NIST

IEEE 1451
Smart Sensor Interface Standard

Sensor Standards Workshop

Fort Bragg, NC

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National Institute of Standards and Technology

United States Department of Commerce

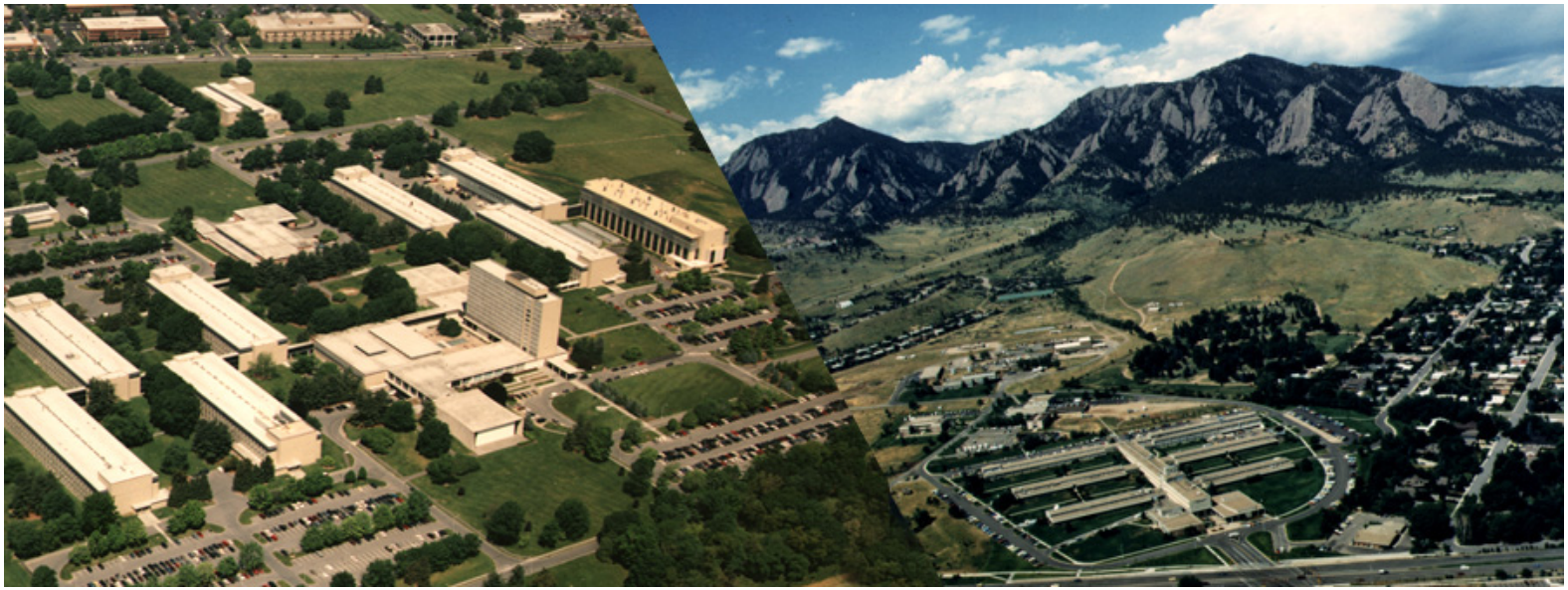
NIST

Outline

- NIST
- IEEE 1451 Smart Transducer Interface Standard
- Benefits of IEEE 1451
- Some Example Applications of IEEE 1451
- Cooperation with OGC and ORNL
- Key points of IEEE 1451

National Institute of Standards and Technology (NIST)

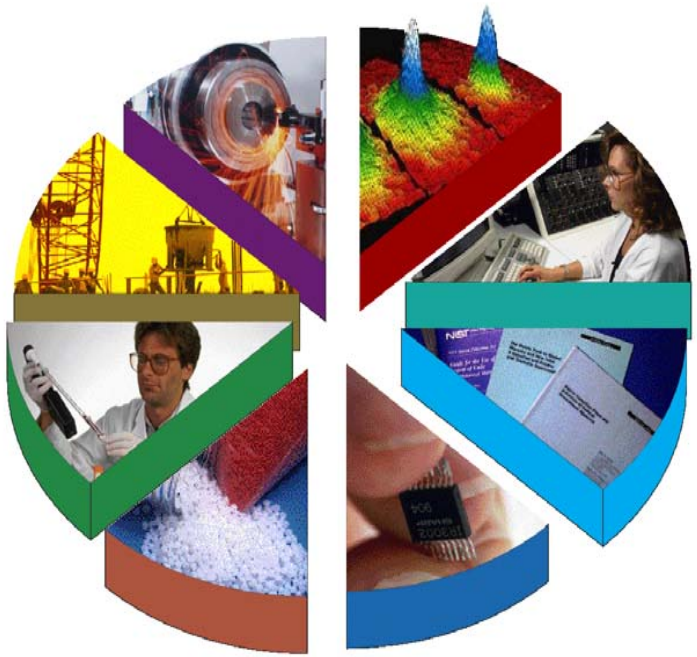
Mission: Develop and promote measurement, standards, and technology to enhance productivity, facilitate trade, and improve the quality of life.



