- Collaboration strategy more fully defined in conjunction with collaboration partners
  - Horizontal OpenO&M™ strategy across all industries and public sector in conjunction with OPC Foundation
  - Choose other OpenO&M™ strategically aligned collaboration partners

Source: MIMOSA and OpenO&M™ Executive Overview, August 2004

OSA/CBM development architecture

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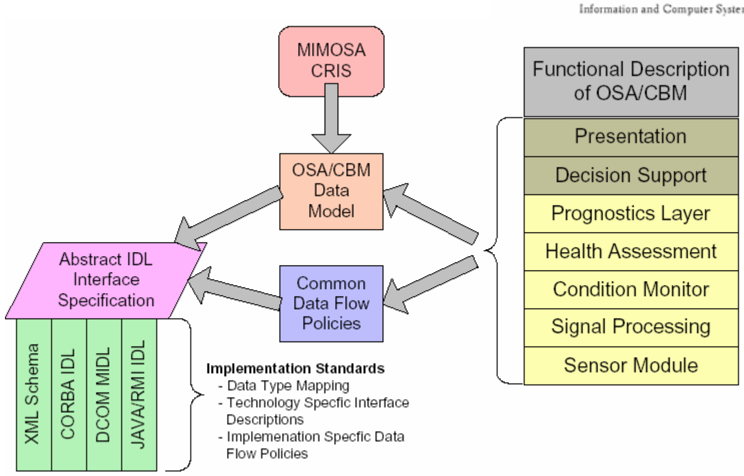

Source: Lebold M., Thurston M.: Open standards for condition-based maintenance and prognostic systems. http://www.osacbm.org/Documents/ConfPapers/MARCON2001_OSACBM_FinalPaper.pdf

MIMOSA CRIS schema

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MIMOSA CRIS (Common Relational Information Schema) defines a relational database schema for machinery maintenance information. The schema provides broad coverage of the types of data that need to be managed within the CBM domain:

- A description of the configuration of the system/equipment being monitored
- A list of specific assets being tracked, and their detailed characteristics
- A description of equipment functions, failure modes, and failure mode effects
- A record of logged operational events
- A description of the monitoring/measurement system (sensors, data acquisition, measurement locations, etc.) and the characteristics of monitoring components (calibration history, model number, serial number, etc.)
- A record of sensor data (and its characteristics) whether acquired on-line, manually logged, or manually acquired using hand held roving instrumentation.
- A means of describing signal processing algorithms and the resulting output data
- A record of alarm limits and triggered alarms
- A means of describing diagnoses of evolving equipment faults and projections of equipment health trends.
- A record of recommended actions and the basis of those recommendations
- A record of work requests from initiation through completion.

CBM open system data flow

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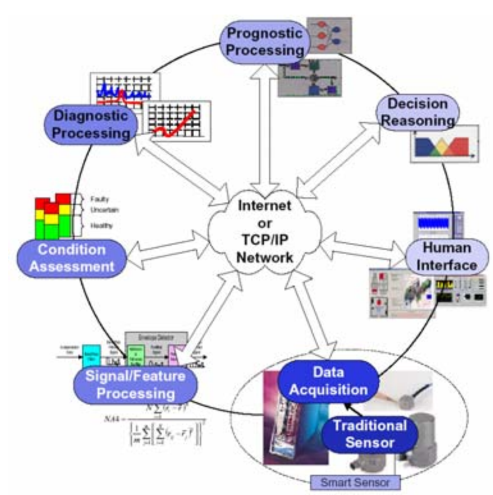

Figure 2 - Data Flow within an Open System CBM Design

Source: Lebold M., Thurston M.: Open standards for condition-based maintenance and prognostic systems. http://www.osacbm.org/Documents/ConfPapers/MARCON2001_OSACBM_FinalPaper.pdf

Generalized inputs and outputs for an OSA prognostic module

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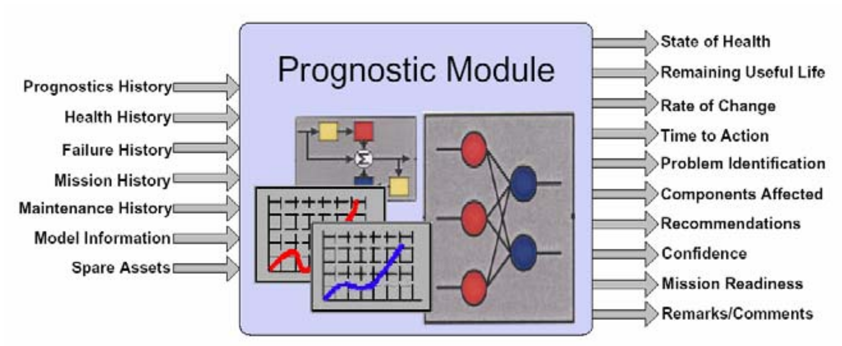

