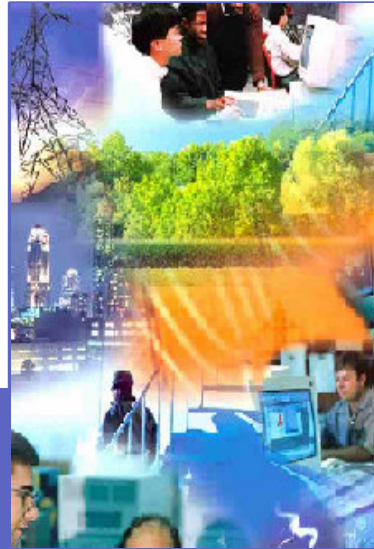




Klaus-Peter Brand

April 2006



Data Model of the Standard IEC 61850



IEC 61850

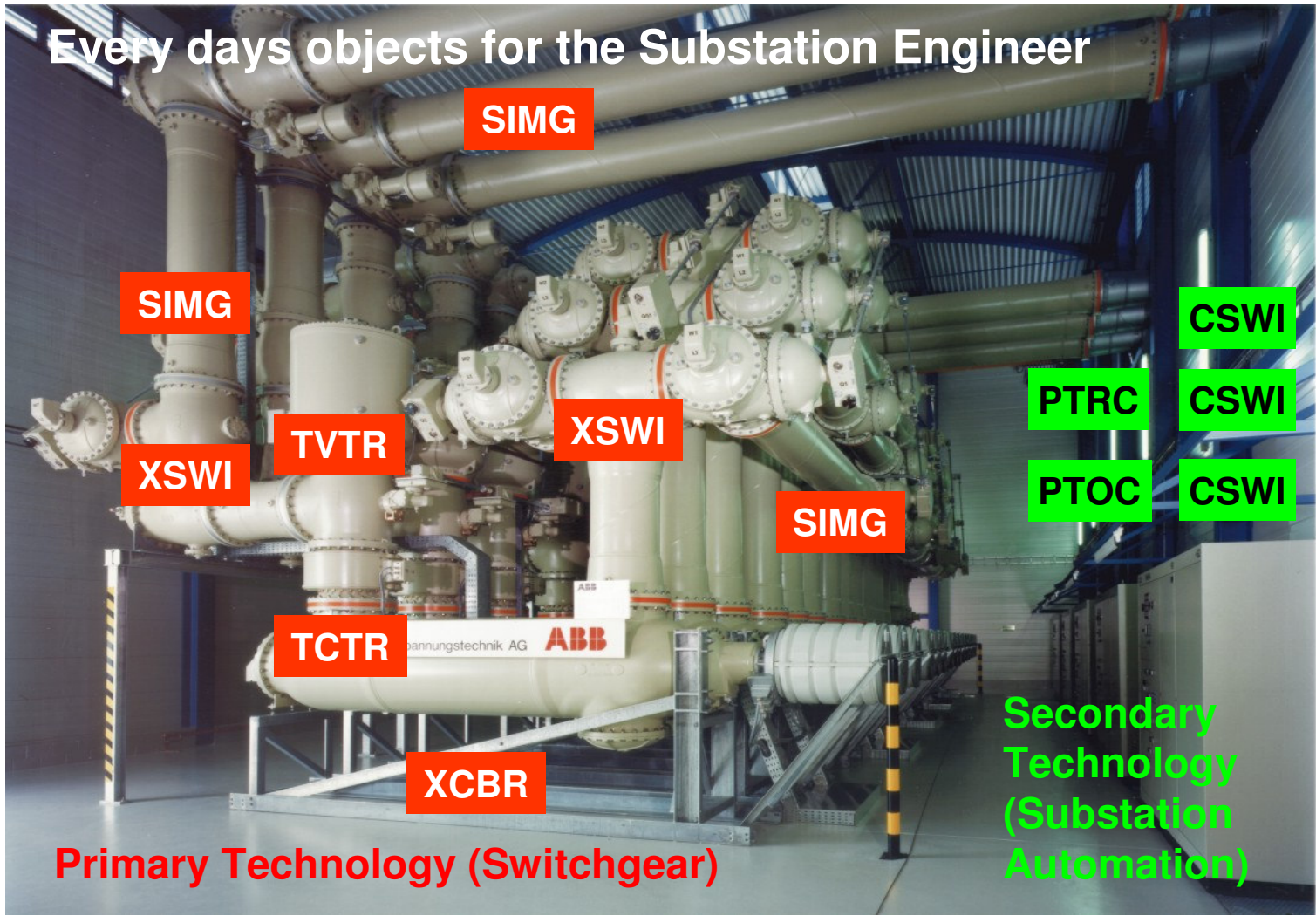
The Data Model

Refers to IEC 61850-7-y

- ❑ **Objects and Logical Nodes**
- ❑ **Hierarchical Data Model**
- ❑ **Communication Services**



User-near, object oriented Data model



Example :
Object
Current
Breaker
XCBR
What
data
belong to
this object ?

