ToSS: Testbed of Smart Sensors

Deniz Gurkan, PhD
Department of Engineering Technology
University of Houston
dgurkan@uh.edu
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Motivation

- Create test procedures for validation of IEEE 1451 NCAP-to-NCAP communications
- Determine possible network performance metrics for a 1451-compatible sensor network
- Implement interoperability tests for off-the-shelf IEEE 1451 components
- Encourage dissemination of IEEE 1451 standard through interoperability

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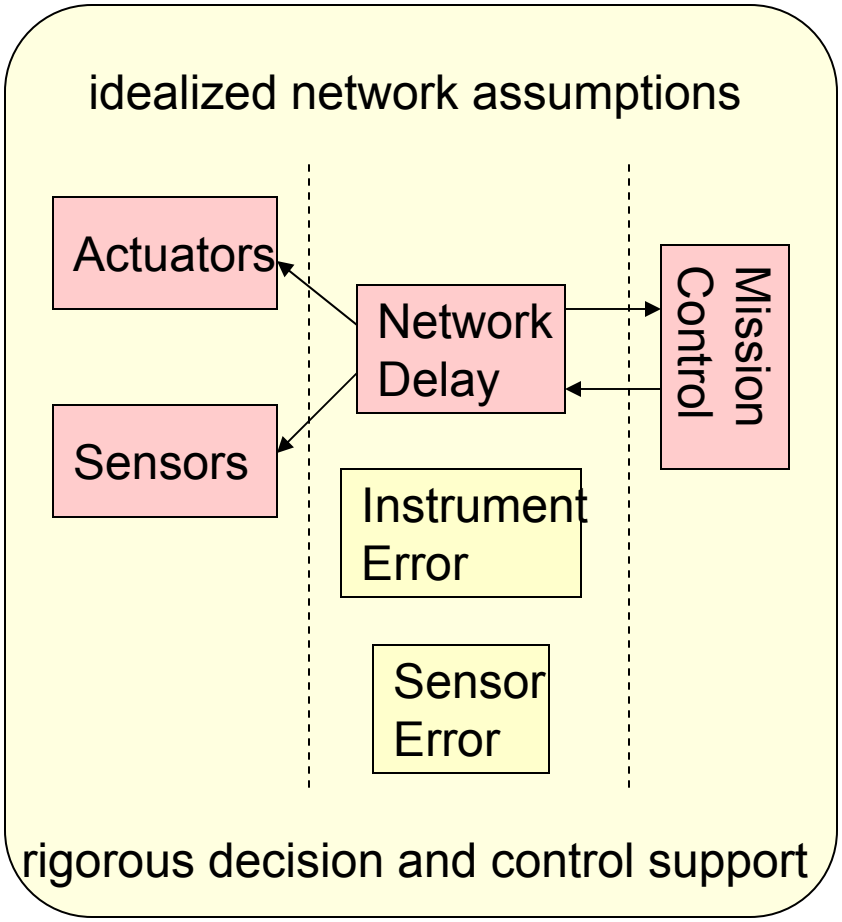
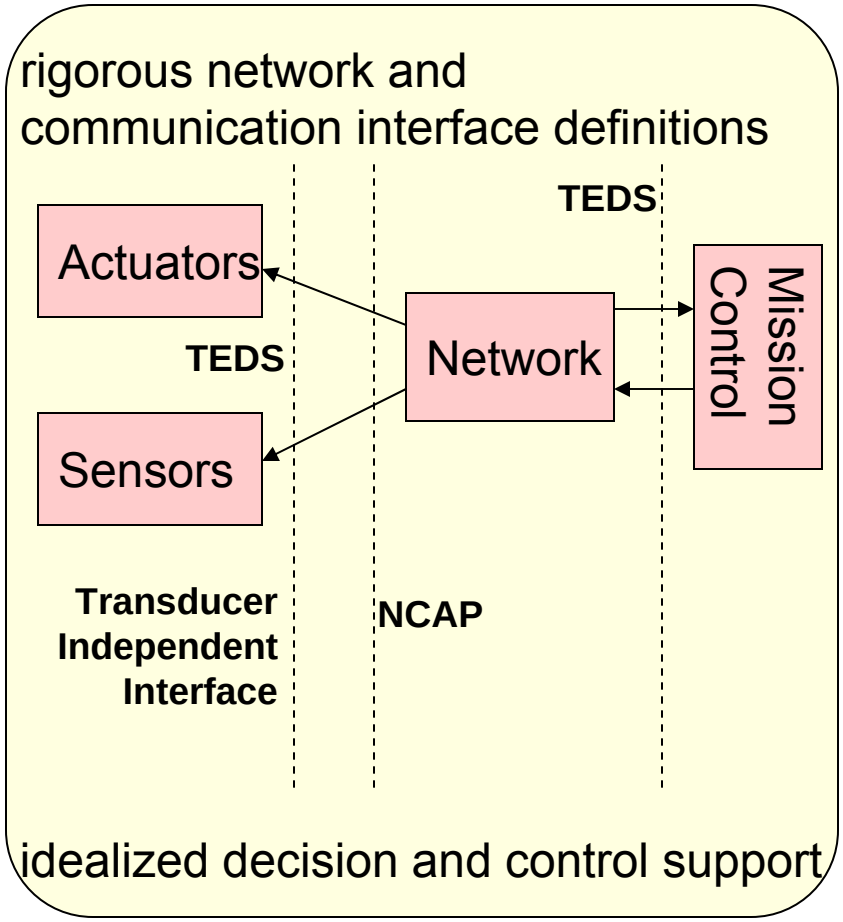
Testbed Research

Isolated work between control and decision support and networking aspects





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Agenda

1. What does IEEE 1451 promise?
2. Overview of IEEE 1451-compatible products
3. NCAP-to-NCAP communication
4. Test Approach
   a. Publish-Subscribe
   b. Client-Server
5. Approach to sensor network performance analysis

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IEEE 1451

Allow manufacturers to build **interoperable** elements of a system: Network Capable Application Processor (NCAP) is a gateway between user's network and Transducer Interface Modules (TIM)