Source: Lebold M., Thurston M.: Open standards for condition-based maintenance and prognostic systems. http://www.osacbm.org/Documents/ConfPapers/MARCON2001_OSACBM_FinalPaper.pdf

What Is OpenO&M™ ?

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- **MIMOSA and OPC Foundation have collaborated to develop a comprehensive, open information architecture for Operations & Maintenance (O&M) information that enable:**
  - Condition Based Operations (CBO)
  - Collaborative Asset Lifecycle Management (CALM)
- **OpenO&M™ leverages existing enabling technology standards**
- **OpenO&M™ leverages a combination of existing OPC and MIMOSA Standards that will continuously improve over time**
  - OPC XML DA & OPC Complex Data
  - MIMOSA OSA-EAI
- **The standards are vendor, platform and application neutral and they are applicable to manufacturing, fleet and facilities O&M applications integration**
- **ISA SP95 has now joined with OPC and MIMOSA in a 3-way Joint Working Group to collaborate in the development and application of OpenO&M™ Standards for Process Industries**
  - MIMOSA – What (Content)
  - OPC Foundation – How (Transport)
  - ISA SP95 – Why (Manufacturing Process Flow Models)

Source: MIMOSA and OpenO&M™ Executive Overview, August 2004

OPC Provides Industry-Standard
interOperability Performance & Connectivity

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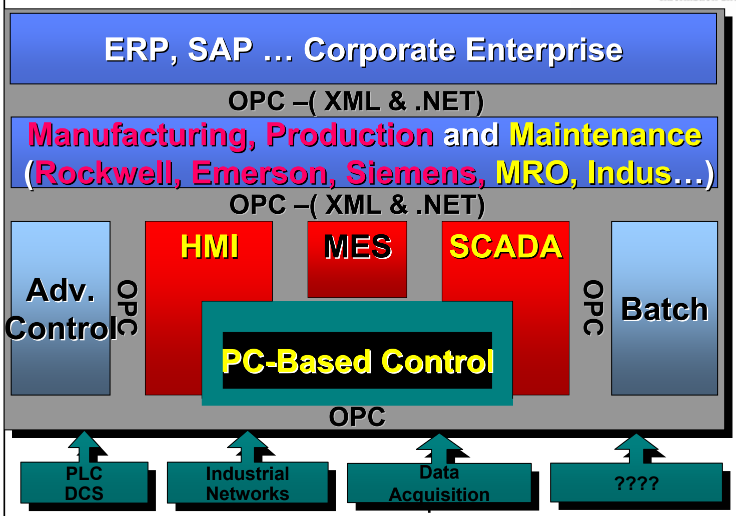

Source: MIMOSA and OpenO&M™ Executive Overview, August 2004

MIMOSA Open Systems Architecture for Enterprise Application Integration (OSA-EAI) Architecture Overview

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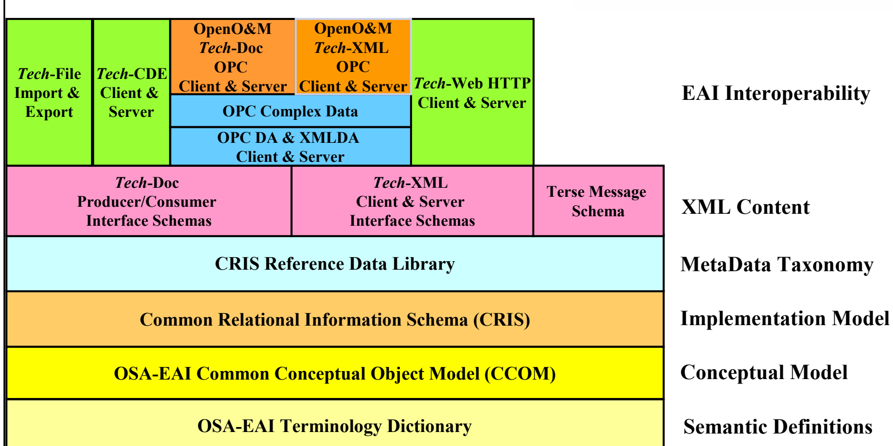

