DIPARTIMENTO DI INFORMATICA
E SISTEMISTICA ANTONIO RUBERTI

SAPIENZA
UNIVERSITÀ DI ROMA

"Open source implementation, by means of Web Services, of monitoring and controlling services for EMS/SCADA Systems"

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Agenda

1. Introduction
2. Design of Data Models
3. Implementation of Web Services
4. Conclusions and Future Work

1. Introduction

Introduction

• Ongoing unboundling and Energy market liberalization in EU;

Innovations in the interaction between:
1.Energy producers;
2.Trasmission companies;
3.Distribution companies;
4.Customers;

- Keeping supply and demand in balance;
- Keeping parameters within nominal boundaries ;
- Having tighter control on the distribution system;
- Use of intelligent metering techniques;

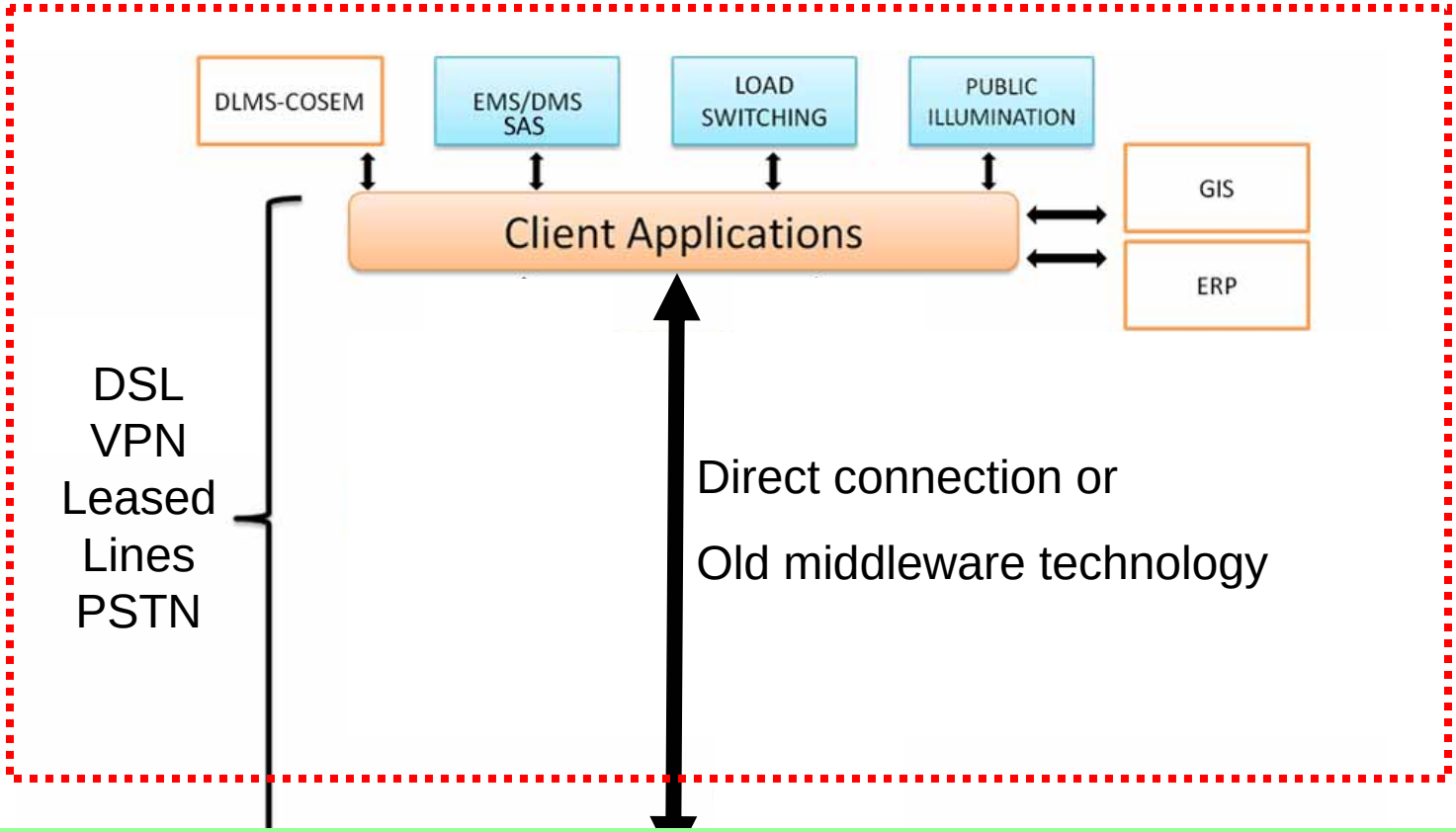
Innovative monitoring and control services for EMS/SCADA Systems

