IEEE 1451: Empowering the Smart Sensor Revolution

# Unification of IEEE 1451 Family - Common Commands, TEDS & Functionality

James Wiczer, PhD

Sensor Synergy, Inc.

Buffalo Grove, IL

www.sensorsynergy.com

SENSOR SYNERGY

Making Sensor-to-Network Connections Simple

# IEEE 1451 Family of Standards

- IEEE 1451.1
- Other Custom Applications
  - ***Resident in Network Gateway Structures - NCAPS***
  - ***Mission: Connect to Network***

IEEE 1451.0

Physical layers
- IEEE 1451.2
- IEEE 1451.3
- IEEE 1451.4
- IEEE 1451.5
- IEEE 1451.6

- IEEE 1451.0 Protocols, TEDS, Functions and Commands Underlie All New & Revised Members of IEEE 1451.x Family of Standards

# Common Features for 1451.x

## A Simplified View

Communications within 1451.x

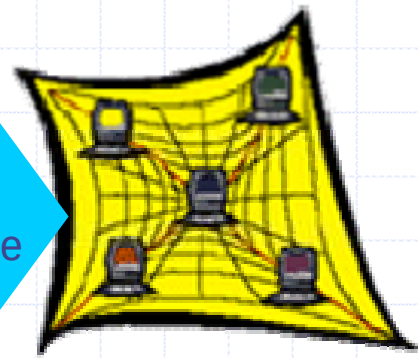
Communications Between 1451.x and External Network

TIM Module

1451.x Specific Communications

NCAP Module

NCAP Specific Network Interface



Smart Sensor **T**ransducer **I**nterface **M**odule

**N**etwork **C**apable **A**pplication **P**rocessor Module

External **Network** Used by Smart Sensor "Clients" to Connect

# Common Functions in 1451.x Based on 1451.0

- Numerous features - See the standard for a complete list of functions
- Plug and Play capability
- Communications to each transducer channel thru TIM via the NCAP
- Adherence to common rules - Data set and message protocols

# Common Functions in 1451.x Based on 1451.0

- Hot Swap Capability
- Status Reporting
- Self-Test Capability
- Service Request Messaging
- Synchronous Data Acquisition from Arrays of Sensors
- Streaming Mode

# Common Functions in 1451.x Based on 1451.0

- API - Application Program Interface
- Command set to interact with smart sensors and actuators
- TEDS Features
  - Meta-TEDS,
  - Transducer Channel TEDS
  - User's Transducer Name TEDS
  - PHY TEDS

# Transducer Electronic Data Sheets - TEDS

- Electronic data sheets for transducers (TEDS) range from simple fixed format tagged data structures to open ended user defined information repositories
- TEDS typically provide information required by the electronic interface or the user's application.

