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Testing of IEC 61850 Devices and Systems



**IEC 61850
Testing**
refers to IEC 61850-10

- Conformance Testing**
- Device Testing**
- System Testing**



Basics of Conformance Testing are defined in
IEC 61850-10 Conformance testing

Conformance Testing
is a

Device Testing



- **Interoperability testing**
 - IEC61850-10: Interoperability test procedures
 - UCA International UG: accredited testing centers (e.g. KEMA)
- **Integration**
 - Version handling & consistency checks (see engineering; example)
 - Communication data visualisation on application level
- **System test**
 - Function tests: **SCD file allows to simulate ...**
 - Process, part of functions, missing IEDs
 - Signal test: **SCD file + terminal list allows automated point-point test**
 - Function performance: **IEC 61850 performance classesb**



The **conformance test** is the test which confirms that the IED under test fulfills the requirements of IEC 61850

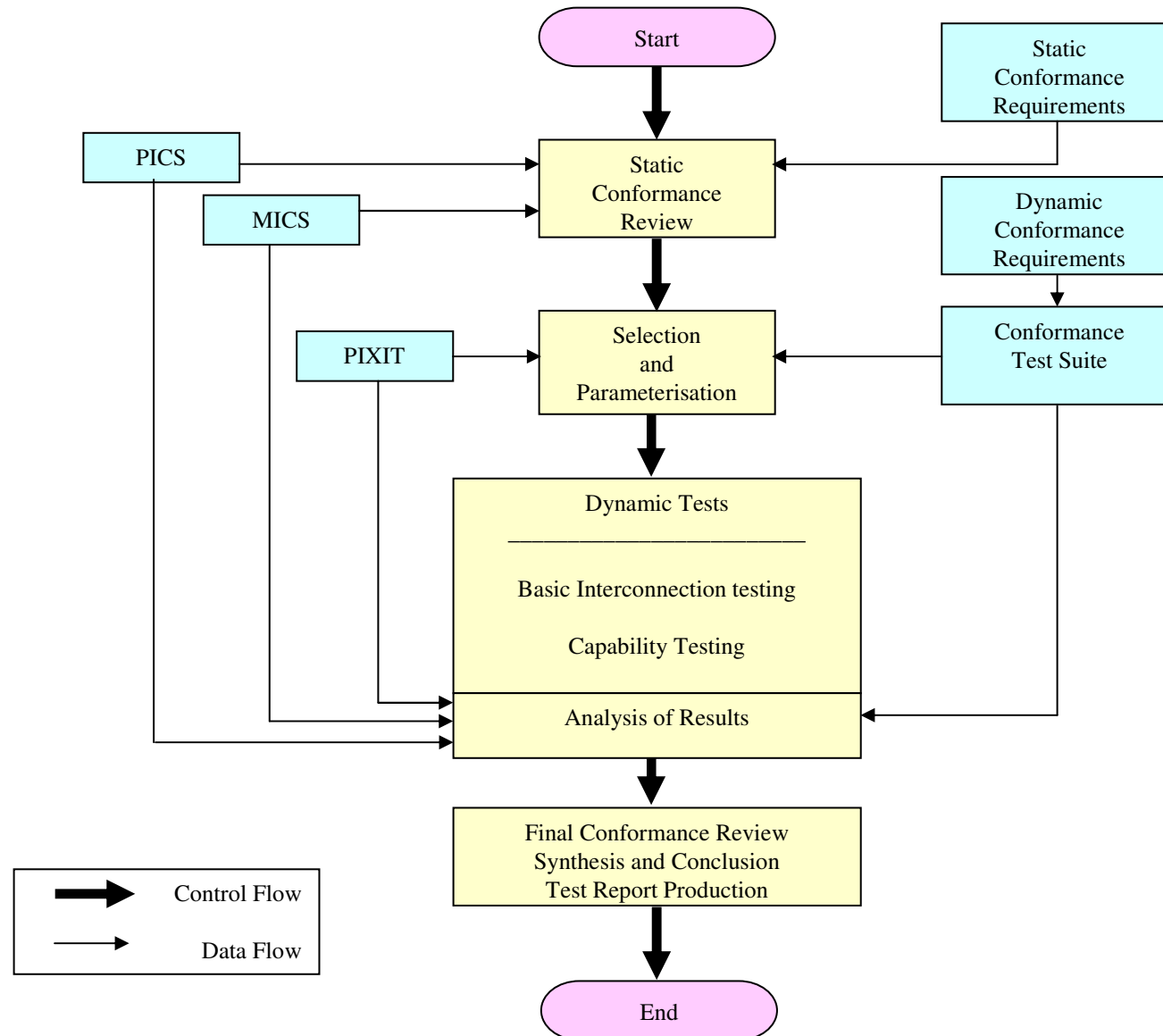
The the key requirements of IEC 61850 is the **Interoperability** of devices of different suppliers