1451.0 – NCAP ↔ TIM setup/manage, API

1451.1 – NCAP logical object model

1451.2 – RS-232

1451.3 – Wired Multi-drop

1451.4 – TEDS Only

1451.5 – Wireless

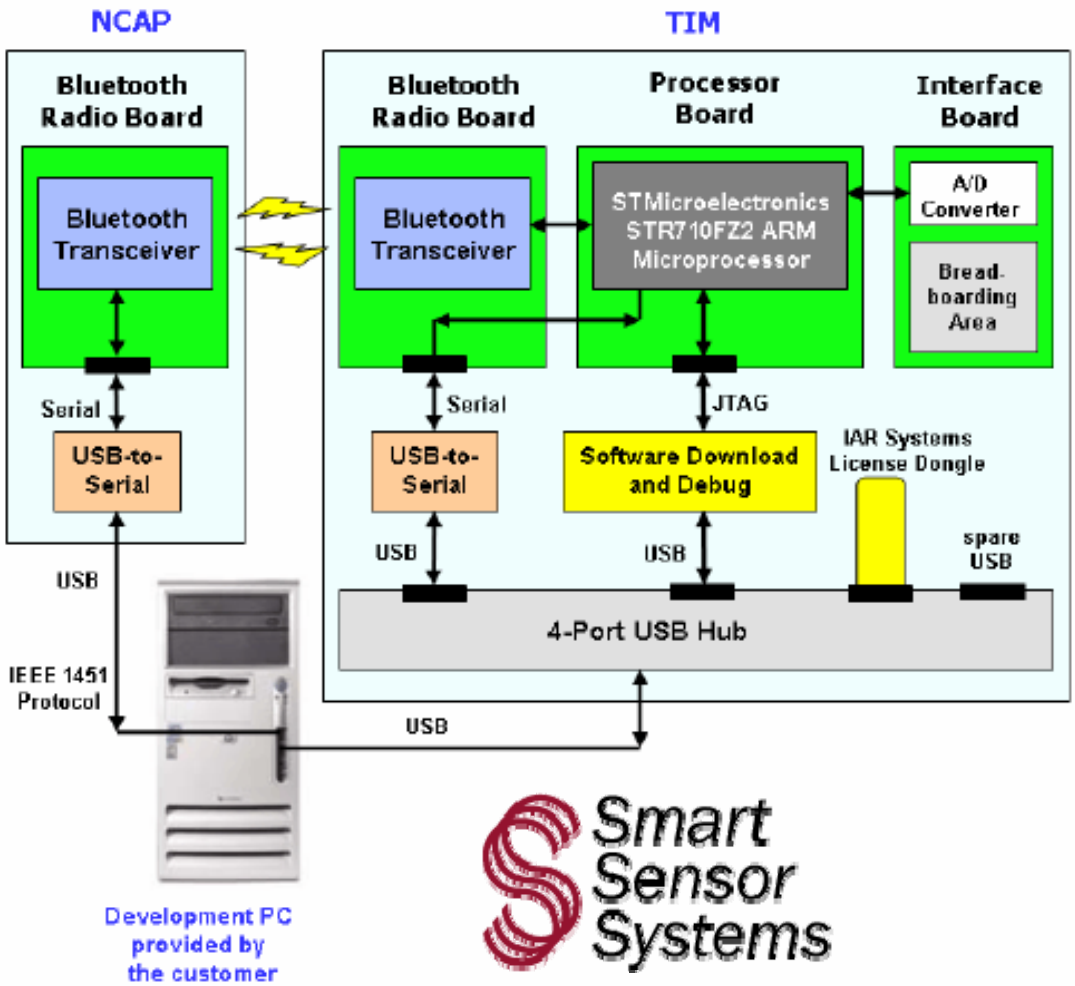
1451.6 – CAN Bus

1451.7 – RFID

IEEE 1451 Compatible Products - 1

Network Capable Application Processor (NCAP)

- Manages TIM(s)
- Converts Data from TIM and applies Corrections
- Transmits corrected data over network



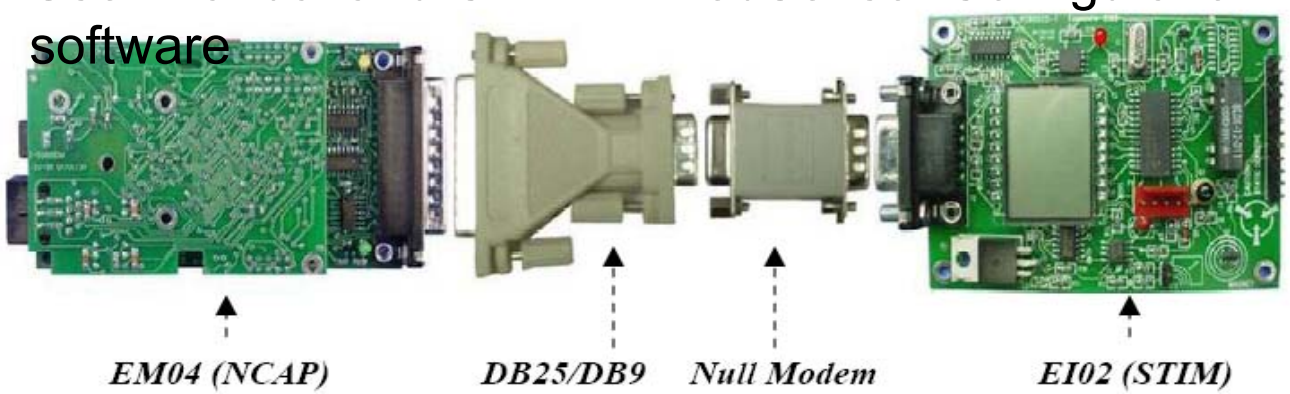
Transducer Interface Module (TIM)

- Acquires the signal and performs A/D Conversion
- Holds Cal Constants and Operating Parameters in TEDS Database

IEEE 1451 Compatible Products - 2

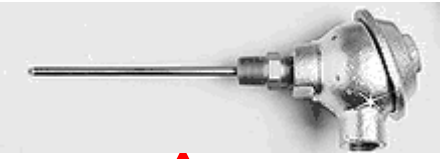
IEEE 1451.2 Prototyping Kit includes:

- EM04a
- EI02
- Wall transformer
- Straight Ethernet patch cable
- Crossover Ethernet patch cable
- ESBus Programming cable
- User Manual and CD with WebSensor Configuration software



Also IEEE 1451.4 Mini NCAP and a Web Sensor available.

IEEE 1451 Compatible Products - 3

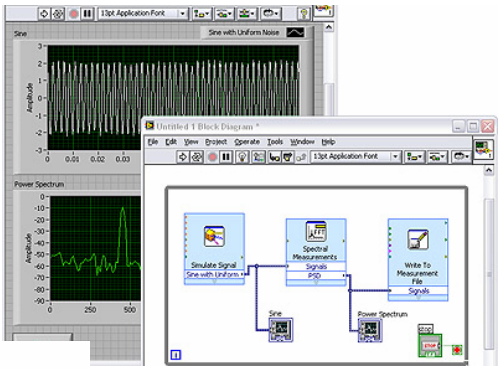


Class II

Sensor (RTD)

resistance temperature detector

LabView Front Panel GUI



IEEE 1451.4

SCC Sensor Module

NATIONAL INSTRUMENTS™

SC-2350 Carrier

PCI-6221 DAQ Card

NI-DAQmx and LabView Running on PC

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IEEE 1451 Compatible Products - 4

TEDS Sensor Interface Kit - Model 400B76
communicate with TEDS sensors over the USB port of a Windows PC. 400B76 reads TEDS from, and writes TEDS to, sensors.