Gaithersburg, Maryland

Boulder, Colorado

NIST Laboratories



- Measurement methods
- Calibration Services
- Standard Reference Materials
- Evaluated scientific data
- Standards development
- Industrial technologies
- Testing laboratory accreditation

manufacturing engineering laboratory • measuring for success


Manufacturing Engineering Laboratory Programs
• Dimensional Metrology
• Homeland and Industrial Control Security
• Intelligent Control of Mobility Systems
• Manufacturing Interoperability
• Manufacturing Metrology and Standards for the Health Care Enterprise
• Mechanical Metrology
• Nanomanufacturing
• Smart Machining Systems
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Example Standards coming from MEL

- The STEP standard family, AP203 (ISO 10303) for configuration-controlled CAD exchange
  - relevant to production of military parts by defense contractors
- The Open System Joint Task Force with in OSD has been supporting AP233 (ISO 10303-233) that supports system engineering
  - relevant to production of military parts by defense contractors
- ANSI/ASME B5 Machine Tool Evaluation Standard
  - direct interaction with U.S. Army Picatinny Arsenal
- Dimensional Inspection Standards (ANSI & ISO)
  - relevant to production of military parts
- Performance metrics for autonomous vehicles and remotely-operated robotic equipment
  - largely funded by DoD

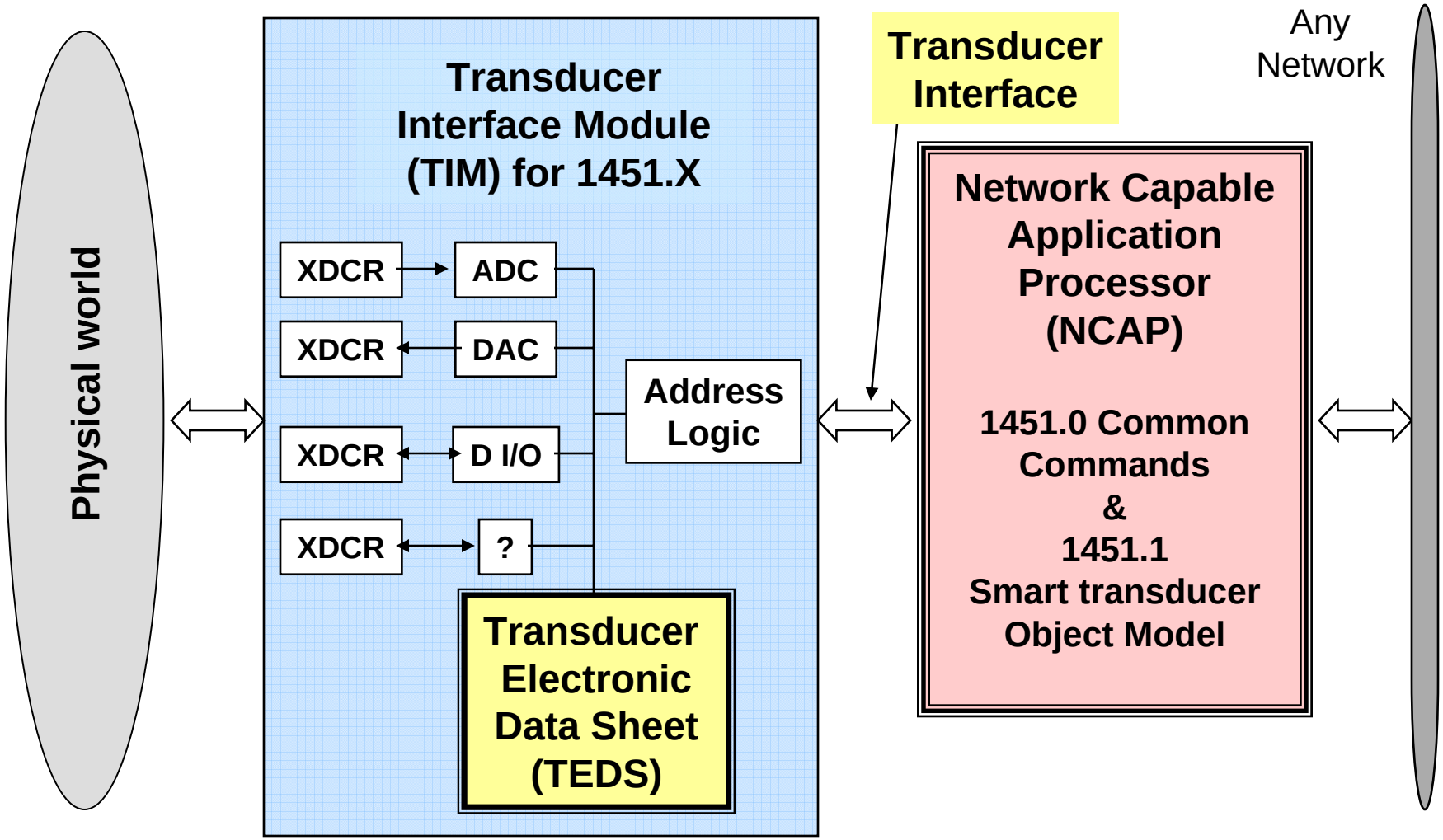
IEEE 1451

- **"Standard for a Smart Transducer Interface for Sensors and Actuators - "**

- **Sponsored by the IEEE Instrumentation and Measurement Society's Technical Committee on Sensor Technology TC-9**

- **Vision and Consensus at a NIST-sponsored workshop (4/94)**
  - **To establish a common communication interface for connecting sensors to sensor buses and networks that is vendor and network neutral**

IEEE 1451 Smart Transducer Interface System Diagram



XDCR = sensor or actuator

Transducer Electronic Data Sheets (TEDS)

TEDS provide sensor ID, measurement range, calibration and user information and more …

- **Meta-TEDS**
- **Transducer channel TEDS**
- **Calibration TEDS**
- **Frequency response TEDS**
- **Physical TEDS**
- **Manufacturer-defined TEDS**
- **End user application specific TEDS**
- **….**