Traditional Systems

Upgrading Issues:

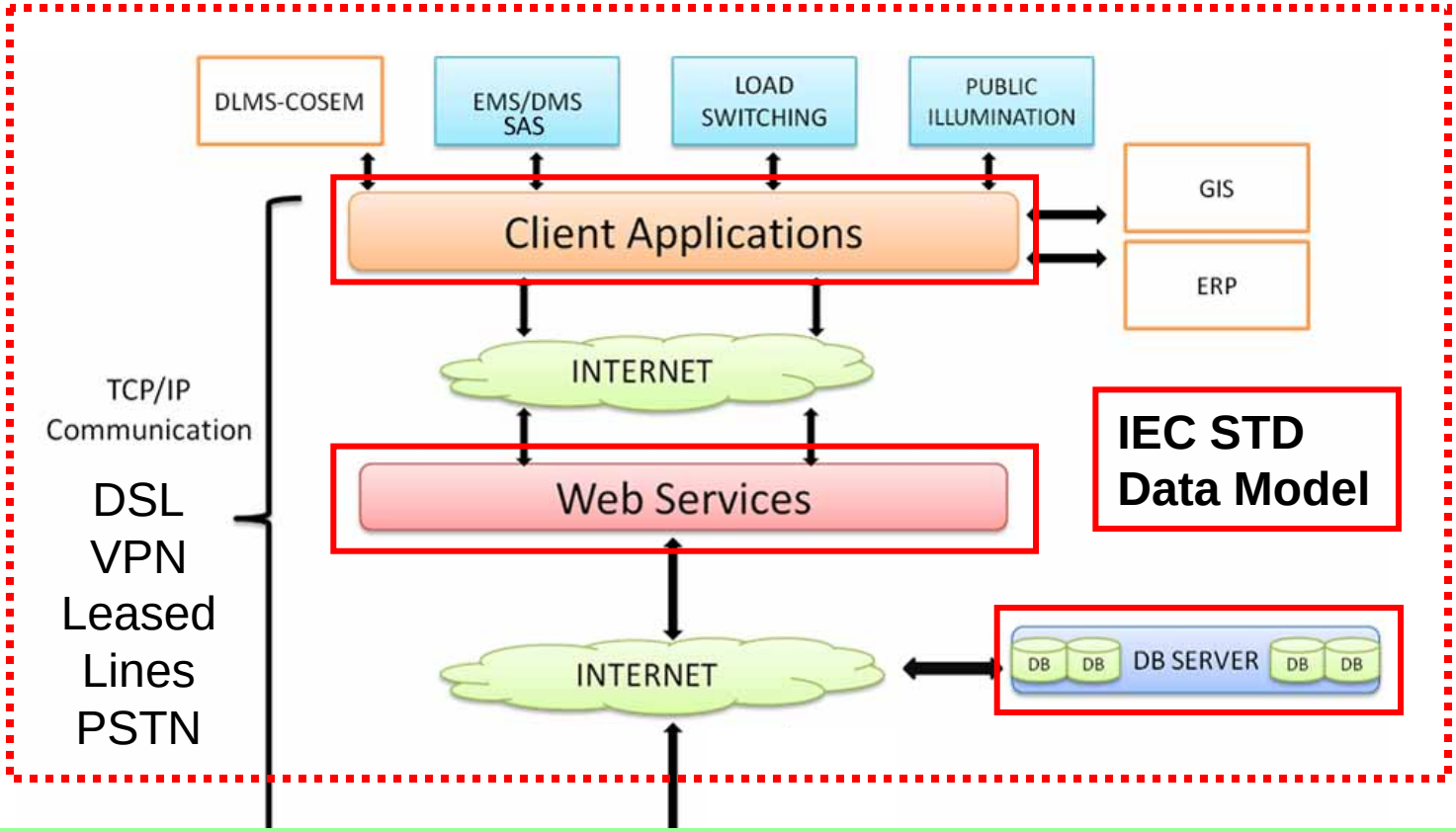
- Currently a wide range of proprietary systems are available;
- Vendor dependent implementations;
- High coupling between application SW and SCADA/HW systems
- Difficult application integration;
- Technological barriers for system migration and/or extensions
- Higher costs for end users(utilities and system operators);