These
Objects
are called
**Logical
Nodes.**



Communication relations between functions in a Substation Automation System

- Information is exchanged between all **devices** which comprise the system
- More precisely, data are exchanged between the **functions** and **sub-functions** residing in the devices
- The smallest part of the **function** that exchanges data is called **Logical Node (LN)** in IEC 61850. The LN performs some operations for the overall function

Functions are not standardized ?



Exchanged Data in Substation Automation System

- More precisely, data are exchanged between the **functions** and **sub-functions** residing in the devices
- The **exchanged data** are grouped to into objects belonging to functions
- The objects called **Logical Node (LN)** may be seen as **Containers** containing the data provided by a dedicated function for exchange (communication)
- The **Name of the Logical Node** may be seen as a **Label** attached to this container

Functions are not standardized !



Naming and Groups of LNs

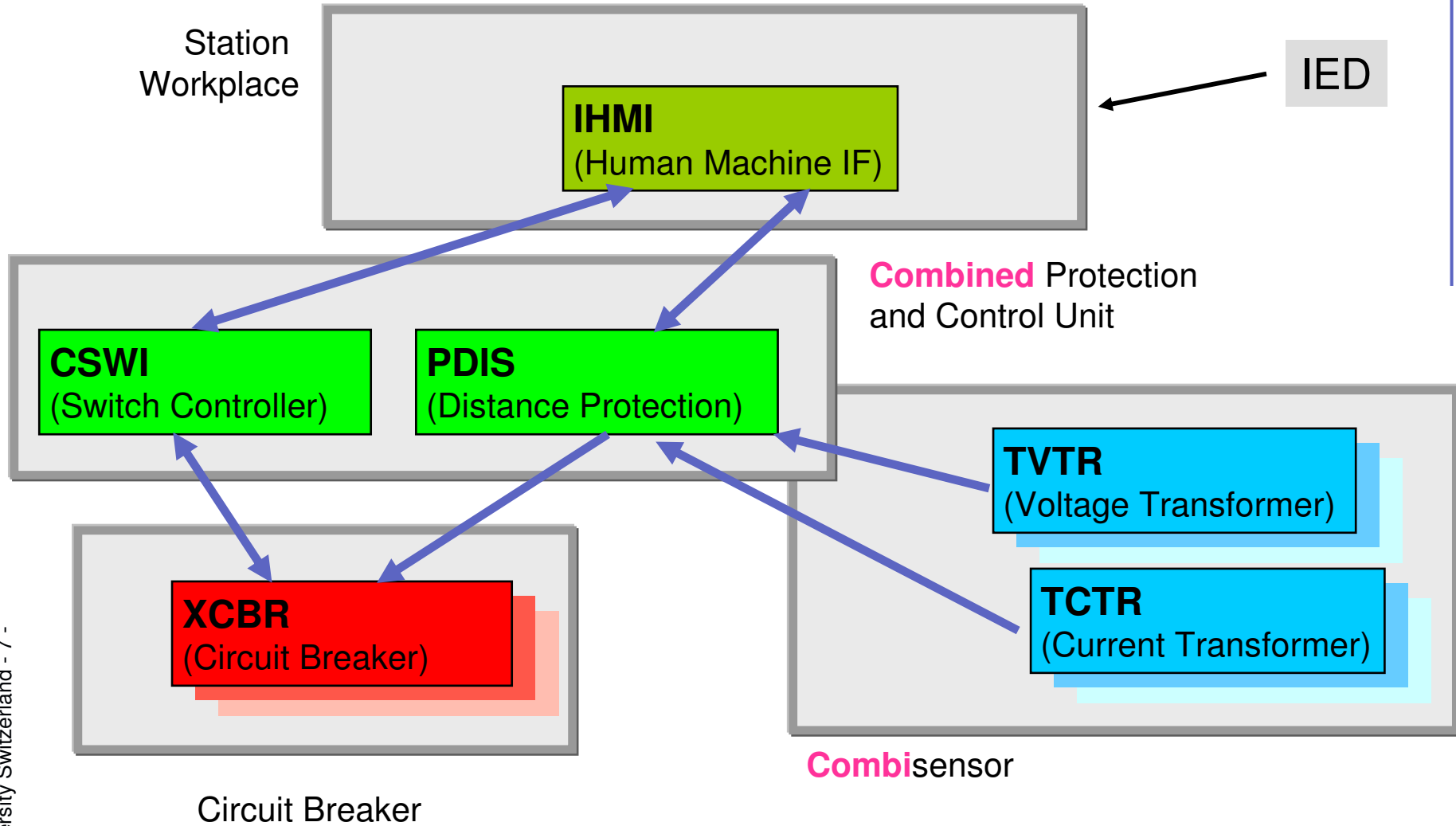
- **L** System LN (2)
- **P** Protection (28)
- **R** Protection related (10)
- **C** Control (5)
- **G** Generic (3)
- **I** Interfacing and archiving (4)
- **A** Automatic control (4)
- **M** Metering and measurement (8)
- **S** Sensor and monitoring (4)
- **X** Switchgear (2)
- **T** Instrument transformers (2)
- **Y** Power transformers (4)
- **Z** Further power system equipment (15)