- **Geo-location TEDS**

Transducer Electronic Data Sheet (TEDS) – cont'd

- **Meta-TEDS**
  - Data structure related information
    - version number
    - number of implemented channels
    - future extension key
    - ...
  - Identification related information
    - manufacturer's identification
    - model number
    - serial number
    - revision number
    - date code
    - product description
    - ...

Transducer Electronic Data Sheet (TEDS) – cont'd

- **Channel TEDS**
  - Transducer related information
    - lower range limit
    - upper range limit
    - physical unit
    - unit warm-up time
    - uncertainty
    - self test key
    - ...
  - Data Converter related information
    - channel data model
    - channel data repetitions
    - channel update time
    - channel read setup time
    - channel write setup time
    - data clock frequency
    - channel sampling period
    - trigger accuracy
    - …

Transducer Electronic Data Sheet (TEDS) – cont'd

- **Calibration TEDS**
  - Data structure related information
    - Calibration TEDS length
  - Calibration related information
    - last calibration date-time
    - calibration interval
    - number of correction input channels
    - multinomial coefficient
    - ….
  - Data integrity information
    - checksum for calibration TEDS

Transducer Electronic Data Sheets (TEDS) –cont'd

- **Frequency Response TEDS**
  - provides the frequency response data for a single transducer channel as a table

- **Transfer Function TEDS**
  - provides the frequency response data for a single transducer channel with an algorithm
  - User can combine this with the desired response to compensate the data

Transducer Electronic Data Sheet (TEDS) – cont'd

- **Commands TEDS**
  - a text-based TEDS to be used by the manufacturer to define new commands
- **PHY TEDS**
  - defines parameters unique to the physical communications media
- **Manufacturer Defined TEDS**
  - allows the manufacturer to define additional features

Transducer Electronic Data Sheet (TEDS) – cont'd

- **Text-based TEDS**
  - allows manufacturer to provide textual information with the device.
  - written in XML (eXtensible Mark-up Language)
  - Binary XML directory
  - Followed by text-based XML TEDS data