Traditional Systems



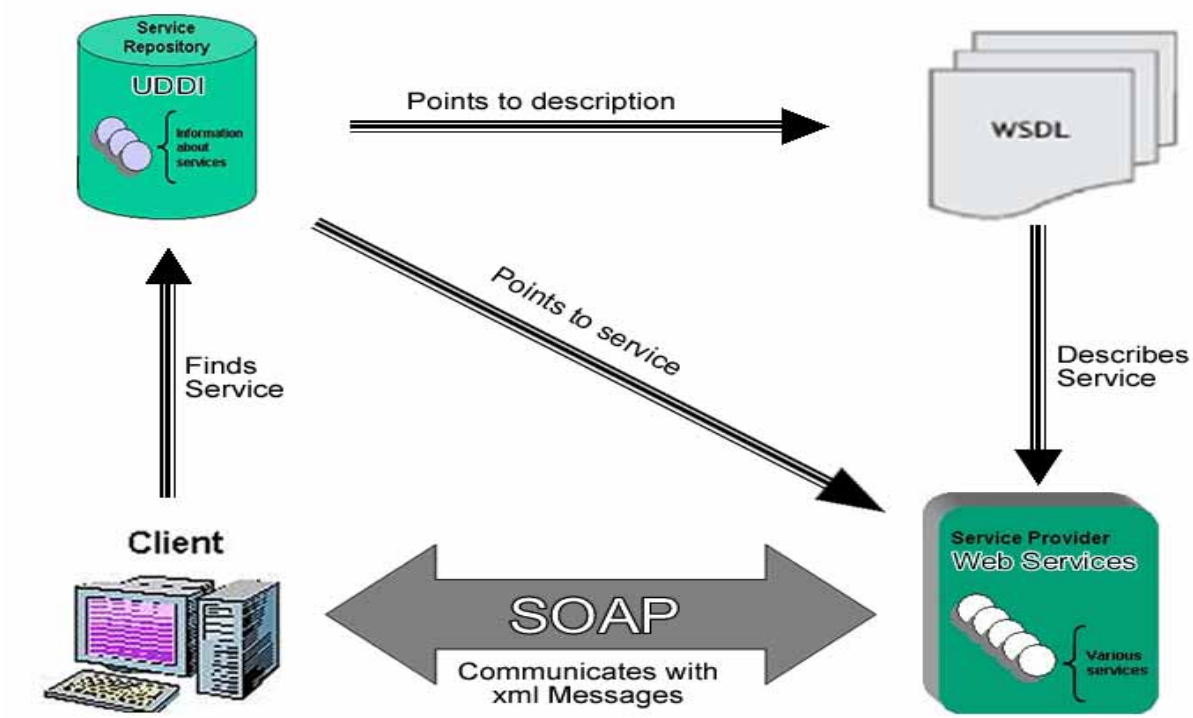
HIGH COUPLING BETWEEN NETWORK SYSTEM AND APPLICATION SW