Limitation : The multiplicity of all existing IEDs for SA is reduced to some few **test devices** or system simulators (test generator, test monitor)

Warning : The conformance tests made up to now certify **not the Conformance in general** but are listing all **successful test cases !**



Flow Diagram of Conformance testing



MICS - Model Implementation Conformance Statement

details the standard data object model elements supported by the device. It shall include definitions of the specific logical nodes, common data classes and data attribute types in the same format as IEC 61850-7-3 and IEC 61850-7-4. These definitions are found also in the ICD file and by the response of the service getDirectory if applicable

PICS – Protocol Implementation Conformance Statement

summarizes the communication capabilities of the system or device to be tested. The static and dynamic conformance requirements shall be defined in a Protocol Implementation Conformance Statement or PICS. It refers also to the stack implementation and the mapping of the model to the stack

The PICS serves three purposes:

- 1) selection of the appropriate set of tests;
- 2) ensure that the tests appropriate to a claim of conformance are performed;
- 3) provide the basis for the review of the static conformance.



PIXIT - Protocol Implementation eXtra Information for Testing

contains device specific information regarding the communication capabilities of the system or device to be tested and which are outside the scope of the IEC 61850 series. The PIXIT is not subject to standardization.

ICD – IED Capability Description (SCL file)

The device shall be delivered with an ICD file. The test entity shall generate from the ICD file the corresponding SCD file of the configuration of the test system. If the test entity requires that the initiator of a conformance test also provides the SCD file, then the test entity shall provide the SSD file and the SCD file of the test system.



Configuration test

- ❑ Test if the ICD file conforms to the SCL XML schema definition according to IEC 61850-6.
- ❑ Check if the ICD configuration file corresponds with the actual data, data types and services exposed by the device under test (DUT) on the network.

Test cases

- ❑ The test cases are built on the proper operation of **services**.
- ❑ **Positive** test cases verify that the IED reacts on services represented by correct messages as it has to do according to IEC 61850
- ❑ **Negative** test cases verify that the IED does not react or sending the the proper error messages according to IEC 61850 in case of receiving wrong services or services represented by erroneous messages



Tested are all services applicable for the device under test

Test of basic client server behavior (association)

List of service related test case groups

Data set model, Substitution model, Setting group control

Reporting model, Log model

GOOSE service, SV services

Control model

File transfer mode

Performance ?



Conformance Testing

is a semi-static device Testing with help of a test generator and a test monitor

IEC 61850

is a standard for dynamic communication of many devices in a Substation Automation (SA) **System**

