Mapping IEC 61850 to CORBA

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Presentation Structure

• **DOTS Context**
  • What is DOTS ? What is the objective ?
  • What are we doing? Where are we going?

• **A CORBA Model for SAS**
  • Understanding Substation Automation Systems
  • SAS as CORBA systems

• **61850 ACSI Mapping to CORBA**
  • Mapping core ideas
  • Mapping itself
DOTS Context

What is DOTS?
DOTS is a project

• Distributed Object Telecontrol Systems and Networks
• Supported by the European IST programme
• Main objective:

” to establish an open software model, built upon real-time distributed object technologies and emergent telecontrol standards to allow the optimum exploitation of the interoperation capabilities of devices and systems in the distributed context of an electric power grid “
DOTS Consortium

- ELIOP (manufacturer, Spain)
- UPM (university, Spain)
- DECAN (IT company, France)
- SCI Labs (industrial DOC, Spain)
- UNINOVA (non-profit Research, Portugal)
- INNOVA (technology marketing, Italy)
- REE (power transmission, Spain)
Telecontrol/ SAS

Operation terminal / Configuration terminal

Front end

Low speed links

High speed links network

IED

RTU

Physical devices

Maintenance terminal

Controlled Plant

SCADA
IEC 61850

- Communication Networks and Systems in Substations
- The standard should ensure, among others, the following features:
  - The complete communication profile will be based on existing IEC / ISO / OSI communication standards, if available.
  - The protocols used will be open and will support self-descriptive devices. It will be possible to add new functionality.
  - The standard will be based on objects related to the needs of the electric power industry.
  - The communication syntax and semantics will be based on the use of common objects related to the power system.
  - The communication standard will consider the implications of the substation being one node in the power grid, i.e. of the SAS being one element in the overall power control system.
Domains in DOTS

- IEC 61850 Domain
- CORBA Domain
- Real-time CORBA Domain
- Embedded CORBA Domain
- Fault-tolerance CORBA Domain
- DOTS Domain
DOTS Pilot

Substation Lanes

Camera

IED-1

IED-2

Pushbutton

Doorbell

GPS

Substation Computer

Configuration Terminal

10BaseT

10BaseT

10BaseFL

Ethernet Hub

Operator Terminal

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Pilot Deployment

- Operation Station
  - Desktop OS
  - Commercial ORB
  - Java
- Configuration Station
  - Desktop OS
  - C++
- Network
- Protection
- Control
- RTU
  - Preemptive RTOS
  - ORB
- Embedded IED with preemptive RTOS & ORB
- IED w/o ORB
- Commercial ORB
- Java

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DOTS Public Documents

• DOTS DL1.2 General Model Definition
  • A general description on how IEC Models can be implemented using CORBA technology

• DOTS DL3.1 ACSI Mapping to CORBA
  • A mapping of the IEC 61850-7-2 (ACSI) to CORBA
Find us

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• **José Antonio Clavijo**
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• Future informative web site
  [www.ist-dots.org](http://www.ist-dots.org)
CORBA in Control Systems

What is the role of the Common Object Request Broker Architecture in control systems?
Design Principles

• Conformant
• Suitable
• Composable
• Modular
• Extensible

• Scaleable
• Simple
• Standard
• Proven
• Performant
A CORBA Model for IEC-61850

Structure and contents of the GMD document
Alignment of IEC 61850

- Alignment of IEC61850 with OMA
  - Function and logical node concepts
  - Interface model
  - Pervasive 3-leveling
  - Message concept
  - Logical connections
  - Object activity and interaction
Core Modeling Guidelines

• Functions
• Logical Nodes
• PICOMs
• Logical Devices
DOTS Base Mapping

Collaborations = Patterns

Deployment = Servers + Nodes

Objects = Servants

Logical Nodes

- HMI
- Sy. Switch.
- Dist. Prot.
- O/C Prot.
- Breaker
- Bay CT
- Bay VT
- BB VT

Functions

- Synchronized CB switching
- Distance protection
- Overcurrent protection

Physical Nodes / Devices

1. HMI
2. Sy. Switch.
4. O/C Prot.
5. Breaker
6. Bay CT
7. Bay VT
8. BB VT
Specific Communication Service Mapping

Structure and contents of the SCSM to CORBA document
What is the ACSI

- The ACSI is an Abstract Communication Service Interface
- Is used by IEC 61850 clients to request services from IEC 61850 servers

Client → Request → Server → Response
Why SCSMs?

- Because the ACSI is abstract it needs concrete realizations to be usable
- They are called SCSMs, i.e. **Specific Communication Service Mappings**
  - Specific
  - Communication
  - Service
  - Mappings
- The purpose of this work is to elaborate a SCSM to CORBA
What is the mapping?

There is no ACSI PDU.

There is just an AL PDU. ACSI services and their parameters are mapped to the AL PDU

PDU: Protocol Data Unit (encoded Message containing the service parameter, etc.)

ACSI Service

Specific Mapping (SCSM)

Application Layer

ACSI PDU

AL PDU

No Protocol
61850 & CORBA Assessment

Assessment of the fitness of 61850 ACSI and CORBA models
Does it Fit?

- This is the IEC 61850 view of the ACSI

ACSI Client

Client Application

Communication Services

Request

Confirm

SCSM

ACSI Server

Server Application

Server Object (e.g., Logical Node n or Data Object)

Communication Services

Response

Indication

SCSM

Communication Stack/Profile
Does it Fit?