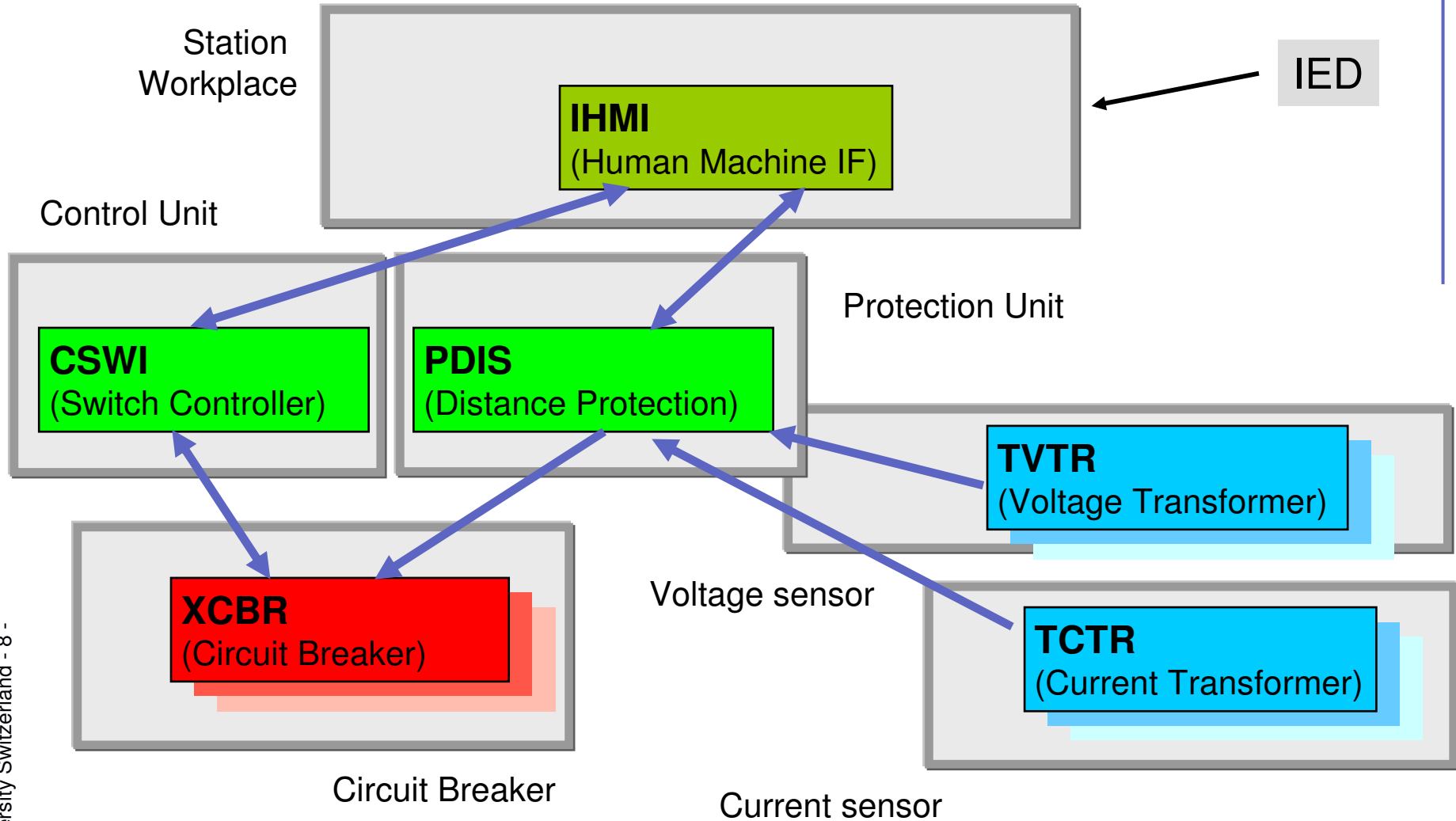
Examples

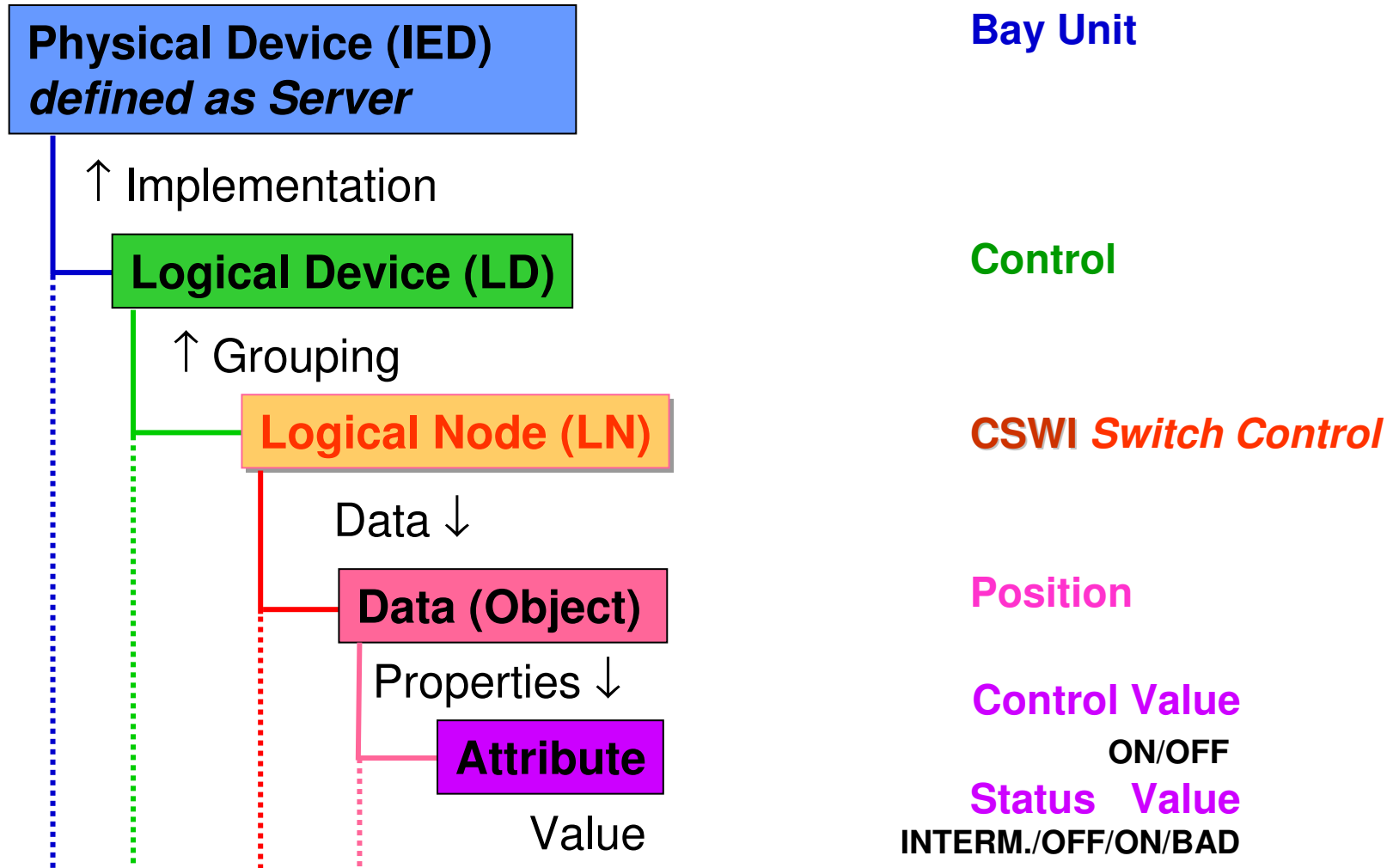
- *PDIF: Differential protection*
- *RBRF: Breaker failure*
- *XCBR: Circuit breaker*
- *CSWI: Switch controller*
- *MMXU: Measurement unit*
- *YPTR: Power transformer*