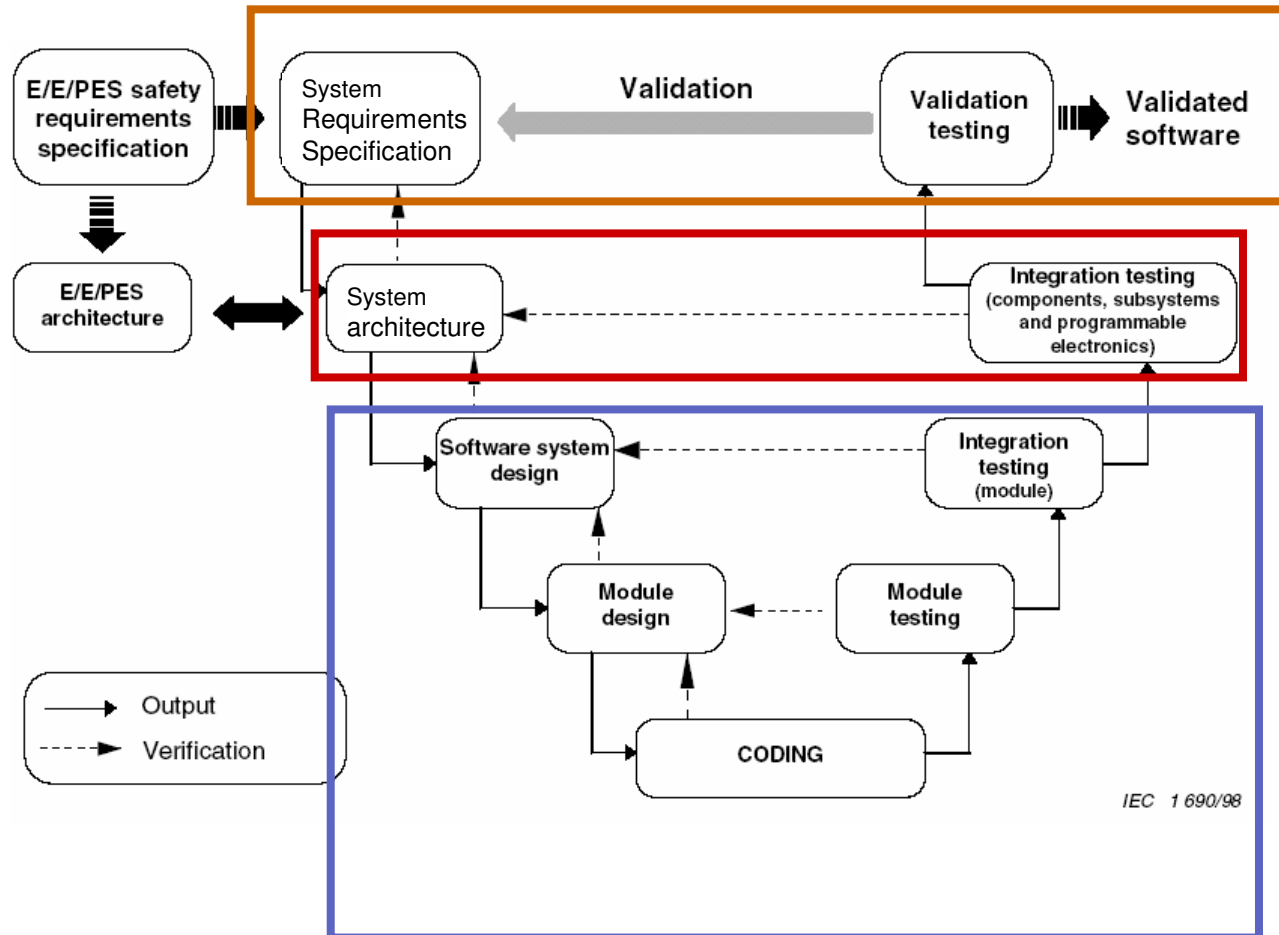
Therefore, the interaction in a system and the related performance has to be tested in a system similar to an SA system b

Conformance and system testing

Therefore, the conformance testing described is necessary but not sufficient that the device behaves interoperable as IEC 61850 intended



System Testing concept from IEC 61508



System level

- Function test
- Performance test
- Signal test

Integration

- Debugging
- Load test

IED level:

- Type test
- Function test
- Interoperability test

Supported by IEC61850



■ Tools needed

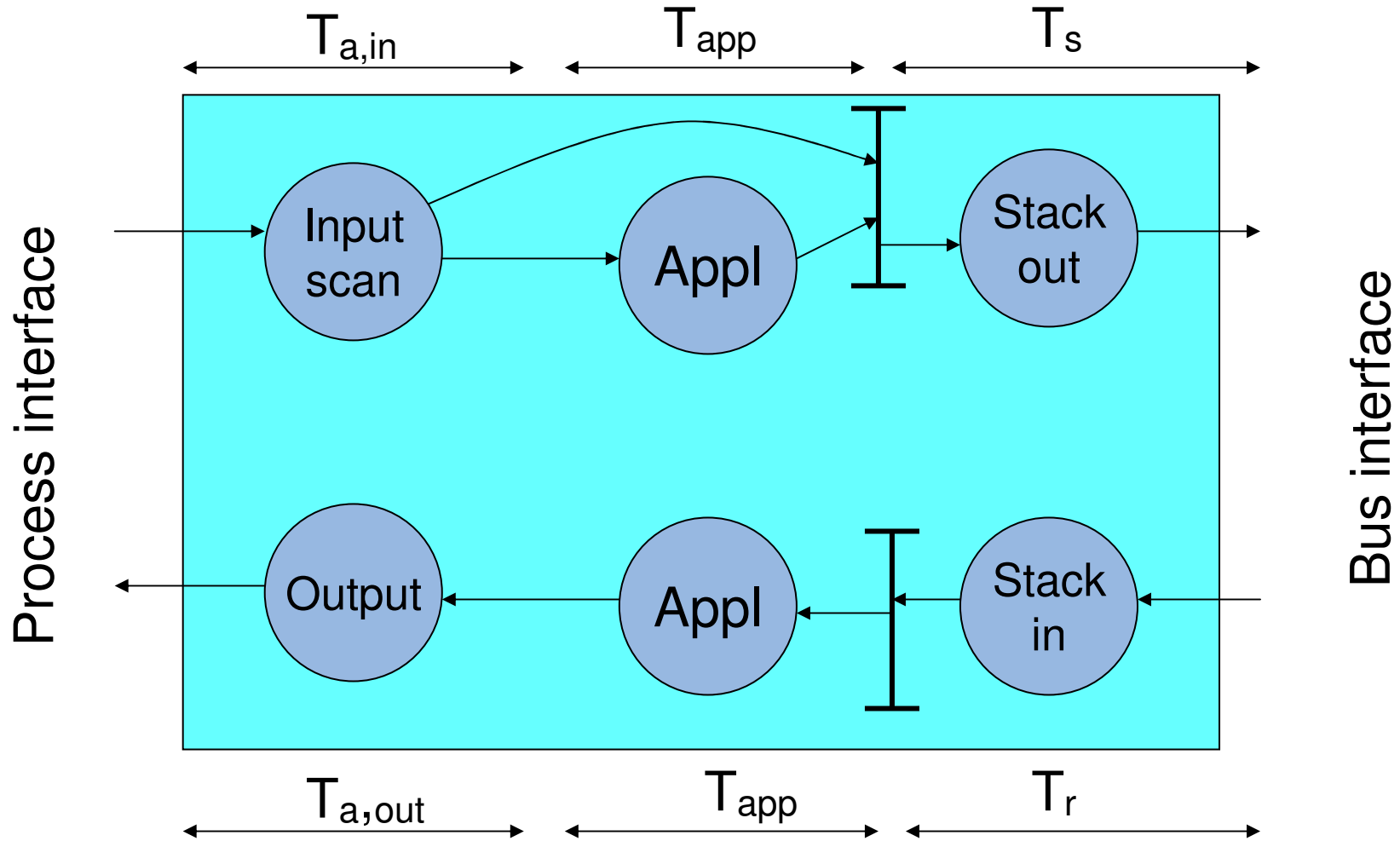
- Version browser: example
- Data browser: example
- Protocol analyser : KEMA, Etherreal -> later