• YES
• This is the CORBA View:
Main problems

• The ACSI is not fully OO
  • In some parts it is truly OO
  • In others is a classical procedural system

• For example:
  • All interactions are performed against one single object: The ACSI server
  • Objects to manipulate are passed as parameters
sequence <ObjectName> ObjectNameList;

// Strict 61850 version ------------------------
ObjectNameList Server::DataObjectDirectory(
    in DataObjectName name)
raises (DirectoryFailed,NoSuchObject);

// More OO version --------------------------
ObjectNameList DataObject::Directory()
raises (DirectoryFailed);
Mapping criteria

What are the decisions done in the mapping
## Fundamental Types

<table>
<thead>
<tr>
<th>ACSI Data Type</th>
<th>CORBA Data Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>OCTET STRING</td>
<td>sequence &lt;octet&gt;</td>
</tr>
<tr>
<td>VisibleString</td>
<td>string</td>
</tr>
<tr>
<td>BIT STRING</td>
<td>sequence &lt;boolean&gt;</td>
</tr>
<tr>
<td>INTEGER</td>
<td>long</td>
</tr>
<tr>
<td>REAL</td>
<td>float</td>
</tr>
<tr>
<td>Sequence</td>
<td>struct</td>
</tr>
<tr>
<td>Array</td>
<td>Array</td>
</tr>
<tr>
<td>ENUMERATED</td>
<td>enum</td>
</tr>
<tr>
<td>NULL</td>
<td>Nil</td>
</tr>
</tbody>
</table>
DOTS Base Mapping

Objects = Servants

Collaborations = Patterns

Deployment = Servers + Nodes

Logical Nodes:
- HMI
- Sy. Switch.
- Dist. Prot.
- O/C Prot.
- Breaker
- Bay CT
- Bay VT
- BB VT

Functions:
- Synchronized CB switching
- Distance protection
- Overcurrent protection

Deployment Nodes:
1. HMI
2. Sy. Switch.
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Mapping of common types

- ObjectName and ObjectReference
- TimeStamp
- RelativeTime
Object Naming

• CORBA Names generated according to naming rules in 61850:
  <LD instance name>/
  <LN instance name>.
  <Data object instance name>.
  <Data attribute instance name>

• Names managed using CORBA Naming Service

<table>
<thead>
<tr>
<th>id field</th>
<th>kind field</th>
</tr>
</thead>
<tbody>
<tr>
<td>Process-AX</td>
<td>SERVER</td>
</tr>
<tr>
<td>my-feeder-XY</td>
<td>LOGICAL_DEVICE</td>
</tr>
<tr>
<td>myXCBR1</td>
<td>LOGICAL_NODE</td>
</tr>
<tr>
<td>Pos1</td>
<td>DATA_OBJECT</td>
</tr>
<tr>
<td>StVal</td>
<td>DATA_ATTRIBUTE</td>
</tr>
</tbody>
</table>
Communication models

<table>
<thead>
<tr>
<th>ACSI</th>
<th>CORBA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Request/response</td>
<td>Request</td>
</tr>
<tr>
<td>Request/no response</td>
<td>Oneway request</td>
</tr>
<tr>
<td>GOOSE message</td>
<td>Push event channel</td>
</tr>
<tr>
<td>Sampled value transmission</td>
<td>Push/pull real-time event channel</td>
</tr>
</tbody>
</table>

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The mapping

Details and examples of the mapping
Sections

- Mapping of Server Model
- Mapping of Association Model
- Mapping of Logical Device Model
- Mapping of Logical Node Model
- Mapping of Data Object Model
- Mapping of Data Attribute Model
- Mapping of Publish And Subscribe Data Transfer
- Mapping of Generic Object Oriented System-wide Events
- Mapping of Control Model
- Mapping of Substitution Model
- Mapping of Transmission of Sampled Measured Values
- Mapping of Time Synchronisation Model
- Mapping of File Transfer
Typical structure

- Overview
- Data and class definition
- Services definition
- IDL
- UML
Example of IDL

interface Server {
    attribute ObjectName ServiceAccessPoint;
    attribute LogicalDeviceList LogicalDevices;
    attribute FileList Files;
    attribute ClientAssociationList ClientAssociations;
    any ServerDirectory (in ClassTypeCode classtype)
        raises (FailedDirectory,NoSuchType);
};
Example of UML

<<Interface>>
Association
(from ACSI)

<<CORBATypedef>>
AssociationList
(from ACSI)

+Associations

<<Interface>>
ClientAssociation
(from ACSI)

<<CORBATypedef>>
ClientAssociationList
(from ACSI)

+ClientAssociations

<<Interface>>
File
(from ACSI)

<<CORBATypedef>>
FileList
(from ACSI)

+Files

<<Interface>>
LogicalDevice
(from ACSI)

+ LogicalDeviceDirectory()

<<CORBATypedef>>
LogicalDeviceList
(from ACSI)

+LogicalDevices

<<Interface>>
Server
(from ACSI)

+ ServerLNDirectory()
+ ServiceAcessPoint
+ ServerFDirectory()
+ ServerCADirectory()
Pending Issues

Things that are still not finished in 61850 and DOTS
IEC 61850

• Frozen (approved) standards
• Complete OO models (UML)
DOTS activities

• IEC Model implementation
• Pluggable transports for CORBA based on IEC protocols
• Demonstrator application