Introduction to the advanced standards for the (utility) industry - UCA™, IEC 61850, and TASE.2 (ICCP)

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With Live Software Demo

UCA is a trademark of EPRI, Palo Alto, CA

Short curriculum vitae of Karlheinz Schwarz

Dipl.-Ing. Karlheinz Schwarz is president of SCC (Schwarz Consulting Company), Karlsruhe (Germany) specializing in distributed automation systems.

He is involved in many standardization activities within IEC (TC 57, TC 65, TC 88), ISO (TC 184), CENELEC (TC 65 CX), IEEE (SCC 36 "UCA", 802), and DIN since 1985.

He is engaged in representing main industry branches in the global standardization and providing consulting services to users and vendors.

Specifically, his contributions to the publication of many standards are considered to be outstanding.

Mr. Schwarz is a well-known authority on the application of mainstream information and communication technologies.

Schwarz Consulting Company (SCC)

Supplier Information, Capabilities, and Experience Profile

The primary business objective of SCC is to provide consulting services to all kind of enterprises for feasibility studies, design, specifying and editing international standards, training, marketing, information dissemination, procurement of distributed systems and open communications for the various aspects of distributed automation systems.

To keep abreast of the latest technical development, SCC is actively involved in workshops, seminars, task forces, and committees of various professional organizations such as ISO, IEC, IEEE, CEN, and CENELEC.

Major Customers of SCC

User: Bayernwerk, Badenwerk, EON, EVS, HEW, Mercedes Benz, RWE, VEW

Vendors: AEG, ABB, Alstom, Bosch, E+H, IDS, Eberle, Kloeckner & Möller, Pepperl & Fuchs, Phoenix Contact, PSI, Repas AEG, SAT, Siemens

Institutes: DIN, EPRI (USA), FGH Mannheim, FH Offenburg, PNO, VDMA, ZVEI

Content

- General Introduction and Overview
- UCA/IEC 61850 Introduction and Overview
  - Substation applications
  - Distributed generation (wind power)
- TASE.2 Introduction and Overview
- Live demonstration of UCA/IEC 61850 software running on PCs over TCP/IP

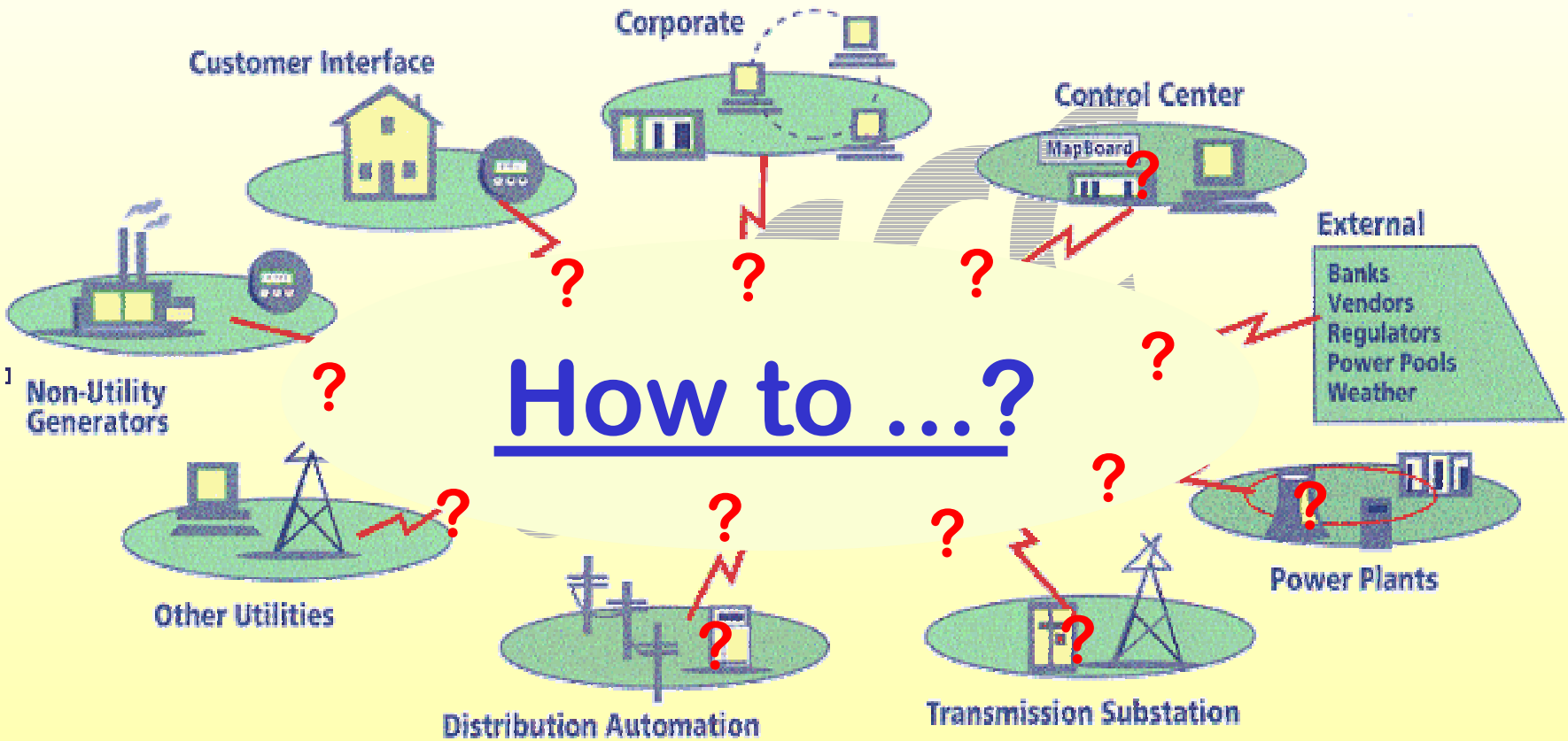
You don´t have to carry the whole load by yourself!

I‘m here to help you!

General Introduction and Overview

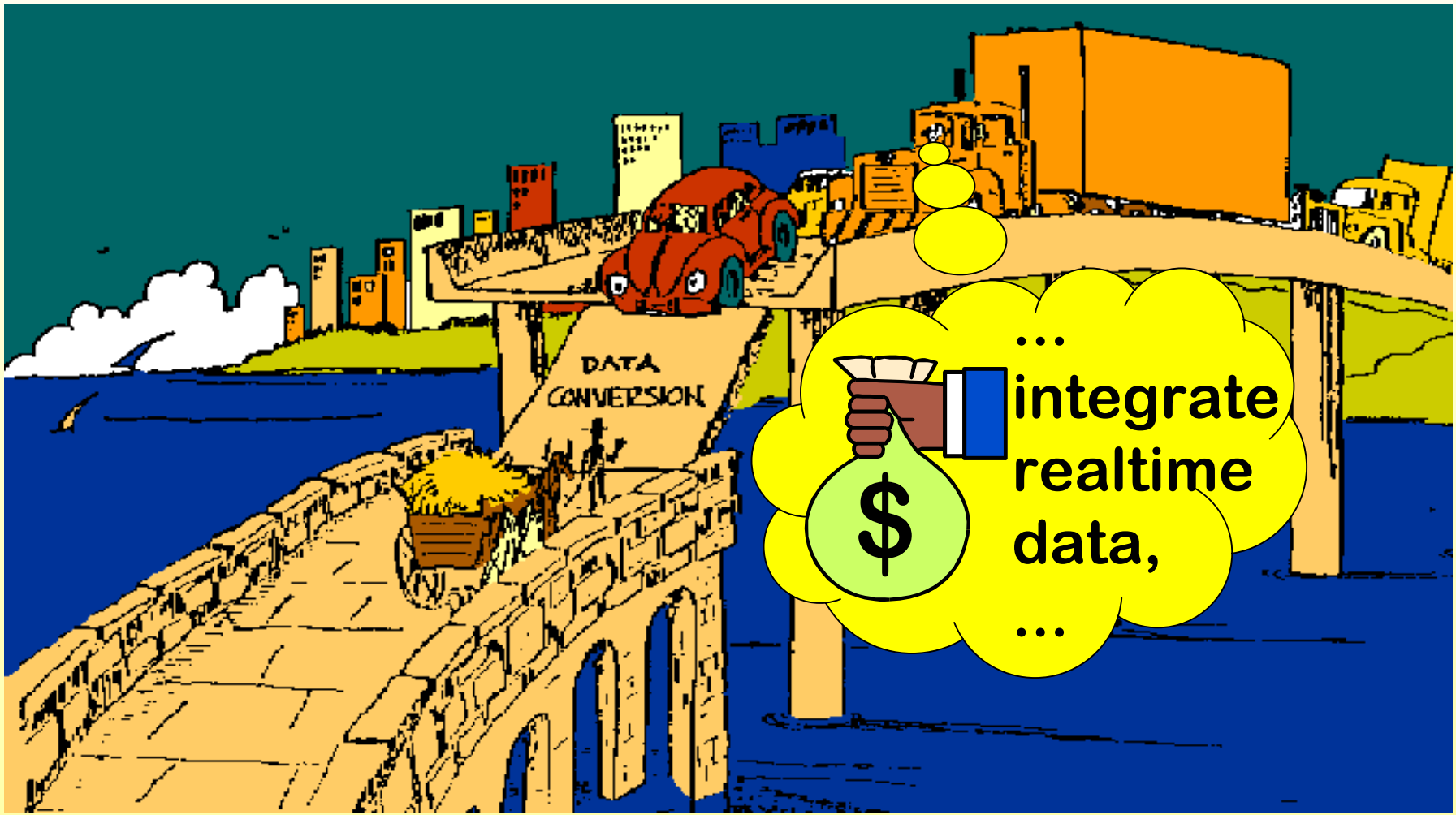
- Motivation
- Parts of IEC 61850
- Data and Logical Nodes (Content)
- Abstract Comm. Service Interface
- UCA and IEC 61850
- Summary

Yesterday:
Islands of real-time information …



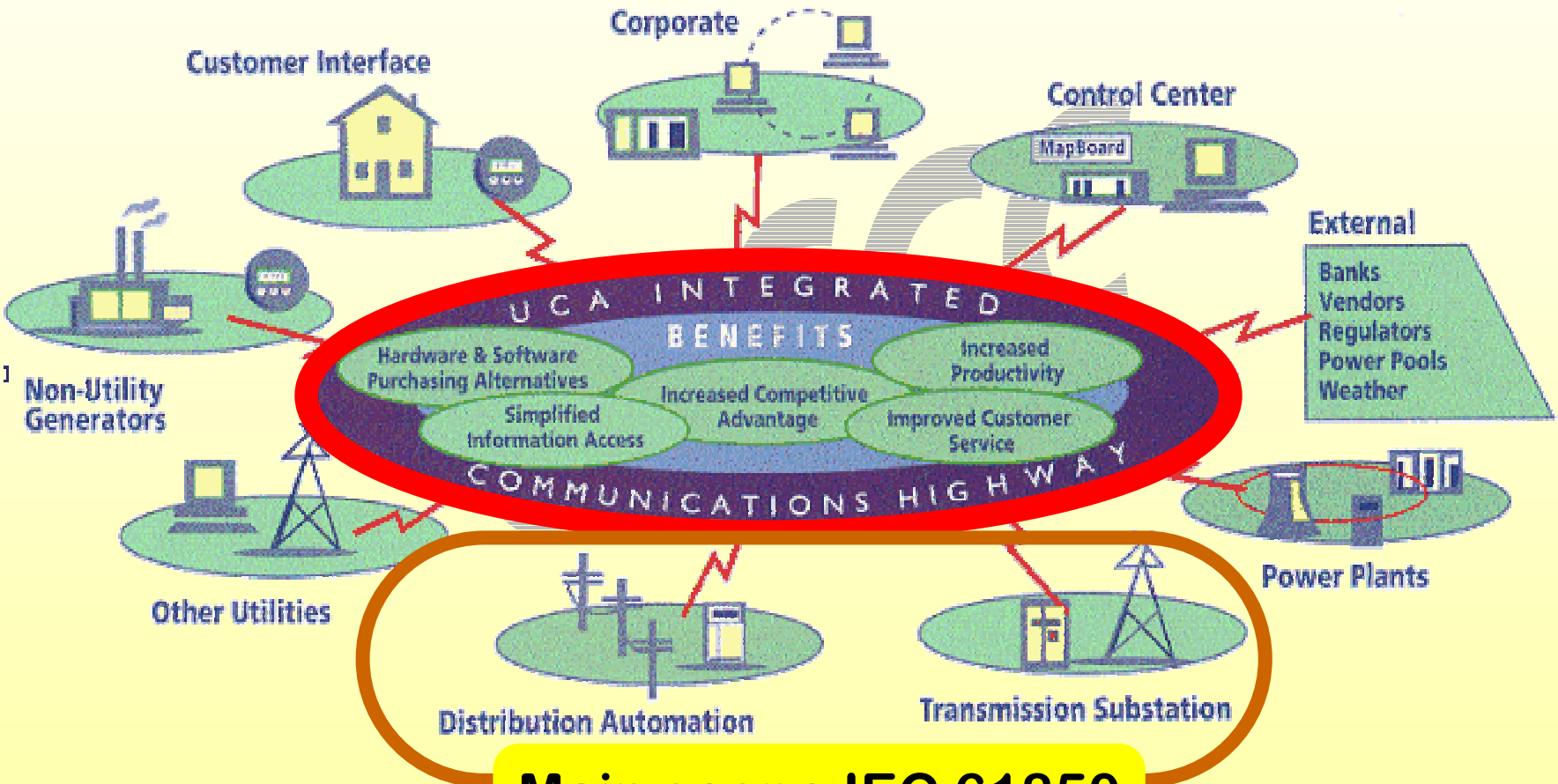
… too many „standards“

Yesterday: Expensive/hard to ...!



TODAY: Seamless communication …

Scope UCA and IEC 61850



Objective of this presentation

benefits!
compare with …

GOMSFE & IEC 61850-7

What is it?
How to apply?

CASM

~~MMS~~
~~ASN.1~~
~~TCP/IP~~
~~Ethernet~~

GOMSFE = Generic Object Model Substation and Feeder Equipment
IEC 61850-7 Substation Standard

Introduction

(text only)

State of the art utility communications

- DNP and IEC 870-5 are the most widely supported of the traditional SCADA protocols.
- UCA (and IEC 61850) represent a new approach to utility communications.

State of the art utility communications

SCADA protocols have traditionally been designed to optimize:

- Bandwidth - number of bytes on the wire
- Hardware utilization - processor speeds, RAM and ROM space

Communications Advancements

- Drastic reduction in bandwidth constraints:
  - Serial technologies (1200 ->56KB)
  - LAN technologies (1MB -> 1GB)
  - Frame Relay, ATM, Wireless LANs, Fiber, etc.
- Drastic reduction in costs due to:
  - adoption of standards (e.g. Ethernet and TCP/IP)
  - explosion of communications markets

Hardware Advancements

- Orders of magnitude changes in processor speeds
- Memory Chip design and production
- Emergence of Flash memories
- Communications co-processors
- VLSI and beyond

Software Advancements

- Standardized programming languages
- Object Oriented Programming
- Distributed Applications
- Graphical User Interfaces
- Advanced Database approaches

Impact of Technology

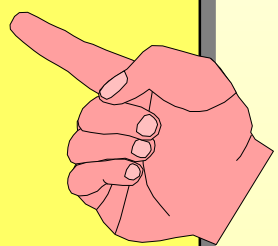
- Wide variety of communications technologies available
- Bandwidth costs greatly reduced
- Greater intelligence implies more points to be monitored, more complex applications
- Focus is shifting from data acquisition to Data Management

Data Management

- Increased number of points implies higher costs for maintaining databases
  - commissioning costs in verifying points
  - more applications accessing the data
  - increased complexity of the applications
- Deregulation will only add to the complexity through increased data sharing

Traditional SCADA

- Move ‘points’ with minimal overhead
- Meaning of points maintained in multiple places:
  - configuration of RTU and/or IED
  - configuration of databases
  - configuration of applications
- Validation is costly, time-consuming

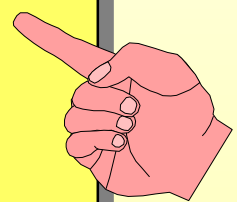


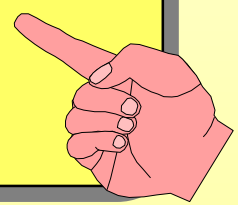
Communications Trends

- Object oriented communications organize the data by function to simplify distributed applications.
- Standardized object models allow for application interoperability.
- Self-description allows for on-line validation.

UCA Advanced Features

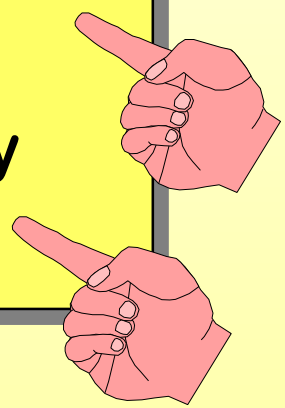
- Standardized object models means that every device supplying a function (e.g. Phase voltage measurements) will serve it the same way.
- Object models include status, analog, and controls, as well as configuration and engineering data (units, scales, deadbands, references, etc.) on-line.





UCA Advanced Features

- Self-description means that every device can be interrogated to find out what is implemented and how it is stored on-line.
- Objects are accessed by name, rather than vendor/model specific point number.
- Databases validation can become highly automated, without vendor config files.



UCA Advanced Features

- Multi-client (master) operation for browsers, engineering consoles, and multiple applications
- Peer-to-peer communications between IEDs
- Enterprise networking through off-the-shelf routers
- Standardized protocol access from the desk top
- Common protocols allow for common network management and support tools

UCA Advanced Features

- UCA also provides
- Password authentication and (optionally) encryption at the end IED
- File directory and access
- Extensibility to future standardized networking approaches (future proofing)
- Upload and download services
- Program management services (start/stop, etc.)

IEC 61850

- Developed by TC57 WG 10, 11, and 12
- Scope is station and process bus within the substation:
  - work is based on UCA
  - some extensions to CASM models
  - some changes to GOMSFE models
  - distributed in 1999 as Committee Drafts (CDs)
  - CDVs to be distributed after March, 2000

Additional UCA Protocols

- UCA Time Synchronization
  - measure path delay and sync clocks
  - works over LAN and serial links
  - allows for trend analysis and quality control
- UCA 'Goose' (Fast Binary) over LANs
  - high-speed binary controls using 'reliable multicast' on Ethernet links
  - defined for high-speed protection applications
  - may be extended to high-speed analogs

Common Application Service Models (CASM)

- Generic communications services
  - data access
  - data (and exception) reporting
  - device control, tagging
  - self describing devices
- Detailed mapping of data objects to MMS
- Detailed mapping of generic services to MMS services

CASM Architecture

- Common services of utility device protocols
- Isolates model from underlying protocols
- Provides standard view of devices for clients
- CASM adds no protocol, just definitions and conventions - requires device models (GOMSFE)

CASM Data Model

- Object model imports from application specific model classes
- Self describing
- Structured data representation
- Naming convention preserves object class hierarchy in MMS representation
- Extensible for vendor specifics, future standardization

CASM Services

- Data Access - basic read/write
- Data Reporting - setup, sequence of reports
- Device Control - direct or SBO, tagging
- Program Management - start/stop/kill
- Journalling - log changes for retrieval

Generic Object Models for Substation and Feeder Devices - GOMSFE

- Defines detailed device models
  - uses common models, classes, and services from CASM
  - models consistent with other functional areas (e.g. customer interface)
- Developed jointly by vendors and utilities

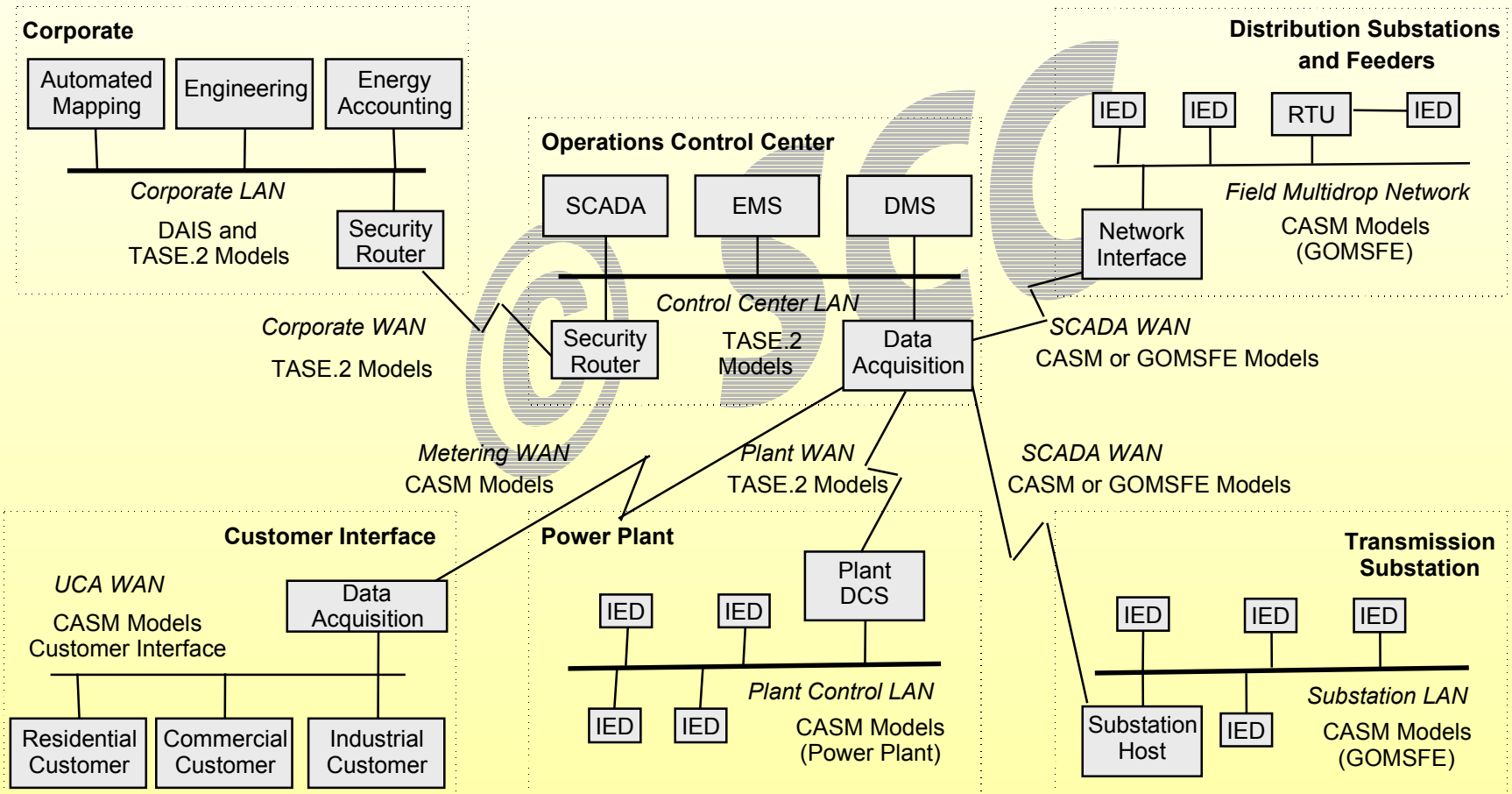
GOMSFE

- Each device model represents agreement between participating vendors
  - defines common representation for mandatory core device functionality
  - defines common representation for optional but common functionality
  - allows vendor specialization and additions

GOMSFE

- GOMSFE is the most highly developed of the UCA device object models
  - customer interface currently under development
  - some efforts underway for power plant models
- Similar efforts beginning for water and gas

Example UCA Utility



UCA / 61850 brief summary

- standard Device CONTENT,
- re-use of Specifications (>>1000 Classes),
- Metadata for process data,
- simplifies Data Maintenance,
- seamless naming convention,
- provides set of required services,
- modern communication technology,
- easy integration into web technology,
- flexible, expandable, and available

Summary

- UCA provides comprehensive models and protocols for throughout the utility enterprise
- UCA published as IEEE TR1550
- UCA includes IEC TC57 TASE.2
- UCA is basis for work in IEC TC57 61850

Summary

- UCA includes traditional SCADA functionality
  - Status, analog, and controls
  - Select before operate
  - Polled data, report by exception, integrity reporting
  - Sequence of event logs

Summary

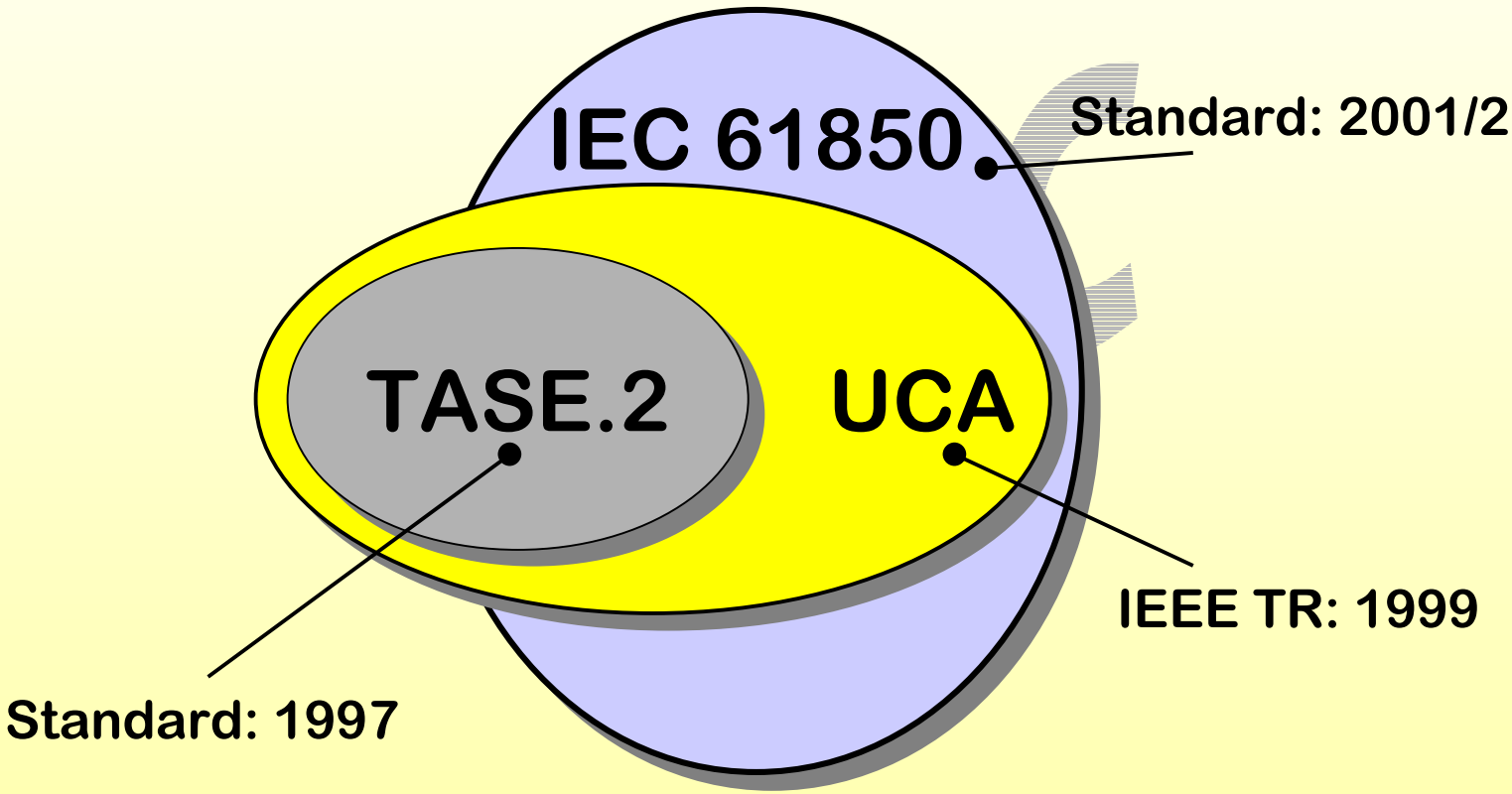
- UCA also supports
  - Standardized Object Models
  - Configuration information
  - Self-description
  - File directory and access
  - Upload and download services
  - Multi-client access

Summary

- UCA also supports
  - Peer-peer communications
  - Enterprise routing
  - Access from the desktop
  - Security
  - File and program management
  - Upload/download