IEEE 1451.4

TEDS Editor by **Kistler**, Type 5000M04

Characteristics: The module is used in conjunction with a personal computer to read and write information stored in TEDS capable sensors.

Model 070A70
Product Type: TEDS In-line Memory Module
TEDS circuit in a housing for non-TEDS sensor, BNC jack to BNC plug

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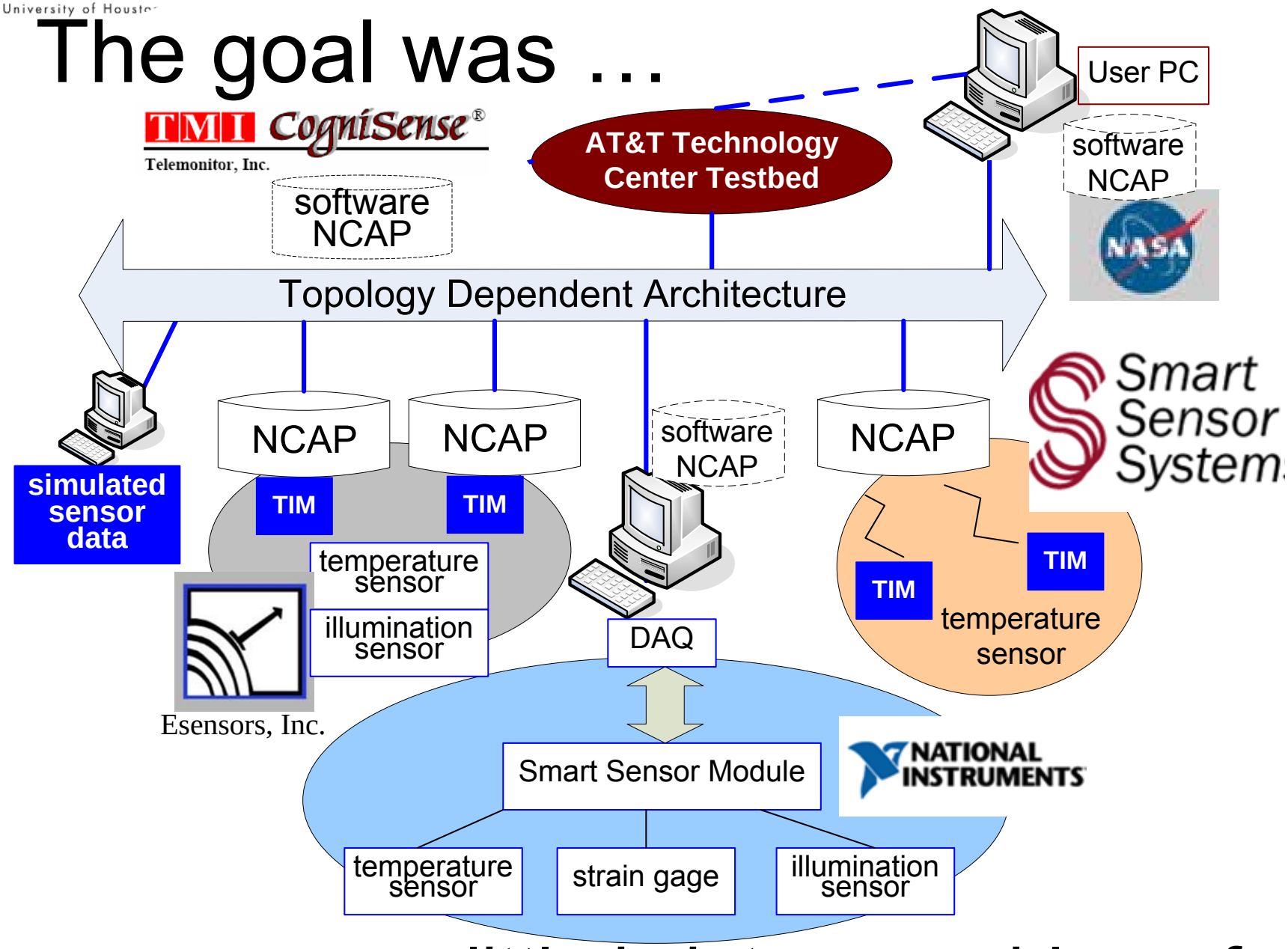
The goal was …



… very little is interoperable so far.

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NCAP-to-NCAP Communication

- Open Source:
  - Network Neutral NCAP
  - NIST: 1451.0 and 1451.5 demonstration
- Basic requirements:
  - Publish-Subscribe
  - Client-Server
  - Subset of network visible operations

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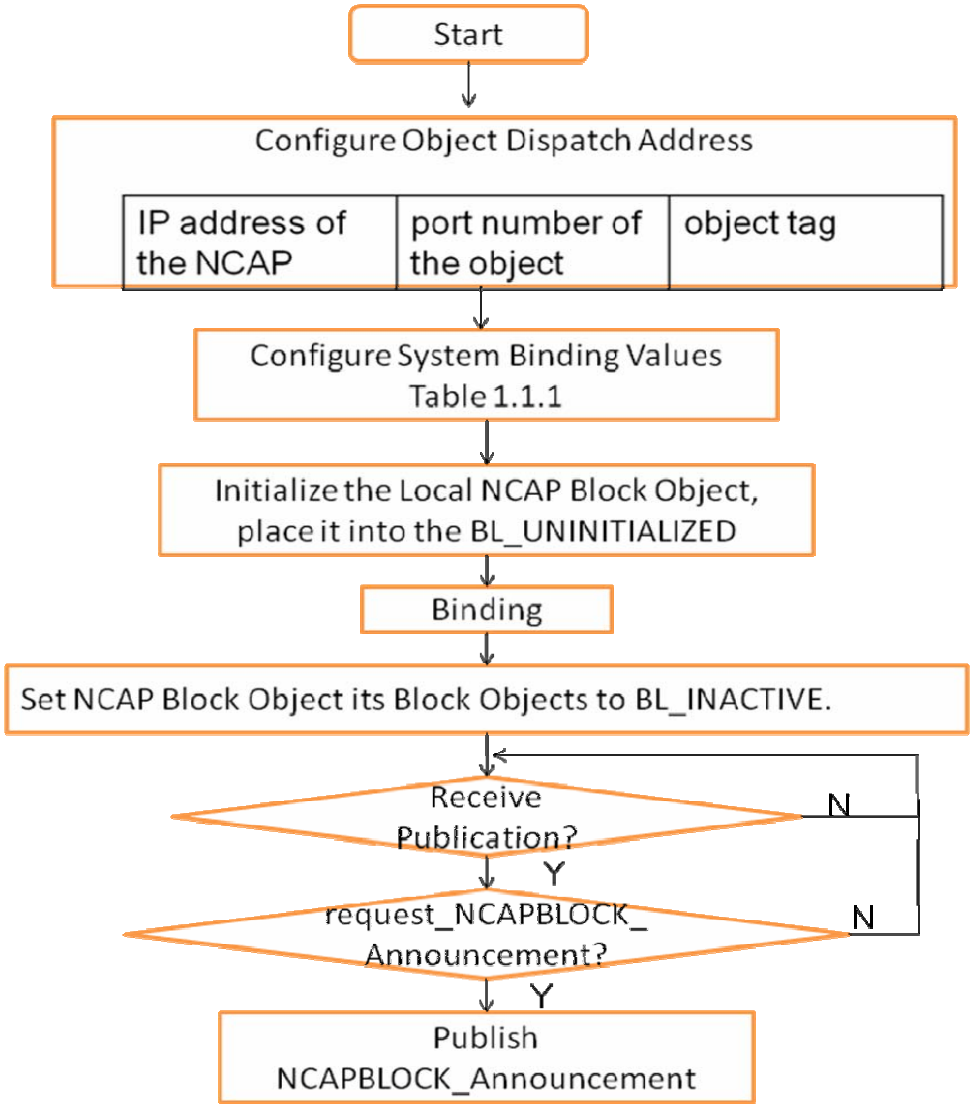
NCAP-to-NCAP Communication: Operational Flow