Source: MIMOSA and OpenO&M™ Executive Overview, August 2004

Forecasting of production capacity – decreasing visibility into the future

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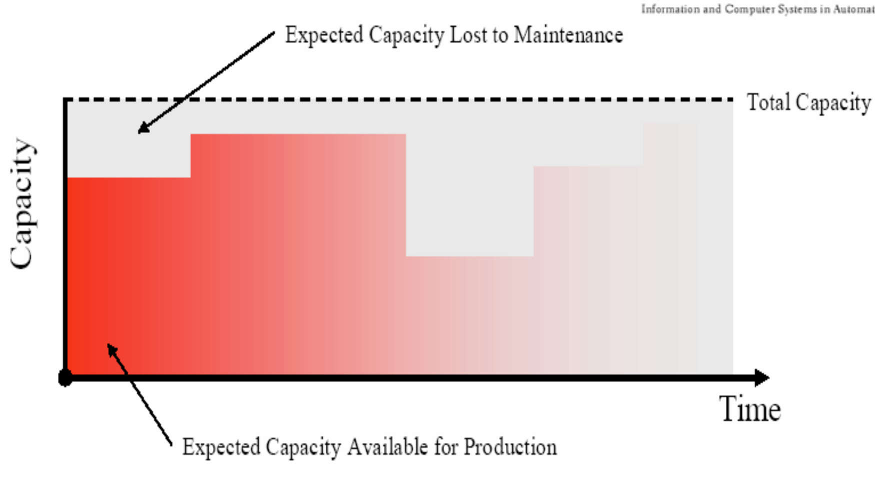

Figure 1 – Capacity Forecast

http://www.mimosa.org/papers/OpenOM%20Whitepaper.pdf

Condition Based Operations (CBO)

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- Condition based maintenace (CBM) enhances the maintenance operations and increases the availability of the production system.
- The condition and maintenance information can also be used for improving the forecast of production capacity within the planning horizon.
- Improved forecast enables condition based production planning and condition based operations which can improve the management of production and of the whole supply chain.

O&M integration without standards

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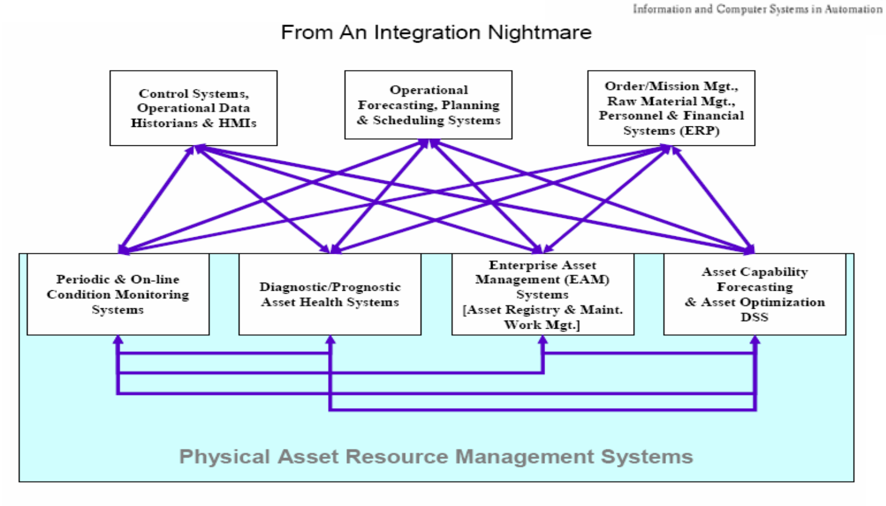