Proposed Scenario



LOWER COUPLING BETWEEN NETWORK SYSTEM AND APPLICATION SW

Web Services



- New applications do not need to be directly integrated to SCADA Systems but only to the Web Services;
- Easier inter-applications integration process;
- Lower complexity and lower costs for system management and updating;
- Use of TCP/IP communication available at relative low costs;

IEC Standards

- **Use IEC Standards for:**
  - Data model;
  - Abstract description of systems and services;
  - Description of abstract standard interfaces;
  - Description of UML classes in order to provide an object-oriented representation of systems;

- **IEC Standards:**
  - **IEC 61970:** → IEC 61970-303, IEC 61970-404, IEC 61970-407 — **Energy Management System**
  - **IEC 61850:** → IEC 61850-5, IEC 61850-7-2, IEC 61850-7-3, IEC 61850-7-4 — **Substation Automation System**

Use of standardised data models allows different vendors application SW to be integrated reducing the necessity for data wrappers

Implementation Steps

- Integration of data models related to IEC 61970 and IEC 61850 International Standards;
- Extension of CIM Model described in IEC 61970-303 in order to manage information regarding typical devices of SAS;
- Redesign of some services described by IEC Standards in order to adapt them to the specifically designed data model;
- Web server implementation of standard interfaces, services and systems abstractly described by IEC Standards;
- Physical network and devices representation made by database tables;

2. Data Model Design

Data Model Design

- Purpose: Design of database used to represent physical devices during Web Services Testing

  - Database which manages data related to EMS and SAS, to be accessed using the services exposed by HSDA interface;
  - Database which stores data concerned with historical data regarding EMS, to be accessed by TSDA interface services;
  - Integration of EMS and SAS data models;

- Design of monitoring and control services based on abstract description provided by IEC Standards:

  - Adaptation of abstract IEC services to the designed data model;
  - Definition of services required for monitoring and control functions;