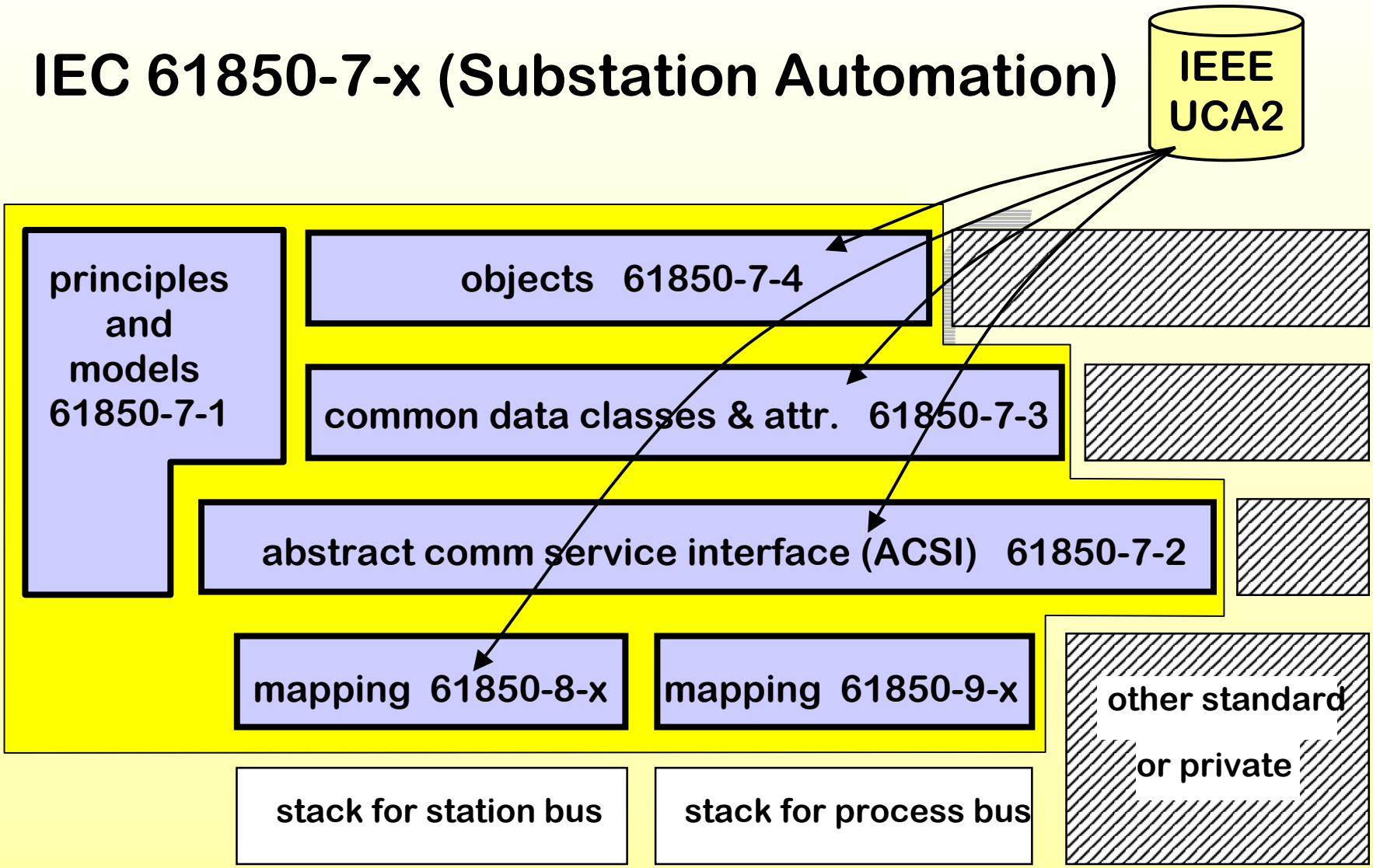
UCA, TASE.2 and IEC 61850

UCA, TASE.2 and IEC 61850



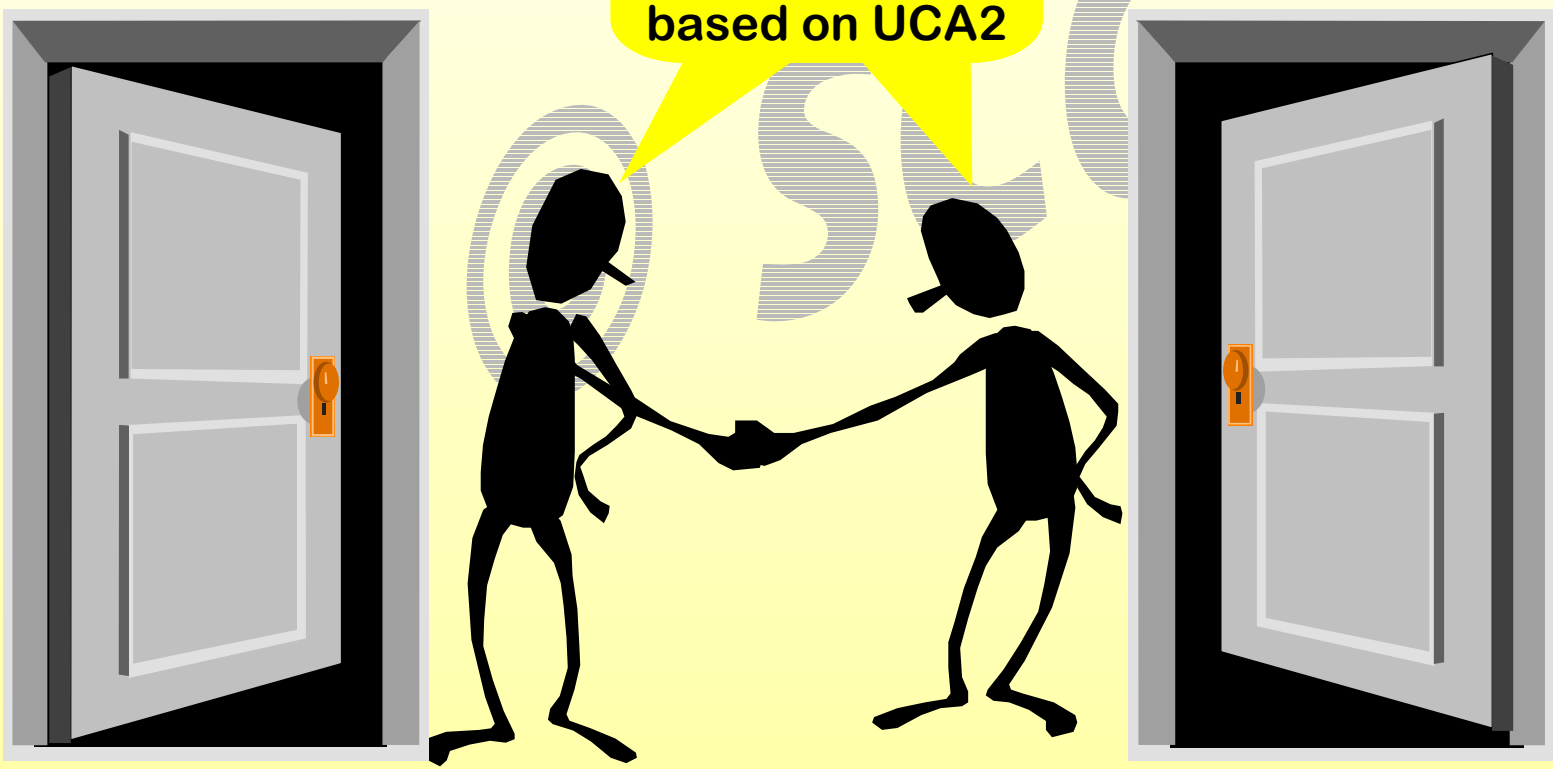
Difference between UCA (without TASE.2) is minor.

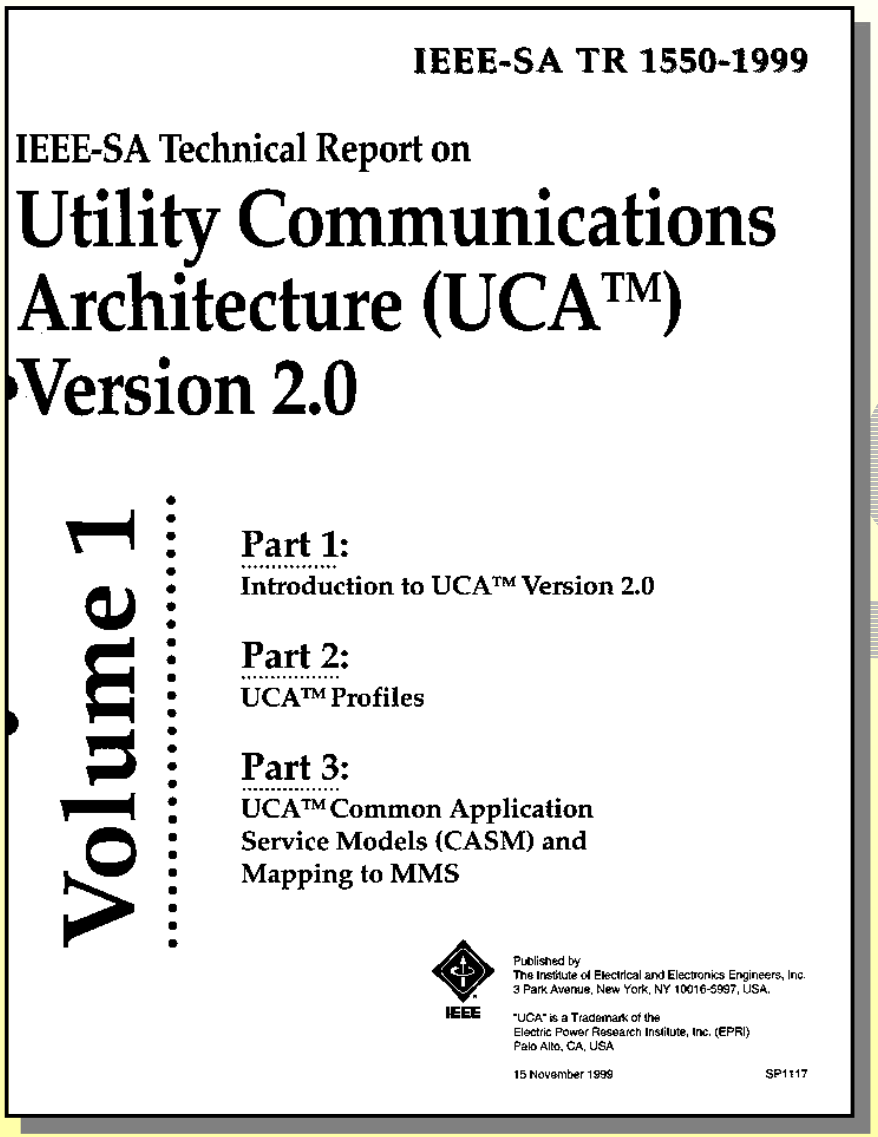
IEC 61850-7-x (Substation Automation)



IEEE Standards Cooordination Committee 36 (SCC 36) - Utility Communications Architecture (UCA)

IEC TC 57 Power system control and associated communications - WG 10, 11, and 12





IEEE-SA TR 1550-1999

IEEE-SA Technical Report on

Utility Communications Architecture (UCA™) Version 2.0

Volume 1

Part 1:
Introduction to UCA™ Version 2.0

Part 2:
UCA™ Profiles

Part 3:
UCA™ Common Application Service Models (CASM) and Mapping to MMS

IEEE

Published by
The Institute of Electrical and Electronics Engineers, Inc.
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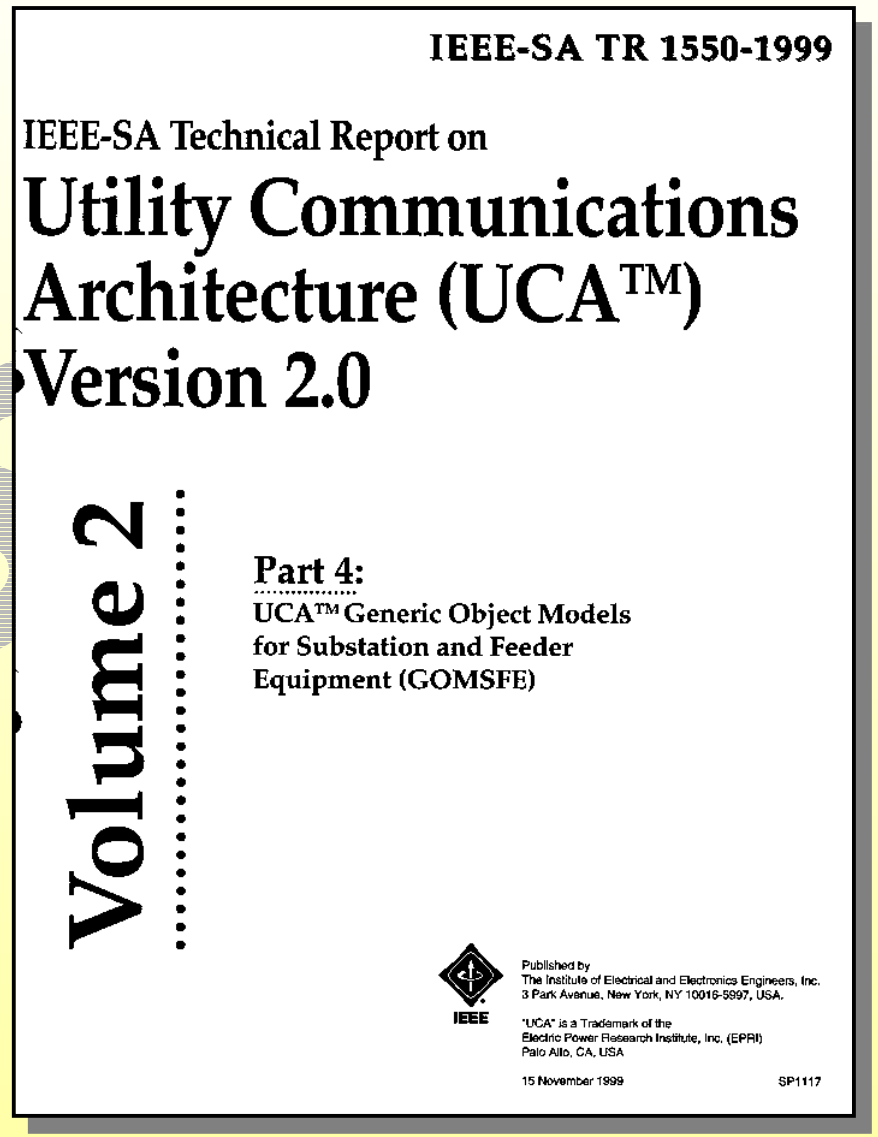
15 November 1999 SP1117



IEEE-SA TR 1550-1999

IEEE-SA Technical Report on

Utility Communications Architecture (UCA™) Version 2.0

Volume 2

Part 4:
UCA™ Generic Object Models for Substation and Feeder Equipment (GOMSFE)

IEEE

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15 November 1999 SP1117

Integrated UCA™ For Gas Industry

Volume 1: Gas Industry Requirements
Volume 2: Gas Industry Device Object Models
Volume 3: Guidelines for UCA Data Acquisition & Control (DAC) System

Final Report, March 2001

ORDERING INFORMATION
Order from Gas Research Institute (GRI)
Requests for copies of this report should be directed to the EPRI Distribution Center, 1355 Willow Way, Suite 2478, Concord, CA 94520, (800) 313-3774.

REPORT SUMMARY
This three-volume report examines the application of the Utility Communications Architecture (UCA) Version 2 by the gas industry to standardize communications for monitoring and control.

IEEE TR 1550 - Utility Communications Architecture (UCA™) Version 2.0

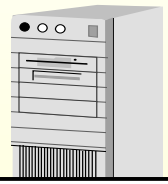
Volume 1:

- Part 1: Introduction to UCA Version 2.0
- Part 2: UCA Profiles
- Part 3: UCA Common Application Service Models (CASM) and Mapping to MMS

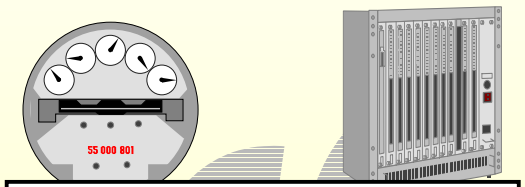
Volume 2:

- Part 4: UCA Generic Object Models for Substation and Feeder Equipment (GOMSFE)

Utility Communication Architecture (UCA)



Real time Database



Real time Device

TASE.2 Object Models	UCA Device Object Models
TASE.2 Services	CASM Services
MMS	
UCA Profiles	

IEC-Standard 60870-TASE.2

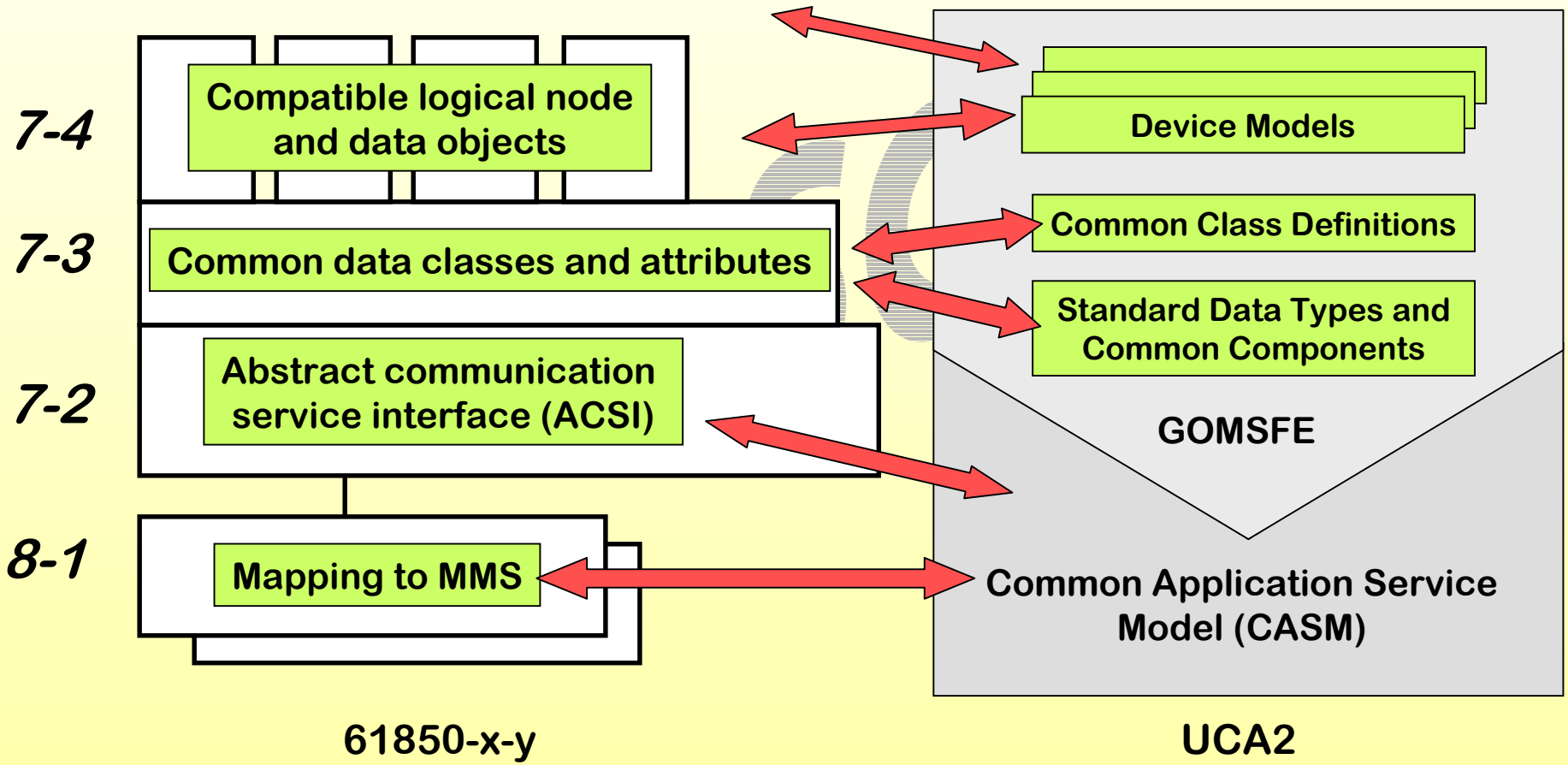
ISO/IEC-Standard 9506

Several Standards

IEC-Standard 61850 / IEEE Technical Report 1550

IEC-Standard 61850 / IEEE Technical Report 1550

IEC 61850 and UCA



IEC 60870-6 TASE.2

UCA2 Profile

	Full 7 CO	WAN 7 CL	Modified 7 CO	Reduced Stack CO	Reduced Stack CL	LAN-Based FAIS	LAN-Based ** Ethernet	TCP/IP RFC 1006	TCP/IP RFC 1070	TCP/IP RFC 1240
Application	MMS ACSE	MMS CL-ACSE	MMS ACSE	MMS ACSE	MMS CL-ACSE	MMS	MMS ACSE	MMS ACSE	MMS ACSE	MMS CL-ACSE
Presentation	Presenta-tion	CL Pres.	FastByte Pres.					Presenta-tion	Presenta-tion	CL Pres.
Session	Session	CL-Session	FastByte Session					Session	Session	CL-Session
Transport	TP4	CLTP	TP4					TP0 TCP	TP4 CLNP UDP	UDP
Network	CLNP	CLNP	CLNP			Auxiliary		IP	IP	IP
MAC Data Link	LLC1 ADLC FT3 or UCA 1	LLC1 ADLC FT3 or UCA 1	LLC1 ADLC FT3 or UCA 1	LLC1 ADLC FT3	LLC1 ADLC FT3 or Ethernet	LLC3 802.4 Token Ring	LLC3 ADLC FT3*over* Ethernet	Ethernet SLIP, PPP (typical)	Ethernet SLIP, PPP (typical)	Ethernet SLIP, PPP (typical)

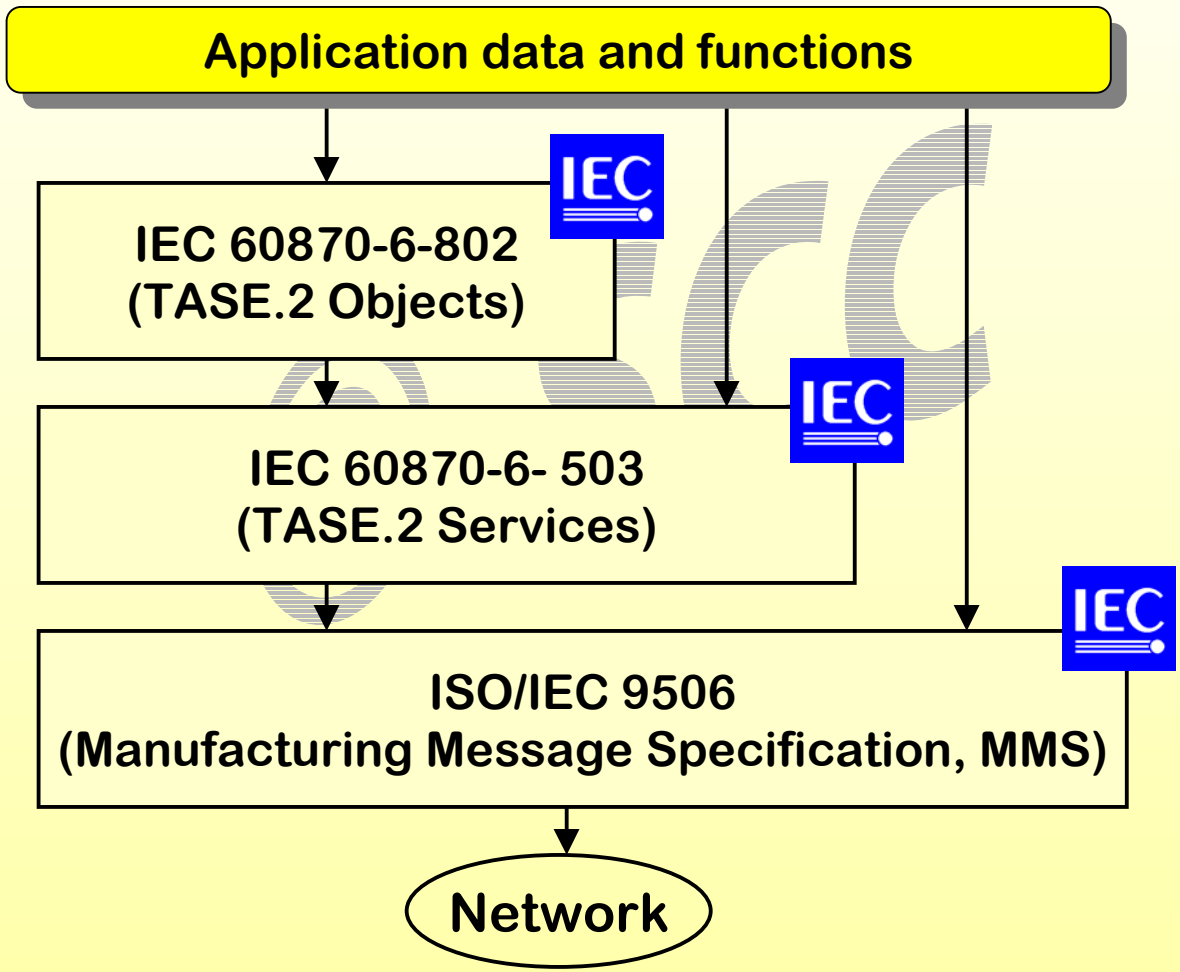
7 Layer **3 Layer** **TCP/IP**

IEC Standard 60870-6

General		*Status*
Application Context and Organisation of Standards	IEC 60870-6-1	TR
Use of Layers 1 - 4	IEC 60870-6-2	IS
Use of Layers 5 - 7	IEC 60870-6-3	
Network Management	IEC 60870-6-4	
TASE.1, ELCOM-90 based		
Service Definition	IEC 60870-6-501	IS
Protocol Definition	IEC 60870-6-502	IS
Application Profile	IEC 60870-6-701	IS
TASE.2 (ICCP - Intercontrol center communication protocol)		
Services and Protocol	IEC 60870-6-503	IS
Application Profile	IEC 60870-6-702	IS
Object Model	IEC 60870-6-802	IS
Transport Profiles		
Transport Profile (TP4,2,0 over X.25)	IEC 60870-6-601	IS
Transport Profile (TP4,2,0 over X.25)	IEC 60870-6-602	CD
Transport Profile (TP0 over TCP/IP, RFC 1006)	IEC 60870-6-603	WD

TASE.2: grau hinterlegt CDV: Committeee Draft for Vote CD: Committeee Draft
TR: Technical Report DIS: Draft International Standard IS: International Standard

TASE.2 - Architecture



TASE.2 - Services

- connections (Association),
- access only to data which are unlocked (Bilateral Table),
- definition of names and structures (Data Value, Data Set),
- one-time inquiry of measurands and status (Data Value, Data Set),
- spontanious transmissions (Transfer Set),
- notifications of a change and event (Transfer Set),
- General interrogation (Transfer Set),
- transmission of equidistant values (Transfer Set),
- formation of groups (Data Set),
- remote configuration of the reporting behavior (Transfer Set),
- control of devices (Device),
- program control (Program),
- exchange of information for deregulated energy markets

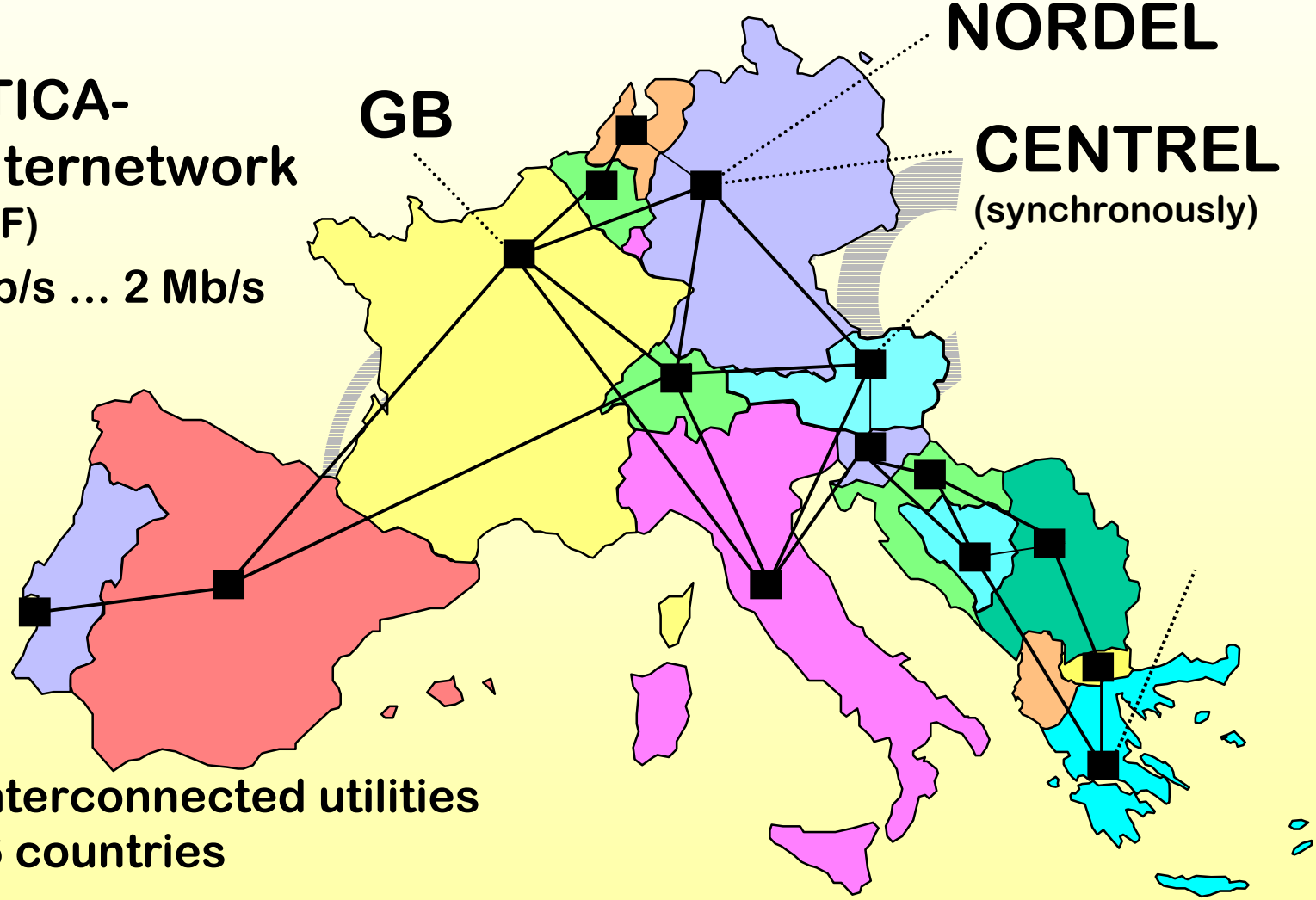
UCPTE

UCPTE stands for

Union pour la
Coordination de la
Production et le
Transport de
l'Energie électrique

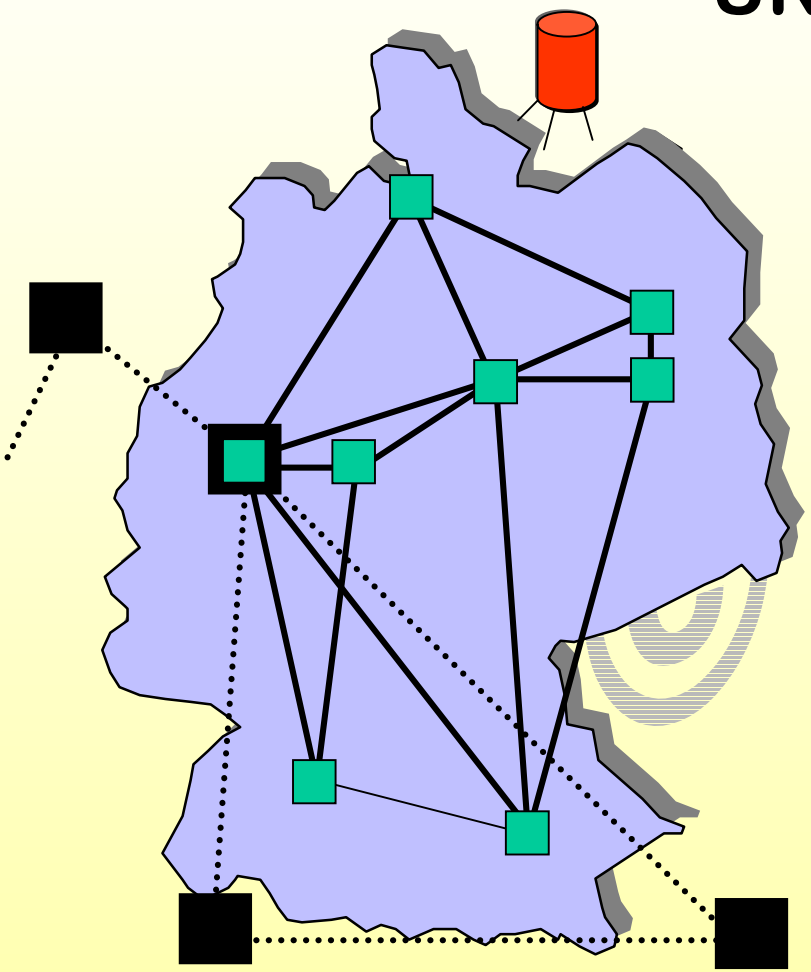
Austria, Belgium, Croatia, France, Germany, Greece, Italy, The Netherlands, Portugal, Spain, Switzerland, The Federal Republic of Yugoslavia

URTICA private backbone router network



URTICA = UCPTE Real-Time Information Communication Architecture

URTICA in Germany

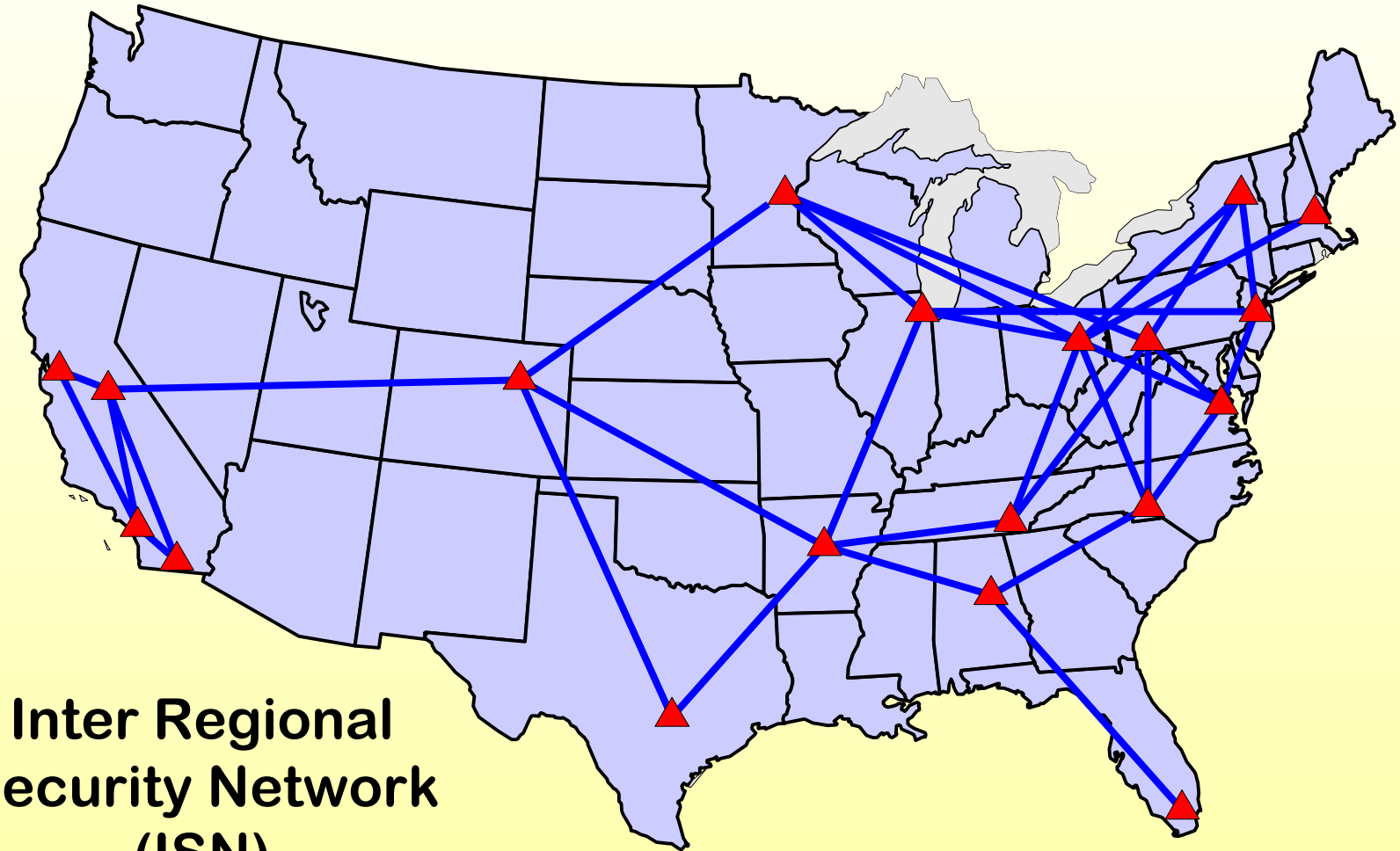


- EnBW Energie Baden-Württemberg
- Bayernwerk
- Berliner Kraft- und Licht (BEWAG)
- Hamburgische-Elektricitäts-Werke (HEW)
- PreussenElektra (PE)
- RWE Energie
- VEAG
- VEW ENERGIE

CH: PIA (7 EVU)

AT: 5 EVU

TASE.2 - Application in the USA



Inter Regional Security Network (ISN)

19 TASE.2 nodes

TASE.2 vendor

- ABB
- Bailey Controls
- CAE
- Cegelec ESCA
- Cycle Software
- General Electric/Harris
- NSR
- QEI
- repas AEG
- Siemens
- SISCO
- Tamarack
- Valmet
- ...