NCAP-to-NCAP Communication: On-the-wire testing

Request_NCAPBlock_Announcement Message

Byte Number	Type	Interpretation	Details
0	UInteger8	Magic Number	0xf7
1	UInteger8	Version Number	0x03
2-3	UInteger16	Total Message Length	0xNNNN
4-5	UInteger16	Header Length	0xNNNN
6	UInteger8	Publication Key	0x04
7-14	Octet8	Publication Domain	0xffffffffffffffff
15-16	Octet Array[N]	Publication Topic	0xNNNN

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7-14	Octet8	Publication Domain	0xffffffffffffffff
15-16	Octet Array[N]	Publication Topic	0xNNNN
17-18	UInteger16	Number of Arguments	0x0002
19	UInteger8	First argument type code	0x1a [Object Tag]
20-21	UInteger16	Number of bytes in first argument	0xNNNN
22-23	Octet Array[N]	Object Tag	0xNNNN
24	UInteger8	Second argument type code	0x16 [Object Dispatch Address]

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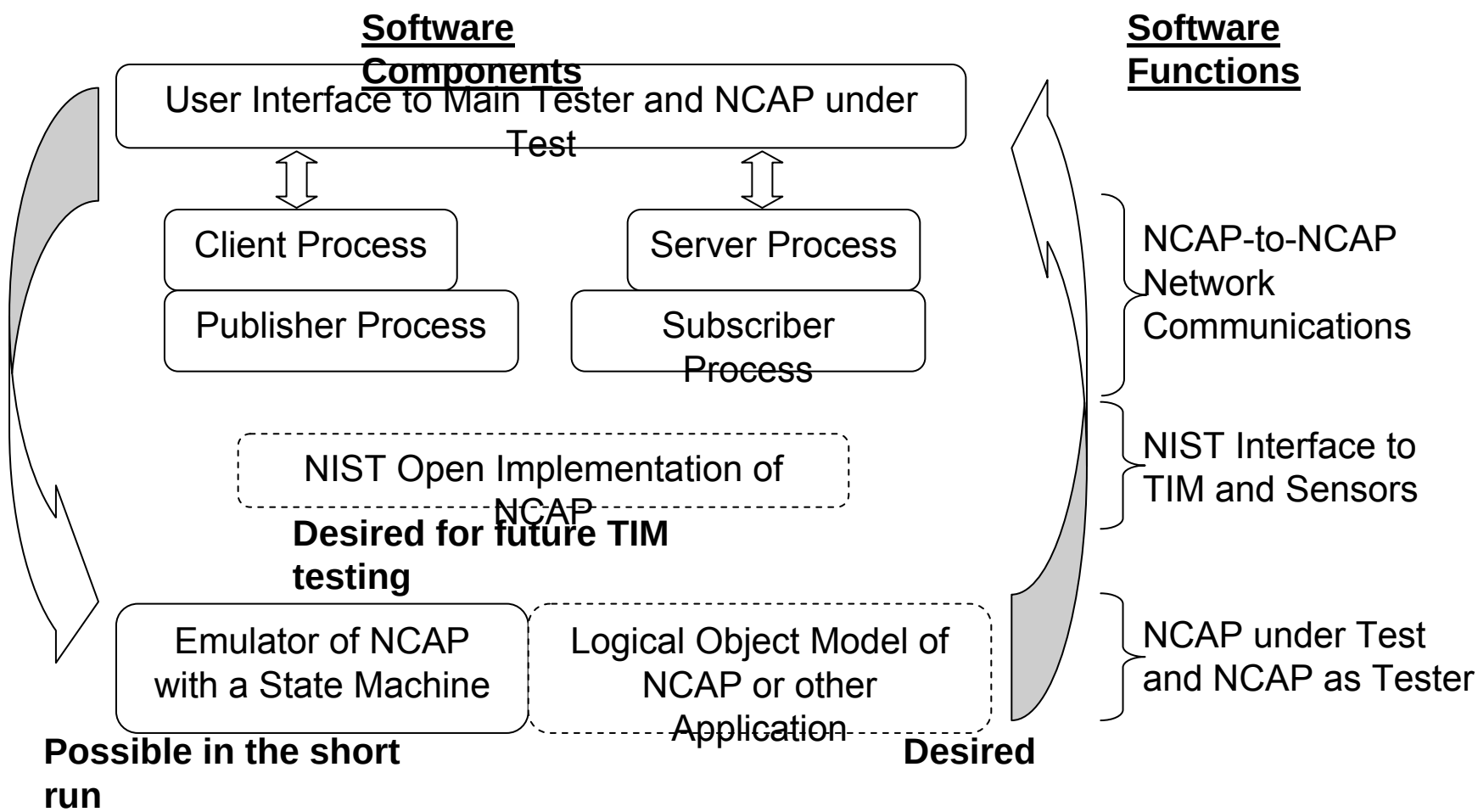
User Interface