Figure 2 - Interfaces Required for O&M Integration without Standards

http://www.mimosa.org/papers/OpenOM%20Whitepaper.pdf

O&M integration with standard interfaces

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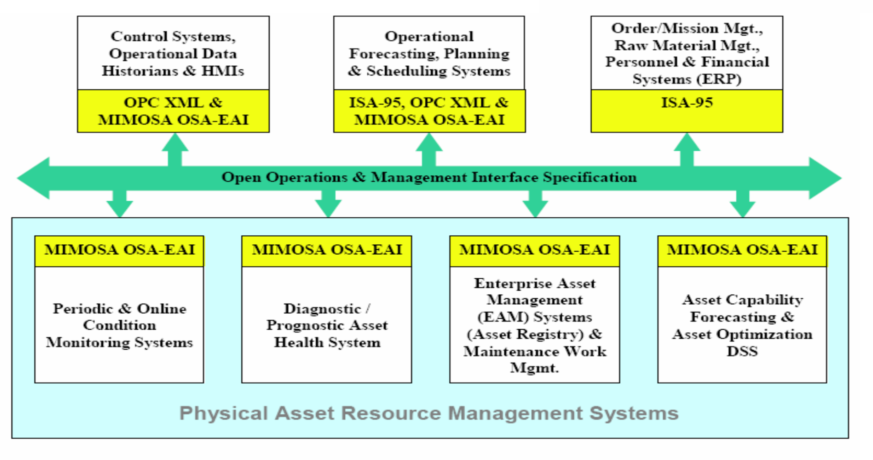

Figure 3 – OpenO&M™ Framework Greatly Reduces the Number of Interfaces

http://www.mimosa.org/papers/OpenOM%20Whitepaper.pdf

OpenO&M model of systems integration and information exchange supporting enterprise and supply chain operations

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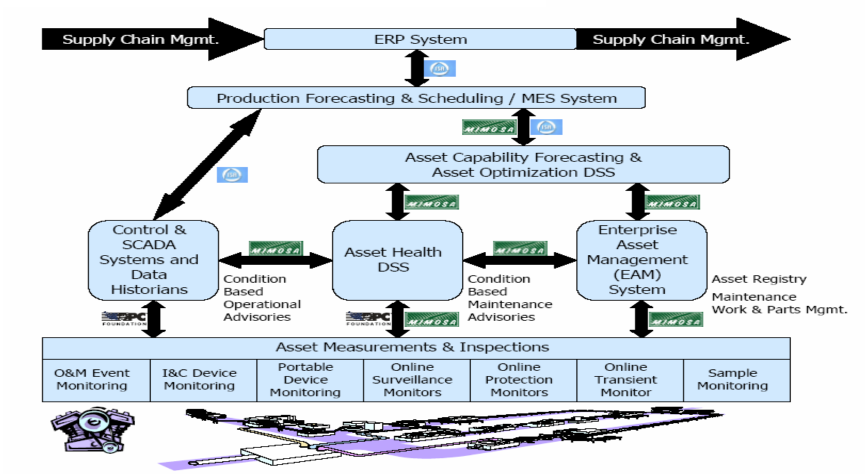

Figure 4 - OpenO&M™ Information Exchanges

http://www.mimosa.org/papers/OpenOM%20Whitepaper.pdf

MIMOSA O&M terminology

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Abbreviations and special terms

CALM	Collaborative Asset Lifecycle Management
CBM	Condition Based Maintenance
CBO	Condition Based Operations
CM	Condition Monitoring
DSS	Decision Support System
EAM	Enterprise Asset Management
ERP	Enterprise Resource Planning
HMI	Human Machine Interface
I&C	Instrument & Control
IEC	International Electrotechnical Commission
ISA	Instrumentation, Systems and Automation Society
ISA-95	Multi-part ISA standard for Enterprise-Control System Integration
ISO	International Organization for Standardization
MES	Manufacturing Execution System
MIMOSA	Machinery Information Management Open Systems Alliance
O&M	Operations and Maintenance
ODHS	Operational Data Historian System
OPC	OLE for Process Control
OSA-EAI	Open Systems Architecture for Enterprise Application Integration
PAM	Plant Asset Management
PLC	Programmable Logic Controller
RTU	Remote Terminal Unit
SP95	ISA's Standards & Practices Committee number 95
XML	World Wide Web Consortium's eXtensible Markup Language

http://www.mimosa.org/papers/OpenOM%20Whitepaper.pdf

Operations and Maintenance (O&M) - conclusions

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- Condition monitoring can enhance the maintenance process by enabling predictive maintenance operations. This can improve the availability of the production system and the process up-time.
- The potential of the integration of operations and maintenance (O&M) related information has not yet been fully realised nor utilised.
- The MIMOSA concepts and reference models of OpenO&M and CBO are aimed to facilitate reaching of that goal.