Plattforms

- IBM RS/6000 AIX V4.1
- Sun SPARC Solaris
- DEC Alpha OpenVMS
- DEC Alpha Windows NT
- DCE Alpha DEC Unix
- Intel PC Windows 95, NT
- Intel PC OS/2 Warp
- Intel PC QNX
- VXWorks
- PSOS
- ...

TASE.2 projects

AMERIKA

Allegheny
Arizona Electric
Associated Electric Cooperative
BG&E
Brazos
Central and Southwest Services (CSW)
Central Maine Power, Augusta, ME
Chugach
CONVEX
Dairyland Power
ERCOT, and nine member utilities
General Public Utilities (GPU)
Houston Light & Power (HLP)
Interstate Power
Iowa Electric, Cedar Rapids, IA
Lincoln Electric, Lincoln, NE
Los Angeles Water & Power
MAIN
Max Control Systems
Mid-America Power Pool (MAPP)
Nebraska Public Power District (NPPD)
NEPEX , including all member utilities
NERC (Inter-Regional Security Network (ISN) interconnecting 22 security nodes throughout USA
New York Power Authority (NYPA)
New York Power Pool (NYPP), including four additional member utilities
Northern States Power (NSP)
Oglethorpe
Ohio Edison
Oklahoma Gas & Electric
Pacific Gas & Electric (PGE)
PEPCO
PJM, and ten member utilities
Public Service New Hampshire (PSNH),
Rochester Gas & Electric (RGE)
South East Power Administration
Southern
Southern California Edison (SCE)
Southwest Power Pool (SPP), including four remote member utilities Entergy, AECI, Utilicorp, and CSW
Southwestern Power Administration
Texas Utilities (TU)
VACAR , including all member utilities
Western Area Power Pool (WAPA)

INTERNATIONAL ICCP PROJECTS

Austria
CFE, Mexico
EdF, France
EVS, Germany
Hong-Kong Electric
Hydro Quebec, Canada
Power Pool of Alberta (PPoA), Canada
Powergrid, India (national power grid for the entire country)
PIA Project, all interconected utilities of Switzerland
UCPTE, central Europe
VEW, Germany
23 Systems at ENEL

IEC 61850 - Communication networks and systems in Substations

IEC TC 57 WG 10, 11, 12

some 60 experts

IEC 61850 - Communication networks and systems in Substations

Part 1:	Basic principles	
Part 2:	Glossary	
Part 3:	General requirements	
Part 4:	System and project management	
Part 5:	Communication requirements for functions and devices models	
Part 6:	Substation automation system configuration language	
Part 7-1:	Basic communication structure for substations and feeder equipment - Principles and models	CDV 3/2001
Part 7-2:	- Abstract communication service interface (ACSI)	
Part 7-3:	- Common data classes	
Part 7-4:	- Compatible logical node classes and data classes	
Part 8-1:	Specific communication service mapping (SCSM) - Mapping to MMS (ISO/IEC 9506 Part 1 and Part 2)	
Part 9-1:	Specific communication system mappings (SCSM) - Serial unidirectional multidrop point to point link	
Part 10:	Conformance testing	

History

Part 7-1: Basic communication structure for substations and feeder equipment - Principles and models

Stage	Document	Date	Target Date
PNW	57/210/NP	24.02.1995	
ANW	57/232/RVN	15.07.1995	15.07.1995
1CD	57/399/CD	12.03.1999	31.12.1998
A2CD	57/421/CC	03.09.1999	31.07.1999
ACDV		22.10.2000	31.12.1999
CCDV	57/516/CDV	23.02.2001	31.01.2001
ADIS			31.10.2001
DEC			28.02.2002

ballot ends: 27.07.2001

PNW = Proposed New Work; 1CD = 1st Committee Draft; ACDV= Draft approved for Committee Draft with Vote; CCDV= Draft circulated as Committee Draft with Vote; ADIS= Approved for FDIS circulation; DEC = Draft at Editing Check

History

Part 7-2: Basic communication structure for substations and feeder equipment - Abstract communication service interface (ACSI)

Stage	Document	Date	Target Date
PNW	57/210/NP	24.02.1995	
ANW	57/232/RVN	15.07.1995	15.07.1995
1CD	57/392/CD	19.02.1999	31.12.1998
A2CD	57/417/CC	03.09.1999	30.06.1999
2CD	57/481/CD	30.06.2000	31.12.1999
ACDV	57/521/CC	16.03.2001	31.10.2000
CCDV	57/522/CDV	23.03.2001	31.03.2001
ADIS			30.11.2001
DEC			31.03.2002

ballot ends: 24.08.2001

History

Part 7-3: Basic communication structure for substations and feeder equipment - Common data classes

Stage	Document	Date	Target Date
PNW	57/210/NP	24.02.1995	
ANW	57/232/RVN	15.07.1995	15.07.1995
1CD	57/393/CD	19.02.1999	
A2CD	57/418/CC	03.09.1999	30.07.1999
2CD	57/482/CD	30.06.2000	31.12.1999
ACDV	57/511/CC	19.01.2001	31.10.2000
CCDV	57/519/CDV	16.03.2001	30.04.2001
ADIS			30.11.2001
DEC			31.03.2002

ballot ends: 17.08.2001

History

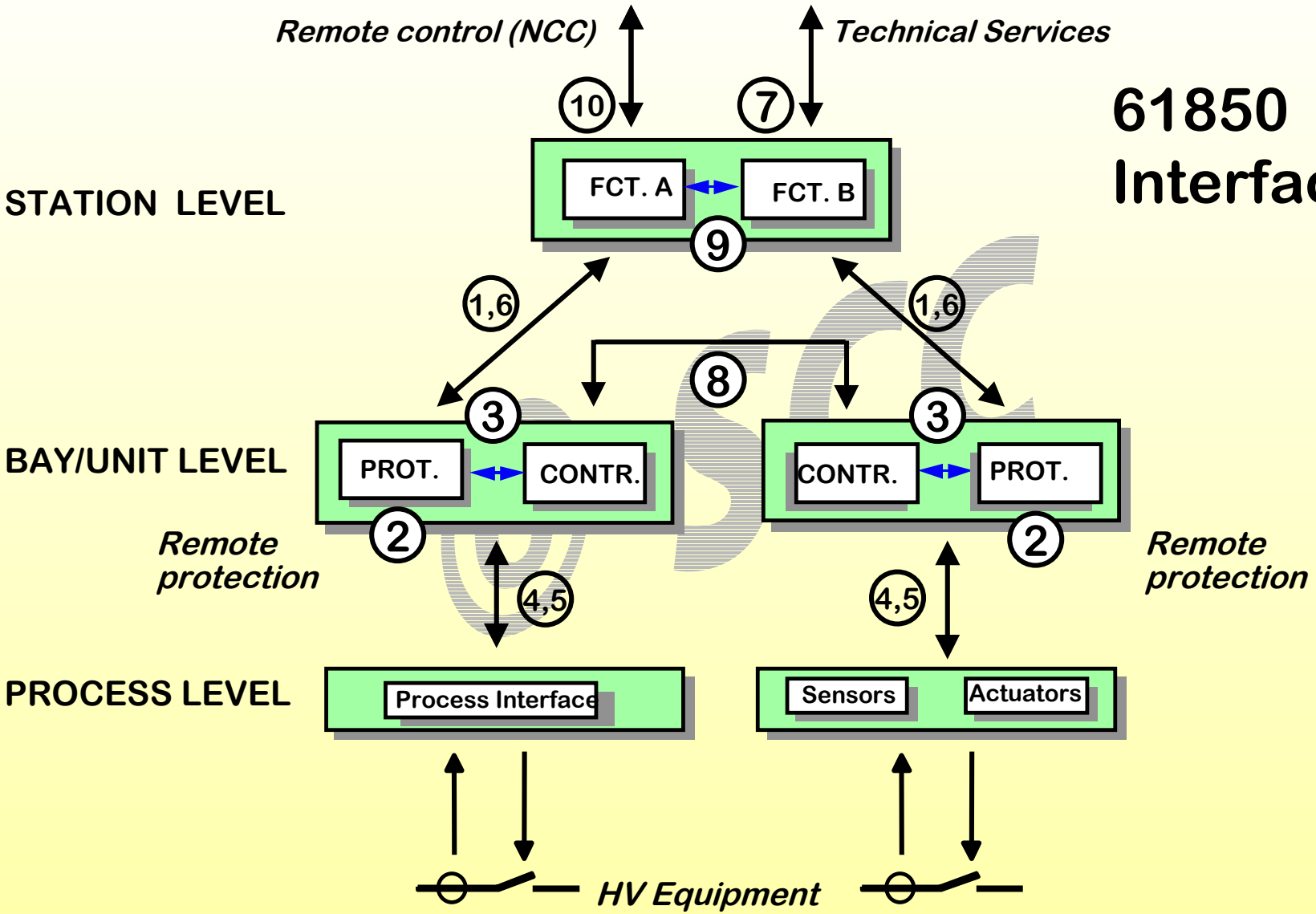
Part 7-4: Basic communication structure for substations and feeder equipment - Compatible logical node and data object addressing

Stage	Document	Date	Target Date
PNW	57/210/NP	24.02.1995	
ANW	57/232/RVN	15.07.1995	15.07.1995
1CD	57/394/CD	19.021999	
A2CD	57/419/CC	03.09.1999	30.06.1999
CCDV	57/520/CDV	16.03.2001	15.07.2000
ADIS			30.11.2001
DEC			31.03.2002

ballot ends: 17.08.2001

Part IEC 61850-5 Communication Requirements for Functions and Device Models

61850 Interfaces



61850 Interfaces

IF1	protection-data exchange between bay and station level
IF2	protection-data exchange between bay level and remote protection (outside the scope of this standard)
IF3	data exchange within bay level
IF4	CT and VT instantaneous data exchange (especially samples) between process and bay level
IF5	control-data exchange between process and bay level
IF6	control-data exchange between bay and station level
IF7	data exchange between substation (level) and a remote engineer's workplace
IF8	direct data exchange between the bays especially for fast functions like interlocking
IF9	data exchange within station level
IF10	control-data exchange between substation (devices) and a remote control center (outside the scope of this standard)

What are Functions in 61850?

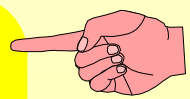
61850-5 INTRODUCTION

„Depending on ...,

the allocation of functions to devices and control levels is not commonly fixed.

This results in ... The standard shall support any allocation of functions...

The description of the functions is not used to standardize the functions, but to identify communication requirements ... within the substation...“



Functions

61850-5 Definitions

Function

„Functions are tasks, which are performed by the substation automation system. Generally, a function consists of **subparts** called

logical nodes *),

which exchange data with each other. By definition, only logical nodes exchange data and, therefore, a function that exchanges data with other functions must have at least one logical node.“

*) logical nodes are about the same as the bricks in UCA™.

Functions

61850-5 clause 5

The functions of a substation automation system (SAS) refer to tasks, which have to be performed in the substation. These are functions to

control, monitor and protect

the equipment of the substation and its feeders. In addition, there exist functions, which are needed to maintain the SAS, i.e. for system configuration, communication management or software management.

Categories of functions (1)

System support

- Network management
- Time synchronization
- Physical device self-checking

System configuration or maintenance

- Node identification
- Software management
- Configuration management
- Operative mode control of Logical Nodes
- Setting
- Test mode
- System security management

Categories of functions (2)

Operational or control

- Access security management
- Control
- Spontaneous change of indications
- Synchronous switching (point-on-wave switching)
- Parameter set switching
- Alarm management
- Event (management and) recording
- Data retrieval
- Disturbance/fault record retrieval

Categories of functions (3)

Local process automation

- Protection function (generic)
- Distance protection (example)
- Bay interlocking

Distributed automatic support

- Station-wide interlocking
- Distributed synchrocheck

Categories of functions (4)

Distributed process automation

- Breaker failure
- Automatic protection adaptation (generic)
- Reverse blocking (example)
- Load shedding
- Load restoration
- Voltage and reactive power control
- Infeed switchover and transformer change
- Automatic switching sequences

The logical node concept

61850-5 clause 9

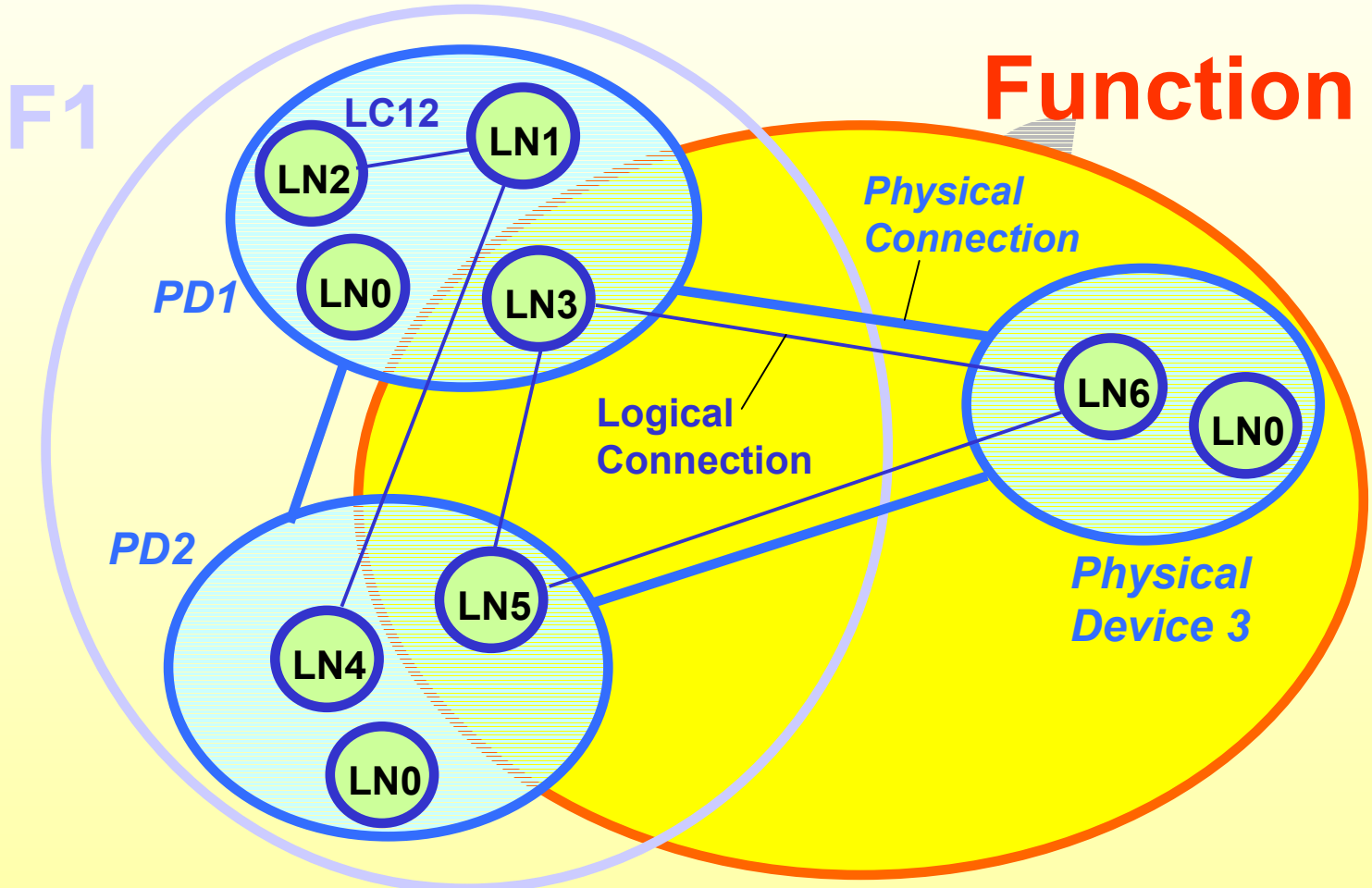
Logical nodes and logical connections:

„To fulfill all the requirements stated above, especially the free distribution and allocation of functions,

all functions are decomposed into logical nodes (LN)

that may reside in one or more physical devices.“

Functions, Devices, Logical Nodes, ...



61850-5 Annex G -Functions

(informative)

Example

Synchronized switching (Point-on-wave switching)

„The **function Synchronized switching** allows closing or opening of the circuit breaker on a dedicated point of wave with a certain accuracy to limit the transient stress both for the breaker and the object to be energized e.g. line...“

Decomposition

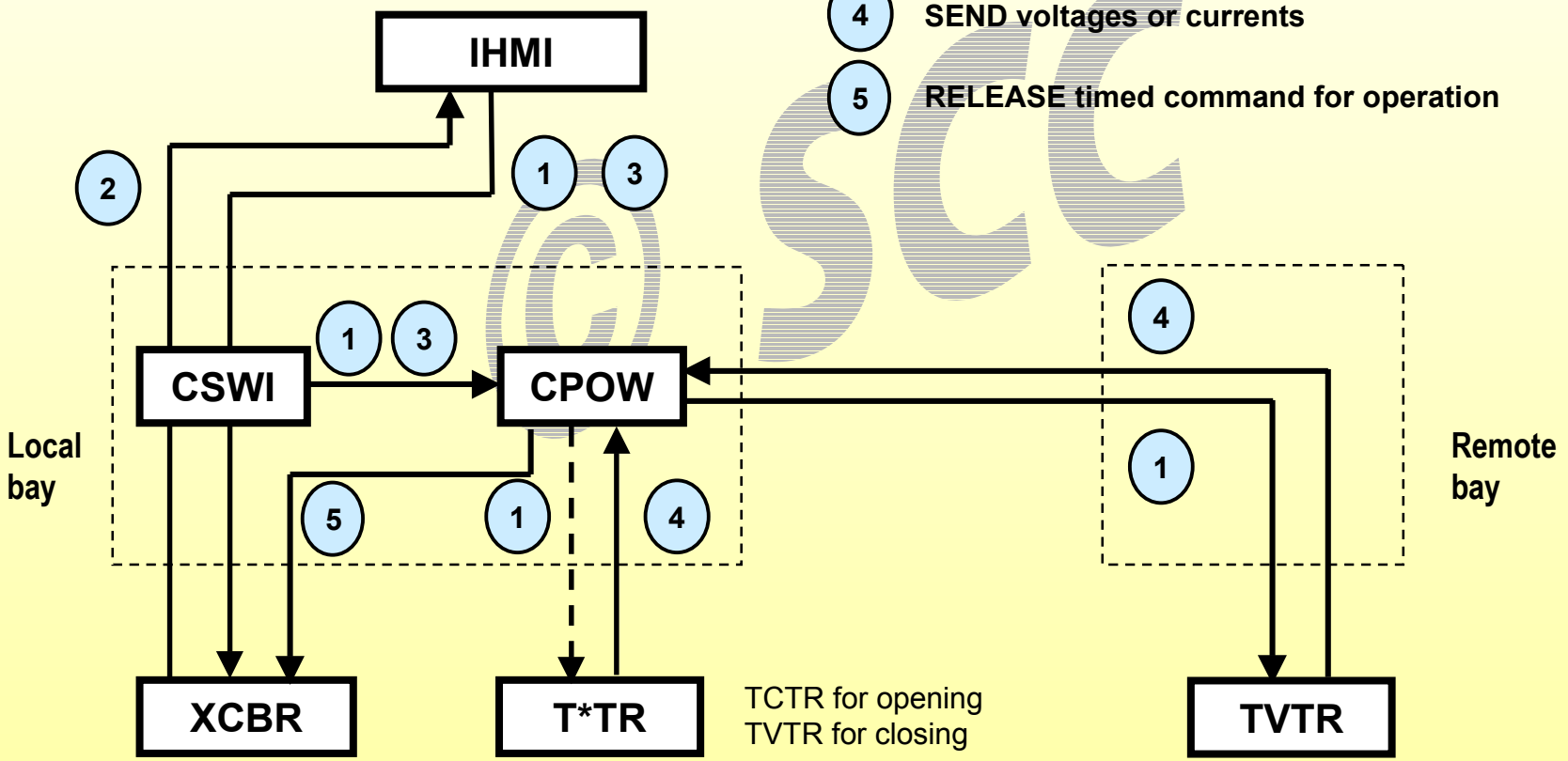
IHMI = Operator interface
CPOW = Point-on-wave breaker controller
CSWI = Switch controller
XCBR = circuit breaker
TVTR = Voltage transformer
TCTR = Current transformer

Functions

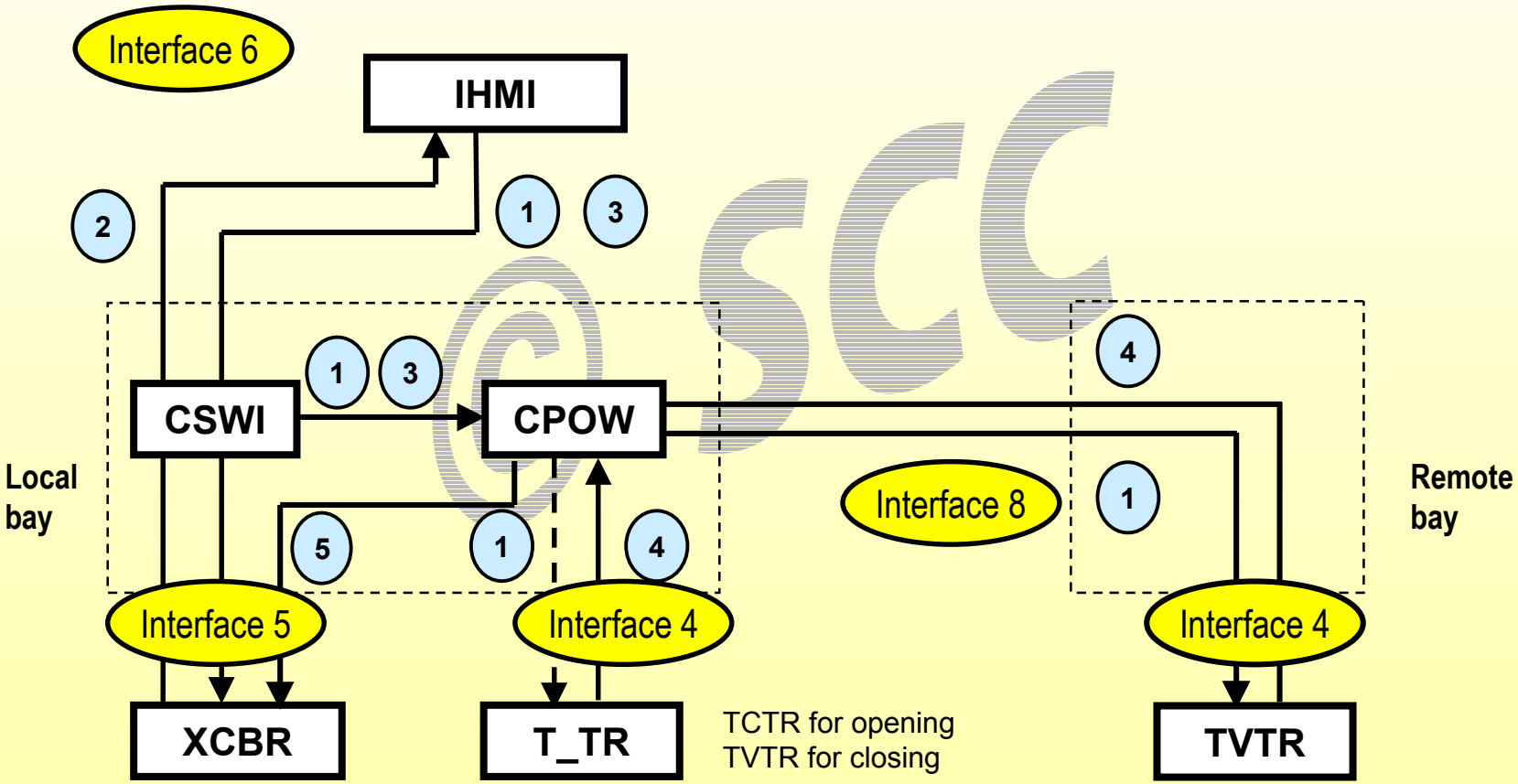
Sequence of messages for point-on-wave switching

Example

1. SELECT breaker for p-o-w Operation activate remote voltage source (for closing). The local current or voltage source may be active anyway
2. CONFIRM selection
3. EXECUTE and start CPOW
4. SEND voltages or currents
5. RELEASE timed command for operation

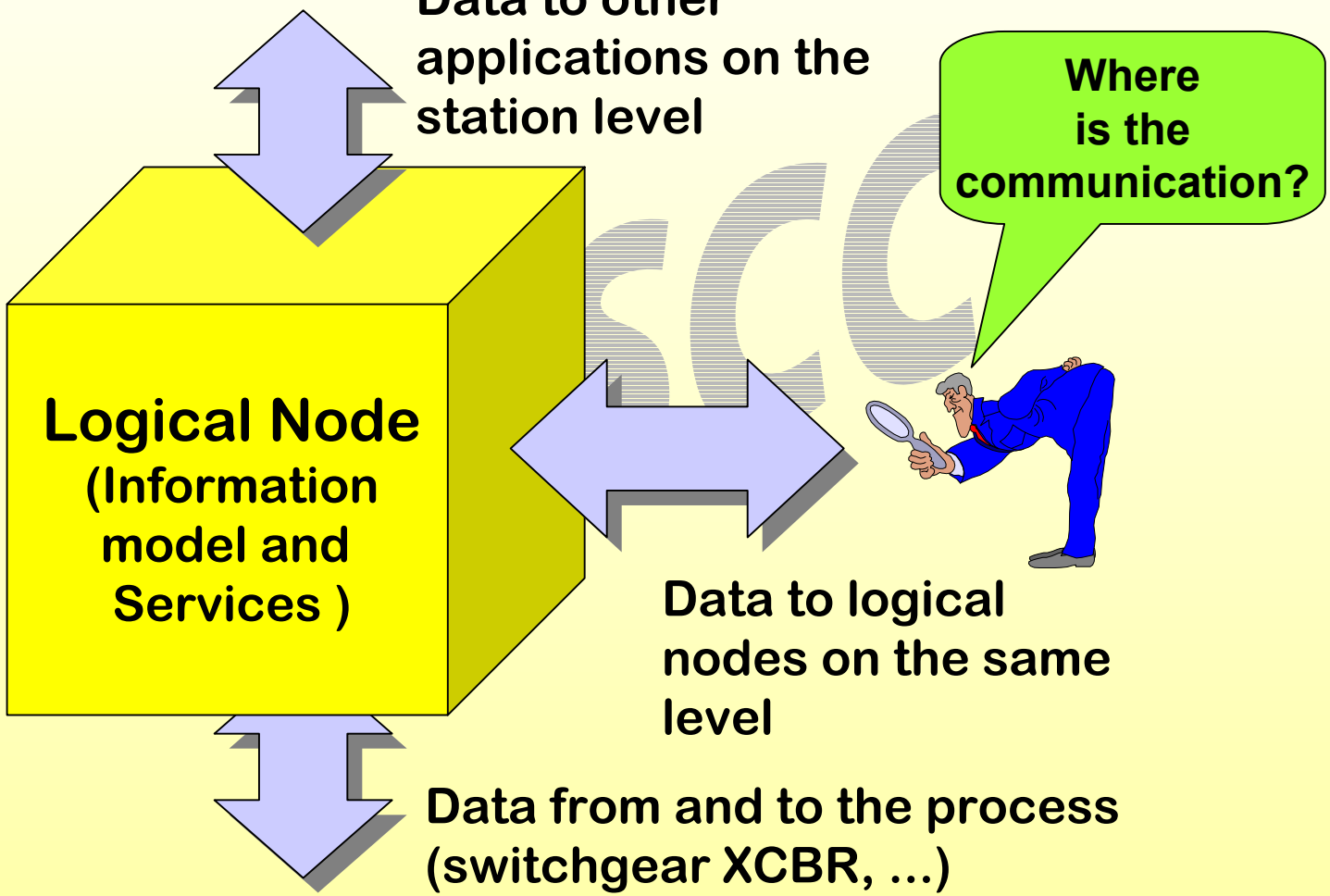


Interfaces involved

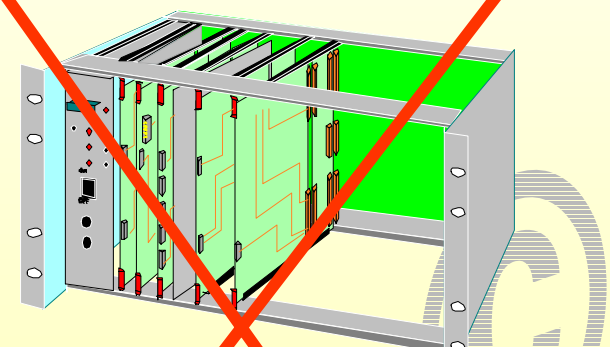


IEC 61850 is highly logical node centric !