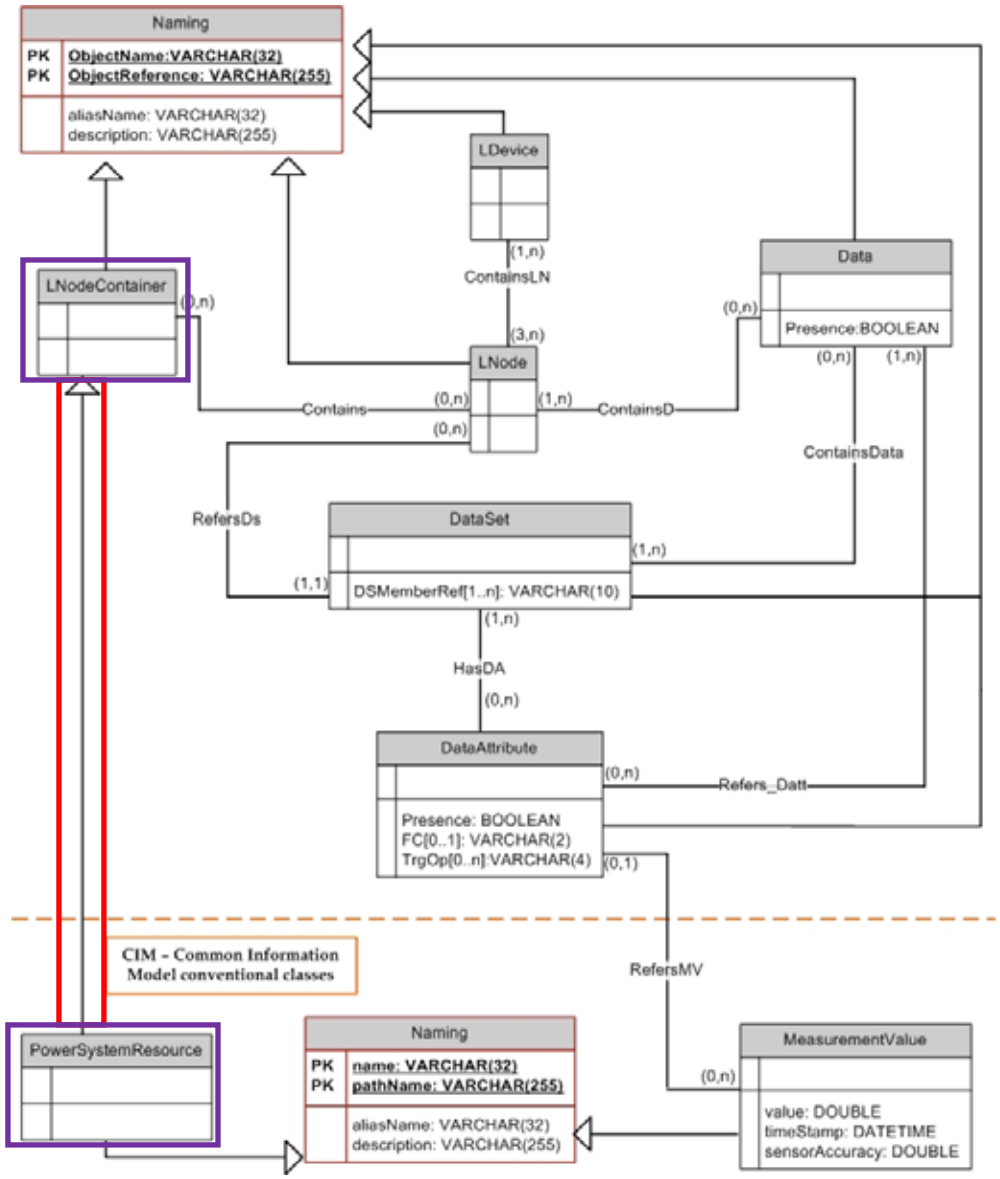
Data Model Integration

- IEC 61960 provides object data models with Common Information Model (CIM) of all typical object of an EMS

- IEC 61850 does provides a description of all typical objects of a SAS but only gives a description of the required information to control them, not an object data model

In order to promote interoperability of applications an IEC 61850 object data model has been developed and integrated within CIM