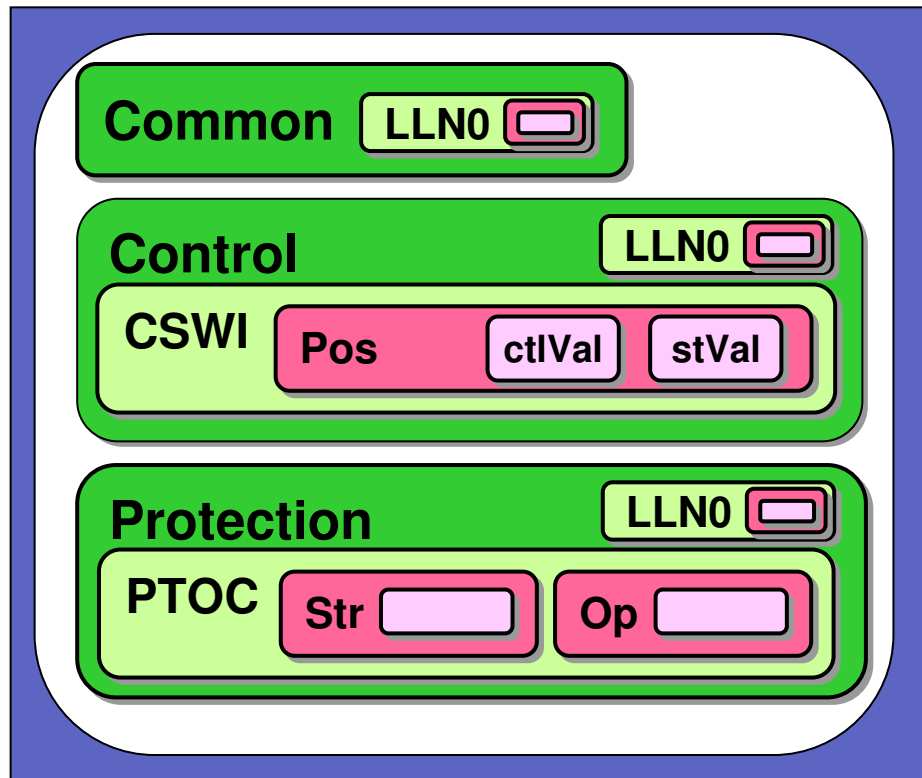
Allocation of LNs to devices (IEDs) – 1







Bay device (IED) as server for Protection and Control



Common
LLNO
Name plate
Vendor
etc.

Control
Switch Control
Position
Control Value
Status Value

Protection
Overcurrent
Start/Pick-up
Operate/Trip



Common Logical Node class				
Attribute Name	Attr. Type	Explanation	T	M/O
LNName		Shall be inherited from Logical-Node Class (see IEC 61850-7-2).		
Data				
<i>Mandatory Logical Node Information (Shall be inherited by ALL LN but LPHD)</i>				
Mod	INC	Mode		M
Beh	INS	Behaviour		M
Health	INS	Health		M
NamPlt	LPL	Name plate		M
<i>Optional Logical Node Information</i>				
Loc	SPS	Local operation		O
EEHealth	INS	External equipment health		O
EENam	DPL	External equipment name plate		O
OpCntRs	INC	Operation counter resetable		O
OpCnt	INS	Operation counter		O
OpTmh	INS	Operation time		O
Data Sets (see IEC 61850-7-2)				
Inherited and specialised from Logical Node class (see IEC 61850-7-2).				
Control Blocks (see IEC 61850-7-2)				
Inherited and specialised from Logical Node class (see IEC 61850-7-2).				
Services (see IEC 61850-7-2)				
Inherited and specialised from Logical Node class (see IEC 61850-7-2).				

M = mandatory, O = optional



Example for Logical Node (2) ref. part 7-4

XCBR class				
Attribute Name	Attr. Type	Explanation	T	M/O
LNNName		Shall be inherited from Logical-Node Class (see IEC 61850-7-2)		
Data				
Common Logical Node Information see Example for Logical Node (1)				
		LN shall inherit all Mandatory Data from Common Logical Node Class		M
Loc	SPS	Local operation (local means without substation automation communication, hardwired direct control)		M
EEHealth	INS	External equipment health		O
EEName	DPL	External equipment name plate		O
OpCnt	INS	Operation counter		M
Controls				
Pos	DPC	Switch position		M
BlkOpn	SPC	Block opening		M
BlkCls	SPC	Block closing		M
ChaMotEna	SPC	Charger motor enabled		O
Metered Values				
SumSwARs	BCR	Sum of Switched Amperes, resetable		O
Status Information				
CBOpCap	INS	Circuit breaker operating capability		M
POWCap	INS	Point On Wave switching capability		O
MaxOpCap	INS	Circuit breaker operating capability when fully charged		O