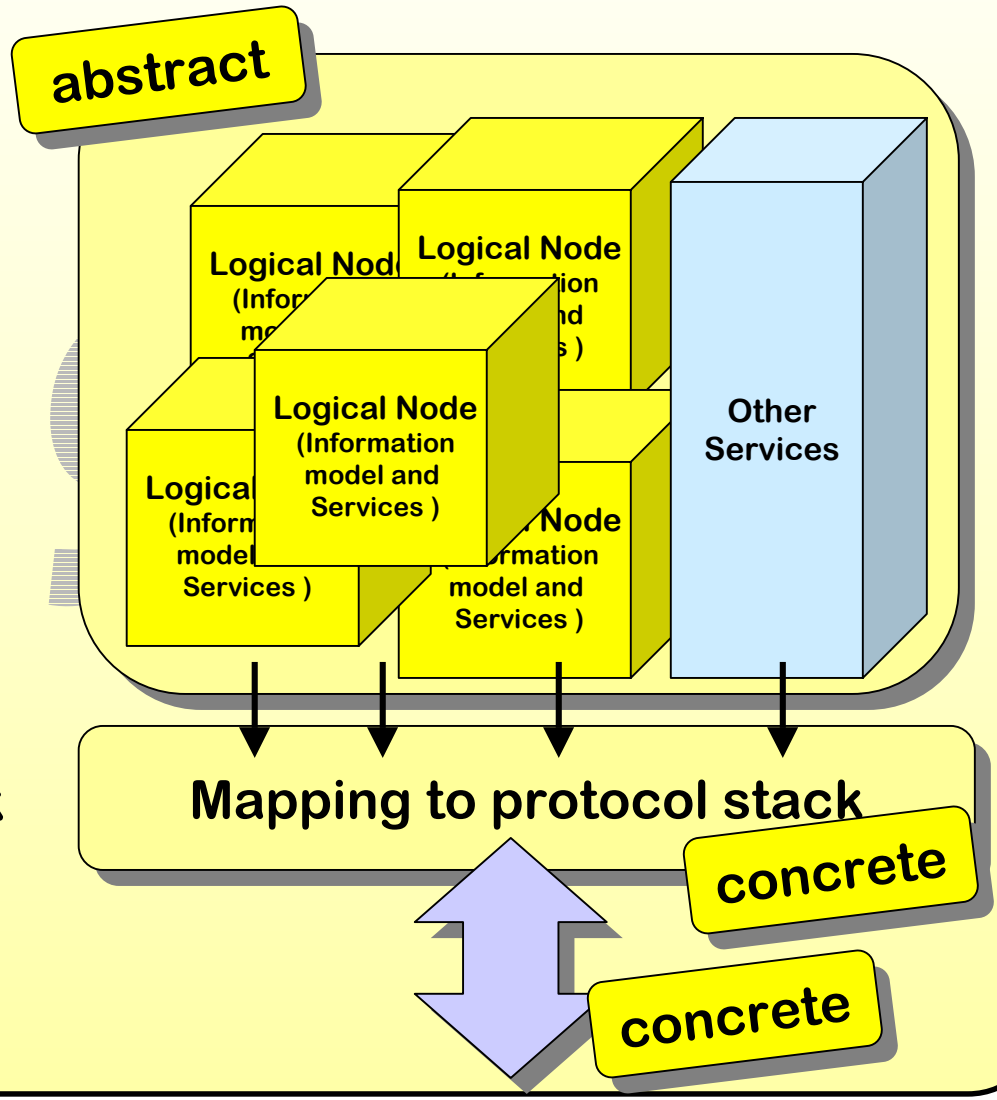
Logical nodes



61850 is abstract and concrete

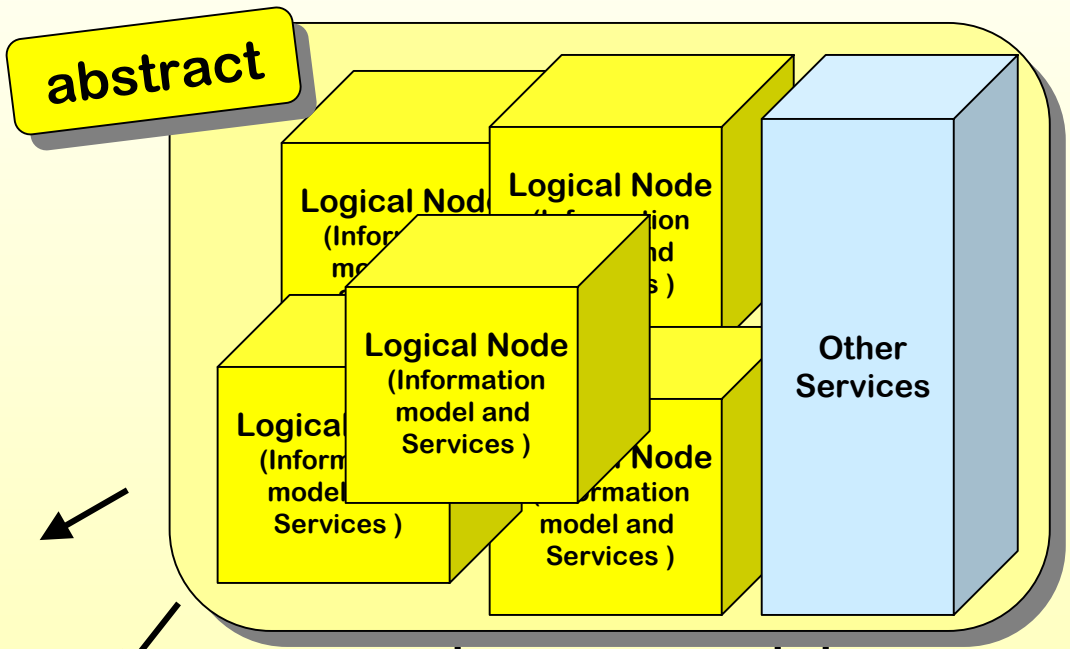


Specific Network
Specific Operating System
Specific Platform
Vendor specific Protocol Stack



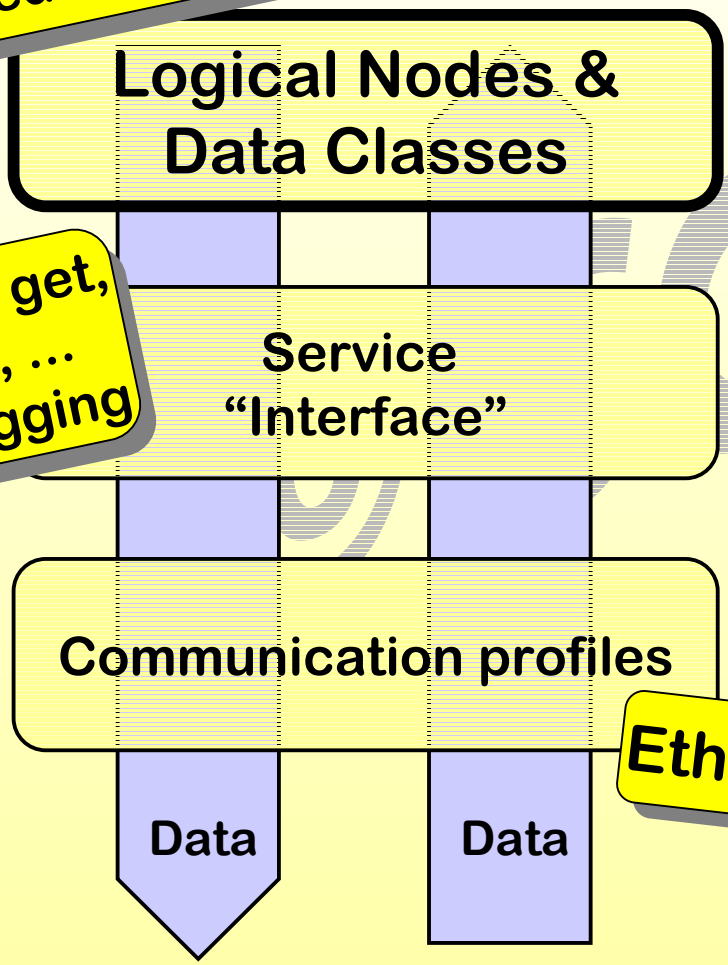
Logical nodes are highly function centric !

Mappings and implementations



IEC 61850 Layering

2000+ entities (name tagged information)



publ./subscr., get, set, control, ... reporting, logging

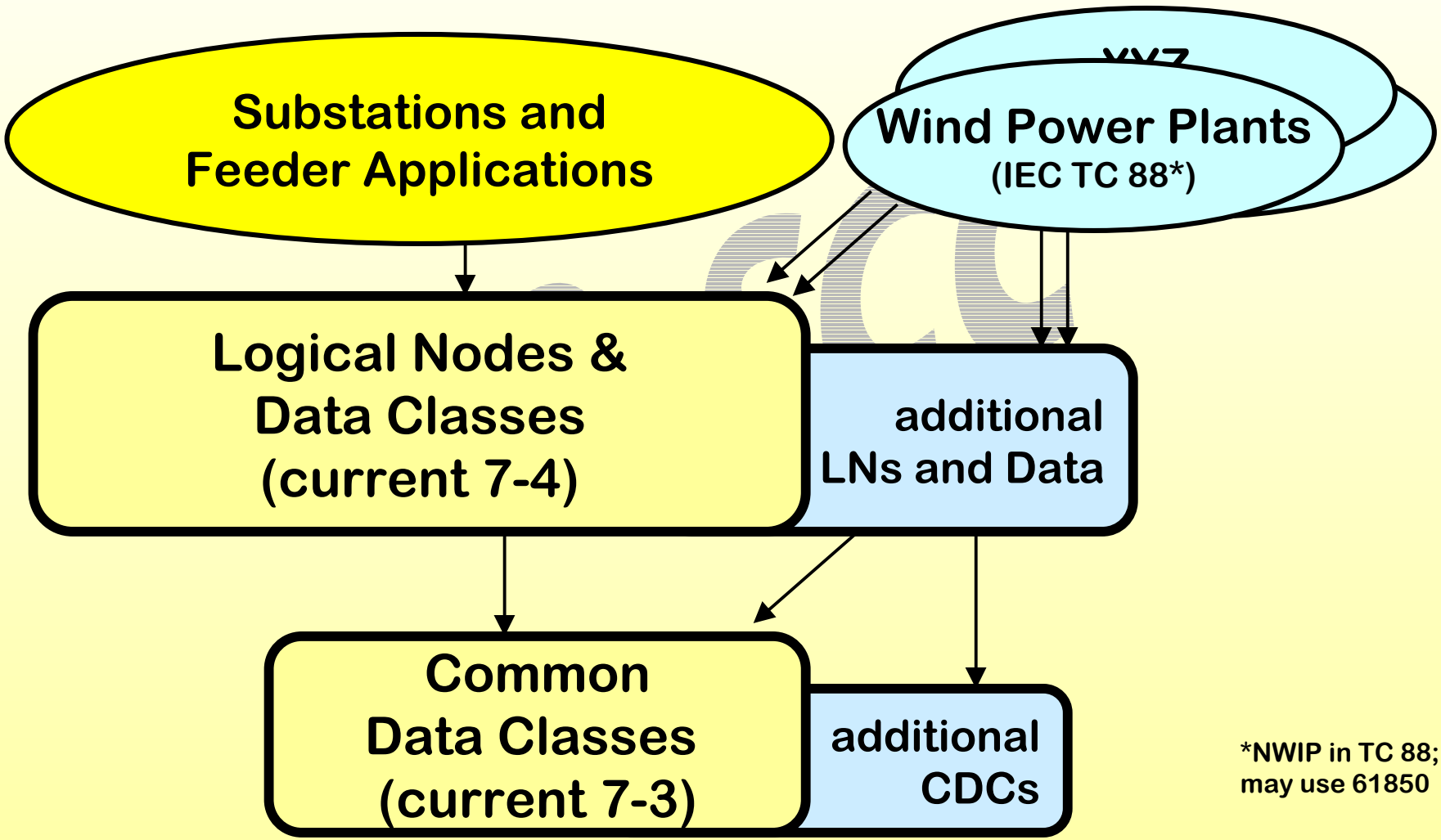
Compatible logical node classes and data classes (7-4 and 7-3)

Abstract communication service interface (ACSI) (7-2)

Mapping to e.g. MMS (8-1)
(CORBA under investigation in Spain)

Ethernet, TCP/IP, OSI

New IEC 61850 Applications



Modeling approach in 61850-7-x

What to be standardized?

„real objects“

time

good base for Standards

"(Abstract) Application Objects"

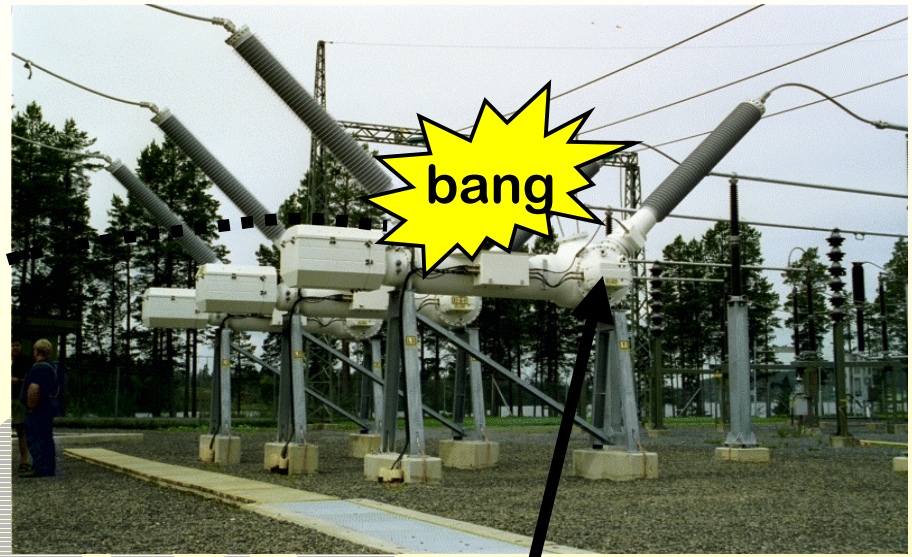
Methods, Languages, Interfaces
for the description and access to application Objects

Life Cycle of System < 15 years

no base for Standards

Innovation of HW and SW

Top-down-approach



computer

Close

Report (closed)

Network

Circuitbreaker1
- Position
- ...

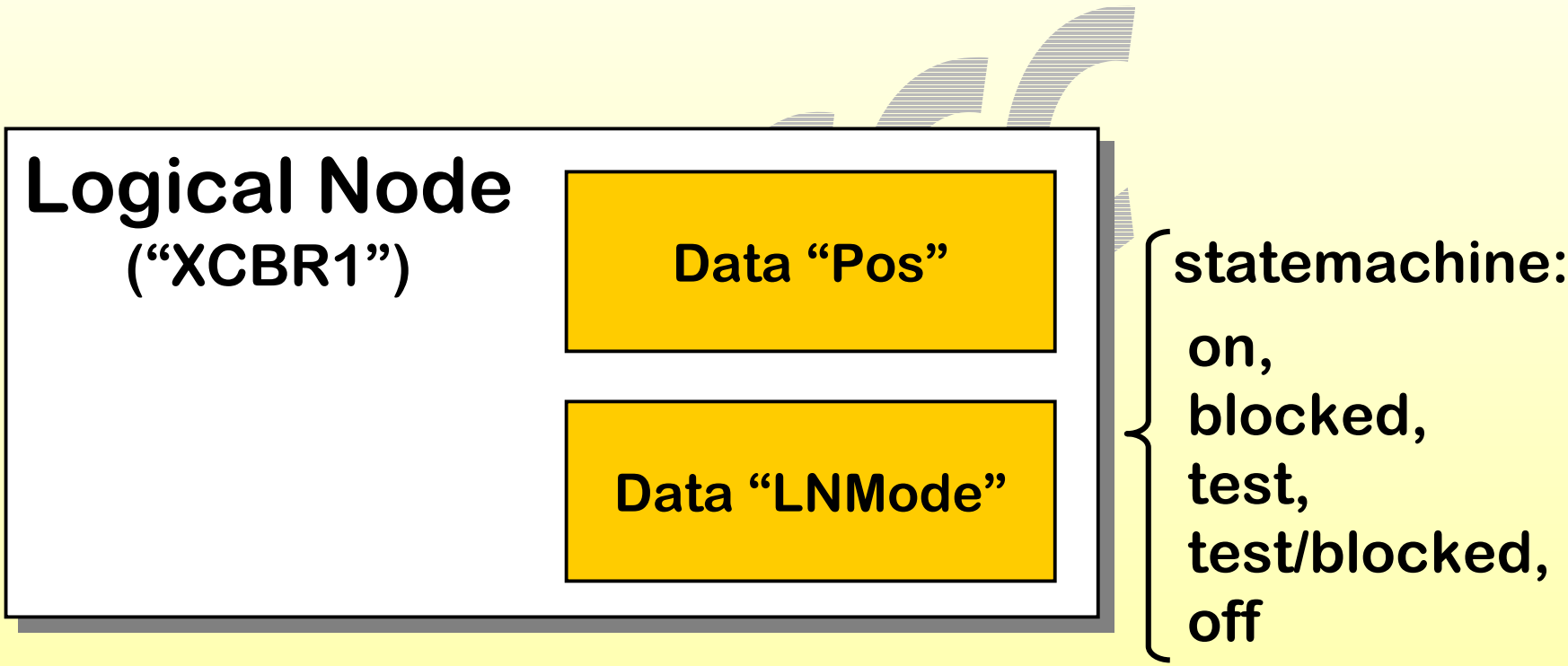
Model of circuit breaker
in a real world controller

Give Position a Home: Data (class)

Data "Pos"

- ctlVal
  - off (FALSE) | on (TRUE)
- stVal
  - intermediate-state (0) | off (1) | on (2) | bad-state (3)
- ...

Give Data a Home: Logical Node (class)



Logical node example (7-4)

14 Data Classes with > 100 attributes

Logical Node: **Circuit breaker**	Name: **XCBR**

Data-Class	DataName	Common Data Class (CDC)	M/O
Basic Logical Node information			
Mode	Mode	Controllable Integer Status (ISC)	M
Behaviour	Beh	Integer Status (ISI)	M
Health	Health	Integer Status (ISI)	M
Name plate	Name	NamePlate (PLATE)	M
Local operation	Loc	Single Point Status (SPS)	M
External equipment health	EEHealth	Integer Status (ISI)	O
External equipment name plate	EEName	NamePlate (PLATE)	O
Operation counter	OperCnt	Integer Status (ISI)	M
Controllable Data			
Switch position	Pos	Controllable Double Point (DPC)	M
Block opening	BlkOpen	Controllable Single Point (SPC)	M
Block closing	BlkClos	Controllable Single Point (SPC)	M
Charger motor enabled	ChMotEna	Controllable Single Point (SPC)	O
Status information			
Circuit breaker operating capability	CBOpCap	Integer Status (ISI)	M
Point On Wave switching capability	POWCap	Integer Status (ISI)	O

DPC - Controllable Double Point (7-3)

DPC Attribute Definition

Name	Type	FC	TrgOp	Value / Value Range	M/O
ctlVal	BOOLEAN	co		off (FALSE) | on (TRUE)	O
stVal	ENUMERATED	sv	dchg, fchg	intermediate-state (0) | off (1) | on (2) | bad-state (3)	M
pulseConfig	PulseConfig	cf			O
operTim	TimeStamp	co			O
q	Quality	st	qchg		M
t	TimeStamp	st			M
origin	Originator	op			O
ctlNum	INTEGER	op		0..255	O
d	Description	dc		Text	O
ctlModel	ControlModel	cf			M
sboTimeout	INTEGER	cf			O
sboClass	ENUMERATED	cf		operate-once | operate-many	O
tag	Tag	ax			O

Pulse Configuration (7-3)

DPC Attribute Definition

Name	Type	FC	TrgOp		
ctlVal	BOOLEAN	co		off	
stVal	ENUMERATED	sv	dchg, fchg	inte on	
pulseConfig	PulseConfig	cf			
operTim	TimeStamp	co			
q	Quality	st	qchg		
t	TimeStamp	st			
origin	Originator	op			
ctlNum	INTEGER	op		0..255	O
d	Description	dc		Text	O
ctlModel	ControlModel	cf			M
sboTimeout	INTEGER	cf			O
sboClass	ENUMERATED	cf		operate-once | operate-many	O
tag	Tag	ax			O

cmdQual
(pulse | persistent)

onDur

offDur

numPls

Time when to operate

Originator and Control Model (7-3)

DPC Attribute Definition

Name	Type	FC	TrgOp	Va
ctlVal	BOOLEAN	co		off (FAL
stVal	ENUMERATED	sv	dchg, fchg	interme on (2) |
pulseConfig	PulseConfig	cf		
operTim	TimeStamp	co		
q	Quality	st	qchg	
t	TimeStamp	st		
origin	Originator	op		
ctlNum	INTEGER	op		0..255
d	Description	dc		
ctlModel	ControlModel	cf		
sboTimeout	INTEGER	cf		
sboClass	ENUMERATED	cf		
tag	Tag	ax		

- not-supported
- bay-control
- station-control
- remote-control
- automatic-bay
- automatic-station
- automatic-remote
- service
- process

- Direct control with normal security
- SBO control with normal security
- Direct control with enhanced security
- SBO control with enhanced security

Measured Value CDC (7-3)

MV Attribute Definition					
Name	**Type**	**FC**	**TrgOp**	**Value / Value Range**	**M/O**
mVal	AnalogValue	sv	dchg		
dbVal	AnalogValue	mx	fchg		
range	Range	mx	fchg		
q	Quality	mx	qchg		
t	TimeStamp	mx			
subID	VISIBLE STRING	sv			
d	Description	dc		- ASC	
units	SIUnits	cf			
sVC	ScaledValueConfig	cf			
db	INTEGER	cf		> 0	
hhLim	REAL	cf			
hLim	REAL	cf			
lLim	REAL	cf			O
llLim	REAL	cf			O
min	REAL	cf			O
max	REAL	cf			O
smpRate	SampleRate	cf			O

dbVal = Dead band value: filtured value.

fchg = Trigger option: Report on change of filtered value.

db = configuration deadband value

See Reporting

Analogue value (7-3)

AnalogueValue Type Definition			
Name	**Type**	**Value / Value Range**	**M/O**
adVal	INTEGER	analogue to digital value	O
i	INTEGER	integer value	O
f	REAL	floating point value	O

At least one of the attributes shall be used.

adVal: The adVal shall represent the raw values or unscaled counts of the analogue-to-digital physical measurement that is used to determine the values of both i and f.

i: The value of i shall represent an integer representation of the measured value. This integer representation I shall be a scaled value. The formula of:

$$f = i \times iScaleFactor$$

shall be true within acceptable error when both i, iScaleFactor, and f are all present.

f: The value of f shall reflect a real representation of the measured value. The technological value shall be represented directly.

Configuration of scaled analogue value (7-3)

ScaledValueConfig Type Definition			
Name	**Type**	**Value / Value Range**	**M/O**
iScaleFactor	REAL	DEFAULT 1.0	O
iOffset	REAL	DEFAULT 0.0	O

This data attribute type shall be used to configure the scaled value representation of the analogue value.

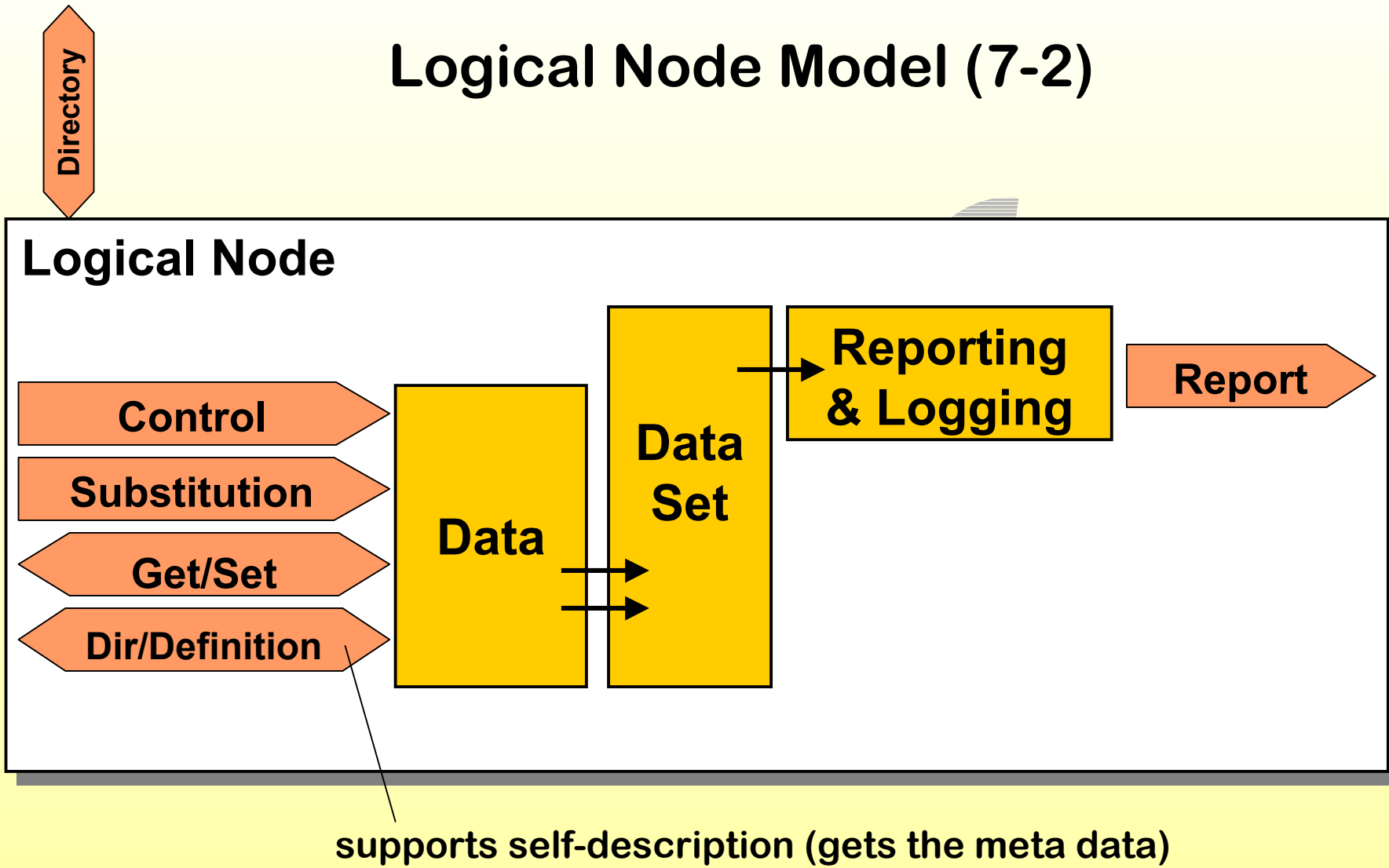
iScaleFactor: The value of iScaleFactor shall represent a REAL scaling factor which is used in the following calculation:

$$f = i \times iScaleFactor$$

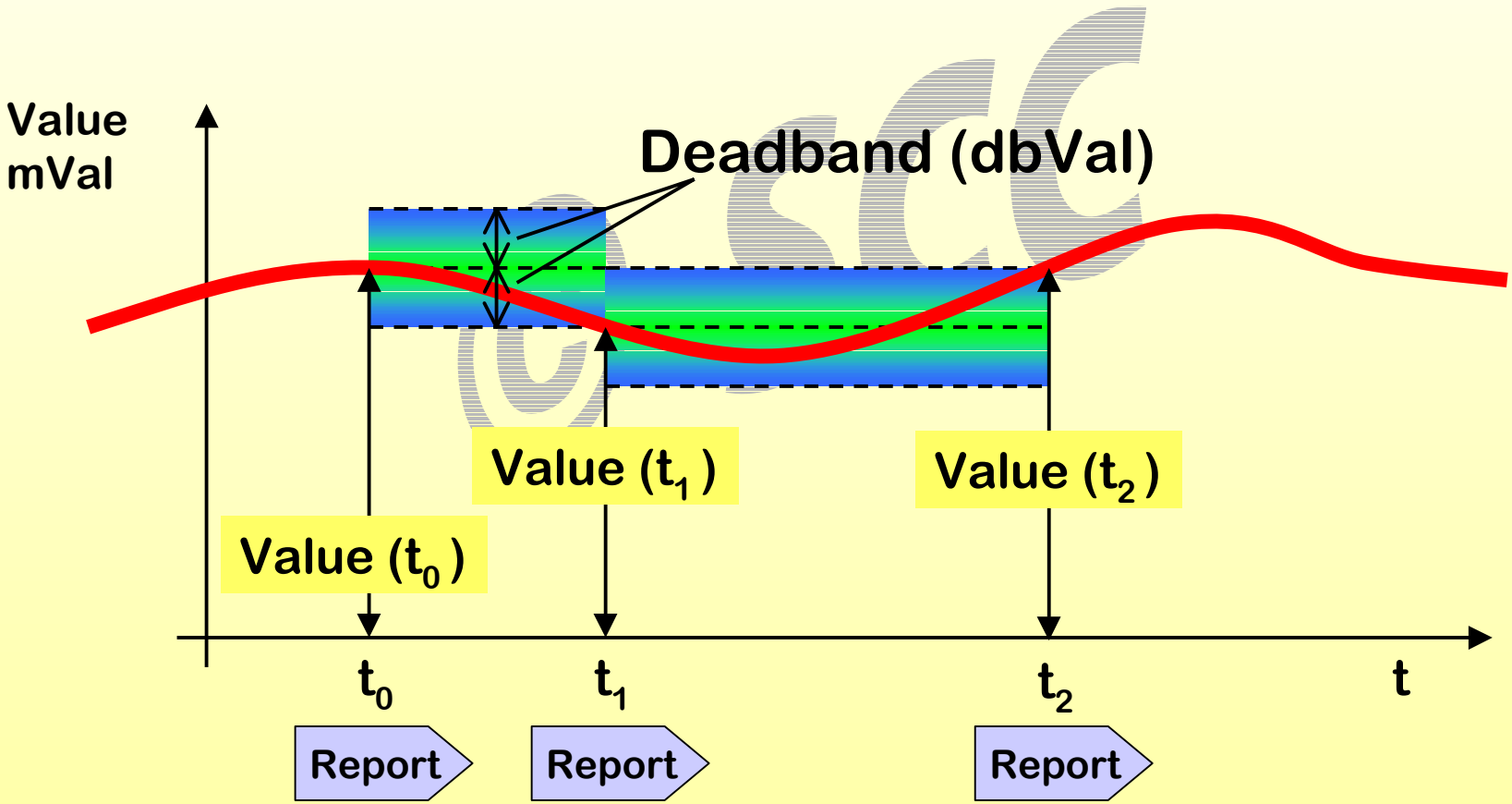
iOffset: The value of iOffset shall represent a REAL offset factor which is used in the following calculation:

$$f = (i \times iScaleFactor) + iOffset$$

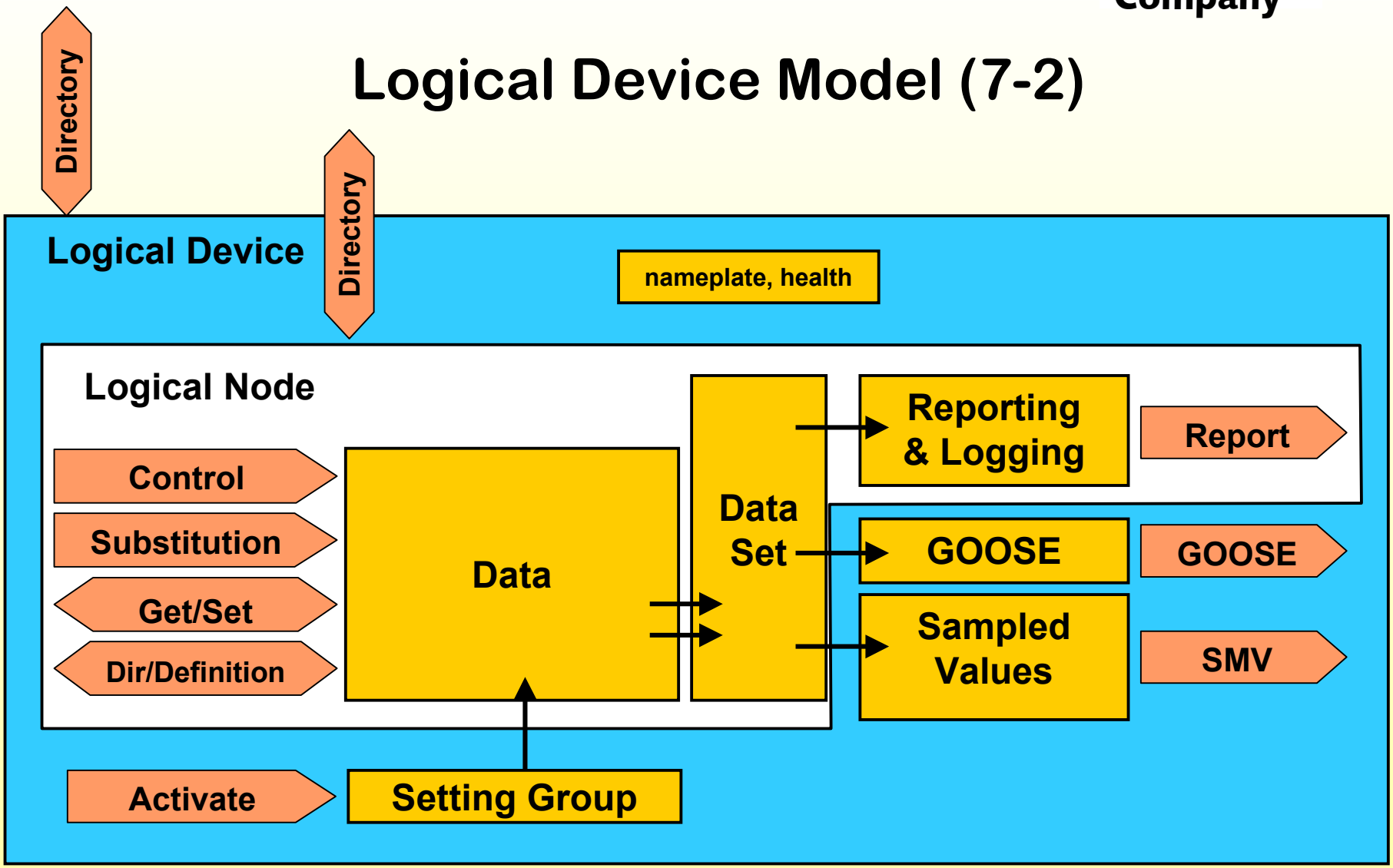
Logical Node Model (7-2)



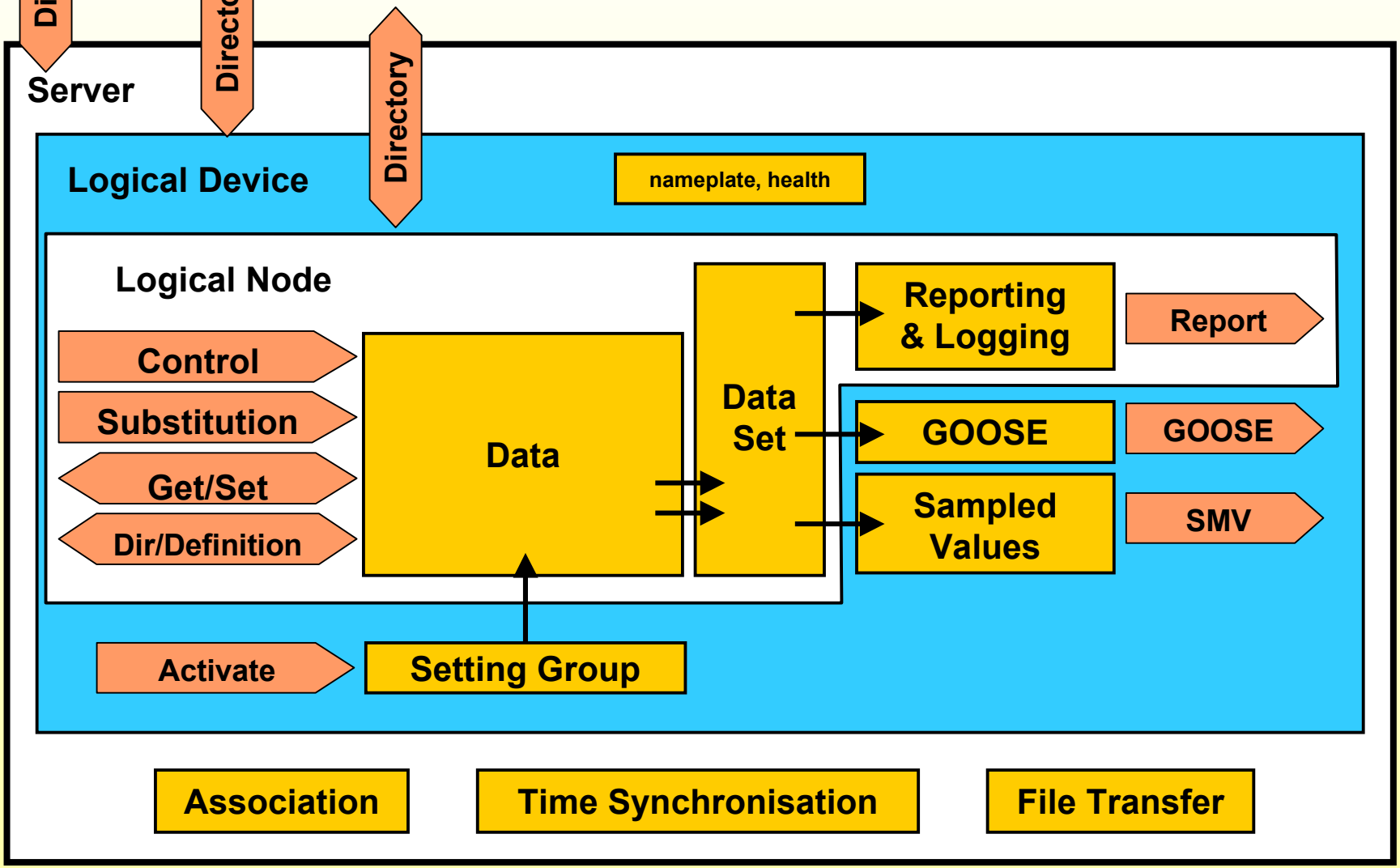
Measurement CONFIGURATION Metadata controls the reporting behaviour of a device



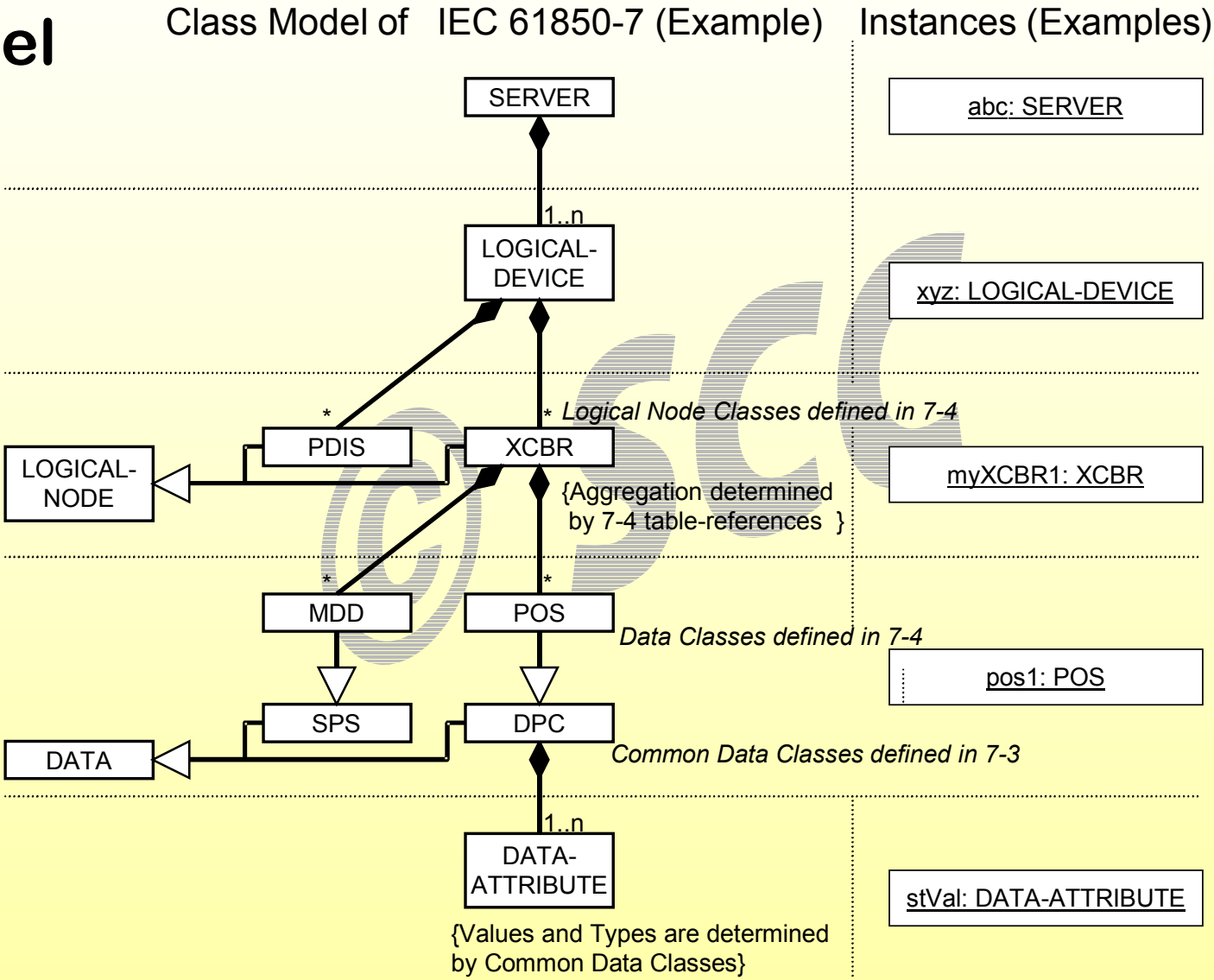
Logical Device Model (7-2)



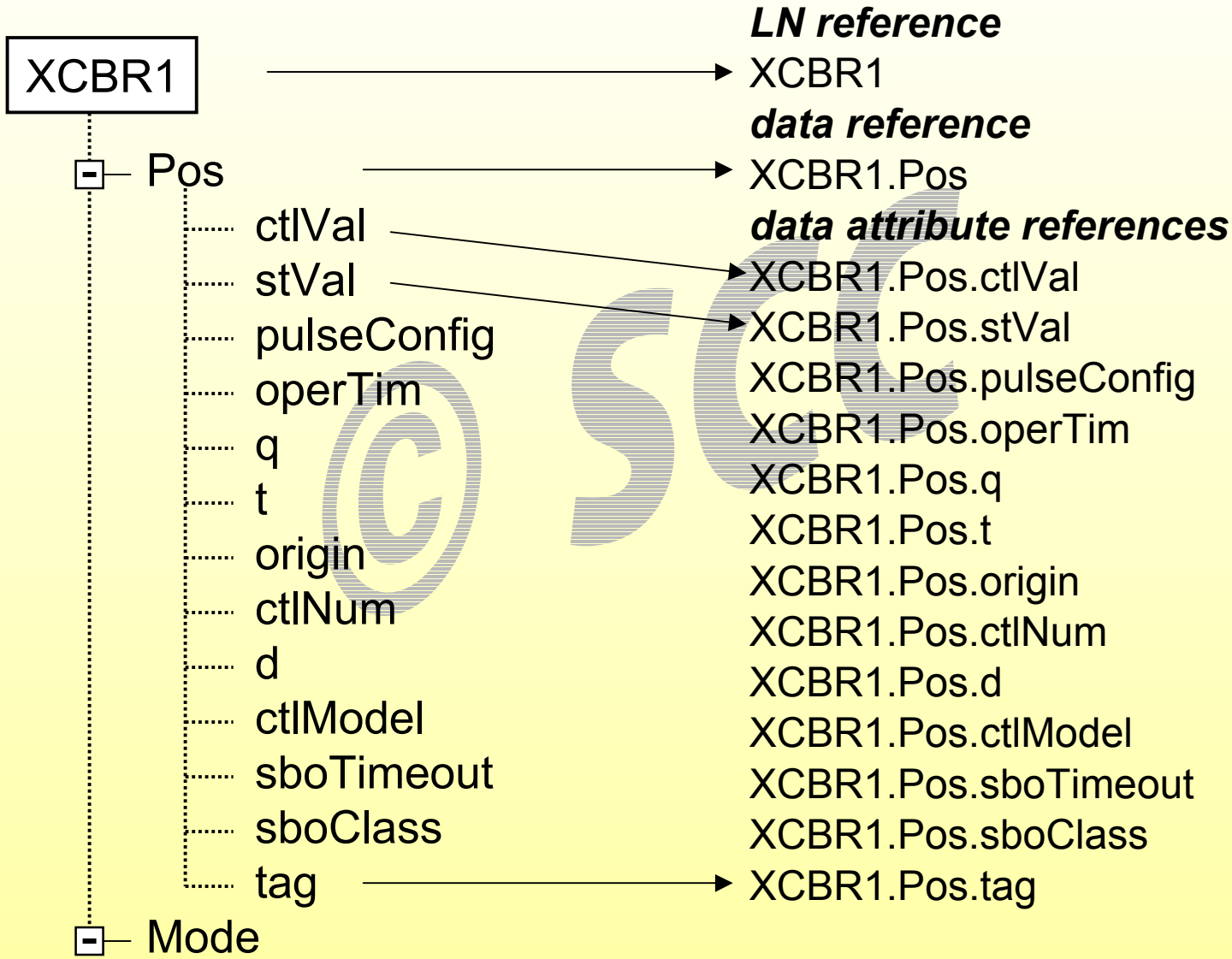
Server Model (7-2)



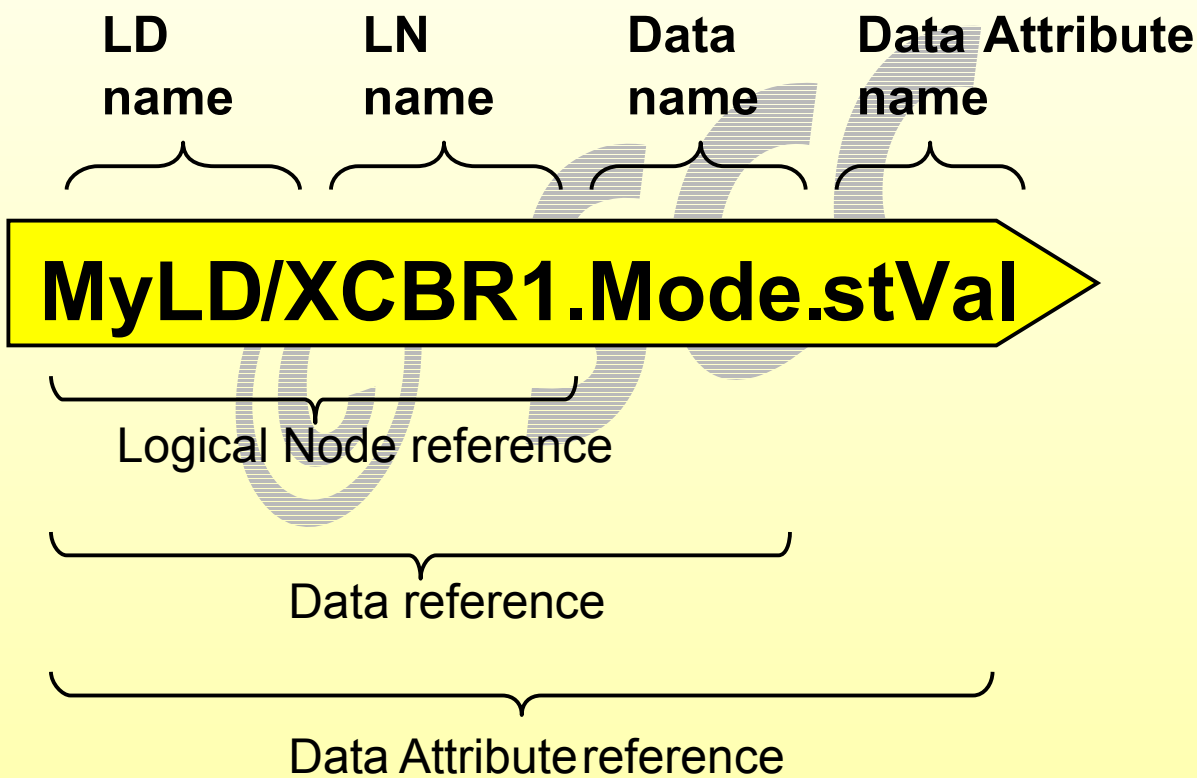
Model


Class Model of IEC 61850-7 (Example)
Instances (Examples)
SERVER
abc: SERVER
1..n
LOGICAL-DEVICE
xyz: LOGICAL-DEVICE
* Logical Node Classes defined in 7-4
PDIS
XCBR
LOGICAL-NODE
myXCBR1: XCBR
{Aggregation determined by 7-4 table-references }
MDD
POS
Data Classes defined in 7-4
pos1: POS
SPS
DPC
DATA
Common Data Classes defined in 7-3
1..n
DATA-ATTRIBUTE
stVal: DATA-ATTRIBUTE
{Values and Types are determined by Common Data Classes}

Circuit Breaker Model



Referencing information (1)



Configuration description language for substation IEDs (Part 6)

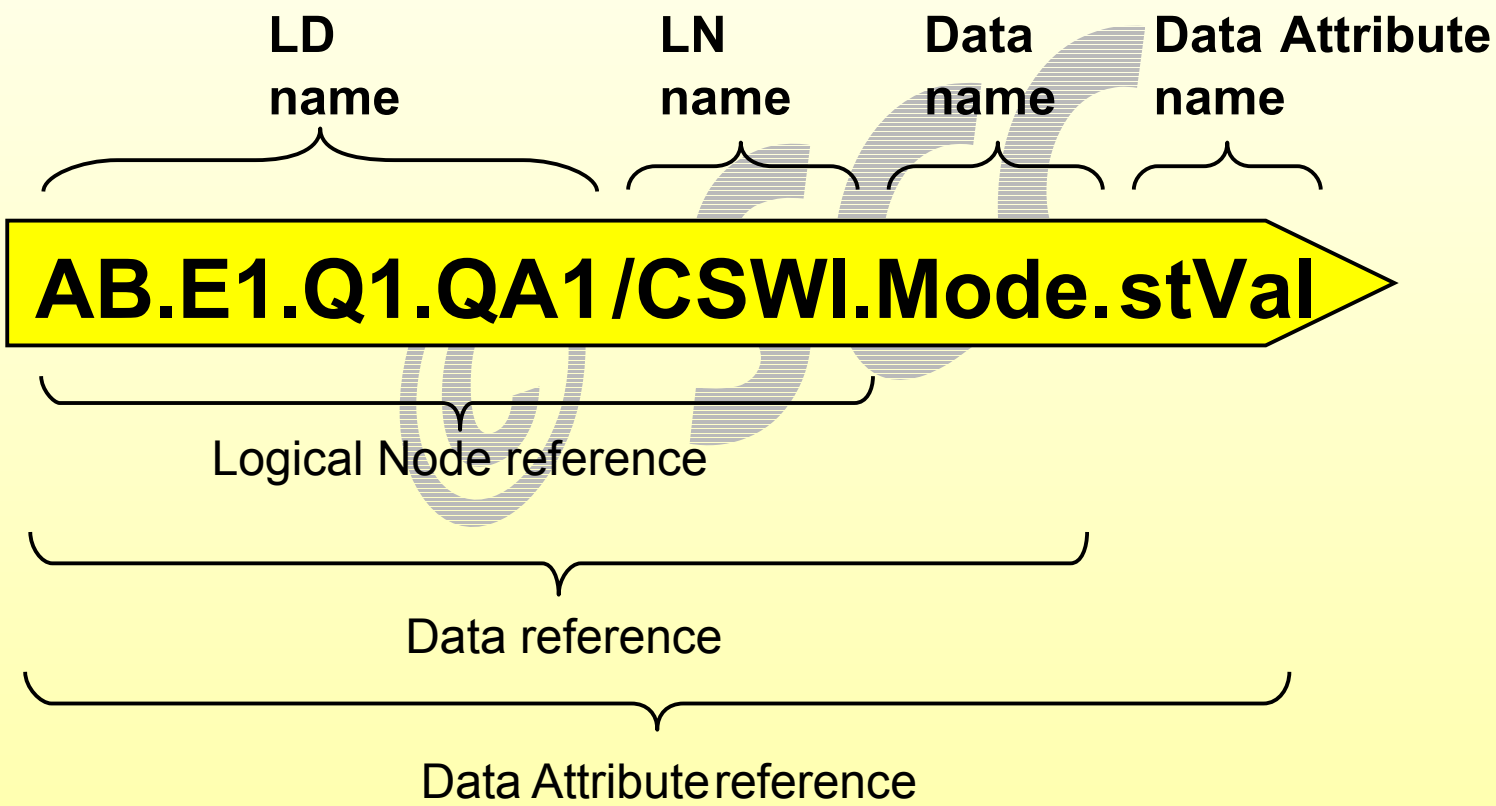
The following example XML file contains a substation section with one bay E1Q1, which contains a circuit breaker QA1 and a disconnector QB1, both electrically connected together at node L1. A LN controller node of type CSWI controls each switch.

```
<Substation Ref="AB">
    <VoltageLevel Ref="E1">
        <Bay Ref="Q1">
            <Device Ref="QA1" Type="CBR">
                <Connection TNodeRef="L1"/>
                <LNode Ref="1" LNClass="CSWI"/>
            </Device>
            <Device Ref="QB1" Type="DIS">
                <Connection TNodeRef="L1"/>
                <LNode Ref="2" LNClass="CSWI"/>
            </Device>
        </Bay>
    </VoltageLevel>
</Substation>
```

valid

IEC 61850-6 DTD

Referencing information (2)



LN groups (7-4)

Logical node groups	Group Designator	How many LN classes?
System Logical Nodes	L	3
Protection functions	P	25
Protection related functions	R	9
Supervisory control	C	3
Generic References	G	3
Interfacing and Archiving	I	4
Automatic Control	A	4
Metering and Measurement	M	5
Switchgear	X	5
Instrument Transformer	T	2
Power Transformer	Y	4
Further power system equipment	Z	12
		79

LN classes (7-4)

Basic Protection Relay, PBPR
Directional element, PDIR
Harmonic restraint, PHAR
Protection Scheme, PSCH
Transient Earth Fault, PTEF
Zero speed or underspeed, PZSU
Distance protection, PDIS
...
Measuring (Measurand unit), MMXU
Metering, MMTR
Sequence and Imbalance, MSQI
Harmonics and Interharmonics, MHAI
Differential Measurements, MDIF
...
Circuit breaker, XCBR
Circuit Switch, XSWI
Gas measurement unit, XGMU
Monitoring and Diagnostics for arcs, XARC
...

Time overcurrent (PTOC = IEEE 51)

Description	Data Name	T	CDC	M/O
Table 2 – Basic Logical Node information				
Mode	Mode		ISC	M
Behaviour	Beh		ISI	M
Health	Health		ISI	M
Name plate	Name		PLATE	M
Resetable operation counter	OperCntRs		ISC	O
Table 8 – Status information				
Started	Start		ACT	M
Operated	Oper		ACT	M
Table 9 – Settings				
Operating Curve Type	ATimCrv		CURVE	M
Phase Start Value	PhsStart		ASP	O
Ground Start Value	GndStart		ASP	O
Time Dial Multiplier	TimMult		ASP	O
Minimum Operate Time	MinOpTim		ISC	O
Operate Delay Time	OpTimDel		ISC	O
Type of Reset Curve	TypRsCrv		ISC	O
Reset Delay Time	RsTimDel		ISC	O
Directional Mode	DirMode		ISC	O

Groups of data classes (7-4)

Group of data classes	How many data classes?
System information	13
Physical device information	11
Measurands	66
Metered values	14
Controllable Data	36
Status information	85
Settings	130
	355

Excerpt of data classes for Measurands (7-4)

Data Name	Definition
A	Phase to ground amperes for Phases 1, 2, and 3, including Angle
Amps	Current of a non three phase circuit
Ang	Angle between phase voltage and current
AnIn	Analogue Input used for generic I/O
ChAnVal	Array of analogue channel numbers and actual values at a certain time (time tag)
CircA	Measured circulating current in a transformer paralleling application
CtlV	Voltage on secondary of transformer as used for voltage control.
Den	Density of gas or other insulating Medium
DQ0Seq	Direct, quadrature, and zero axis quantity
ECC	This is the measured current through a Petersen Coil in neutral compensated networks.
FDkm	The distance to a fault in kilometres
FDOhm	The distance to a fault in Ohms
HaRmsA	Current Harmonic RMS (un-normalized THD) for A, B, C, N
...	...

