OPC UA Tech. Introduction

Uwe Steinkrauss (Unified Automation)
Agenda

- OPC UA Introduction
technical overview on the fundamental building blocks

- OPC UA Update
enhancements introduced with V1.02 and V1.03

- OPC UA Enhancements
future technologies coming soon
Classic OPC

- Data Access
- Historical Data Access
- Alarms & Events
Requirements for OPC UA

- Wide adoption of OPC
  - Security
    - Access control
  - Performance
  - Internet Firewalls
- OPC used as common system interface
  - Robustness
    - Fault tolerant
  - Redundancy
  - Platform independent
  - Type system
- Communication between distributed systems
  - Modeling Data
    - Base for other standard data models
      - Meta data
      - Method calls
      - Complex data
  - Scalability
    - Common model for all OPC data
  - Embedded devices
    - MES ERP
  - SCADA
OPC UA – Next Generation OPC

- Definition 2003 – 2006
- Verification and Implementation 2006 – 2008
- Final OPC Foundation Release 2009
- IEC 62541 Release 2010 – 2012

- **OPC UA = established OPC features**
  - Platform independence
  - Standard internet and IP based protocols
  - Built in security features
  - Generic object model
  - Extensible type system
  - Scalability through profiles
  - Migration path from Classic OPC
OPC UA Object Model & Type System

OPC DA and HDA

OPC Commands

OPC UA Object

Variables

Methods

Events

OPC A&E
Nodes and References

- Everything in the UA Address Space is a Node
- UA defines a none extensible list of 8 Node Classes

Each Node Class has a defined set of Attributes
- Nodes are connected by References
Object Type (Class) & Object Instance
OPC UA Transport – Protocol Bindings

XML Web Services

Optimized OPC UA Binary

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Message Based Security
Protocol Implementation – UA Stacks

Client Application

- API Call
- Client API
- Message Encoding
- Secure Channel
- Transport

Implementations in
- ANSI C / C++
- .NET
- JAVA

Server Application

- API Call
- Server API
- Message Encoding
- Secure Channel
- Transport

API Message Structure

Raw Message
API structure encoded as byte array or XML document

Secured Message
Raw message signed and encrypted with security header

Wire
Transport Message
Secured message with transport header

UA Stack

Implementations in
- ANSI C / C++
- .NET
- JAVA
OPC UA Services – Generic UA API

- Protocol independent OPC UA API
- Services to
  - Discover Servers and Endpoints
  - Browse Server Address Space
    - Instances
    - Type System
  - Read and Write current data
  - Read History of Data and Events
  - Call Methods
  - Subscribe for
    - Data Changes
    - Events
  - Create / Delete Nodes and References

- Generic Services
  - No feature specific extensions
  - Features added through Information Models
OPC UA Built In Information Models

- **Data Access**
  - Representation of Process Variables
  - E.g. AnalogItemType with unit and range

- **Alarms & Conditions**
  - Representation of Process Alarm Systems
  - State machines for Alarm states
  - Events for state changes
  - Methods feedback like Acknowledge

- **Historical Access**
  - Information about historized data and events

- **Programs**
  - Representation of programs
  - Manipulate programs like start, stop
  - State of a program execution
  - Result data handling
OPC UA Companion Models

- **Standard Information Models**
  - Use case specific models
  - Industry specific models

- **Definition based on**
  - collaboration with other standards
  - special use cases and requirements

- **Already available**
  - Device Integration (DI)
  - Analyzer Device Integration (ADI)
  - IEC 61131-3 (PLCopen)
  - Field Device Integration (FDI)
  - Building Automation (BACnet)

- **More ongoing**
  - Oil&Gas Subsea (MDIS)
  - Auto Identification (AIM)
  - AutomationML
Vendor Specific Extensions

- **Product Internal Interfaces**
  - Used for configuration and diagnostics
  - Used between applications from the same product or vendor
  - Can use information models optimized for use cases