M = mandatory, O = optional



DPC class					
Attribute Name	Attribute Type	FC	TrgOp	Value / Value Range	M/O/C
DataName	Inherited from Data Class (see IEC 61850-7-2)				
DataAttribute					
<i>control and status</i>					
ctlVal	BOOLEAN	CO		off (FALSE) on (TRUE)	AC_CO_M
operTim	TimeStamp	CO			AC_CO_O
origin	Originator	CO, ST			AC_CO_O
ctlNum	INT8U	CO, ST		0..255	AC_CO_O
stVal	CODED ENUM	ST	dchg	intermediate-state off on bad-state	M
q	Quality	ST	qchg		M
t	TimeStamp	ST			M
stSeld	BOOLEAN	ST	dchg		AC_CO_O
<i>substitution</i>					
subEna	BOOLEAN	SV			PICS_SUBST
subVal	CODED ENUM	SV		intermediate-state off on bad-state	PICS_SUBST
subQ	Quality	SV			PICS_SUBST
subID	VISIBLE STRING64	SV			PICS_SUBST
<i>configuration, description and extension</i>					
pulseConfig	PulseConfig	CF			AC_CO_O
ctlModel	ENUMERATED	CF		status-only direct-with-normal-security sbo-with-normal-security direct-with-enhanced-security sbo-with-enhanced-security	M
sboTimeout	INT32U	CF			AC_CO_O
sboClass	ENUMERATED	CF		operate-once operate-many	AC_CO_O
d	VISIBLE STRING255	DC		Text	O
dataNs	VISIBLE STRING255	EX			AC_DLN_M
cdcNs	VISIBLE STRING255	EX			AC_DLNDA_M
tag	Tag	AX			O
Services					
As defined in Error! Reference source not found.					

M = mandatory, O = optional
 xC_... = conditional



Free allocation of Logical Nodes to devices is based on free allocation of functions to devices

- ❑ The support of free allocation Logical Nodes (functions and sub-functions) allows an *optimization* of systems today and tomorrow
- ❑ The free allocation is controlled by *strict rules* and the concept of IEC 61850
- ❑ The free allocation does not disturb *interoperability* but may increase the requirements for tools
- ❑ The free allocation is limited by the device capacities as described in *data sheets* same as today



Strict rules for Extensions

- ❑ **Existing** Logical Nodes, Data, and Attributes shall be used if applicable
- ❑ **Mandatory** data shall be provided if claiming conformance
- ❑ Before making any extension, the **Optional** data shall be used if applicable
- ❑ If the conditions apply, **Conditional** data get mandatory
- ❑ For **Extensions** of Logical Nodes, first data defined for other Logical Nodes shall be used
- ❑ In creating data extensions, combinations of well-defined **Terms** shall be used
- ❑ **Name spaces** shall be used for any extension referring to some document where the meaning and the use of these extensions is defined

M = mandatory, O = optional



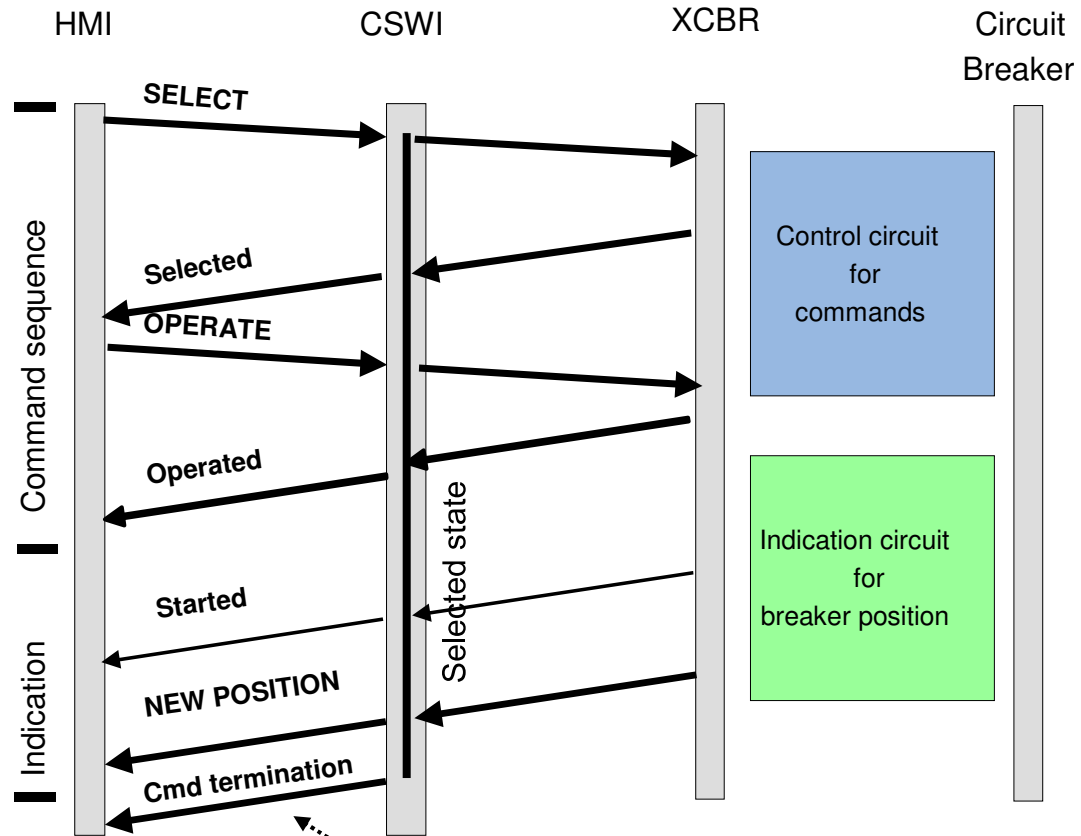
- ❑ **read** a value / attribute
- ❑ **write** configuration attributes
- ❑ **control** a device (direct operate / **select before operate**)
- ❑ **event oriented** communication with reporting
- ❑ local storage of time-stamped events in a **log**
- ❑ get **directory information**
- ❑ **file transfer** for e.g.
 - ❑ parameter and software download
 - ❑ upload from monitoring information like travel curves or history of gas density values
- ❑ **Transfer of generic object oriented system events (GOOSE)**
- ❑ **Transfer of sampled (analog) values (SV)**