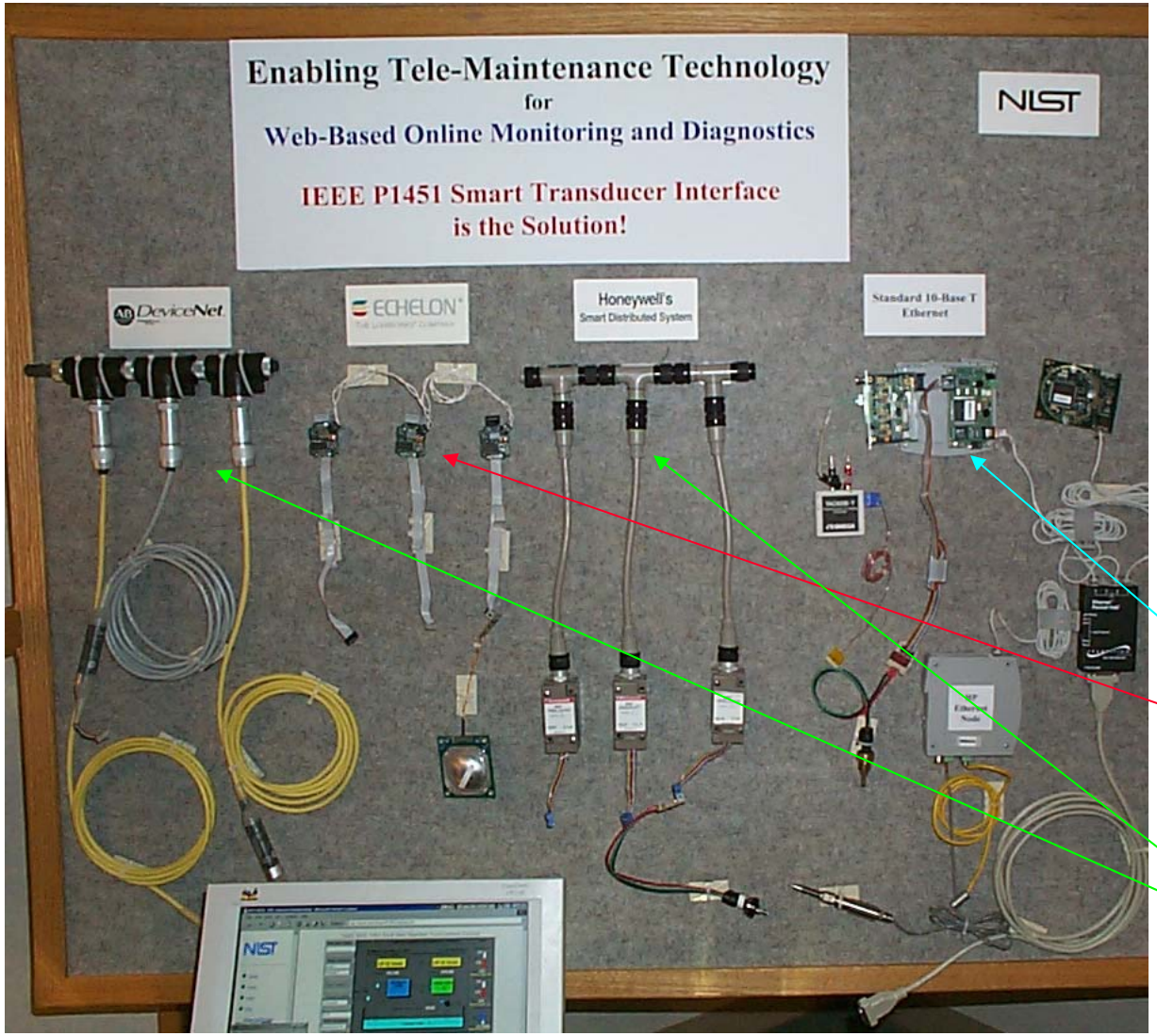
- **End user application specific TEDS**
  - written by the user with user data

- **Geo-location TEDS**
  - specify location of transducer
  - data block in GML (Geography Markup Language)

Benefits of having a TEDS with a Transducer

TEDS

- ✓ enable self-identification and self-description of sensors and actuators
- ✓ eliminate human errors from manual entering of data and system configuration steps
- ✓ eliminate recalibration when replacing sensors
- ✓ provide self-documentation
- ✓ reduce costs of setup and teardown sensors
- ✓ simplify field installation, upgrade, and maintenance of sensors by simply "plug and play" devices into a system or network



IEEE 1451 Proof-of-Concept Demonstration

- **Self-identification**
- **Plug-and-Play**

<u>Sensor Networks</u>

- **Ethernet network**
- **Neuron-based building automation network**
- **CAN-based industrial network**

What is IEEE 1451?