Integration of IEC data models

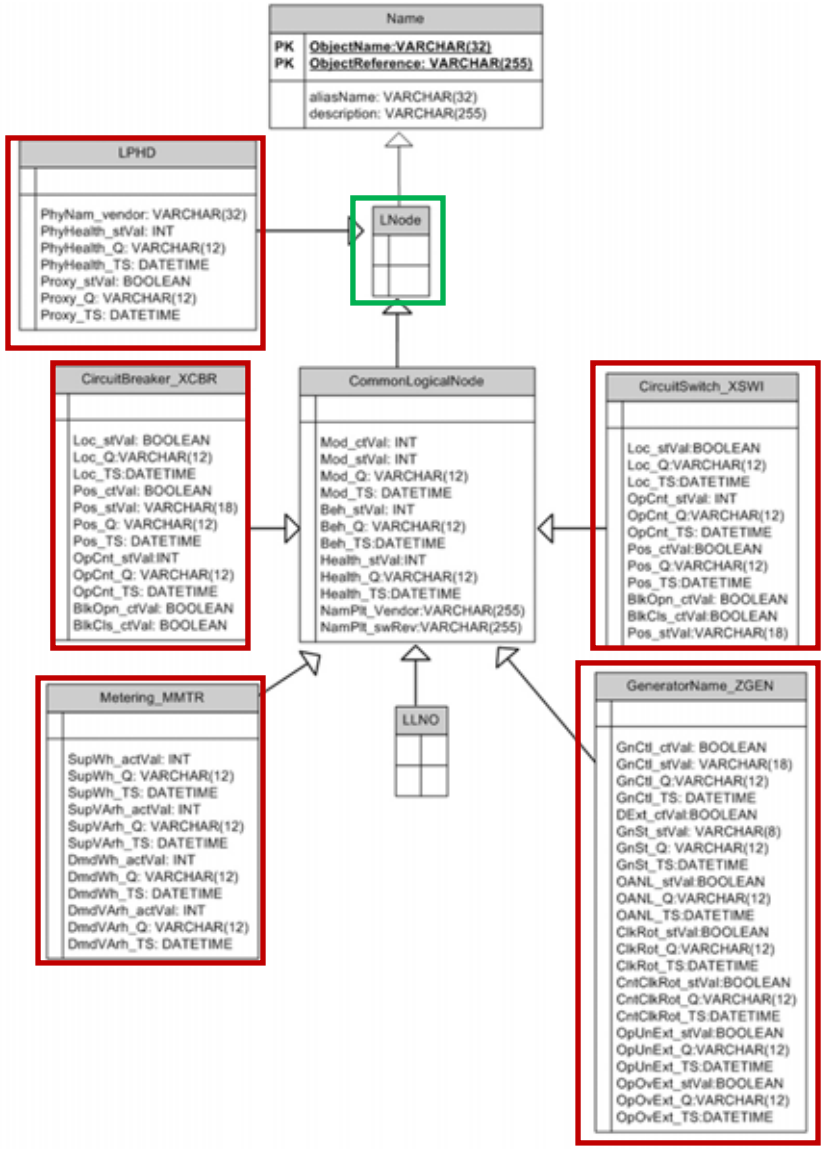


- Integration of CIM Model of IEC 61970 Standards with data model used to basically represent SAS devices;
- Logical Node Concept derived from IEC 61850 Standard;

- The IS-A relationship is used to link PowerSystemResource entity of CIM Model and LogicalNodeContainer of IEC 61850 Standard data model;

Integration of the CIM Model allows IEC 61970 applications to manage typical Substation Automation System Functions;

Data Model for IEC 61850



- Definition of specific entities in IS-A relationship with LNode in order to represent Substation Automation System devices;

- Desing of new entities starting from logical nodes and data classes information provided by IEC 61850-7-3 and IEC 61850-7-4 Standards;

- The new entities introduced are:
  1. Breaker;
  2. Circuit Switch;
  3. Metering devices;
  4. Generator;

3. Web Services Implementation

Implemented Services

- Design of monitoring and control services starting from IEC 61970-404, IEC 61970-407 and IEC 61850-7-2 Standards: standard interfaces have been developed and included;
- Main testing purpose: manipulation of database attributes which represent physical devices and controllable parameters;

Emulation of monitoring and control actions towards physical devices and generators