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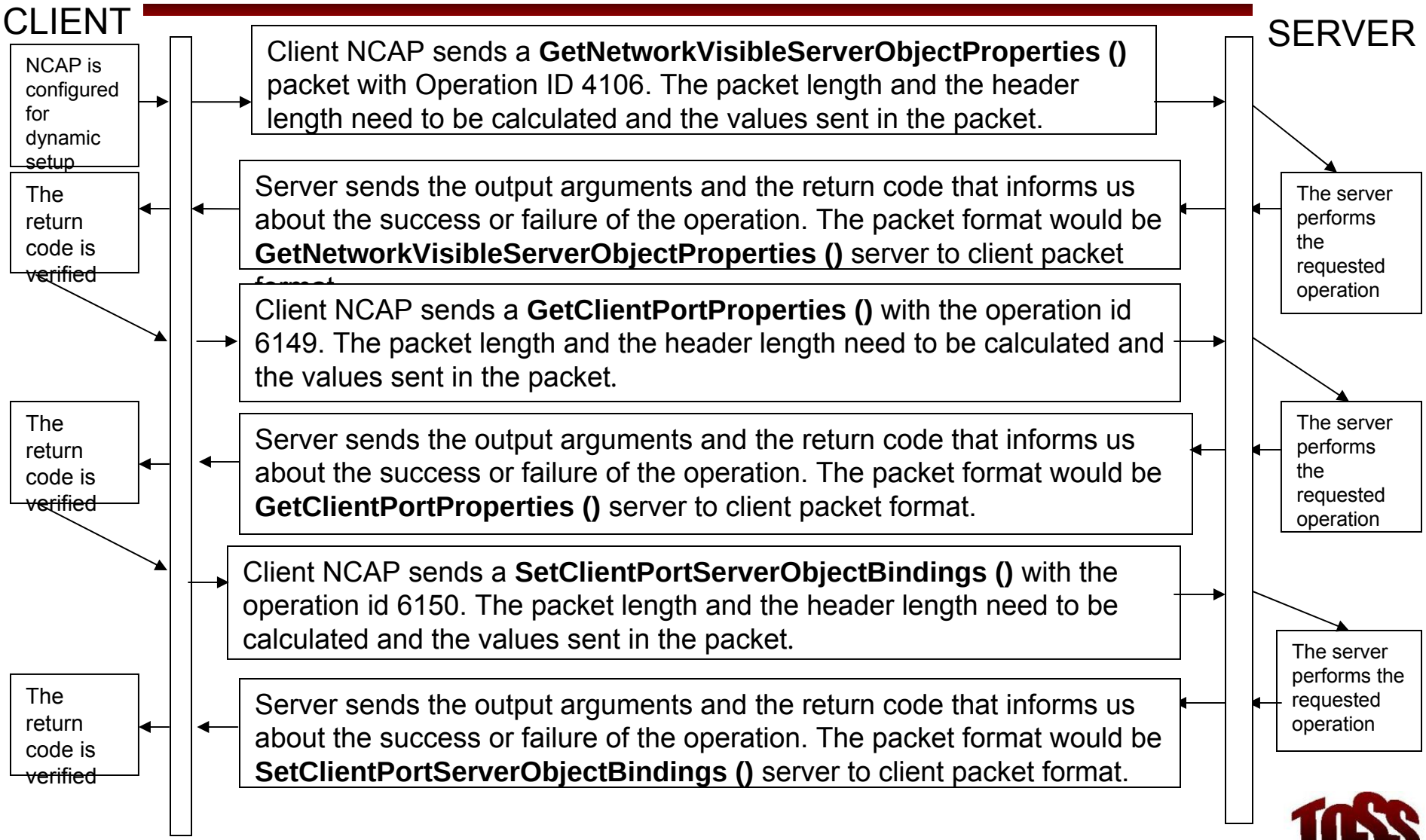
NCAP-to-NCAP Communication



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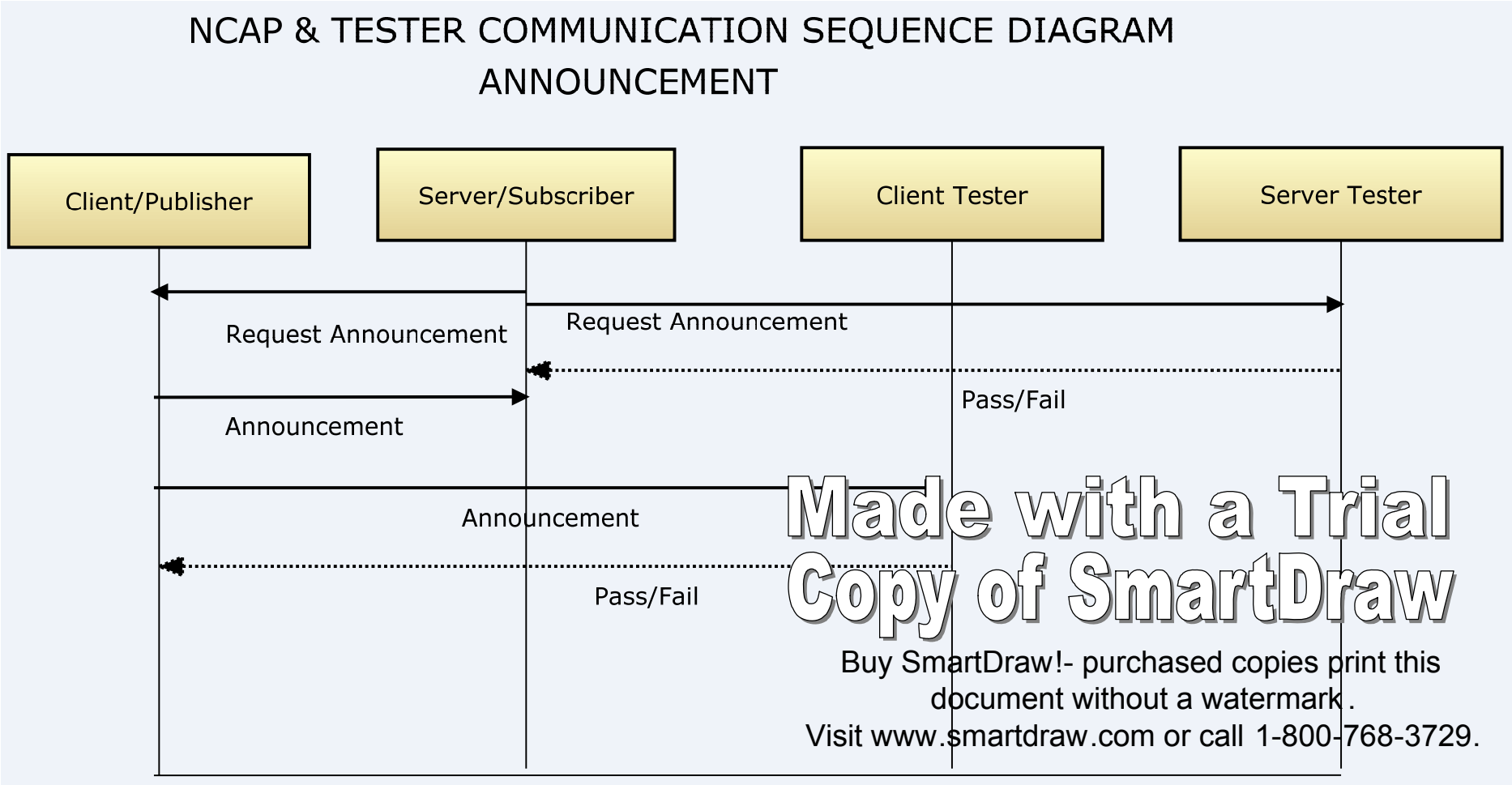
Testing