- **External Interfaces**
  - Used between systems from different vendors
  - Should layer on top of standard information models
  - Types should be derived from standard types
OPC UA Specifications

OPC Unified Architecture Specifications

Core Specification Parts
- Part 1 - Concepts
- Part 2 - Security Model
- Part 3 - Address Space Model
- Part 4 - Services
- Part 5 - Information Model
- Part 6 - Service Mappings
- Part 7 - Profiles

Access Type Specification Parts
- Part 8 - Data Access
- Part 9 - Alarms and Conditions
- Part 10 - Programs
- Part 11 - Historical Access

Utility Type Specification Parts
- Part 12 - Discovery
- Part 13 - Aggregates
OPC UA Profiles

- **Conformance Unit**
  - Represents specific feature
  - Defines a list of test cases for the feature

- **Profile**
  - Named grouping of features
  - Full Featured
    - Combination of Profiles and Conformance Units that can be used stand alone
  - Facet
    - Profile that can be used only in combination with other Profiles

- **Certification Test**
  - Vendor defines list of supported Profiles
  - Certification Test executes test cases for the supported Profiles
  - End users can rely on tested Profiles
Example: OPC UA Server Profiles

Facets building on top of Full Featured Profile

- Alarms & Conditions
- Event Subscription Server Facet
- Method Server Facet
- Historical Access
- Complex Data
- Redundancy
- Device Integration
- PLCopen

Standard UA Server

- Address Space
- Data Access
- Security
- Binary Protocol

Full Featured Profile

OPC Day Belgium, 2015
Example: Iterative Development DA

Connect → Server → Variable_1
Value = -2
DataType = Int32
AccessLevel = Read
Historizing = False

Standard UA Server
Address Space → Data Access
Security → Binary Protocol
Iterative Development DA + HDA

Connect ➔ Server ➔ Variable_1 ➔ Historical Access
Browse ➔ Address Space ➔ Standard UA Server
Read ➔ Security
Subscribe ➔ Data Access ➔ Binary Protocol

Variable_1:
- Value = -2
- DataType = Int32
- AccessLevel = Read
- HistoryRead
- Historizing = True
**OPC Foundation Profile Web Site**

http://www.opcfoundation.org/profilereporting

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### OPC UA Profiles

Following are the currently defined profiles, arranged according to their application category.

- **SERVER Category**
  - Facets
    - Core Characteristics
    - Data Access
      - Embedded DataChange Subscription Service
      - Standard DataChange Subscription Service
      - Enhanced DataChange Subscription Service
      - Data Access Server Facet
      - Complex Type Server Facet
    - Base Eventing
    - Alarm & Condition
    - Generic Features
    - Redundancy
    - Historical Access
    - Aggregates
    - Programs Model
  - Full Featured
    - None Embedded Device Server
    - Micro Embedded Device Server
    - Embedded UA Server Profile
    - Standard UA Server

- **CLIENT Category**
  - Facets
    - Core Characteristics

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### "Standard UA Server" Profile

**Description**

This Profile is a full featured Profile that defines a minimum set of functionality required for PC based OPC UA servers. Such a server must provide the base address space structure with type nodes, instance nodes and diagnostic information. The Server must provide connection establishment through the OPC UA TCP binary protocol with security and the creation of at least 50 parallel sessions. It includes view services like browsing and the attribute services for reading and writing of current values. In addition, the monitoring of data changes is included with a minimum of 5 subscriptions for half of the required sessions (total 225) and a minimum of 500 monitored items for half of the subscriptions (total 56250).

**URI**

http://opcfoundation.org/UA-Profile/Server/StandardUA

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This page lists the conformance units of the selected profile with their name and description. Conformance units that are inherited via included Profiles are not listed by default. Use the following radio buttons to change this default behaviour.