Standard ways to connect sensors and actuators to networks and systems that facilitate

Interoperability

At the SensorGov Conference on Sept 13-14, 2004.

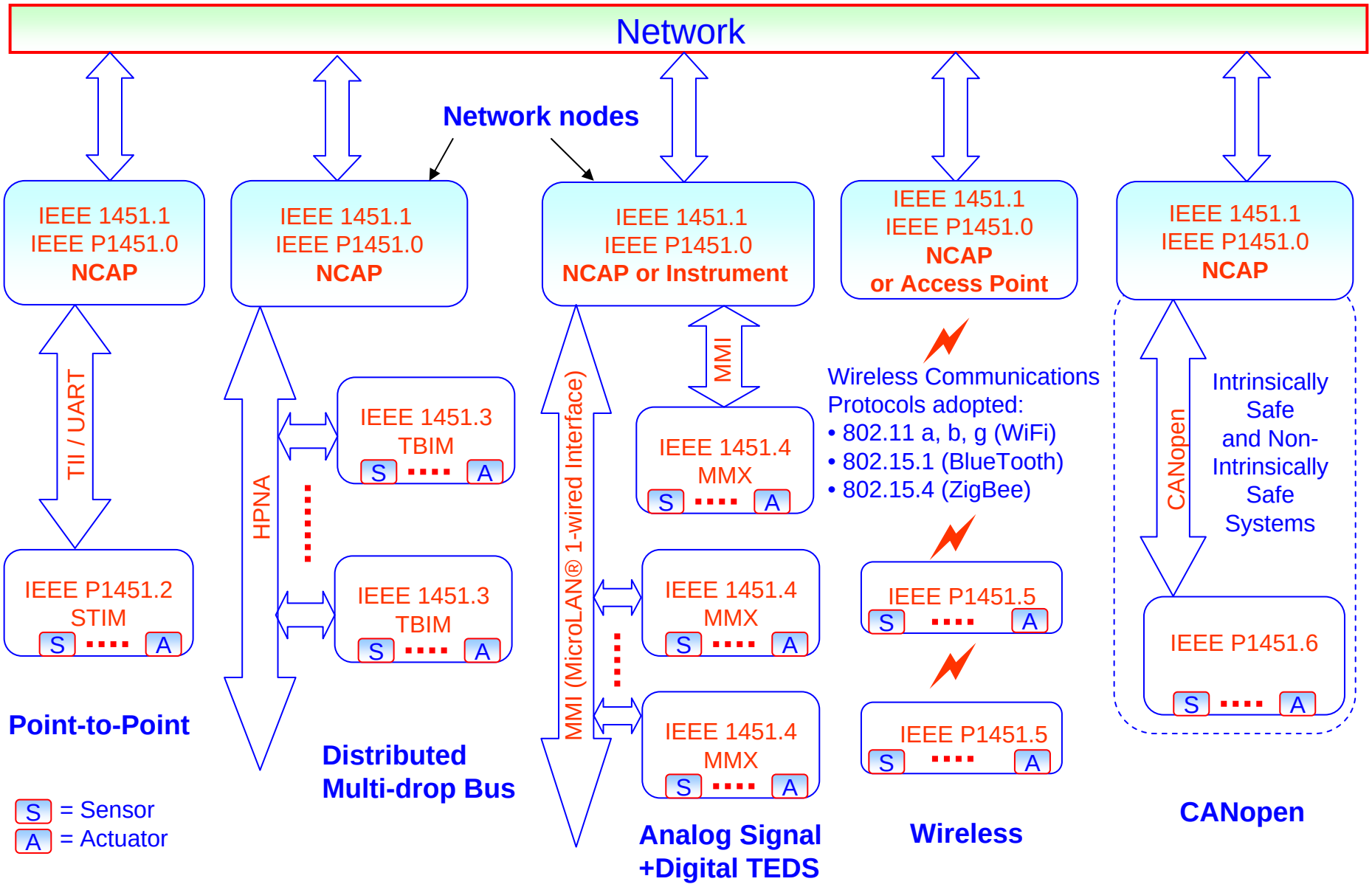
Dr. Vitalij Garber, Director of Systems Integration, Defense System, Office of Under Secretary of Defense summed it up very clearly,

"…from sensors perspective, let's tie them together for interoperability ...