- 3 related types of tests:
  - Conformance Test
  - Functionality Test
  - Performance Test
- Conformance and functional of higher priority

Flow *publish-subscribe*



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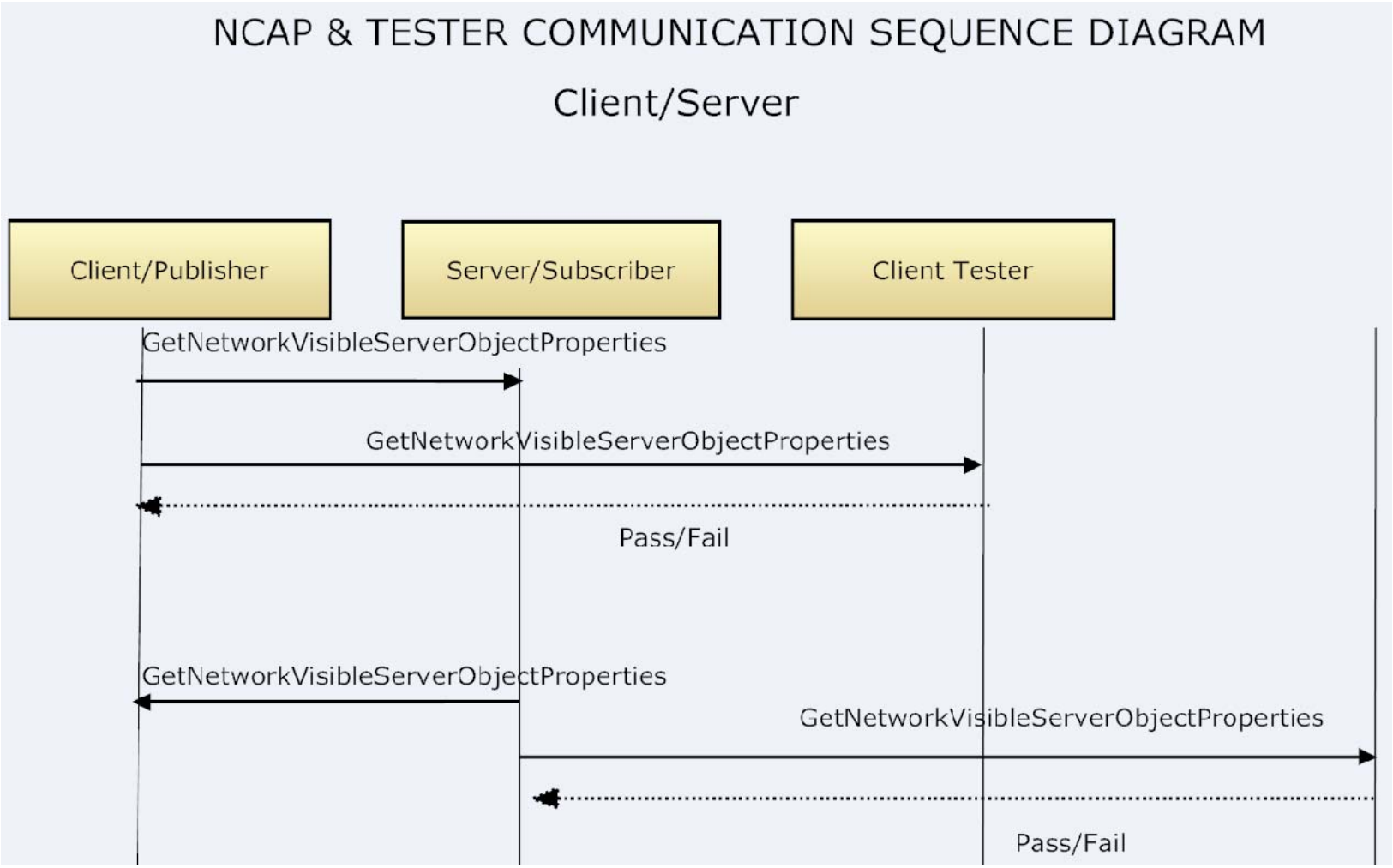
Flow *client-server*



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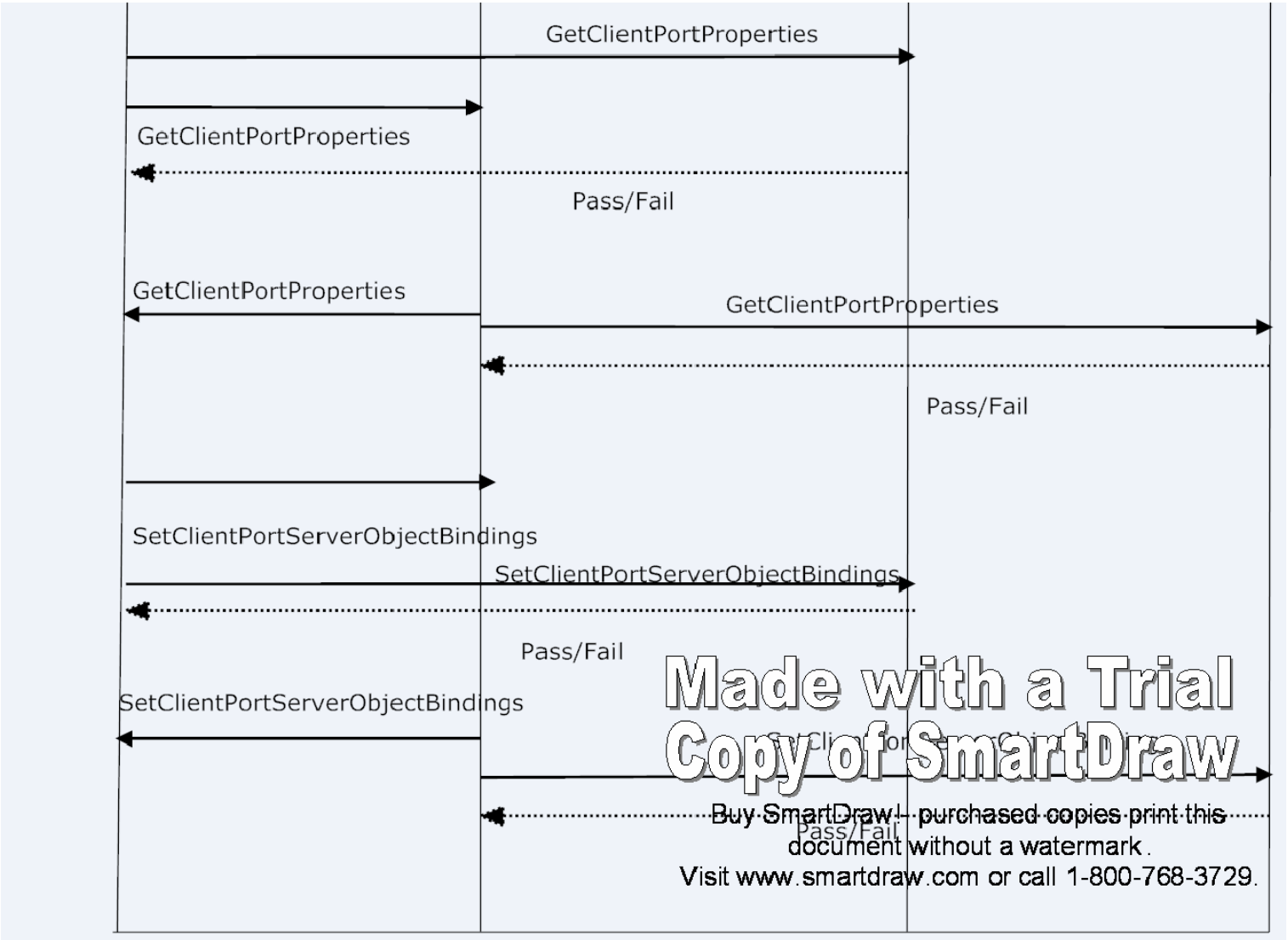
Flow *client-server* cont.