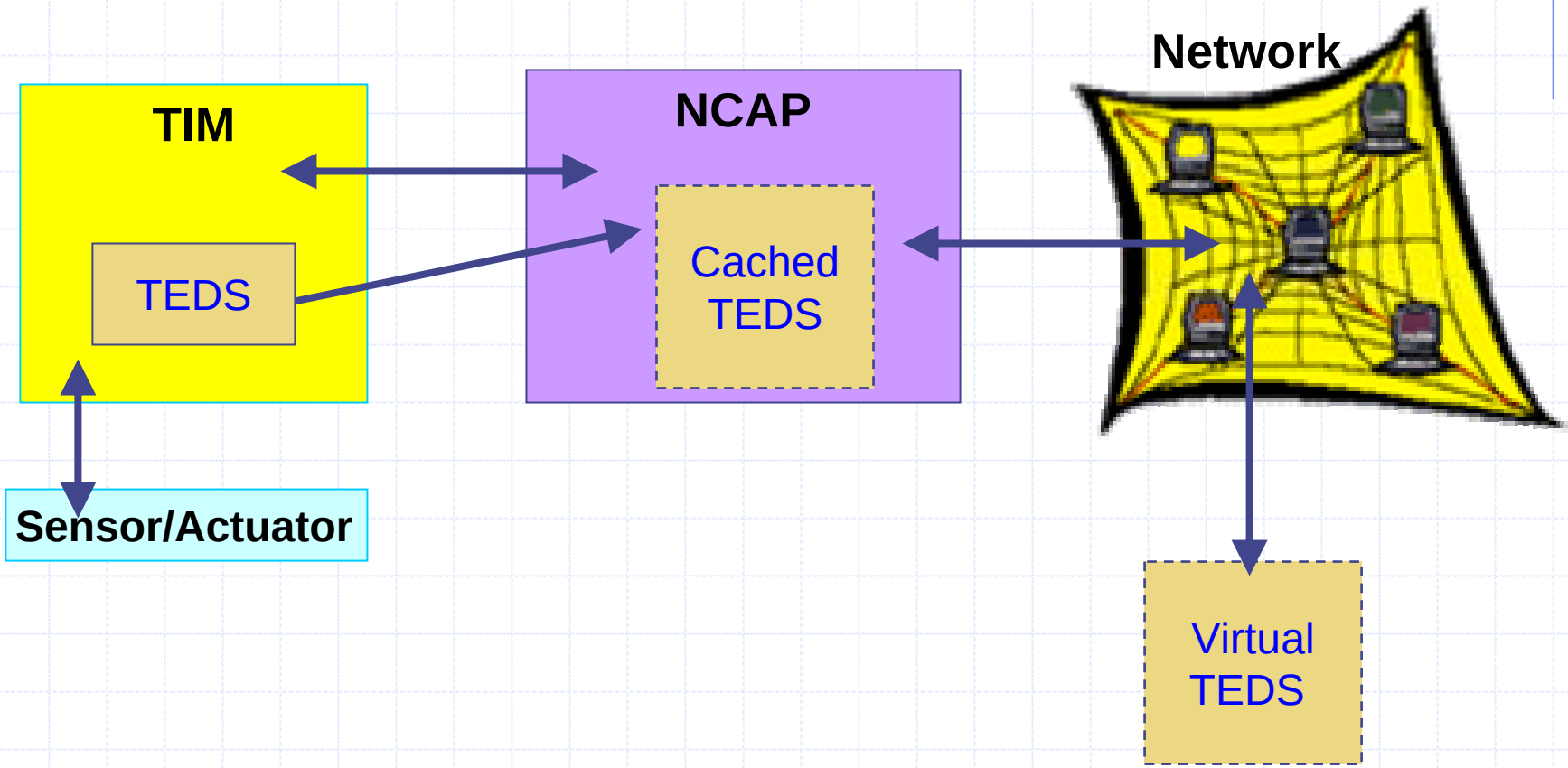
# What is a TEDS?

- Transducer Electronic Data Sheet = TEDS
- Information stored in memory in the TIM
- Like and electronic analog of paper data sheet but more - Application specific features
- Like a File, a Logically Consistent Set of Information, Adhering to the 1451 Specs (Rules) and Describing an Aspect of Transducer Interface.

# What is a TEDS?

- Transferred to the NCAP for later use
- Contains settings and constants for the transducer - sensor or actuator
- May contain general information about all transducers of a certain type made by a certain manufacturer
- Or *Applications Specific* information about a particular sensor in a specific application at a unique location

# Where Do TEDS Live?



# How the NCAP uses the TEDS

- Identification
- Operating Modes
- Operating Limits
- Calibration Parameters
- Functionality and Configuration

# How the End-User's Application Uses TEDS

- Operating Parameters
- Location and Function
- Text for User Interface
- High Level Command Translation

# The **POWER** of the TEDS

- Look - Up in the Sky -
  - It's a Bird,
  - No It's a Plane
  - No… Its (super)-TEDS!!!
- Able to Interface Tall Building with a Single Network!
- TEDS is a KEY attribute that ENABLES Smart Sensor Interface Open-Standards!