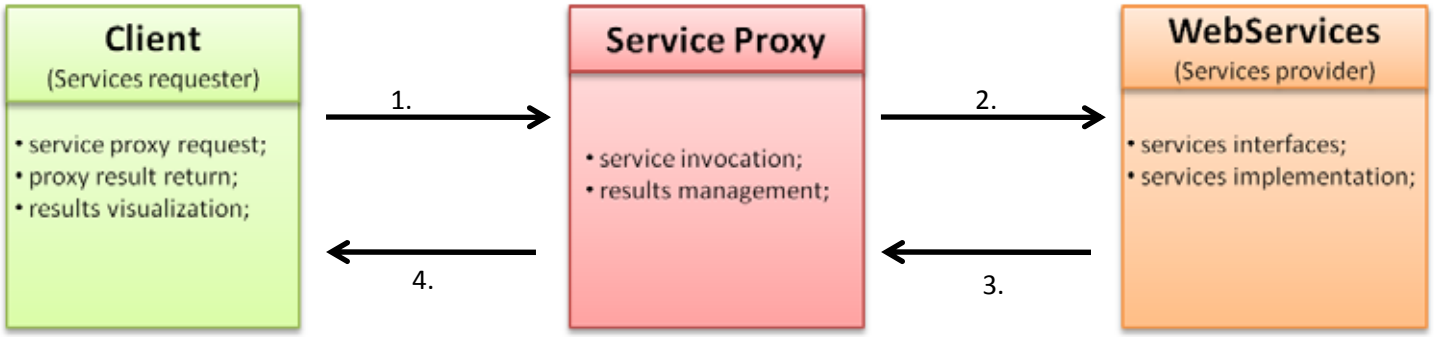
- Services:
  - Physical network topology downloading;
  - Reading and writing of tables attributes;
  - Management of groups of devices;
  - Devices' operations control;
  - Devices' measurements management;

Roughly 200 of these services have been implemented and tested

Web Server Implementation

- Implementation:
  - Apache AXIS2 Open Source Web Services;
  - Open Source Database MySQL;
  - Java Programming Language;

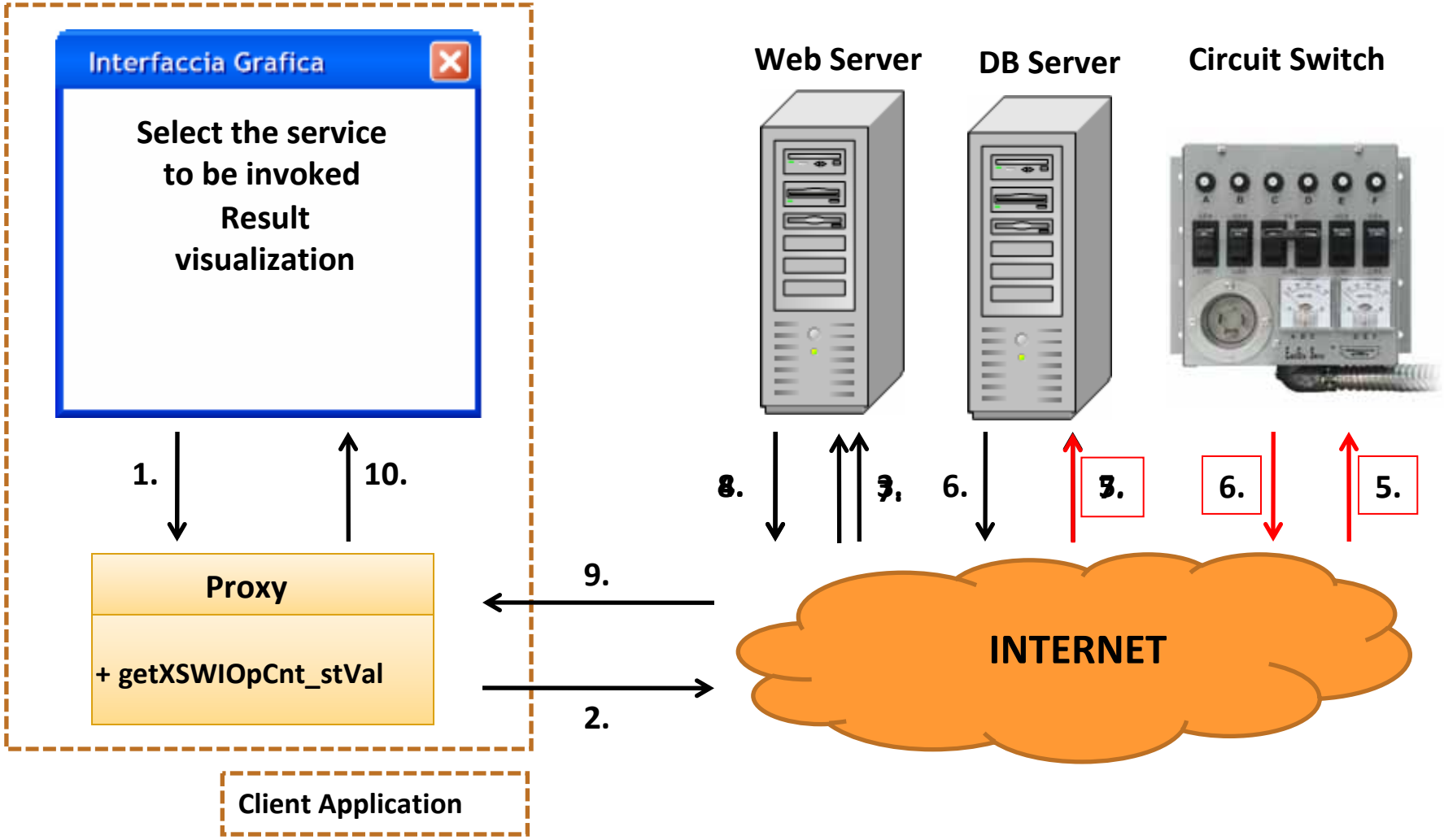
- Implementation based on “Service Proxy Pattern” (SPP):