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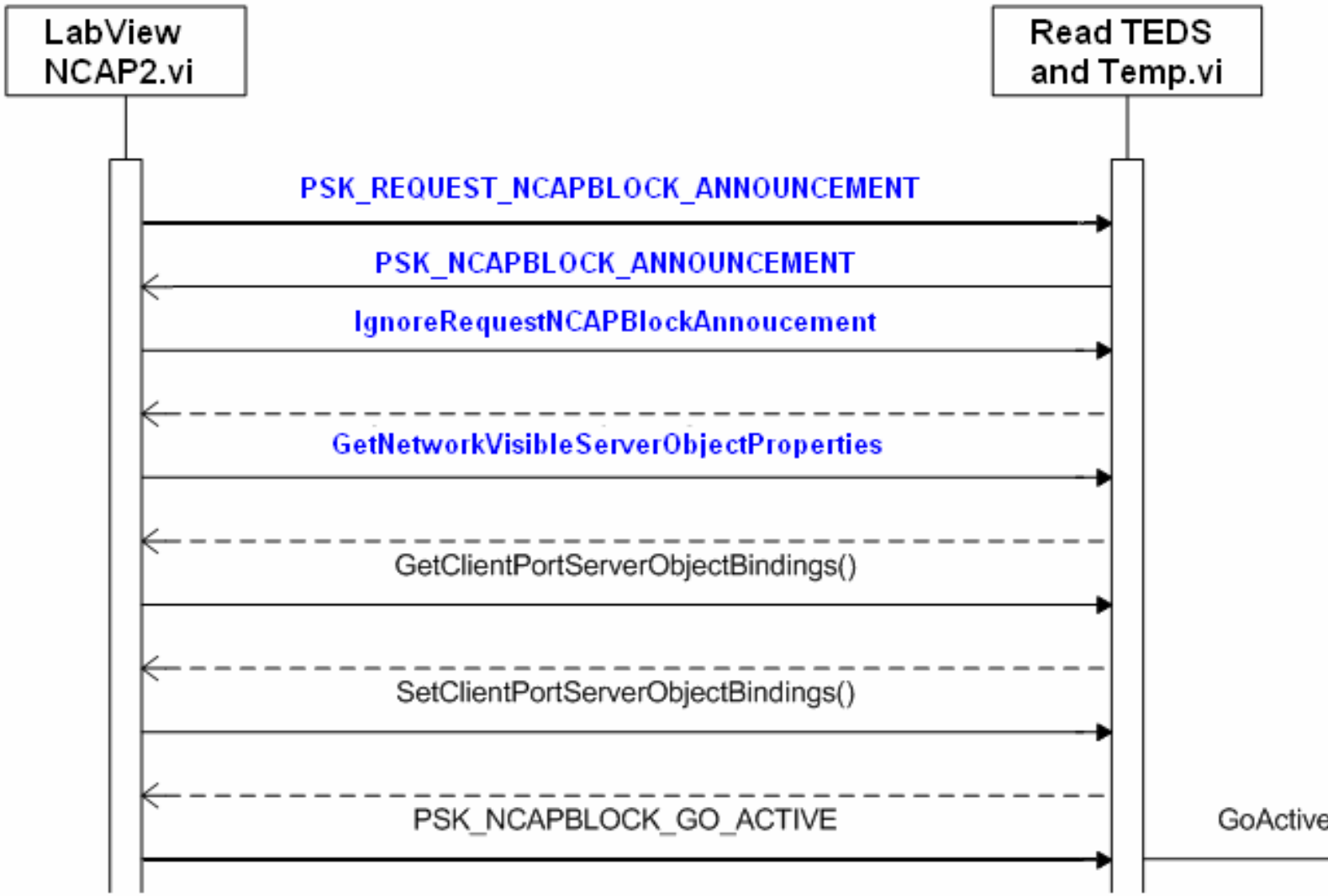
LabView NCAP