# The **POWER** of the TEDS

- TEDS can be viewed as the knowledge repository for smart sensors
- More than the electronic equivalent of paper data sheets, TEDS is a dynamic, application specific Database that customizes smart sensors for a specific application

# The **POWER** of the TEDS

- Enable transducer self-identification with name TEDS and UUID codes
- Enable connection of sensors and actuators to networks in seconds! - No elaborate keyboard entry of configuration parameters

# The **POWER** of the TEDS

- Enable “in the Field” transducer replacements with ease - Cal factors already specified in TEDS
- Able to accommodate various physical units, languages, and operating parameters -TEDS has units & language parameters
- Eliminate human error prone data entry with TEDS file transfers
- And Much More

# Meta TEDS

- Must be resident on TIM
- Contains unique “UUID” identifier
- Contains worst case timing parameters
- Contains trigger and operating configuration

# Transducer Channel TEDS

- Typically, a channel is defined for each sensor or actuator - that is each channel must have its own TEDS structure
- *Collections of Channels* can be grouped into
  - Control Groups
  - Vector Groups

# Transducer Channel TEDS

- Each transducer channel must have one channel TEDS data structure describing the channel
- Contains detailed info on the channel
  - Physical Units
  - Operating Limits
  - Transducer Data Format
  - Timing Info

# User's Transducer Name TEDS

- Contains text name that the application uses to identify the sensor
- Examples
  - Manifold Output Temperature
  - Chemical Sensor Measuring Ethylene Oxide
  - Gamma Radiation Sensor

# Calibration TEDS

- Cal TEDS is an optional TEDS - as many as one for each channel as few as no Cal TEDS in the entire system
- Contains information necessary for the NCAP to convert raw data into calibrated data in SI or user specified units.

# Calibration TEDS - Continued

- Rich set of calibration algorithm accommodate linear regression, polynomial curve fit, lookup table, etc.
- Two (2) other TEDS available for complex corrections:
  - *Frequency Response*
  - *Transfer Functions*

# Manufacturer-defined TEDS

- Allows a 1451.x manufacturer of TIM devices to specify additional customized commands and data structures.

# Physical Layer - PHY TEDS

- Allows each 1451.X family member to customize the details of the physical layer (electrical) interface between the NCAP and the TIM

# Other TEDS Include ---

- Text TEDS
- End user's application specific TEDS
- Essentially limitless user extensibility

# How Many TEDS are Required?

- It Depends - Typically 3 or 4
  - Meta TEDS,
  - Channel TEDS,
  - User's Transducer Name TEDS
  - Different members of the 1451 family may require other TEDS like PHY TEDS

# Classes of Common 1451.0 Commands for IEEE 1451.x

- Commands to TIMs from NCAPs
- Commands to one or all transducers from NCAPs via TIMs
- Commands to the TIM and transducers from NCAPs

# Types of Common Activation Commands

- Activate (operate)/ De-Activate (Idle) Transducer Channel
- Activate/De-Activate (Sleep) TIM

# Types of Common Infrastructure Commands

- Read/Write TEDS
- Perform Self-Test on TIM
- Read/Write Service Request Status
- Read/Write Event Status

# Types of Common Transducer Operational Commands

- Trigger - Setup and Initiate
- Read Transducer State (Sensor or Actuator)
- Write Transducer (typically Actuator)
- Halt Trigger

# Common Triggering (Sampling) Mode

- Sample on receipt of trigger signal
- Free running with trigger to store data
- Immediate -- in response to request
- Continuously acquire data & store in buffer

# Common Access to 1451.x Objects from Network Clients

- Includes a common TCP/IP request/response protocol between network connected remote clients and 1451.X objects
- For example, an internet-based PC can request sensor data from an internet connected 1451.X objects using a common syntax and common commands

# Common Access to 1451.x Objects from Network Clients

- Enables same command set to query across a network any 1451.X smart transducers that uses 1451.0

- For example, *Get Sensor Measurements* command will use the same command to connect a web browser to a 1451.2, 1451.3 or 1451.5 device - just need to know the device's IP address.

# Summary - IEEE 1451.0 Functions and Commands

- 1451.x compliant devices using 1451.0 provide a broad range of commonly requested transducer functionality using a powerful command set that includes a set of common query tools across the 1451.x family

# Thanks for Listening about 1451 Smart Sensor Interfaces

Available for Questions and General Discussion after the talk and at the Sensor Synergy's booth

*Sensor Synergy's Booth is Located at #336 and*

*Visit IEEE 1451 Booth Located at # 450*

Contact: James Wiczer at 847-353-8200 *or* jwiczer@sensorsynergy.com *or* visit www.sensorsynergy.com