1

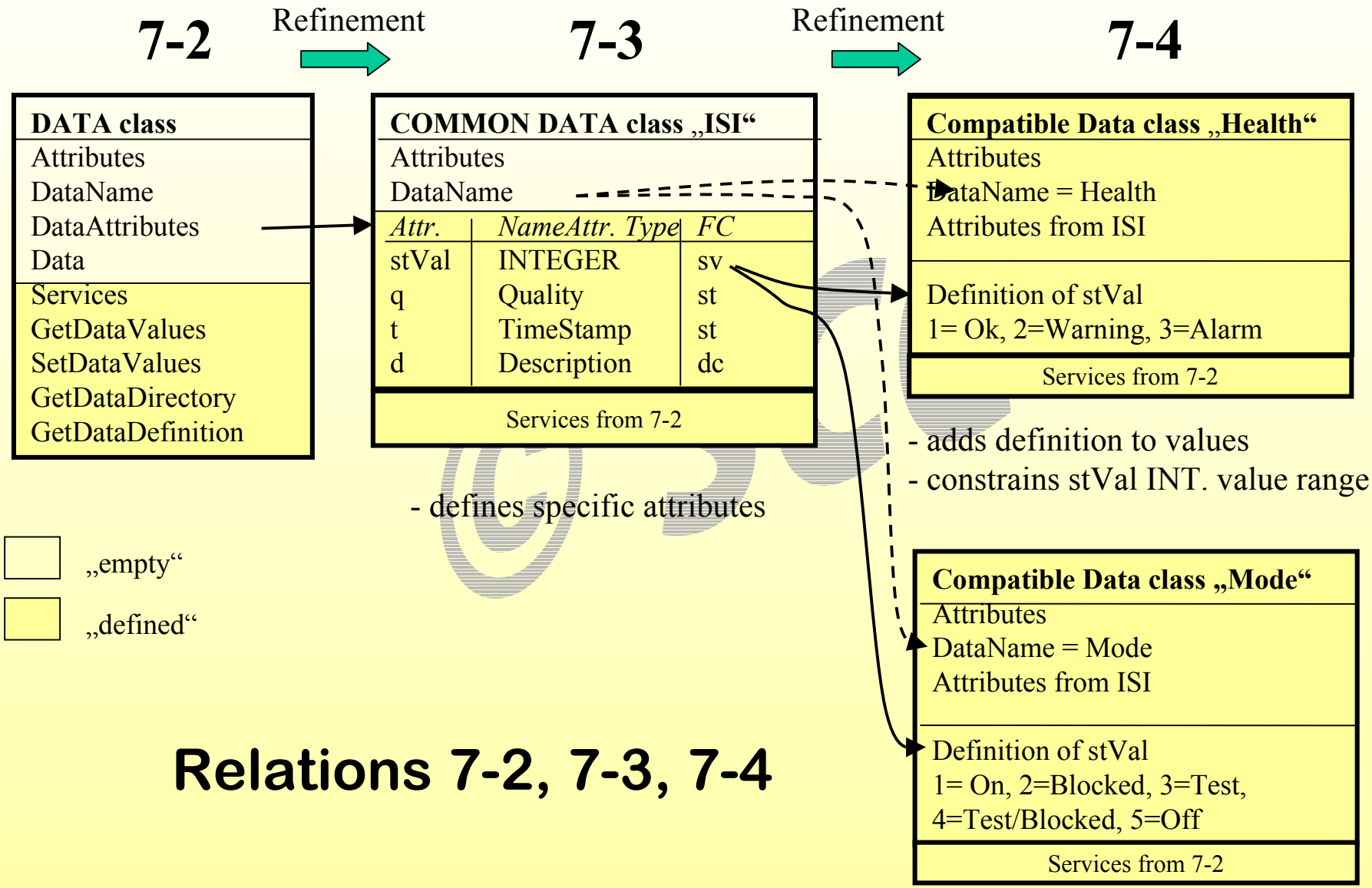
66

Excerpt of common data classes (7-3)

Common Data Class Specifications for Status Information
Single Point Status (SPS)
Double Point Status (DPS)
Step Position Information (SPI)
Status Indication Group (SIG)
Integer Status (ISI)
Name Plate (PLATE) …
Common Data Class Specifications for Measurand Information
Measured Value (MV)
WYE Class
Delta (DEL)
Sequence (SEQ) …
Common Data Class Specifications for Controllable Status Information
Controllable Single Point (SPC)
Controllable Double Point (DPC) …
Common Data Class Specifications for Controllable Analogue Information
Analogue Set Point (ASP)
Protection Pickup Setting Group (PUG)
Setting Curve (CURVE) …

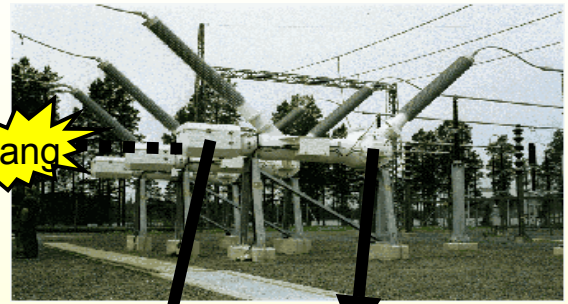
1

20



Relations 7-2, 7-3, 7-4

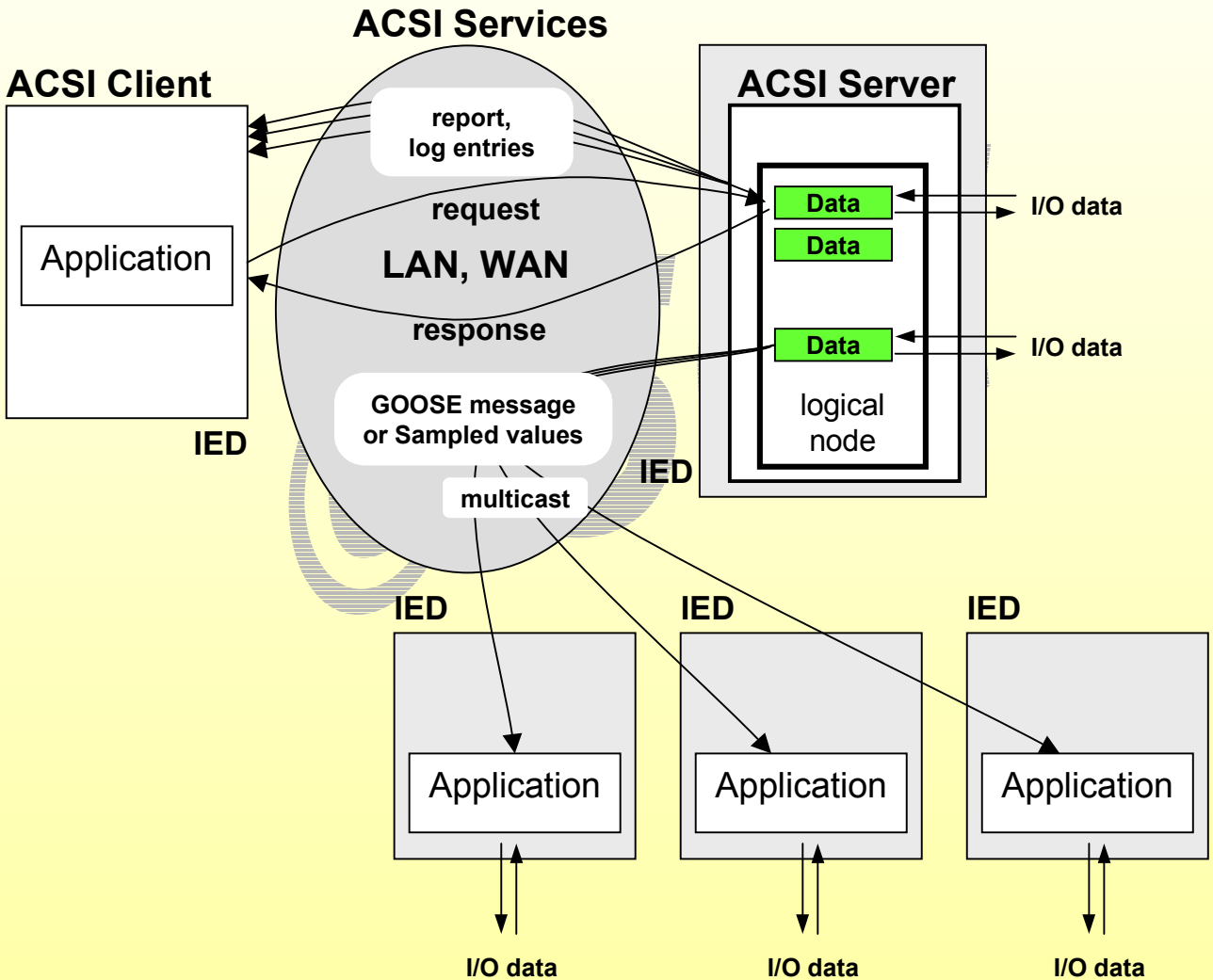
Example



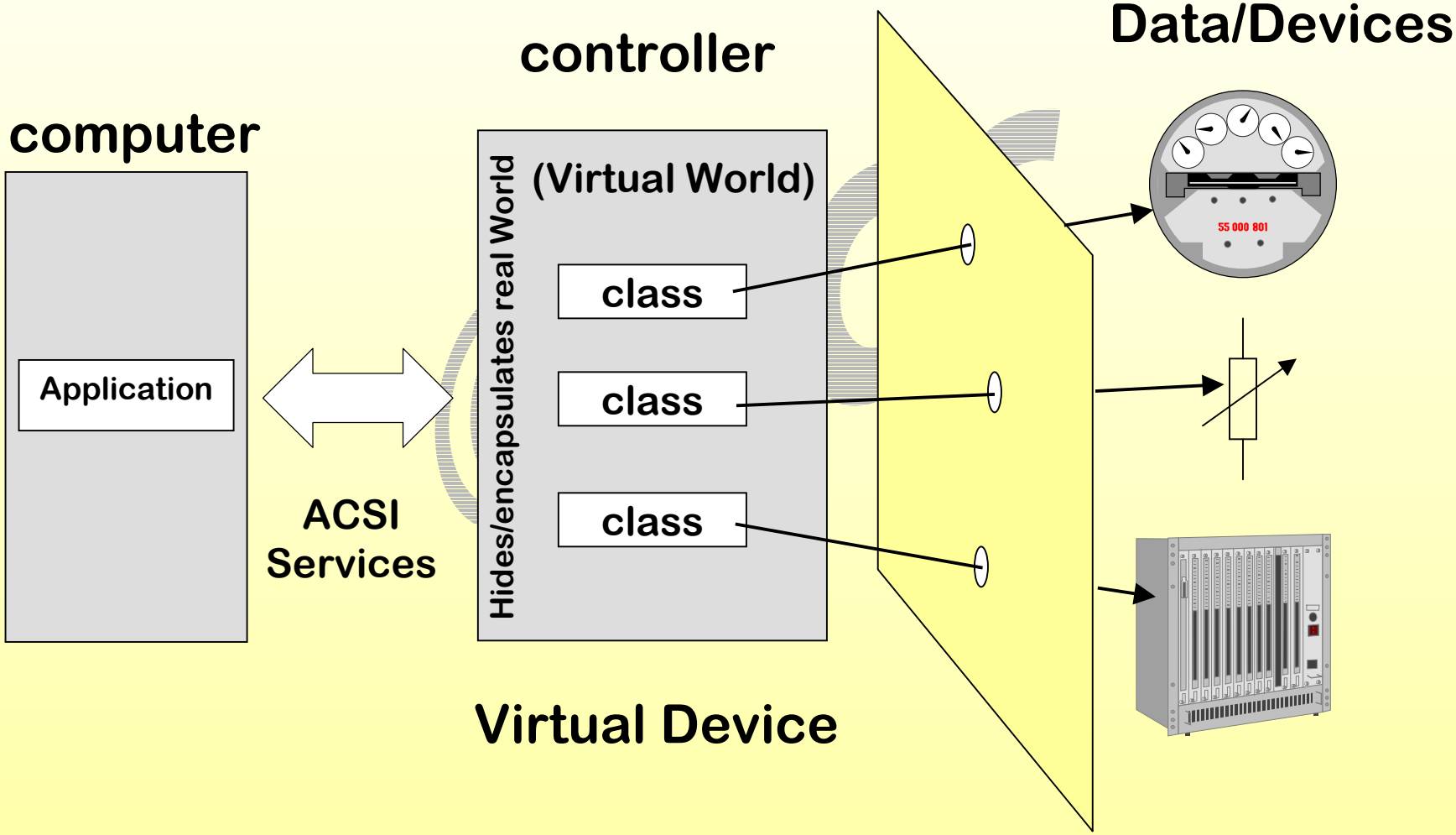
Mapping

ACSI models and services (7-2)

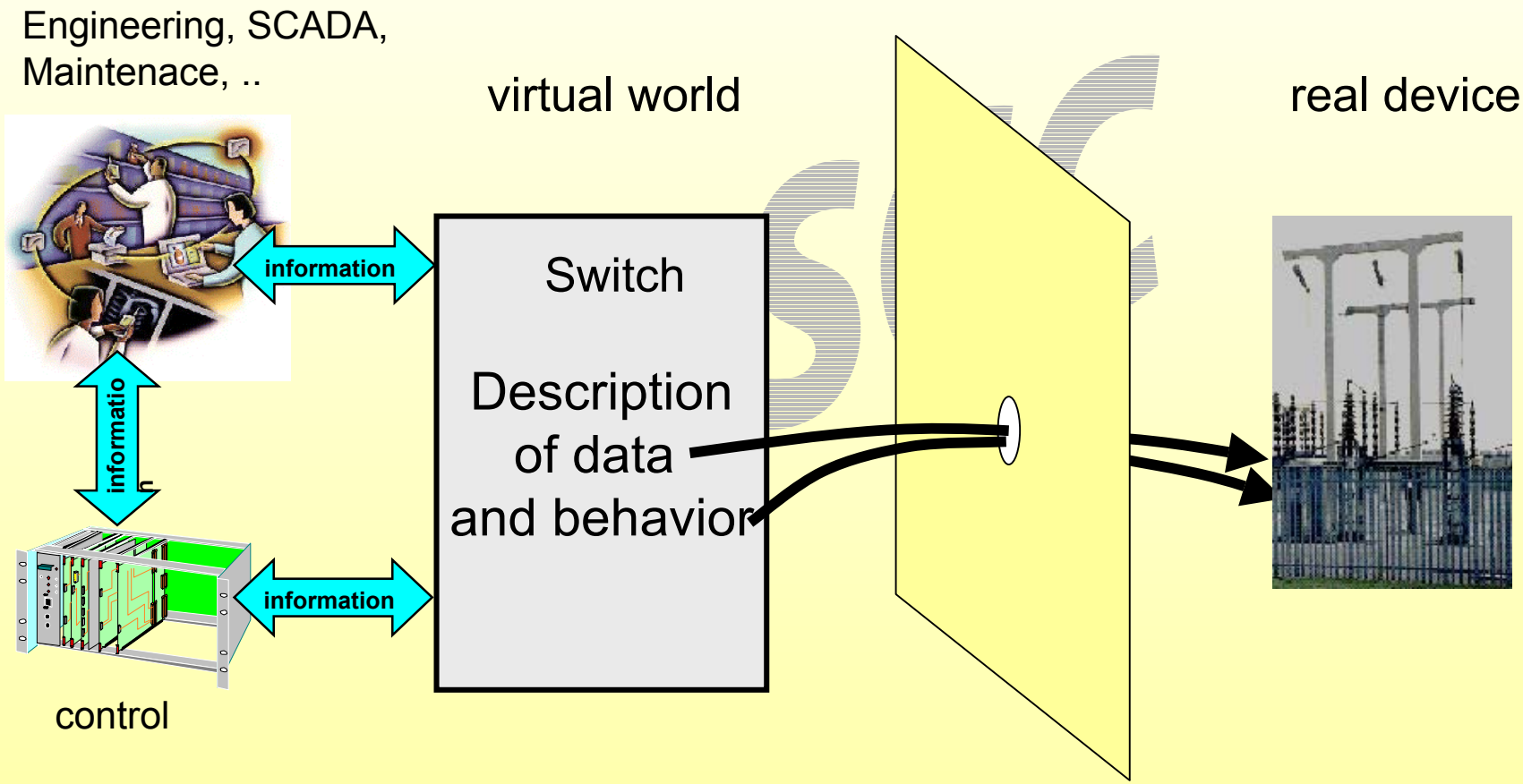
ACSI communication methods



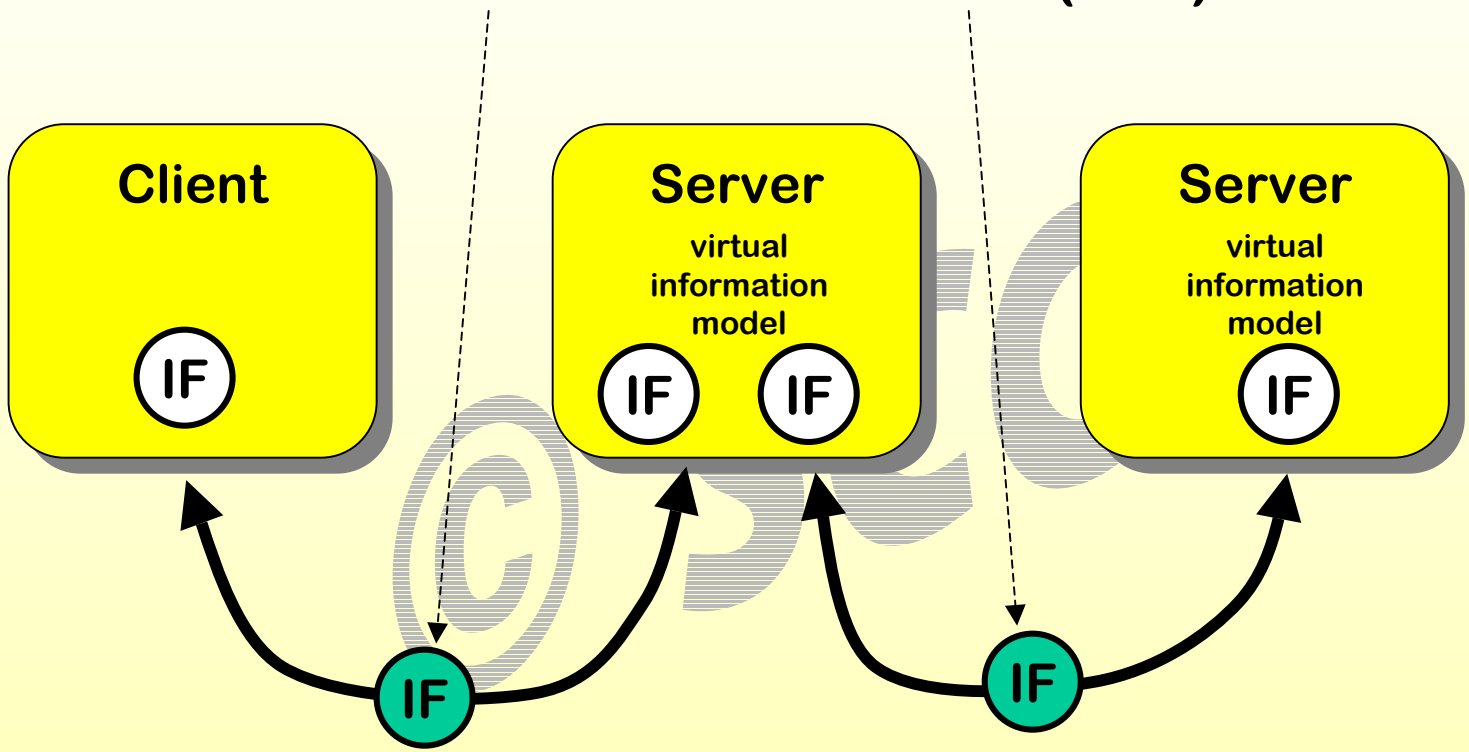
Virtualisation



Virtualisation and usage

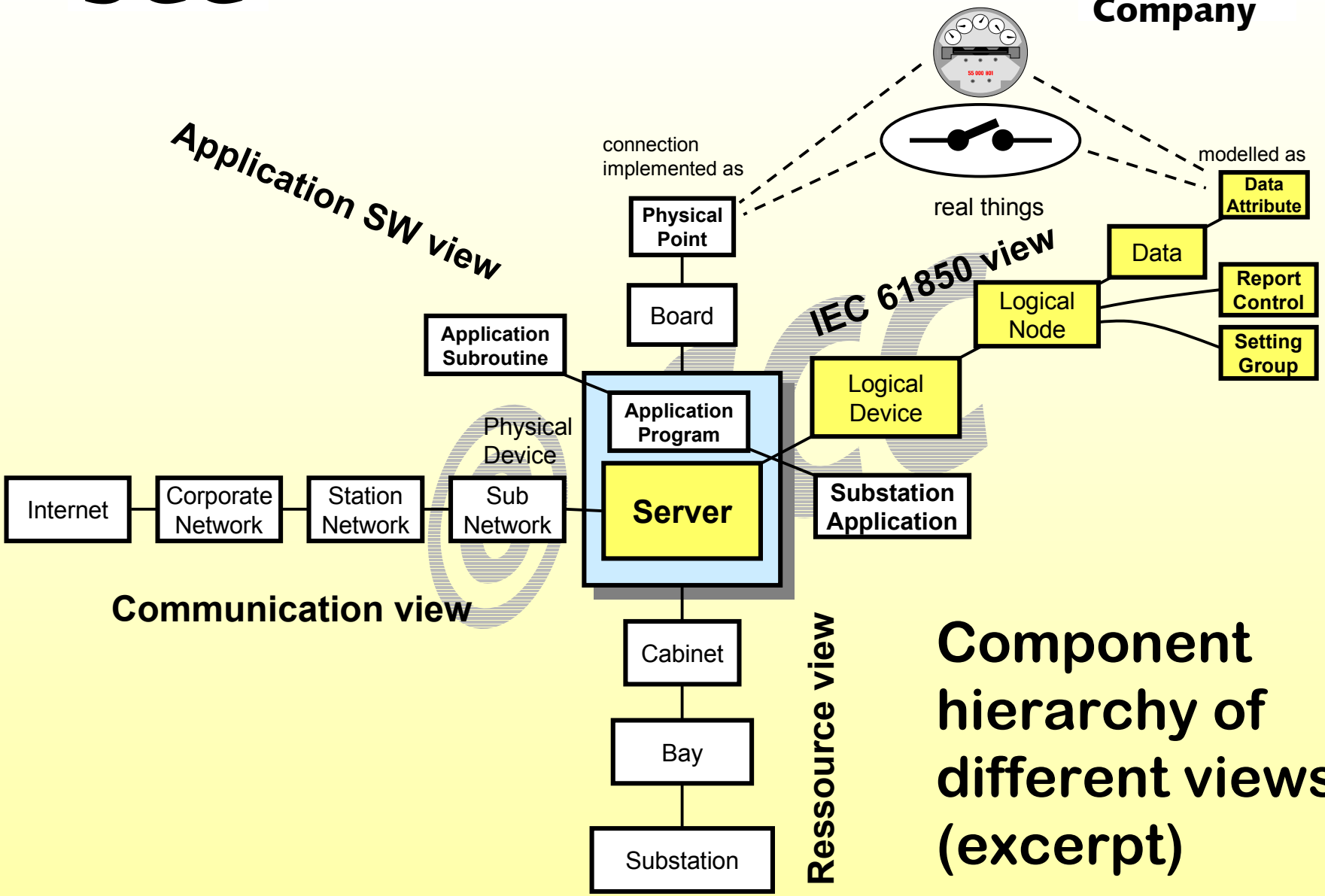


Interfaces IEC 61850 (7-2)



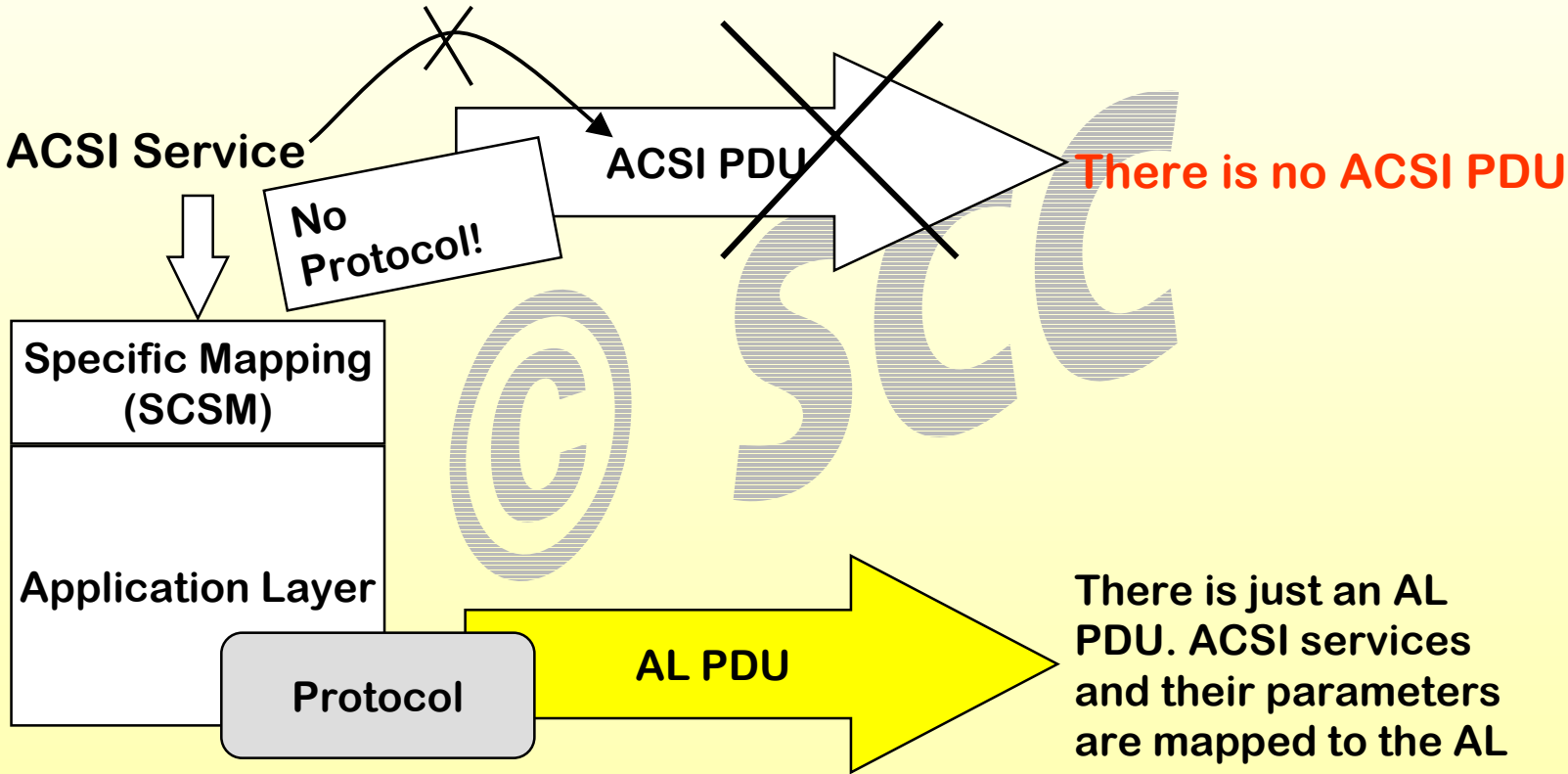
- Get, Set, ...
- Report, QueryLog, ...

- Generic object oriented system-wide events (GOOSE)
- Transmission of sampled values

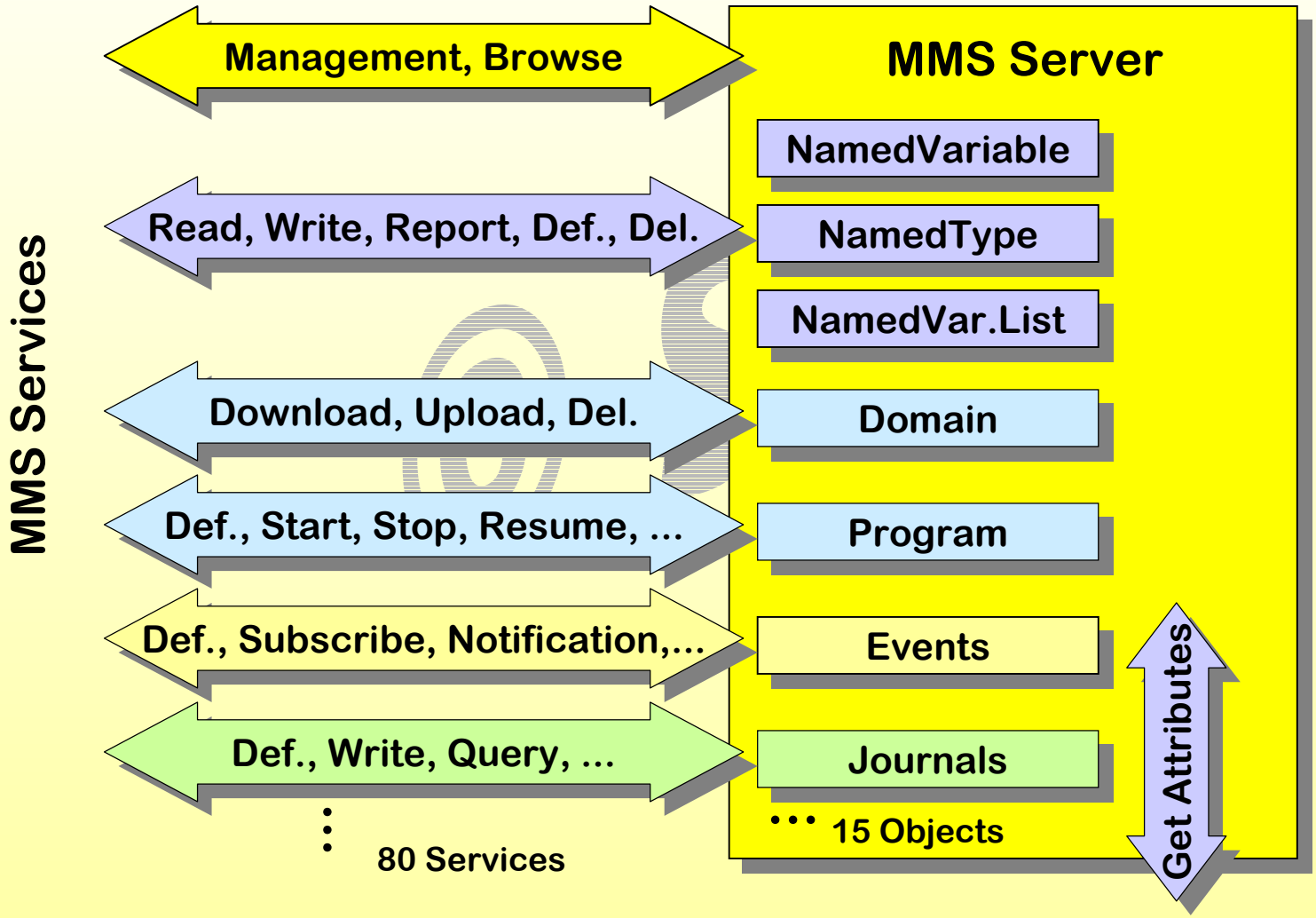


Component hierarchy of different views (excerpt)

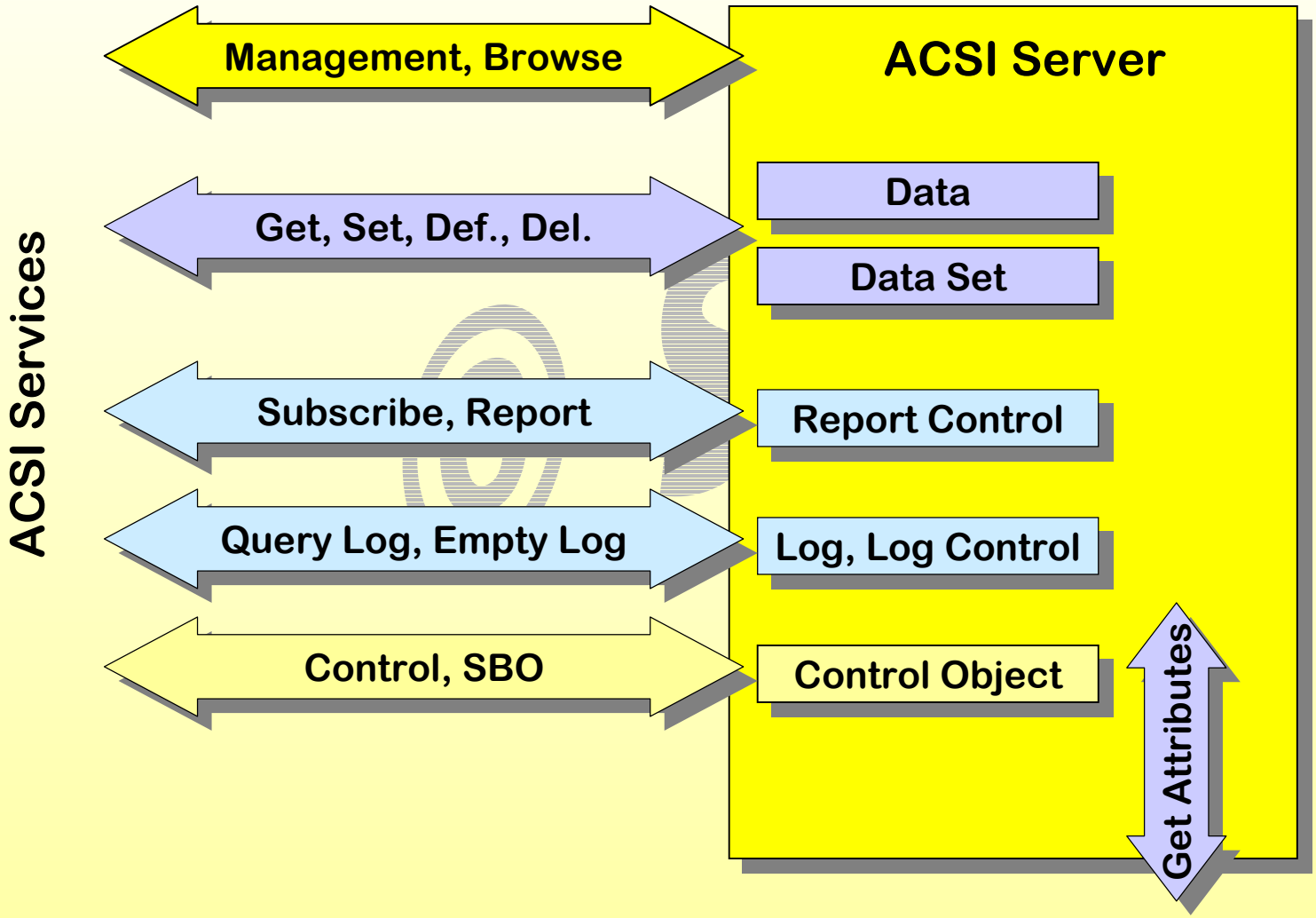
ACSI does not define PDUs



Manufacturing Message Specification (ISO/IEC 9506)