 Non time-critical Services

 Time-critical Services

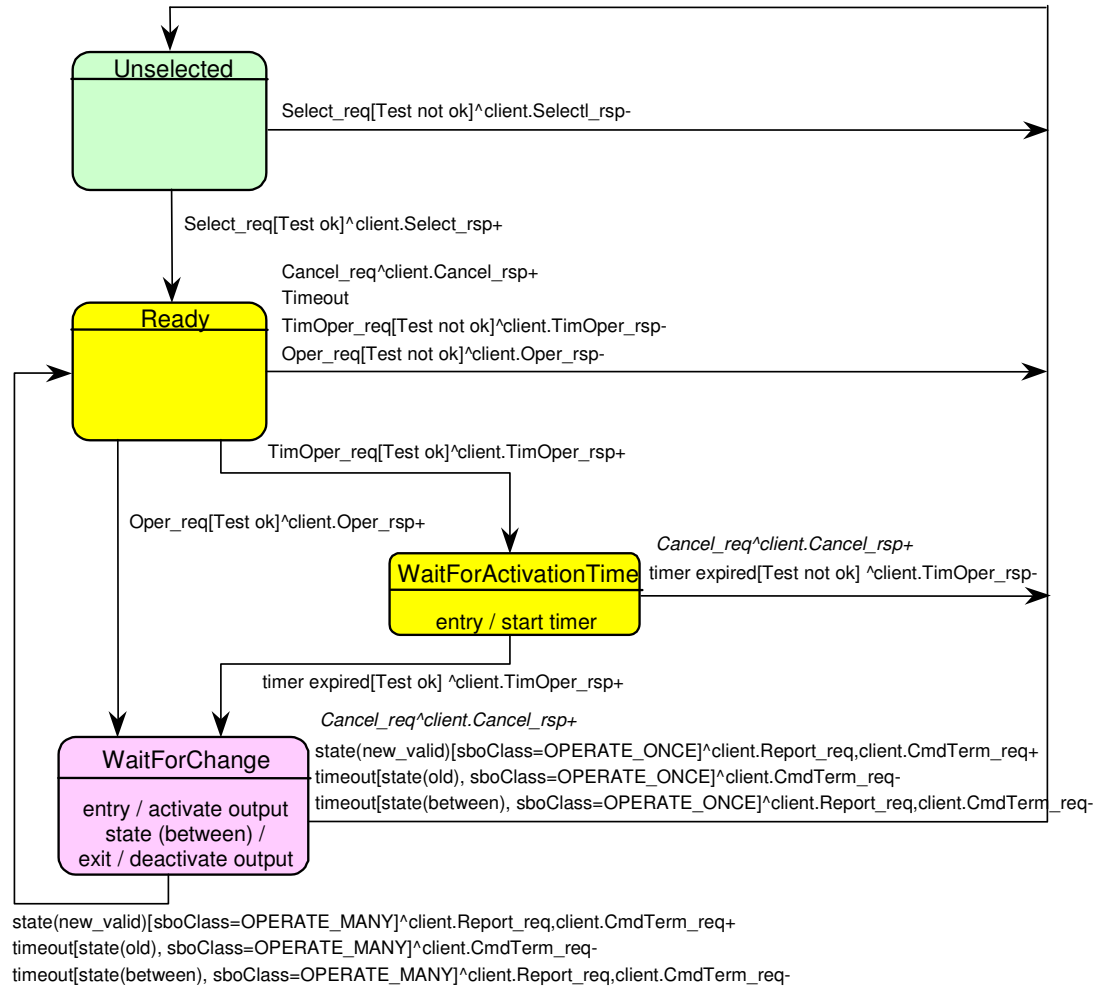


Example: Select before Operate



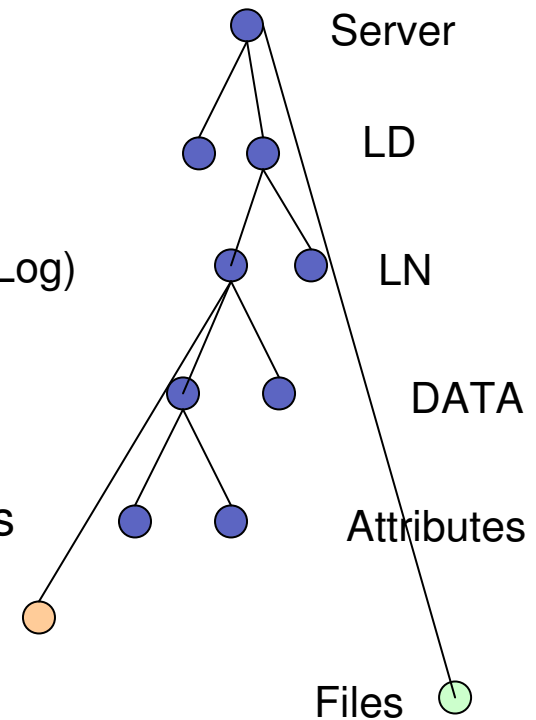
Enhanced security

Select before Operate – state diagram



Example: Directory services

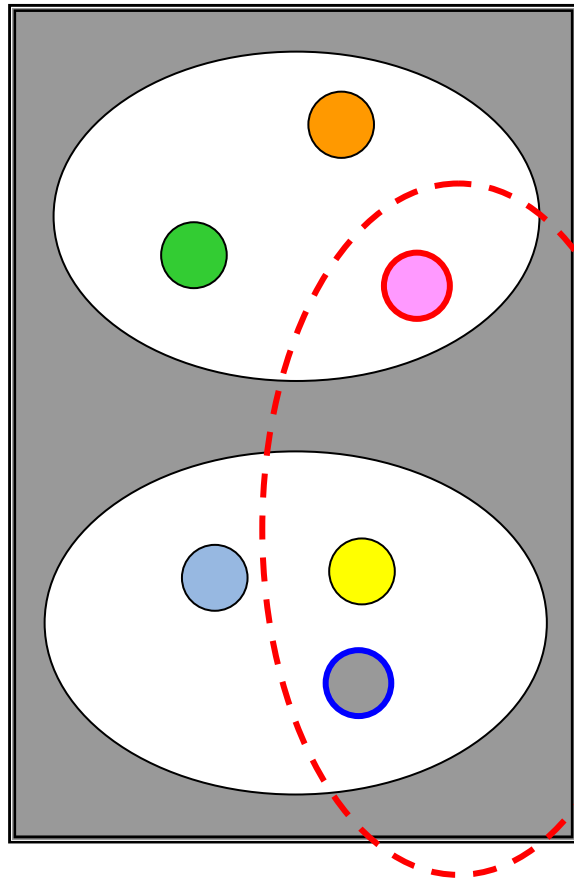
- GetServerDirectory (Files, LDs)
- GetLogicalDeviceDirectory
- GetLogicalNodeDirectory(DATA, DataSet, CBs, Log)
- DATA
 - GetDataDirectory -> List of Attributes
 - GetDataDefinition -> Data/Attribute properties
- GetDataSetDirectory -> Members of DataSet
- GetFileAttributeValues



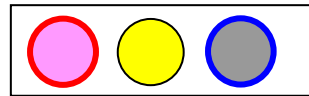
- ❑ All these three services send data **spontaneously**, i.e. without being asked from a Master or Client
- ❑ For defining the data to be transmitted by these services, a **Data Set** is defined comprising all these data out of the overall data model (for Report, GOOSE or SV)
- ❑ The starting event (conditions) when the data transmission is started starts has to be defined in a **Control Block** (for Report, GOOSE or SV)
- ❑ The starting event for Reporting and GOOSE messages may be a **change of a value**, a crossing of a boundary, etc.
- ❑ The starting event of sending synchronous sampled values (SV) is a “**clock event**”



Logical Device (LD) with two Logical Nodes (LN) containing all Data

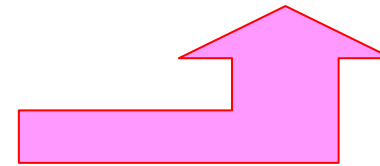


Definition of **Data Set**



The configurable **Report, GOOSE and SV control block** defines, when a report, a GOOSE message, or SV are send based on the Data in the **Data Set**

No Data avalanche, only predefined data will be send.



- ❑ Transfer of **generic object oriented system events (GOOSE)**
- ❑ Transfer of **sampled (analog) values (SV)**

To understand how to handle **time critical** services on Ethernet, some communication Know-how is needed.

Will be explained later !