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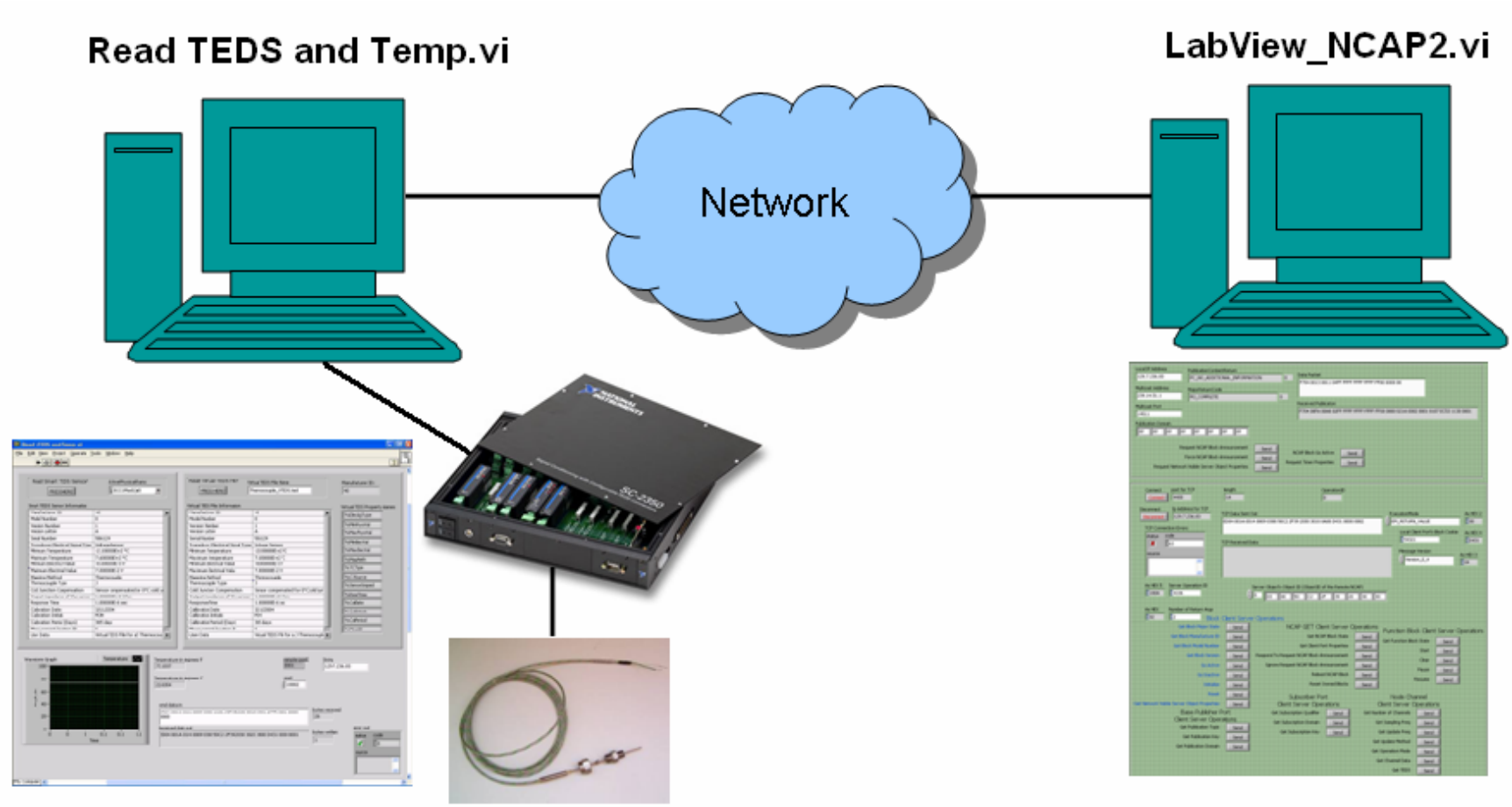
LabView Hardware



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Testing Challenges

- No real implementation or application
  - NCAP-to-NCAP communication
  - Network physical layer and topology
- User and implementation platform choices
  - On-the-wire formatting
  - Protocol
  - Application
- No finalized vision of the standard or the industry
  - Localized PlugFest on 1451 at UH

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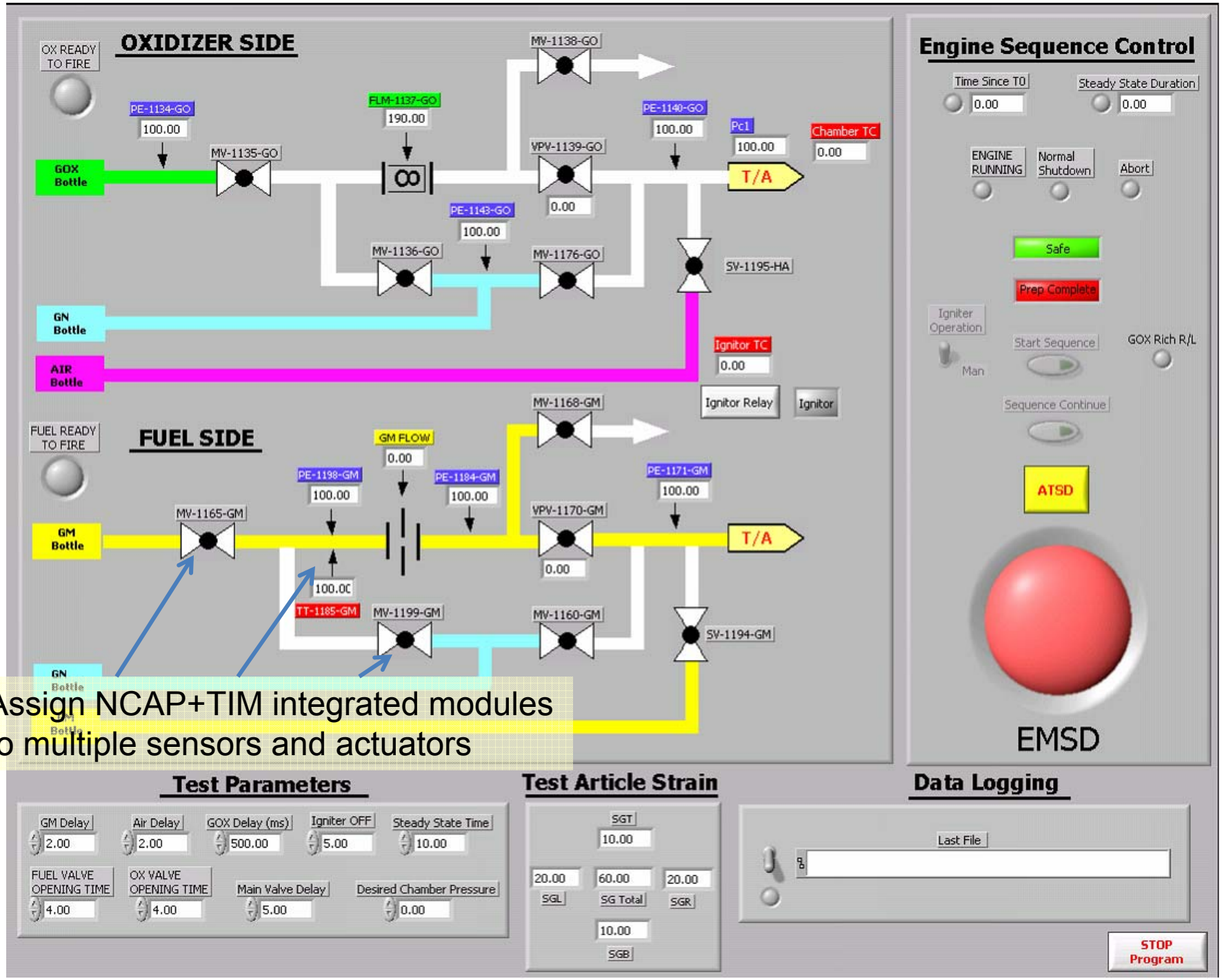

Assign NCAP+TIM integrated modules to multiple sensors and actuators

Thank You

Comments and Suggestions Welcome

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