- Benefits introduced by SPP:
  1. It is possible to reuse the same service in other parts of the application at price of including standard SPP code into applications;
  2. Further ease for applications integration;

Interaction Example

- **getXSWIOpCnt_stVal**: returns the value of the attribute OpCnt _stVal relative to the circuit switch passed in input;

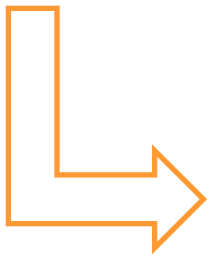


4. Conclusions and Future works

Conclusions

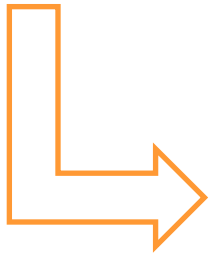
Open source implementation of monitoring and control services for EMS/SCADA Systems can be realised through:

1. Use of Standardised (IEC) data models and object-oriented representations for EMS/SCADA Systems and devices :



- Facilitates integration and interoperability between applications of different vendors and systems;
- Reduces the dependance on single vendor applications
- Reduces of management and maintenance costs paid by network operators and utilities;

2. Use of Web Services and Services Proxy Patterns:



- Reduces coupling between the system and applications;
- Encourages integration of new SW and plug and operate applications;
- Encourages use of commonly used ICT infrastructures
- Reduces management and maintenance costs paid by network operators and utilities;

Future works

- Extension on the CIM Model described by IEC 61970-303 in order to assure:
  - energy price visualization in case of real-time dispatching systems
  - fuel cell model representation
- Implementation tailored to Wind Farms management and control;
- Definition of Quality of Service strategies on the service calls;
- Event-handling implementation via Web Services;
- Implementation of security strategies;
- Test Bed trialling and validation;

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Thank you

Ongoing Research on energy at DIS:

- **Control Strategies for Wind Farms**
- **Generation portfolio optimisation in liberalised energy markets**
- **DG and MG control techniques**
- **Measurement-Based Fraud Detection algorithms in LV grids**

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Specific Axis 2 Issues

- Implementation of synchronous and asynchronous calls;
- Synchronous and asynchronous interaction for EMS services;
- Synchronous interaction for SAS services;
- Simple Object Access Protocol (SOAP);

Java Modules	XML e WSDL files
• **Services Implementation** • **Clients** • **Proxies** • **CallBack** • **GUI**	• **EMS.wsdl:** AXIS2 services description; • **services.xml:** message receiver and action mapping definition; • **build.xml:** compiling information definition;