■ Concept for performance measurement and protection verification

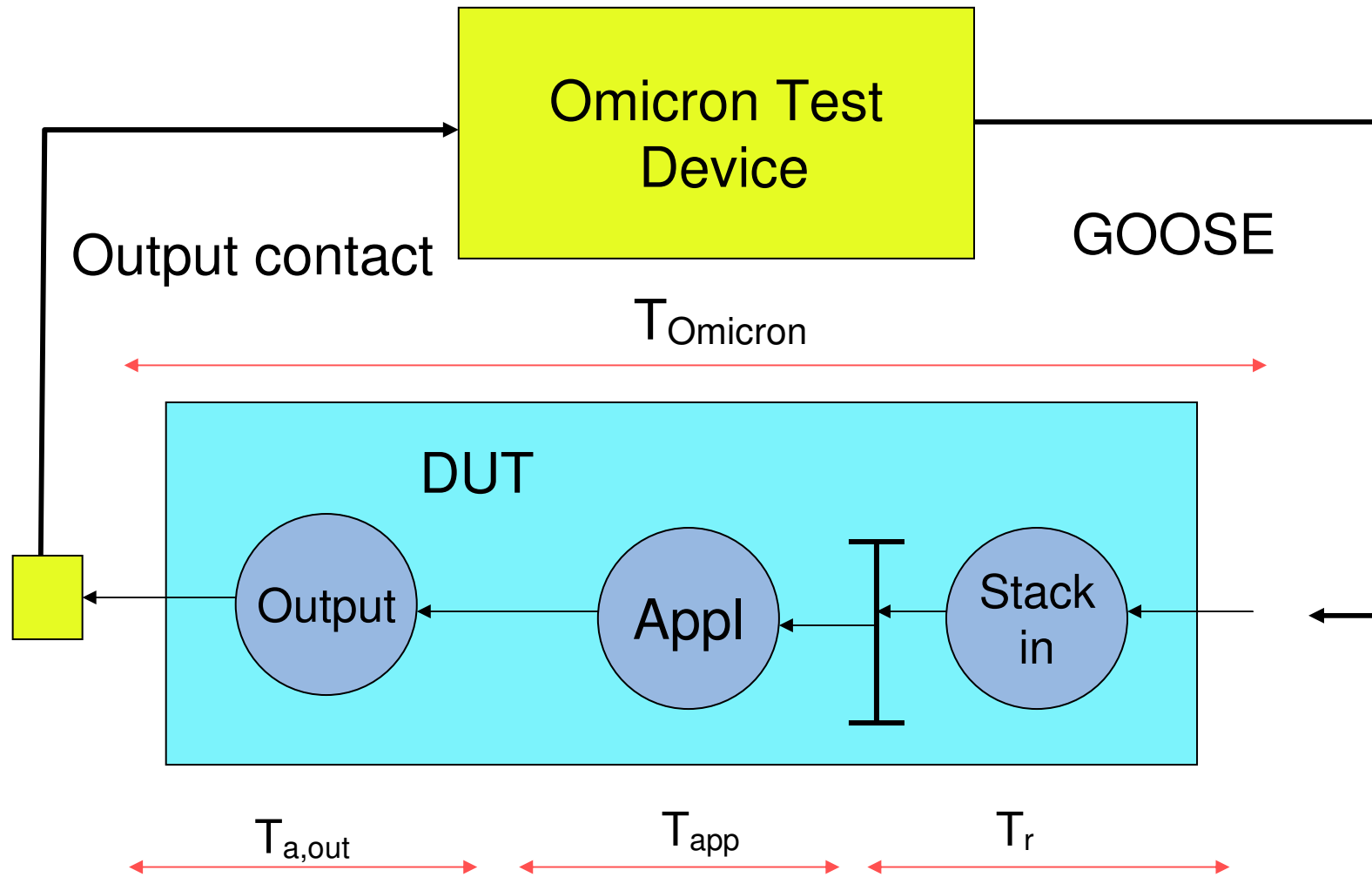
- Omicron testing tool:
 - Simulates analog inputs / protection faults
 - Measures trip reaction time
 - Measures GOOSE sending time caused by Trip / Startb