ACSI (Abstract communication service interface)



ACSI models and services (7-2) (1)

Service model	Description	Services
Server	Represents the external visible behaviour of a device. All other ACSI models are part of the server.	ServerDirectory
Application association	provision of how two or more devices can be connected. Provides different views to a device: restricted access to the server's information and functions.	Associate Abort Release
Logical device	Represents a group of functions; each function is defined as a logical node.	LogicalDeviceDirectory
Logical node	Represents a specific function of the substation system, e.g., overvoltage protection.	LogicalNodeDirectory
Data	Provides a means to specify typed information, e.g., position of a switch with quality information, and timestamp.	GetDataValues SetDataValues GetDataDefinition GetDataDirectory
Data set	Allow to group various data together.	GetDataSetValue SetDataSetValue CreateDataSet DeleteDataSet GetDataSetDirectory

ACSI models and services (7-2) (2)

Service model	Description	Services
Substitution	Supports to replace a process value by a manually entered value.	Substitute UnSubstitute
Setting group control	Defines how to switch from one set of setting values to another one and how to edit setting groups.	ActivateSG SetSGValues GetSGValues GetSGControl
Reporting and logging	Describes the conditions for generating reports and logs based on parameters set by the client. Reports may be triggered by changes of process data values (e.g., state change or deadband) or by quality changes. Logs can be queried for later retrieval. Reports may be send immediately or deferred (buffered). Reports provide change-of-state and sequence-of-events information exchange.	**Buffered report control**: Report AckReport GetReportControlValue SetReportControlValue **Unbuffered report control:** Report GetReportControlValue SetReportControlValue **Logging:** GetLogControlValue SetLogControlValue QueryLogByTime GetLogStatusValue QueryLogByEntry

ACSI models and services (7-2) (3)

Service model	Description	Services
Generic substation event model (GSE)	Provides the possibility for a fast and reliable system-wide distribution of input and output data values; peer-to-peer exchange of IED binary status information. *Includes the UCA™ GOOSE (=GSSE – generic substation state event) and Generic object oriented substation event (GOOSE – more common approch than the UCA GOOSE).*	**GOOSE and GSSE:** GetReference GetGSEElementNumber GetGSEControlValue SetGSEControlValue
Transmission of sampled values	Fast and cyclic transfer of samples, e.g., of instrument transformers.	**Multicast SMVC:** GetMSMVCValues SetMSMVCValues **Unicast SMVC:** GetUSMVCValue SetUSMVCValue GetNextUSMVC
Control	Describes the services to control, e.g., devices or parameter setting groups.	Select SelectWithValue Cancel Operate CommandTermination Synchrocheck TimeActivatedOperate
Time and time synchronisation	Provides the time base for the device and system.	
File transfer	defines the exchange of huge data blocks like programs.	GetFile SetFile DeleteFile FileDirectory

50

Characteristics of reporting and logging

- **timely reports** serve as an early indication to clients,
- **logging of events** for later retrieval (sequence-of-event),
- the impact on network bandwidth is **minimised**,
- sending reports only **when required** (controlled by several attributes),
- low frequency **integrity** scan and client initiated **general interrogation**.
- ***polling*** ***data values at any time (Get)***

Trigger options:

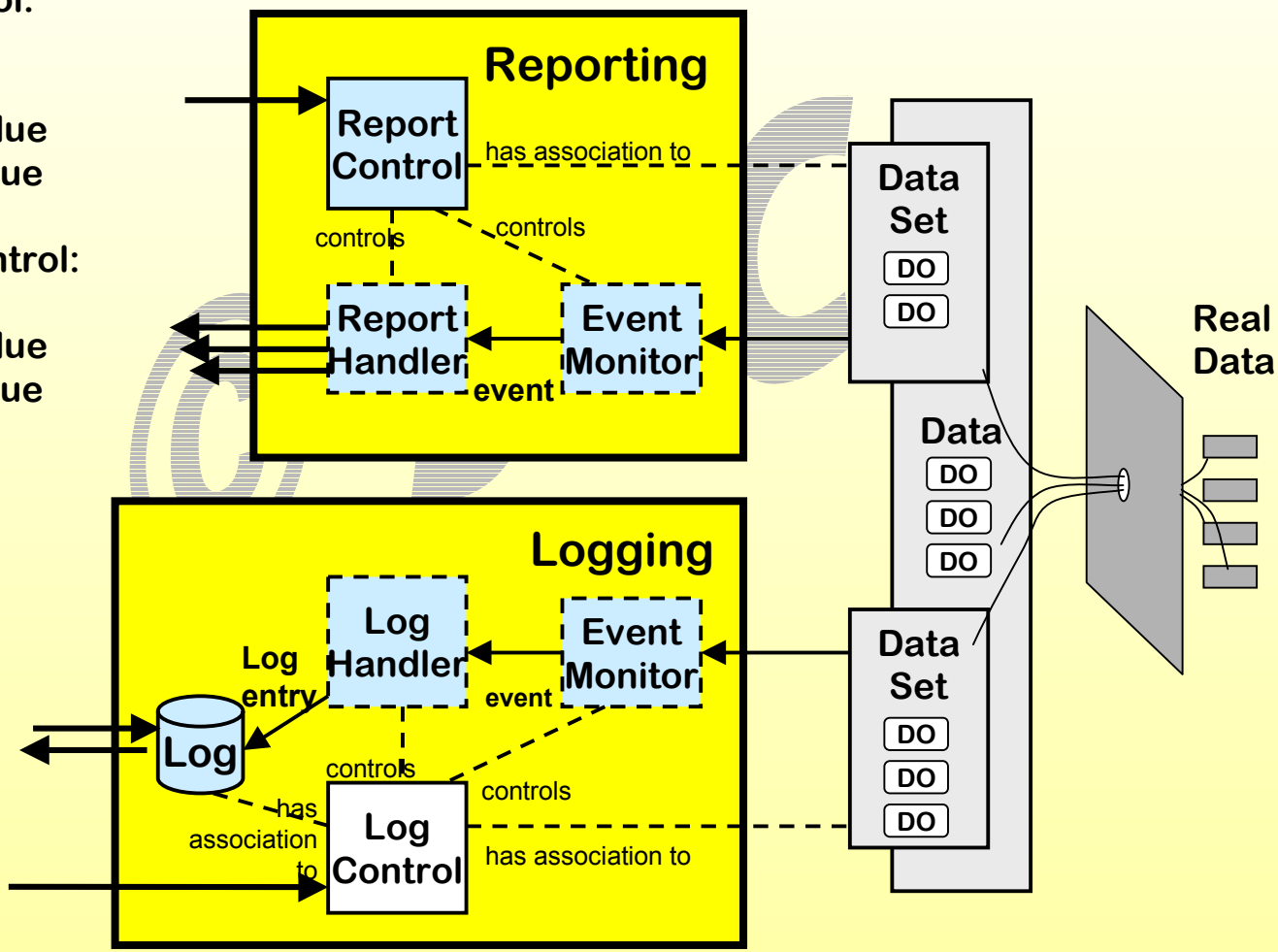
data-change
filtered-data-change
quality-change
cyclic-integrity
general-interrogation
data-set-directory

Basic building blocks for reporting and logging

Buffered report control:
- Report
- AckReport
- GetReportControlValue
- SetReportControlValue

Unbuffered report control:
- Report
- GetReportControlValue
- SetReportControlValue

Logging:
- GetLogControlValue
- SetLogControlValue
- QueryLogByTime
- GetLogStatusValue
- QueryLogByEntry



Buffered report control

Events (trigger options data-change and/or quality-change) are buffered (to some practical limit) for transmission, such that

data is not lost

due to transport flow control constraints or loss of connection.

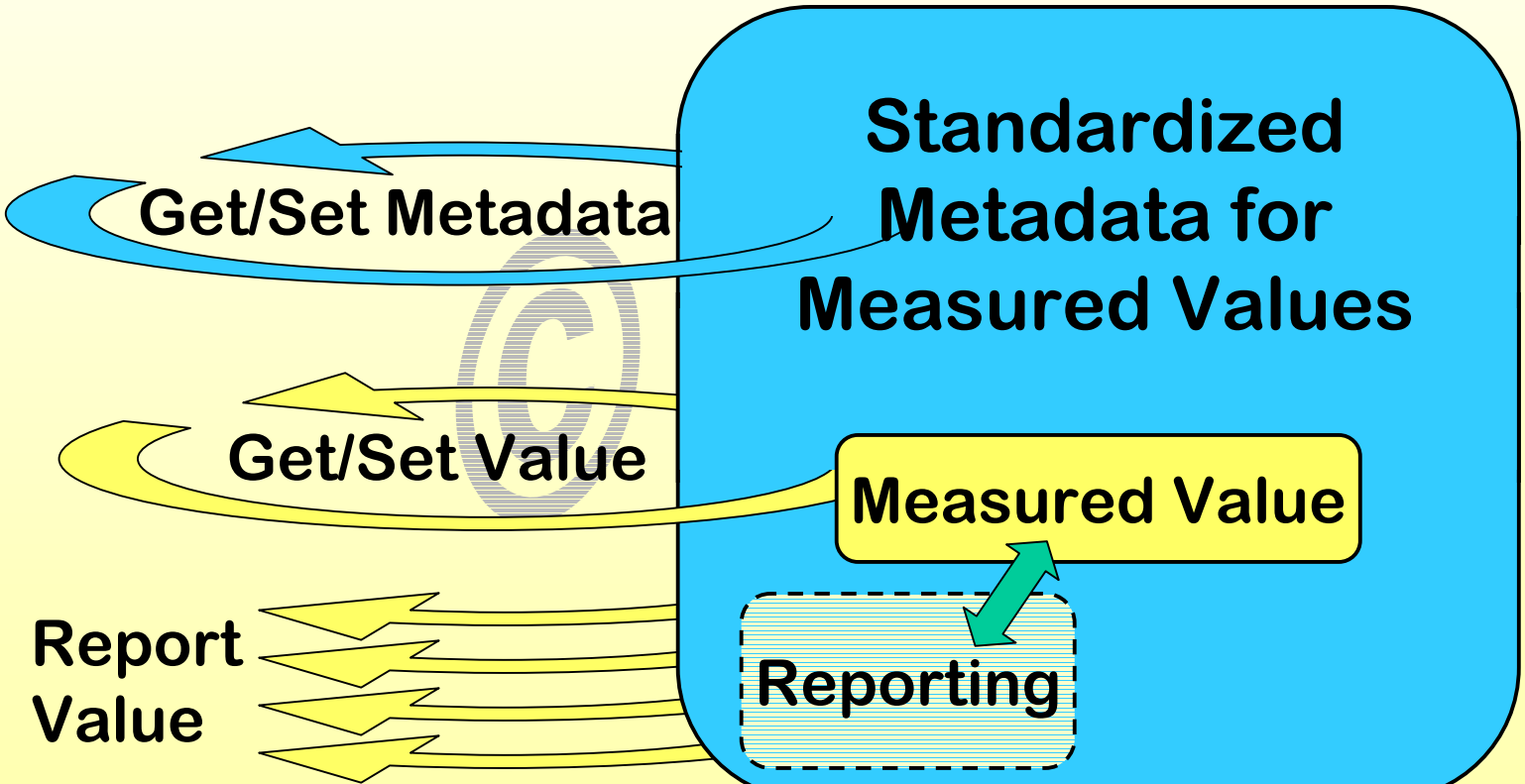
Unbuffered report control

Events are transmitted on a

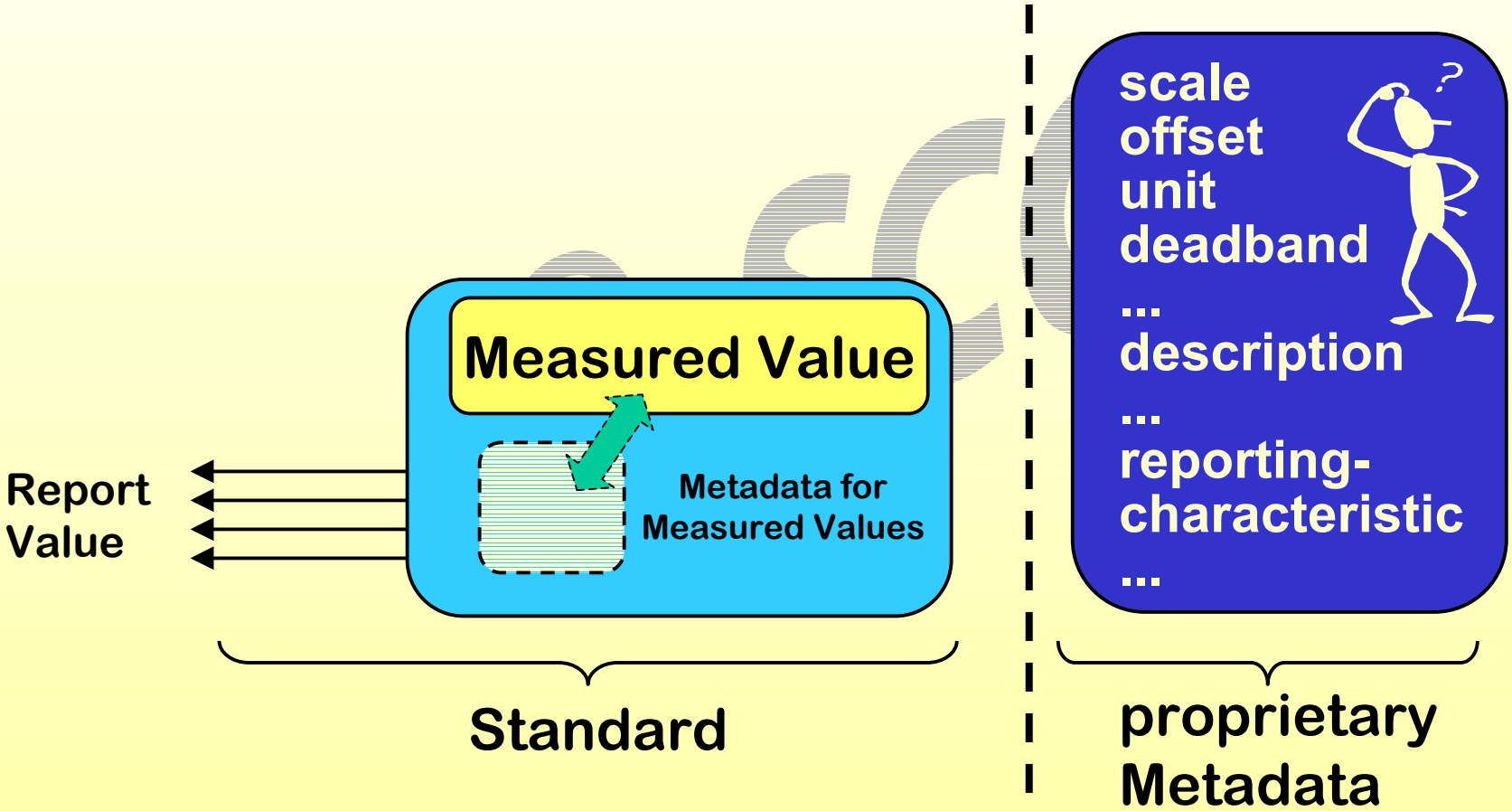
'best efforts' basis.

If no association exists, or if the transport data flow is not fast enough to support it, events may be lost.

Some UCA/IEC 61850 Metadata



IEC 60870-5-101 Metadata

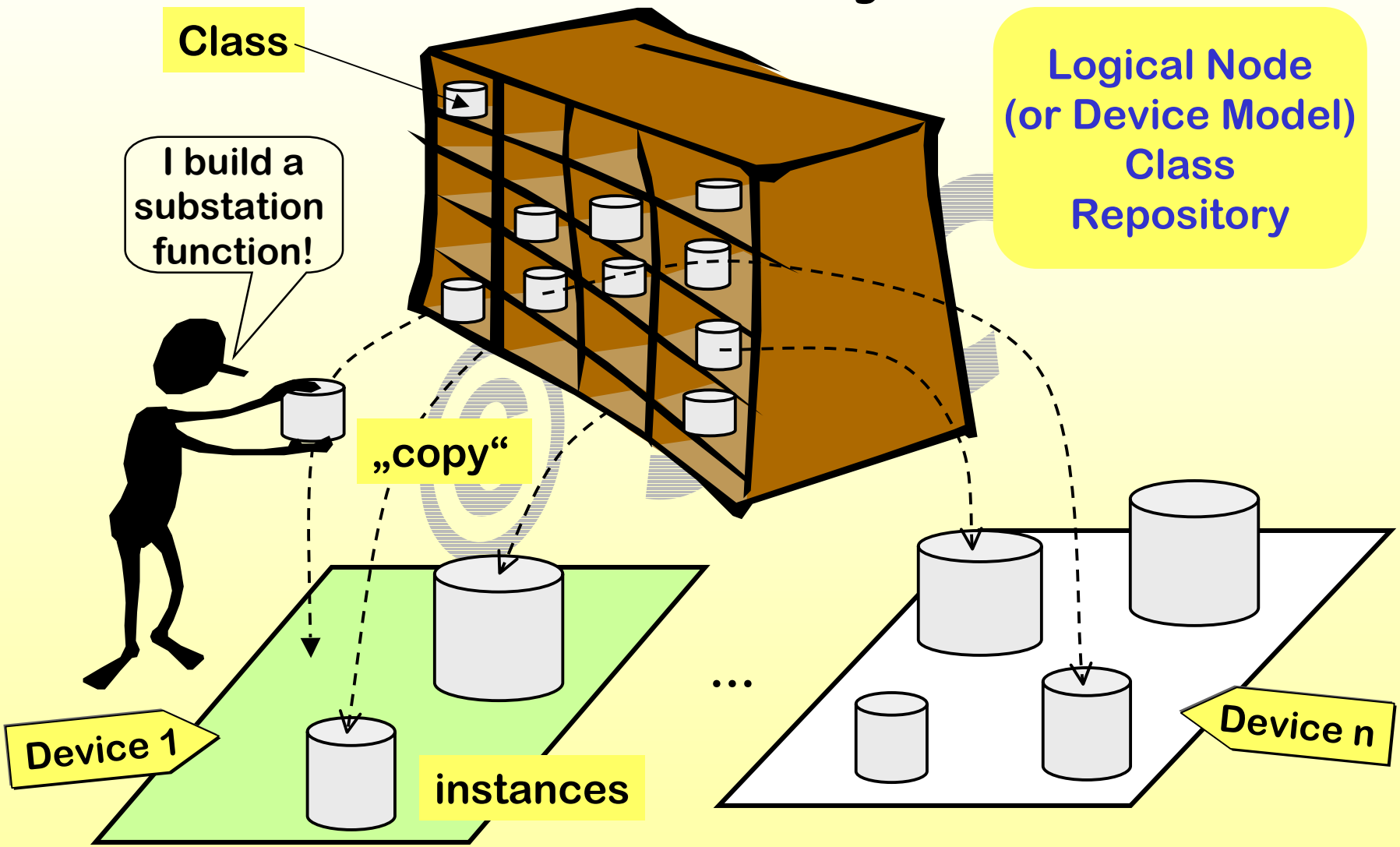


Comparison

Features	*870-5*	*TASE.1*	*UCA2* TASE.2	*UCA2* CASM/ GOMSFE
Application data and encoding	**Yes**	**Yes**	**Yes**	**Yes**
Basic data models and services	Limited and fixed		**very flexible, can add new**	
common and specific data structures and services	view	view	**some**	**many**
Data structures for device models	No	No	No	**many**
Device models	No	No	No	**many**

Building (server) devices

Re-usability



Embedded UCA and Internet Technology

- Sub-Credit card size PC
- JUMPtec DIMM-Concept
- Embedded LINUX
- Embedded UCA (IEEE TR1550)
- Embedded Web, ftp, telnet server
- 10 Mbps Ethernet (2nd board)
- TCP/IP
- basic services
- 350 Objects

UCA SW -> 200 Kbyte EXE (GNU compiler)

UCA2-konforme Software für embedded systems

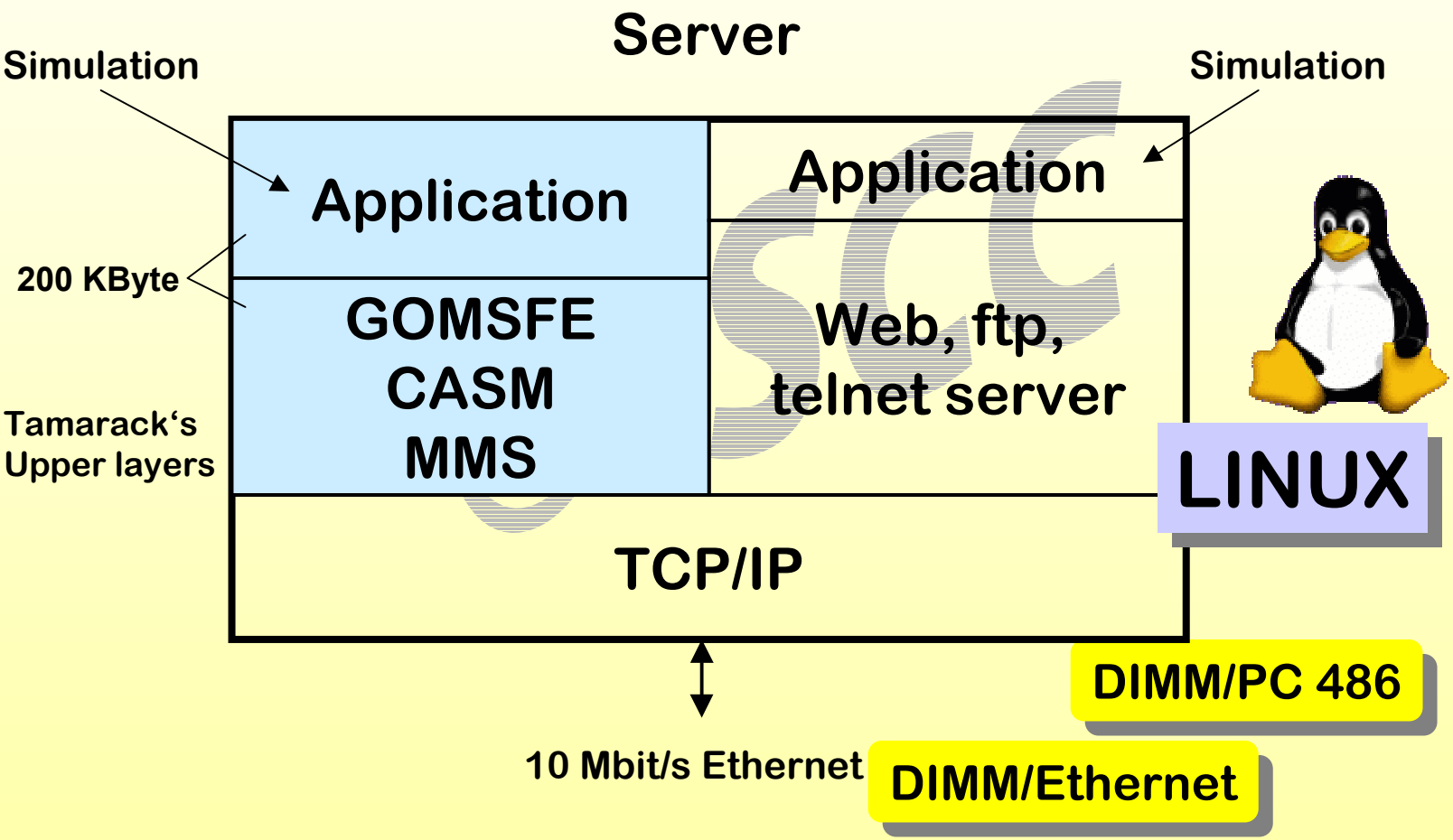
Component	Size
OSI Lower Layers	32K
Upper Layers and MMS	32K
CASM	13K
GOMSFE Model, Integration	2-5K
Total	**79-82K**

(mittlerer Funktionsumfang)

Main stream technologies applied

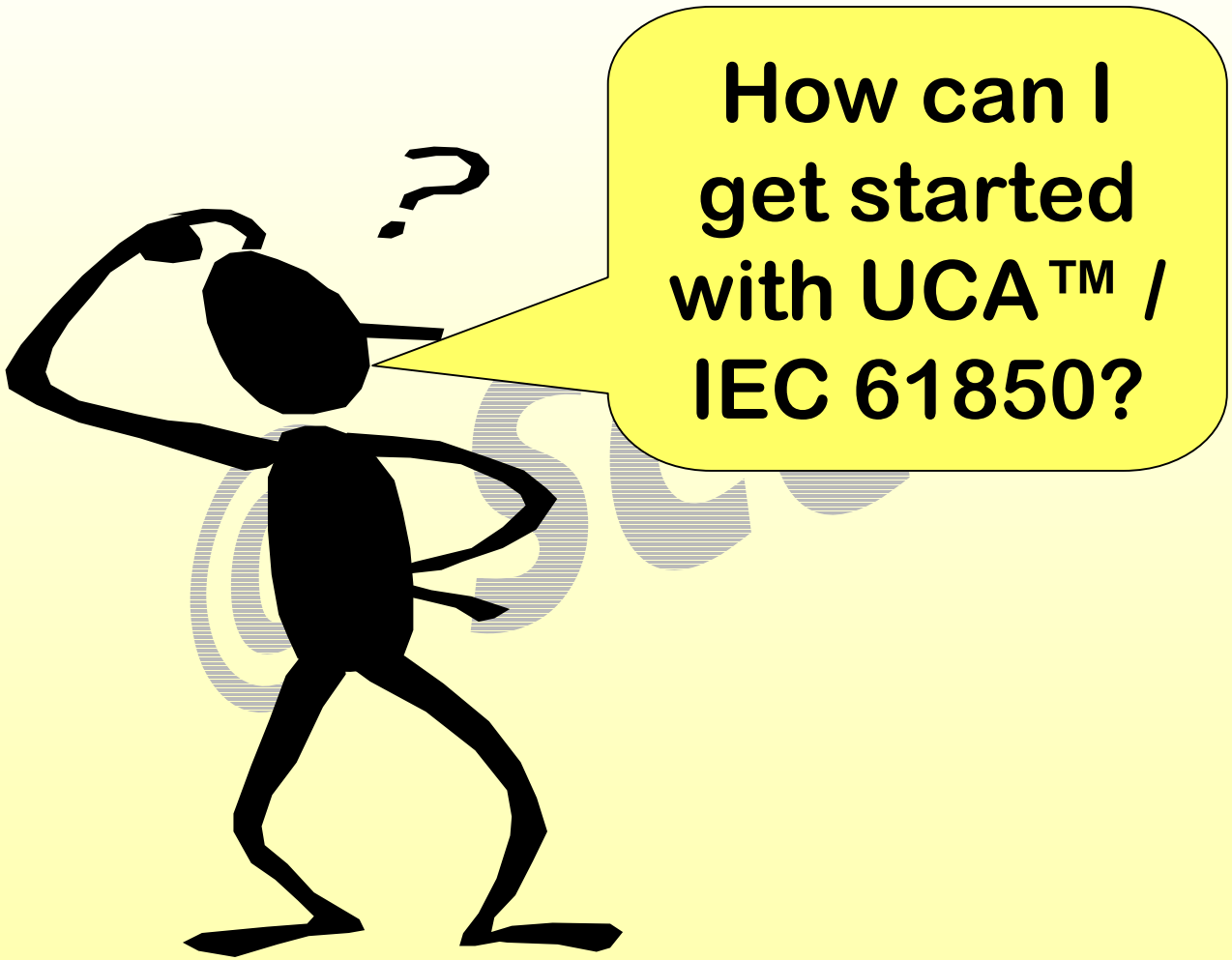
- UCA™
- TCP/IP, web, ftp, telnet, ...
- UML, XML
- LINUX, ...
- Highly integrated chips
- „Giga Technologies“ (Gbit/s, GHz, Gbyte)

Software Architektur



Possible Applications

- Gateways
- Embedded into IEDs (Intelligent Electronic Devices)
- RTUs (Remote Terminal Units)
- Tele-control
- PLCs (Programmable Logic Controllers)
- PCs (Personal Computers)



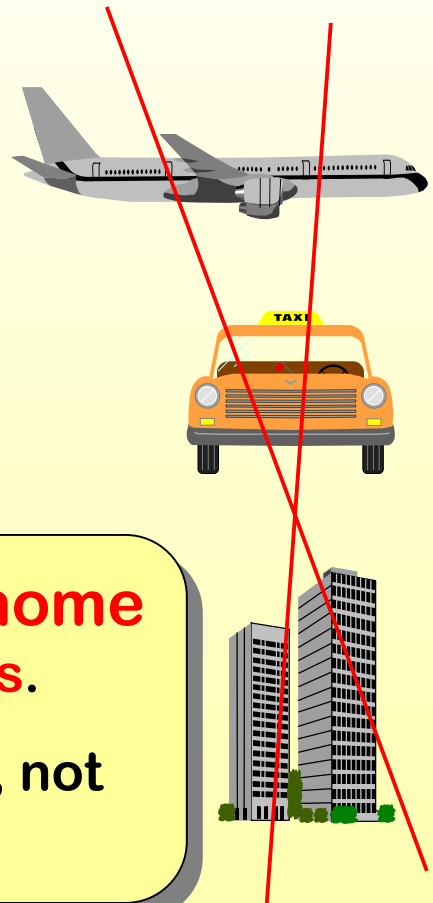
UCA/IEC 61850 Evaluation Kit

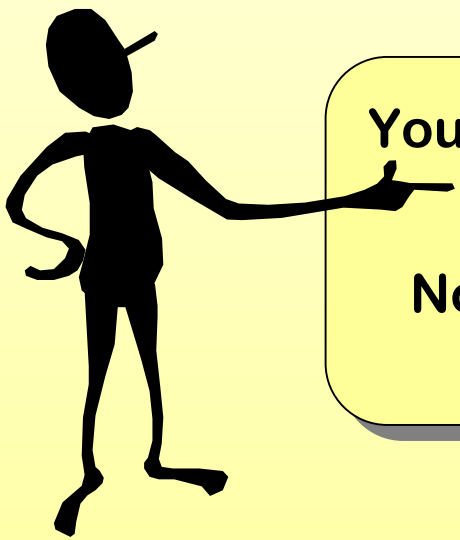
NettedAutomation and EPRI offer an comprehensive

UCA™/IEC 61850 and MMS

Evaluation Kit

for the **best possible start.**





You can **stay in your office** or **at home** and try it – **between your own PCs**.