- Show only explicitly included conformance units
- Show also conformance units from included profiles
- Show all existing conformance units
- Show relationship of Conformance Units with Units and Profiles for Clients / Servers

### Base Information

<table>
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<td></td>
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<td>Support Diagnostic Objects and Variables</td>
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### Discovery Services

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**OPC Day Belgium, 2015**
# Summary OPC UA

OPC Unified Architecture stands for…

## Data Modeling
- Generic object oriented modeling
- Objects with variables, methods and events
- Extensible type system
- History for data and events
- State machines, programs, alarms & condition
- Complex data

## Communication
- Integrated security mechanisms
- High speed UA TCP protocol
- Web services for internet
- Platform independent
- Built in robustness and fault tolerance
- Redundancy

## Collaboration
- UA is IEC standard
- UA is base for other information models
- EDDL and FDT
- MIMOSA
- OMAC
- PLCopen

## New Applications and use cases
- Profiles for different use cases
- Scalability
- Integration in embedded systems
- MES and ERP systems
- Specialized versions for different industries
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  future technologies coming soon
OPC UA Version 1.02 Highlights

- Maintenance Release
  - Compliance and other clarifications
- Final Release Historical Access
  - OPC UA Part 11 – Historical Access
  - OPC UA Part 13 – Aggregates
- Feature Highlights
  - File Transfer through FileType object
  - HTTPs based protocols
  - Standard XML schema for address space
    - Offline browsing
    - Address space import and export
    - Machine readable format of information models
  - Global Directory Service and ad-hoc discovery
  - Enhanced redundancy mode and network redundancy
File Transfer

Object Type representing File Interface

- File Type
  - PropertyType: Size
  - PropertyType: Writable
  - PropertyType: UserWritable
  - PropertyType: OpenCount
  - Open
  - Close
  - Read
  - Write
  - GetPosition
  - SetPosition

Meta Data Properties

File Access Methods

Objects representing Files

- FolderType: MyFiles
  - FolderType: Pictures
  - FileType: Family.jpg
  - FolderType: Documents
    - FileType: OPC UA Part 4.pdf
    - FileType: Fax template.doc
    - FileType: Project calculation.xls

- File system represented with Folder and File Objects
- No limitation for file size
- Synchronized access to files
# HTTPS based Protocol Bindings

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**V 1.01**

Message Based Security (preferred)

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**V 1.02**

Only Transport Security

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Use Cases XML Schema (NodeSet2)

Import of standard or application specific information models

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Use Cases XML Schema (NodeSet2)

OPC UA Server → Export → Offline Browsing → OPC UA Client

Import and export of OPC UA Address Space

OPC UA Server → Export → Import → OPC UA Server
Local Discovery Service (LDS)

available today

Discovery with LDS:
- Network nodes with OPC UA server must be known
- Servers register with local LDS or have LDS included
- LDS is running on defined port (4840)
- LDS provides Server and Endpoint Discovery for local network node
- Manual security configuration
Ad-Hoc Discovery / Dynamic DNS

**Features provided:**
- Host name resolution without central DNS server
- Find network nodes with OPC UA in local network

**Advantage:**
- No central infrastructure required

**Limitation:**
- Works only in local subnet

Prototype available
Global Directory Service (GDS)

GDS Features:
- Certificate creation / management
- Certificate Authority (CA)
- Management of Certificate Revocation Lists (CRL)
- Push / Pull of Certificates / CRL
- Network wide server registry

Central Server

GDS (Port:4840)
- Pull / Push Certificates
- List of registered UA Servers

- Security Config
- Find Servers
- Security Config
- Register Server

GE first on market
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Communication Extension (PubSub)

- Use case driven: M2M
- Extremely fast one-to-many communication
- In local network (maybe Time Sensitive Network (TSN))
Communication Extension (PubSub)

- Use case driven: IoT
- Many-to-one (the cloud) communication
- In global network (optionally use Relay/Broker)

The Cloud

- OPC UA Client (Subscriber)
- OPC UA Server
- Relay Broker (optional)

AMQP (advanced message queuing protocol)

OPC UA Server

OPC UA Server

OPC UA Server (Publisher)

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Thanks for Your Attention!

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