IED model with key figures



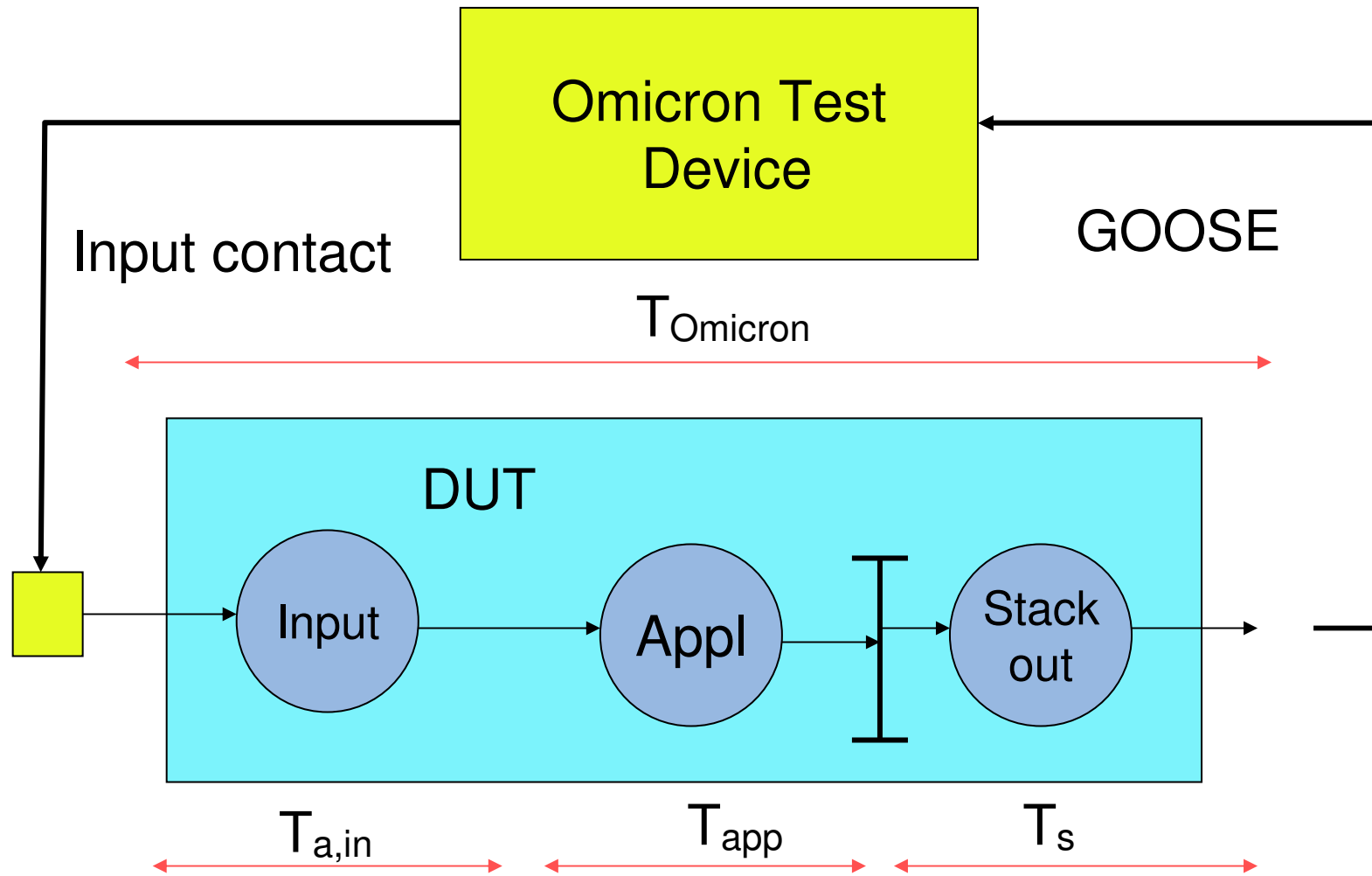
GOOSE receive measurement



$$T_r = T_{Omicron} - (T_{app} + T_{a,out} + 0.1 \text{ ms})$$



GOOSE send measurement



$$T_s = T_{Omicron} - (T_{app} + T_{a,in} + 0.1 \text{ ms})$$



■ Basic needs

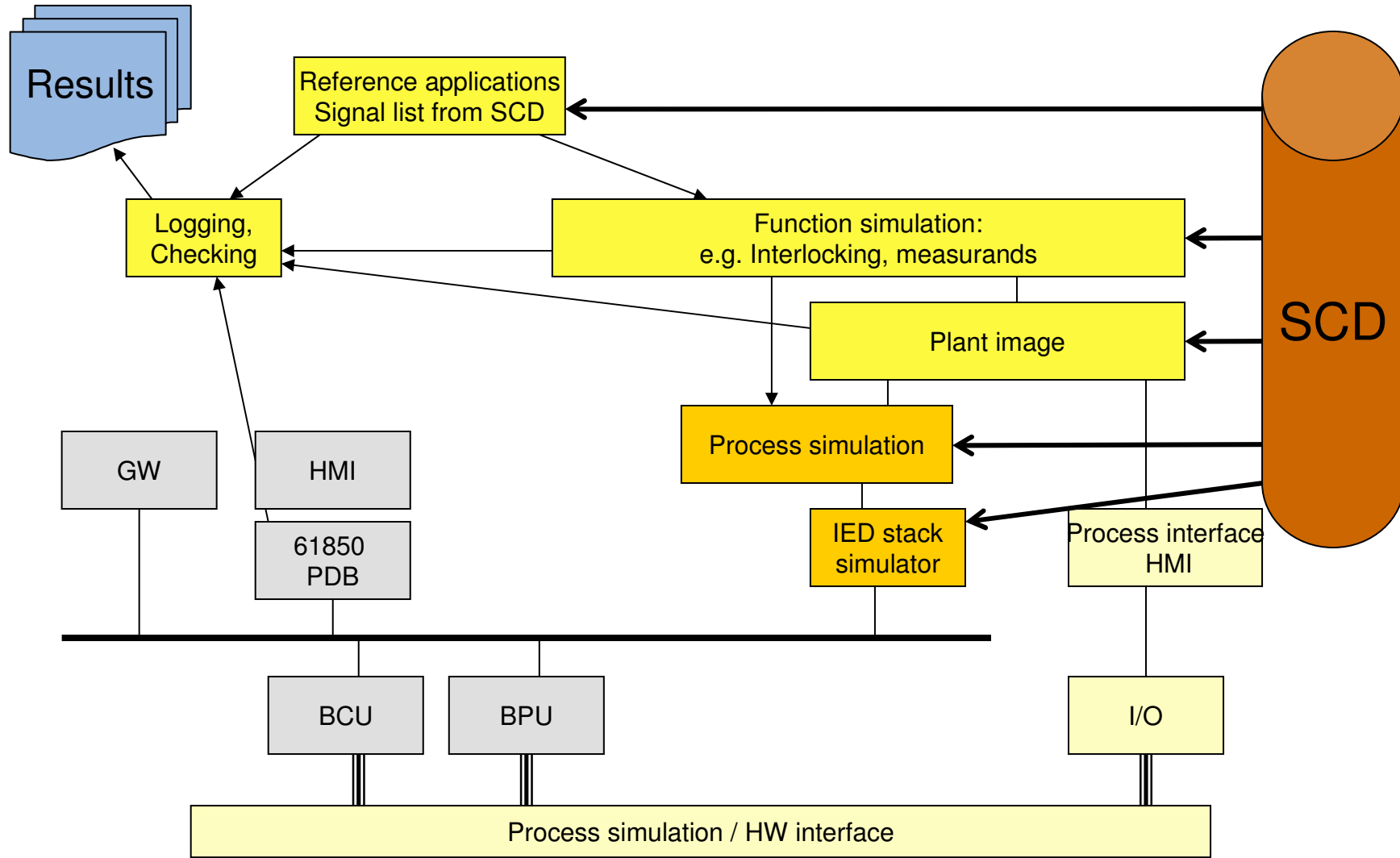
- Process simulation needed
- Often only typical bays are physically build
 - => simulation of missing bays / IEDs to test system functions like interlocking, breaker failure,...

■ IEC 61850 data model & SCL allow...

- Process simulation from single line and process interface description
- IED communication simulation from IED description



Test system architecture



- **Switching simulation:** CSWI, XCBR, XSWI
- **Interlocking simulation:** CILO
 - Based on single line topology
- **Measurand simulation:** TVTR, TCTR, MMXU, MMXN
 - Based on generator / load definition and single line topology



As part of the quality assurance for IEC 61850 products and systems

ABB is performing complementary **system tests** of all ABB devices and selected third party products in his **System Verification Center** in Switzerland