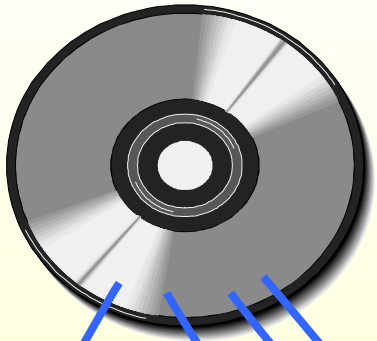
Not traveling, not staying at a hotel, not sitting in a seminar, ... !

UCA™/IEC 61850 and MMS Evaluation Kit CD-ROM

- UCA™/IEC 61850 and MMS servers
- UCA™/IEC 61850 and MMS clients
- UCA™/IEC 61850 and MMS analyzer
- Documentation
- UCA™ 1.0 and 2.0 (IEEE TR 1550)
- UCA™/IEC 61850 Tutorial
- User Forum on the Evaluation Kit
- Telephone service

www.nettedautomation.com/solutions/uca/evalkit/

EvalKit Use



UCA™/IEC 61850 and MMS Evaluation Kit (NettedAutomation)

UCA Client (SISCO)

UCA Server (Tamarack)

UCA Server (Tamarack)

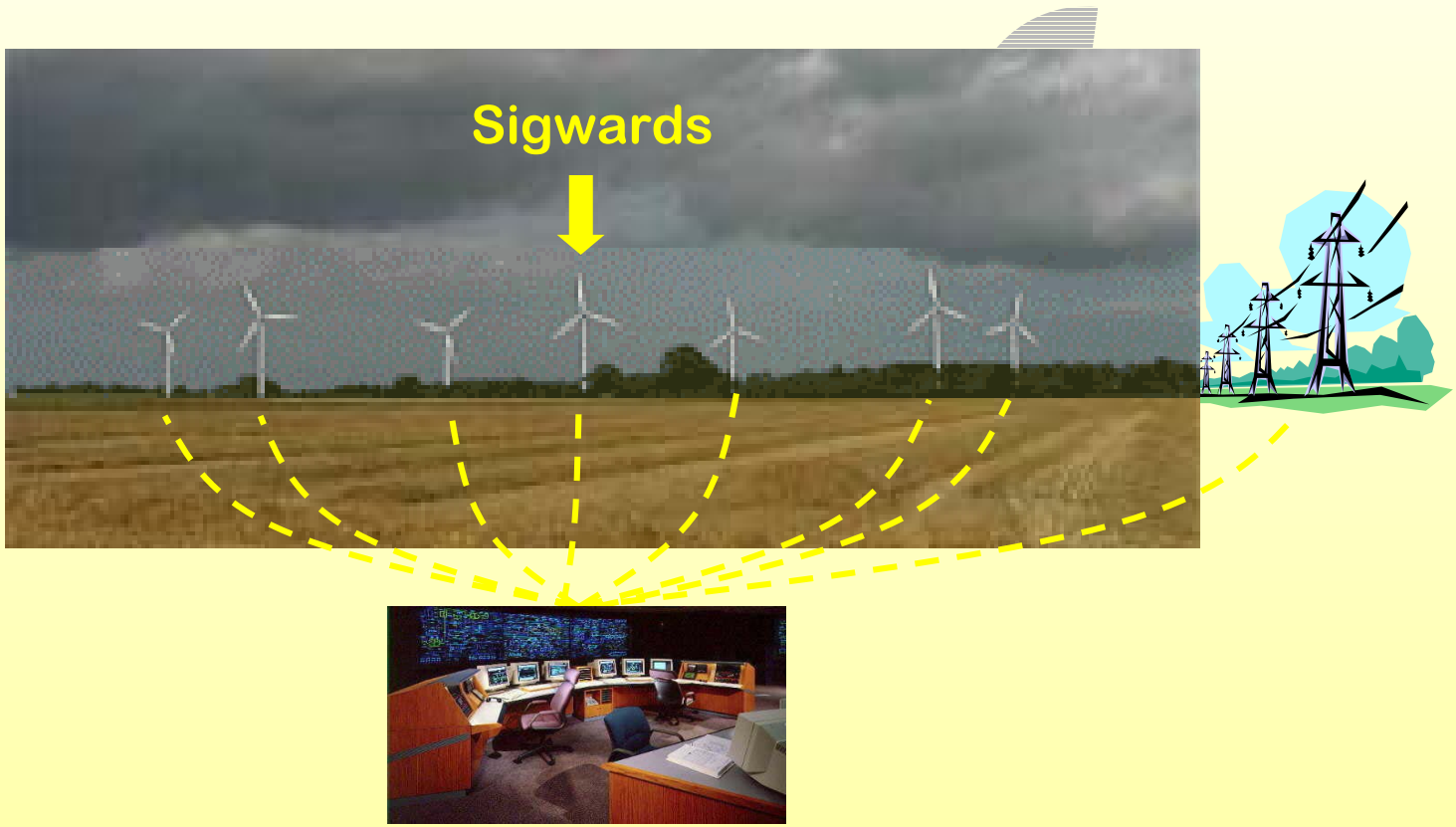
LINUX box

TCP/IP

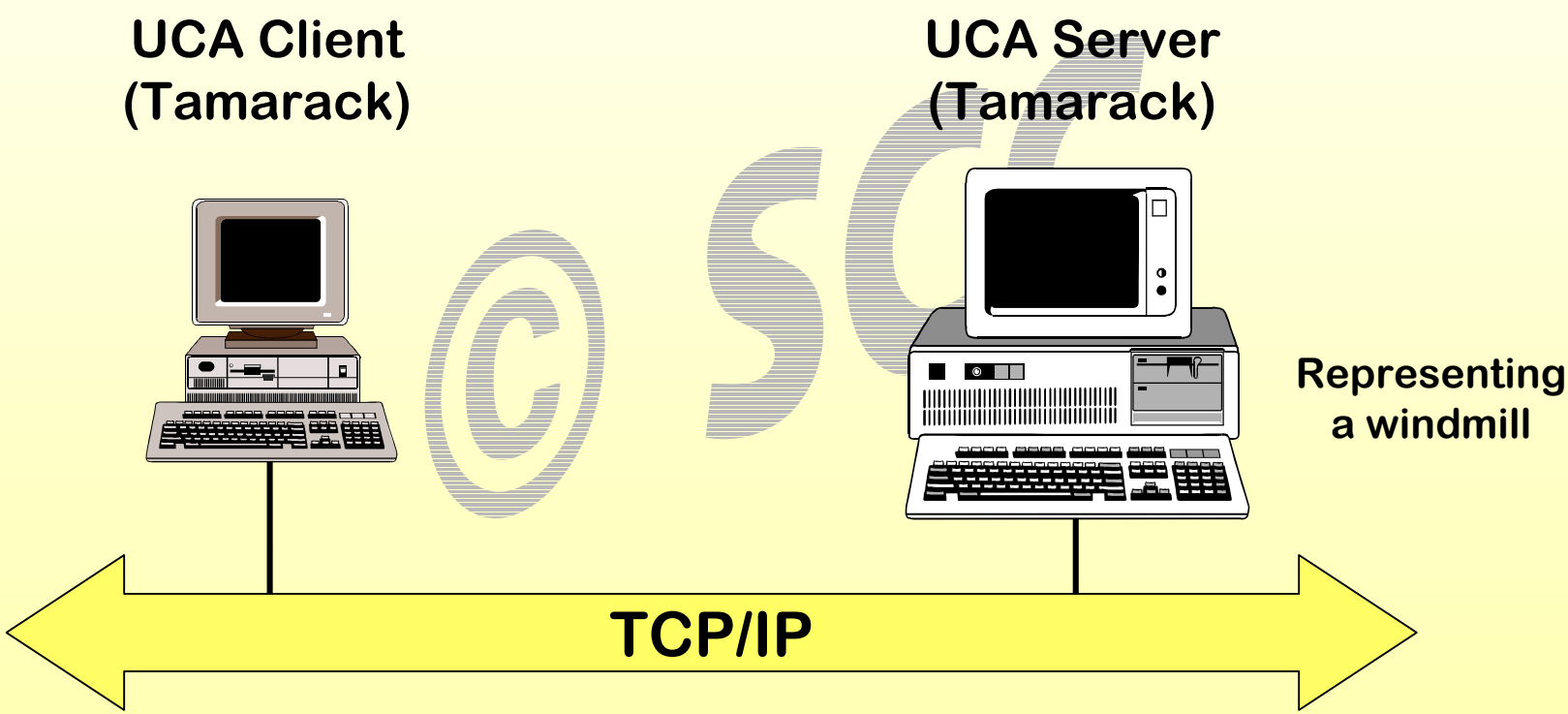
Analyzer (KEMA Connect)

Demonstration of UCA/IEC61850 software provided by Tamarack and NettedAutomation

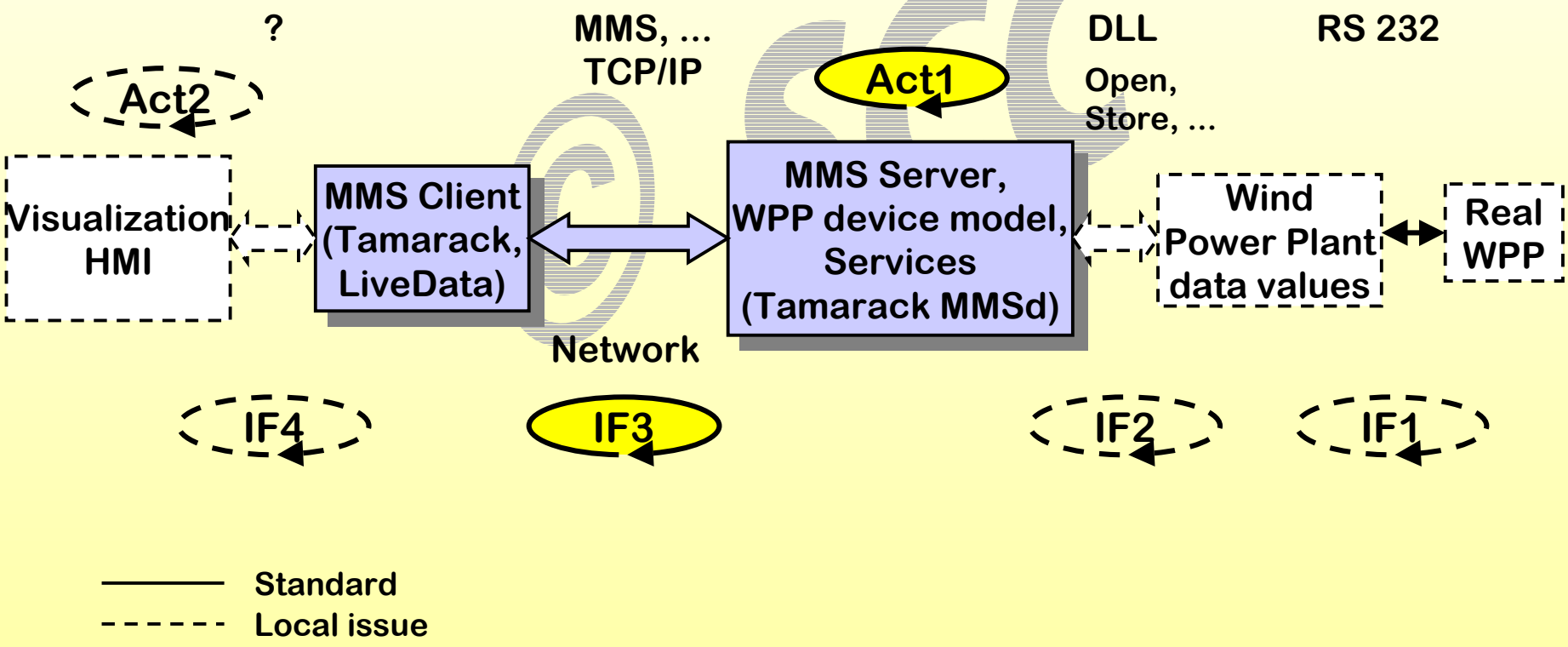
SCADA for Wind Power Plants



Test topology



What is provided?



Wind power plant model

Wind generator

…

Measurands (MX)	Name
Generator speed	*GenSpeed*
Duty factor sent to gen.	*DFacSToGen*
	Slip
	GenA
	GenBeTemp
	GenTemp
	Gen2Temp

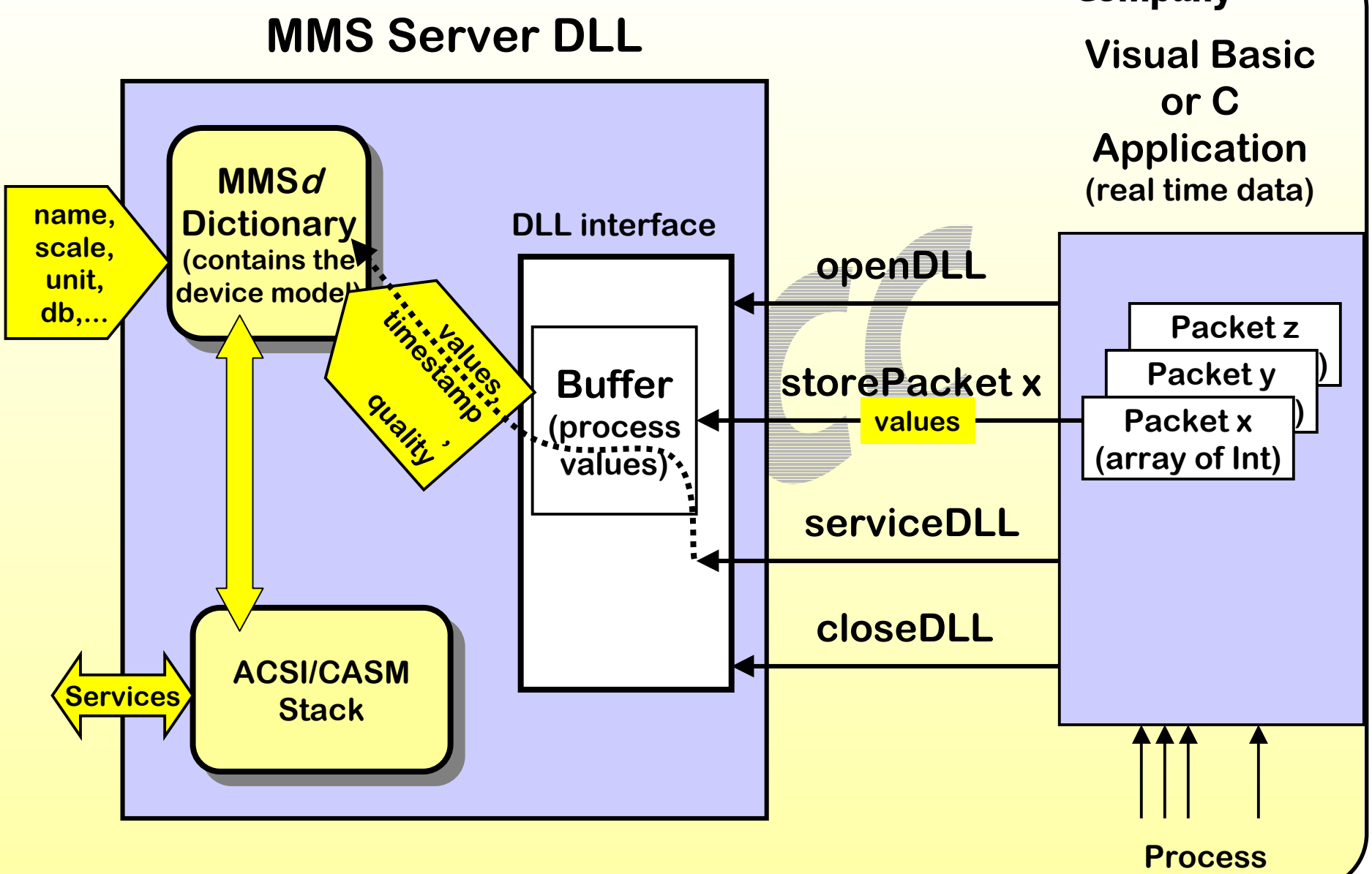
Wind turbine

Measurands (MX)	Name
Energy G1	*MX.WhG1*
Energy G2	*MX.WhG2*
Energy consumption	*MX.WhConspt*
Total time	*MX.TimeTotal*
Time G1	*MX.TimeG1*
Time G2	*MX.TimeG2*
Time with fault status	*MX.TimeFltSt*
Time with grid ok	*MX.TimeGridOk*
Time with wind for prod	*MX.TimeWndProd*

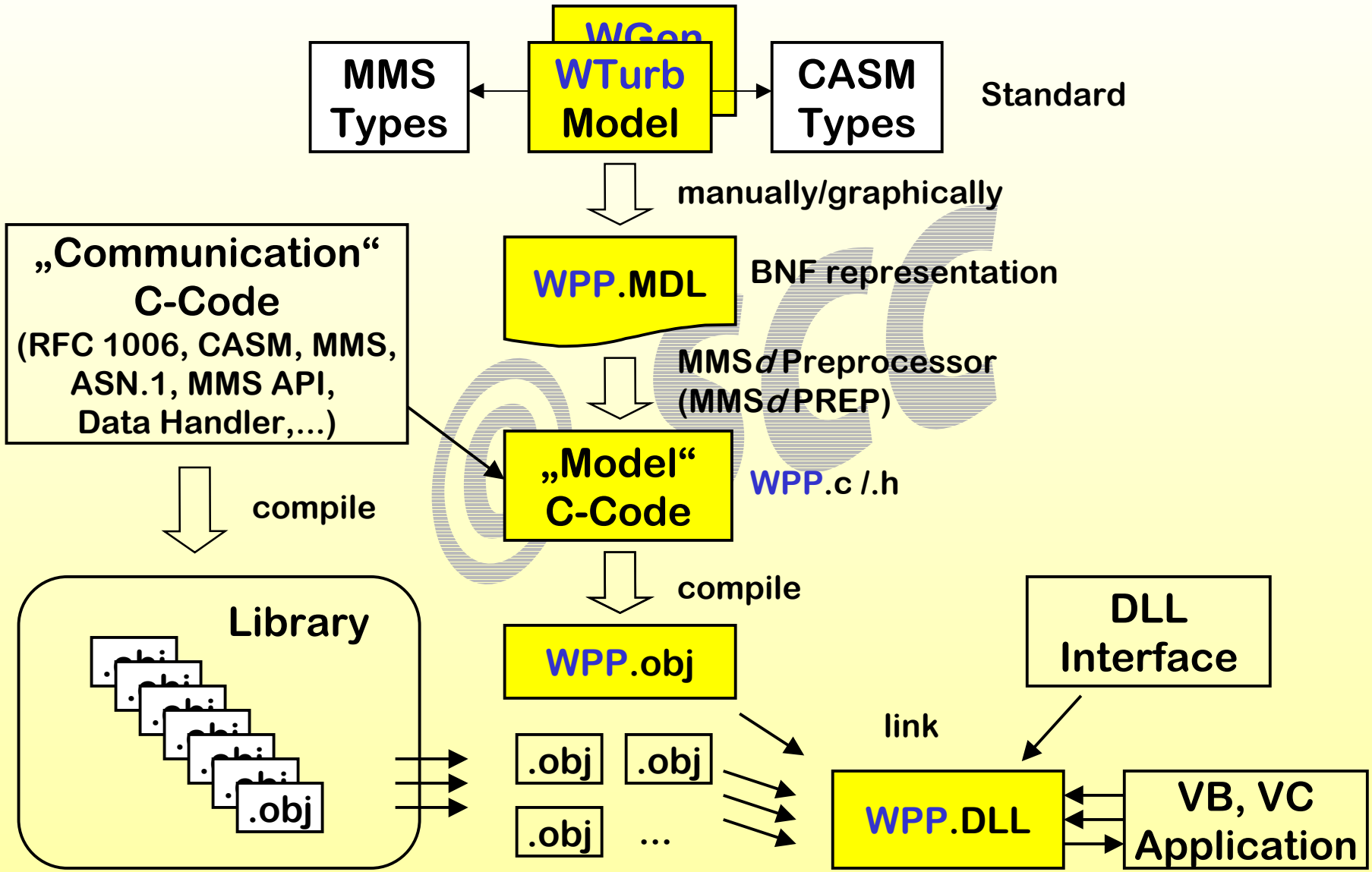
Wind generator

LN: Wind generator **Name: WGen**

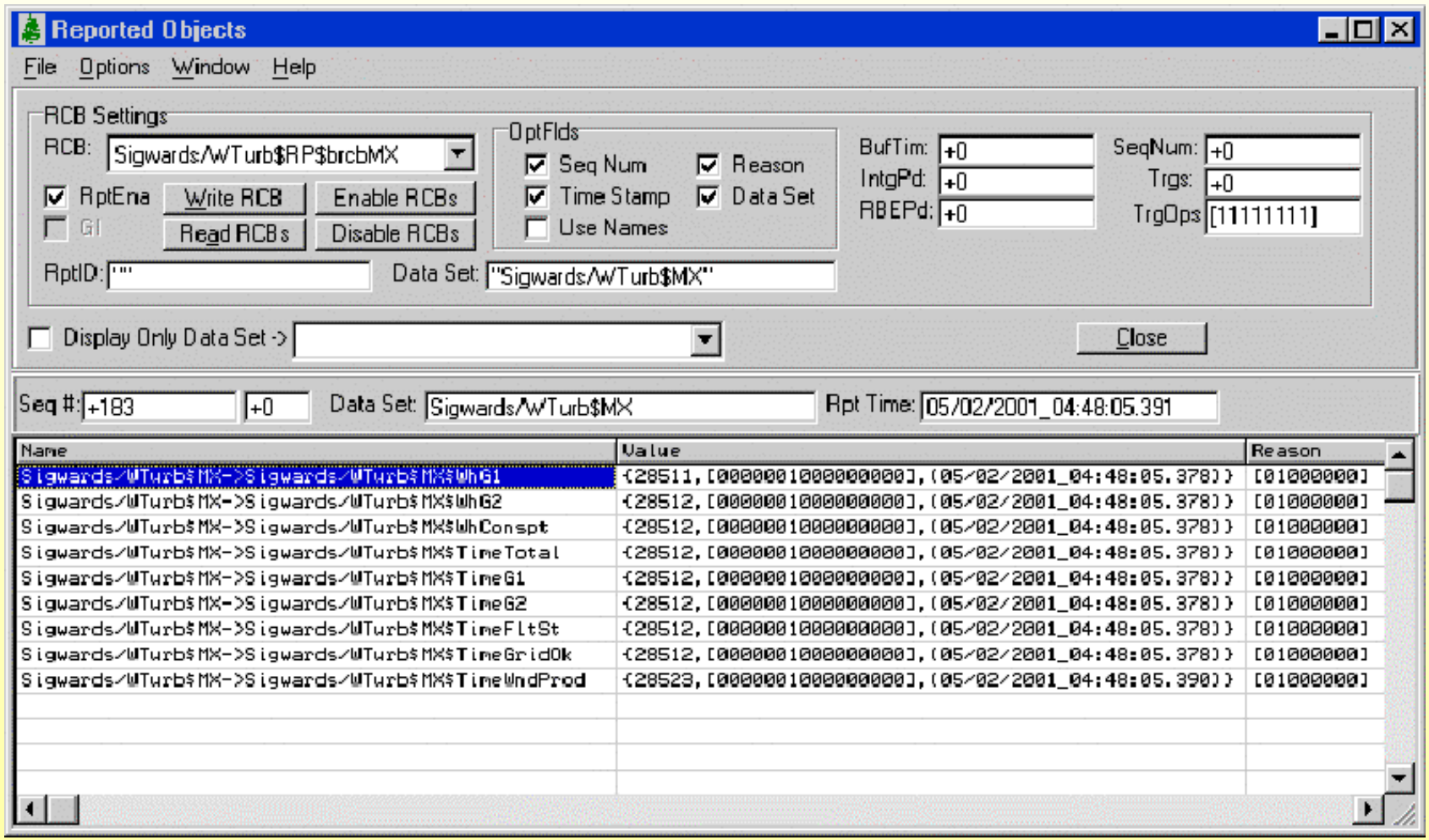
Data Description	Data Class Name	CDC	M/O	Unit	Scale
Table 2 – Basic Logical Node information					
Mode	Mode	ISC	M		
Behaviour	Beh	ISI	M		
Health	Health	ISI	M		
Name plate	Name	PLATE	M		
Resetable operation counter	OperCntRs	ISC	O		
Table 4 – Measurands					
Generator speed	GenSpeed	MV	M	rpm	1
Duty factor sent to generator	DFacSToGen	MV	M		
Slip	Slip	MV	M	%	0,1
Gen current (Weier)	GenA	MV	M	A	0,1
Gen bearing temp	GenBeTemp	MV	M	°C	1
Generator temp	GenTemp	MV	M	°C	1
Generator 2 temp	Gen2Temp	MV	M	°C	1
Table 8 – Status information					
Thyristor opening	Tyropen	SPS	M		
Generator connected	GenCon	SPS	M		
Heat generator (order)	HeatGen	SPS	M		
Status word from Weier	SWW	ISI	M		



Tamarack's approach (example)



Wind generator Reports



UCA Substation Initiative (UCA Users Group*)

* starts in September 2001

UCA Users Group

The UCA(tm) Users Group has now been incorporated as a Not-For-Profit, Engineering organization. At this time, the Users Group has 8 founding members: AEP, BPA, Cinergy, ComEd, Coned, NSP, TECO and KC Associates.

It is planned to have the first meeting of the Users Group to vote for the Board of Directors and start formal operation 20-21 September 2001 at the Substation Initiative Meeting in Madison, Wisconsin (USA).

UCA Users Group

- Proactively set the direction for future UCA technology
- Vote on new UCA content and changes
- Leverage expenditures for development, testing and problem solving
- Provide proactive input to standards making bodies
- Develop a test methodology
- Develop utility site tests and procedures.
- Coordinate technology transfer through user/vendor test groups, meetings, workshops and document sharing

UCA Substation Initiative Utilities

- American Electric Power
- Arizona Electric Power Cooperative
- Ameren
- Boston Edison
- Baltimore Gas & Electric
- Bonneville Power Administration
- Cinergy
- CFE - Mexico
- ComEd
- ConEd
- Duke
- Duquesne Light and Power
- ESKOM
- Florida Power Corp
- GPU Energy
- Indianapolis Power & Light
- National Grid Co
- Northern States Power
- NUON
- Ontario Hydro
- Potomac Edison Power Co
- Pennsylvania Power and Light
- Southern California Edison
- Tampa Electric
- Texas Utilities
- Tennessee Valley Authority
- VEW
- ...

> 1/3 of North American Market

UCA Substation Initiative Vendors

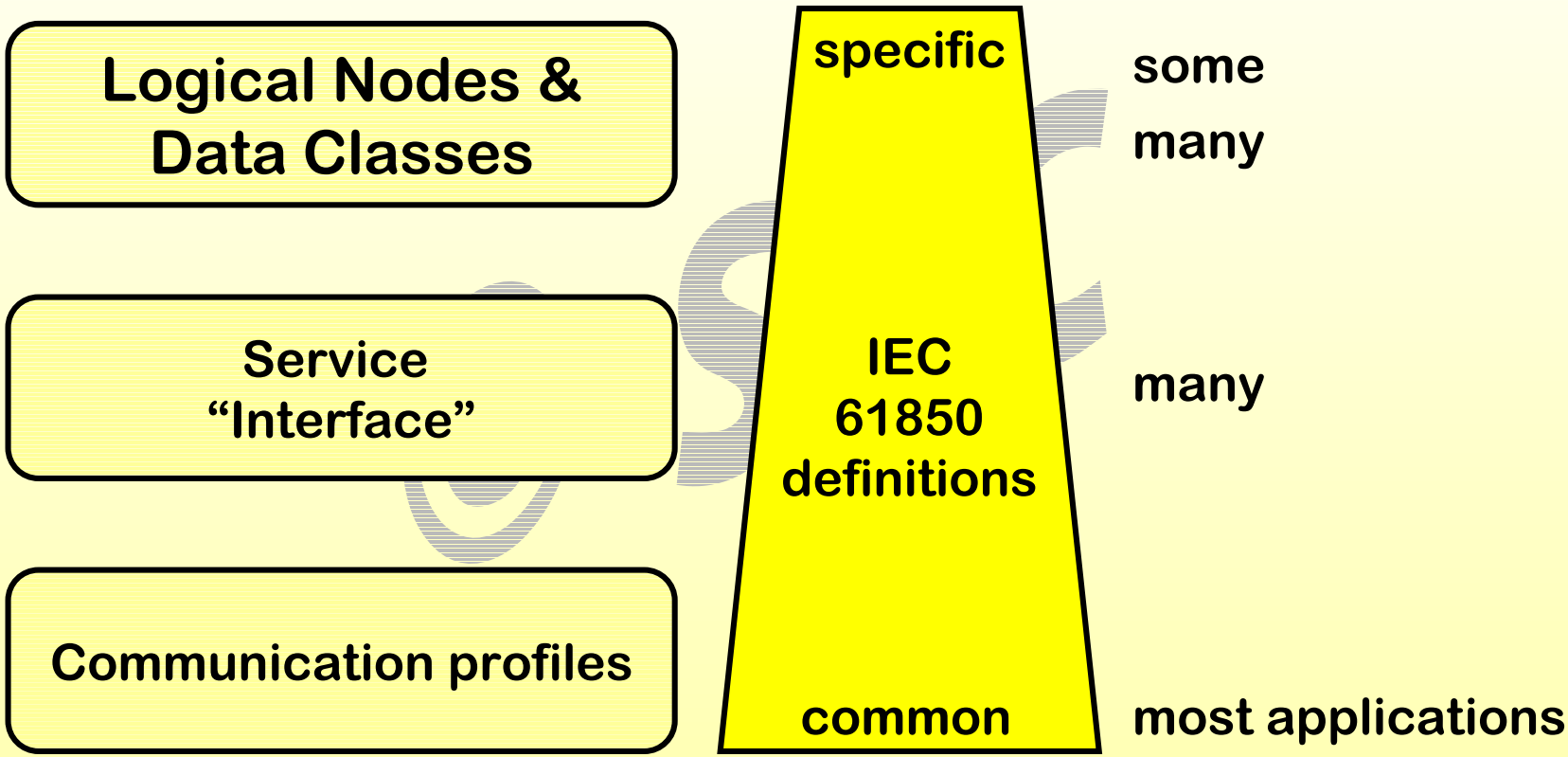
- ABB
- Basler
- Beckwith
- Bitronics
- Cooper Power Systems
- Doble Instruments
- Dranetz/BMI
- Electrotech
- Alstom
- GE/Multilin Protection Sytems
- GE/Harris Energy Systems
- Telegyr
- Schneider Electric
- Schweitzer Engineering Labs
- Siemens
- Tasnet
- RFL
- Omicron
- Avo International
- Bailey Control Networks
- QEI Inc
- Toshiba
- Mitsubishi
- ...

Summary

- Standard DATA / (DEVICE) MODELS
- Standard IT solutions
- Paradigm shift - signals to functions

- Easy data integration / maintenance
- Reduces costs in system life cycle
- Applicable in almost all industries

IEC 61850 can be used for ...



... most industrial automation domains

Questions ?

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www.nettedautomation.com