…net all sensors and provide seamless operation.

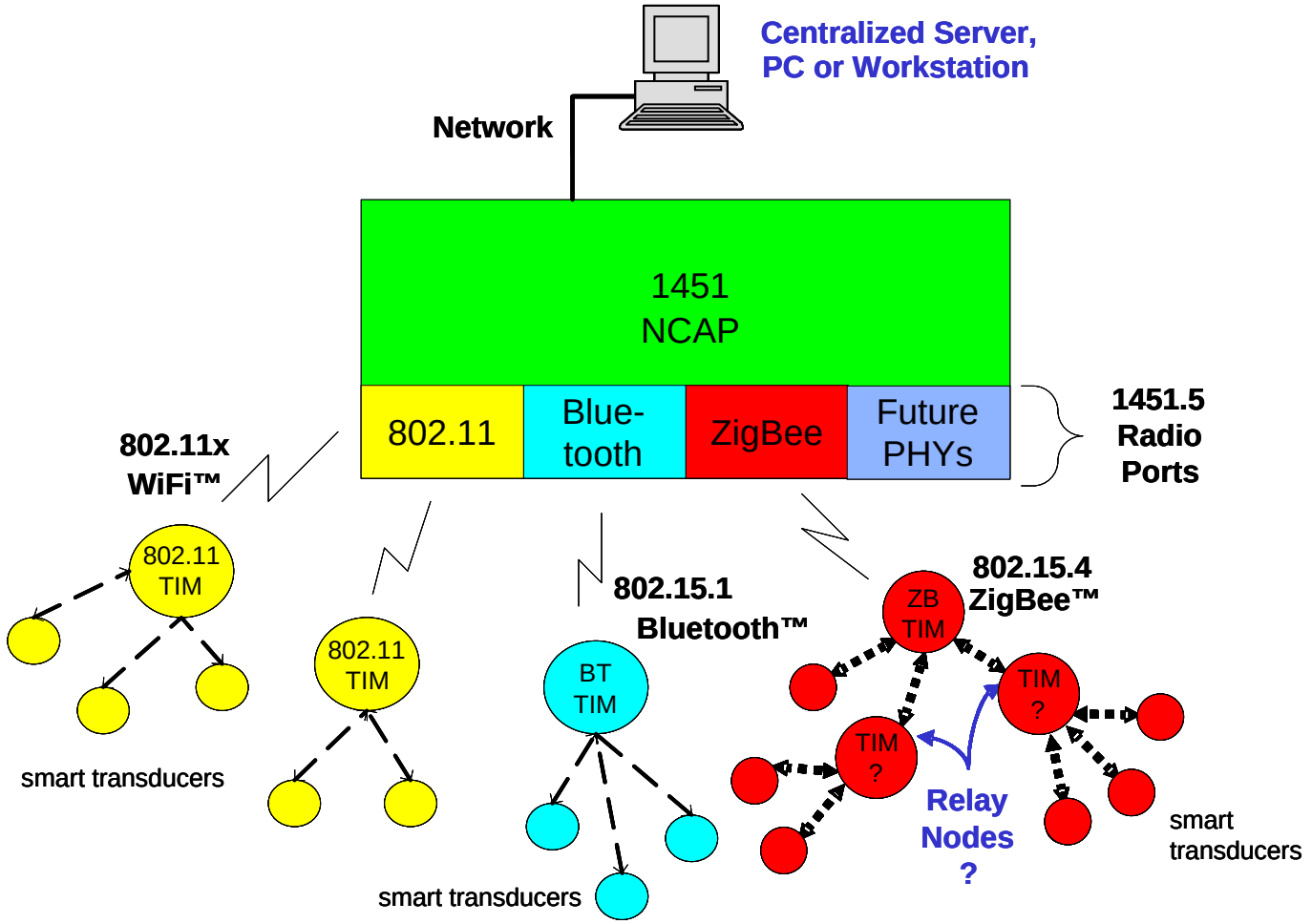
… maximum use of commercial standards and approach."

IEEE 1451 Family of Standards



IEEE P1451.5 Wireless Sensor Standard

- adopting existing wireless communication protocols and
- including TEDS



Status of the Family of IEEE 1451 Standards

- **IEEE Std 1451.1-1999,** Network Capable Application Processor (NCAP) Information Model for smart transducers -- *Published standard, being revised*

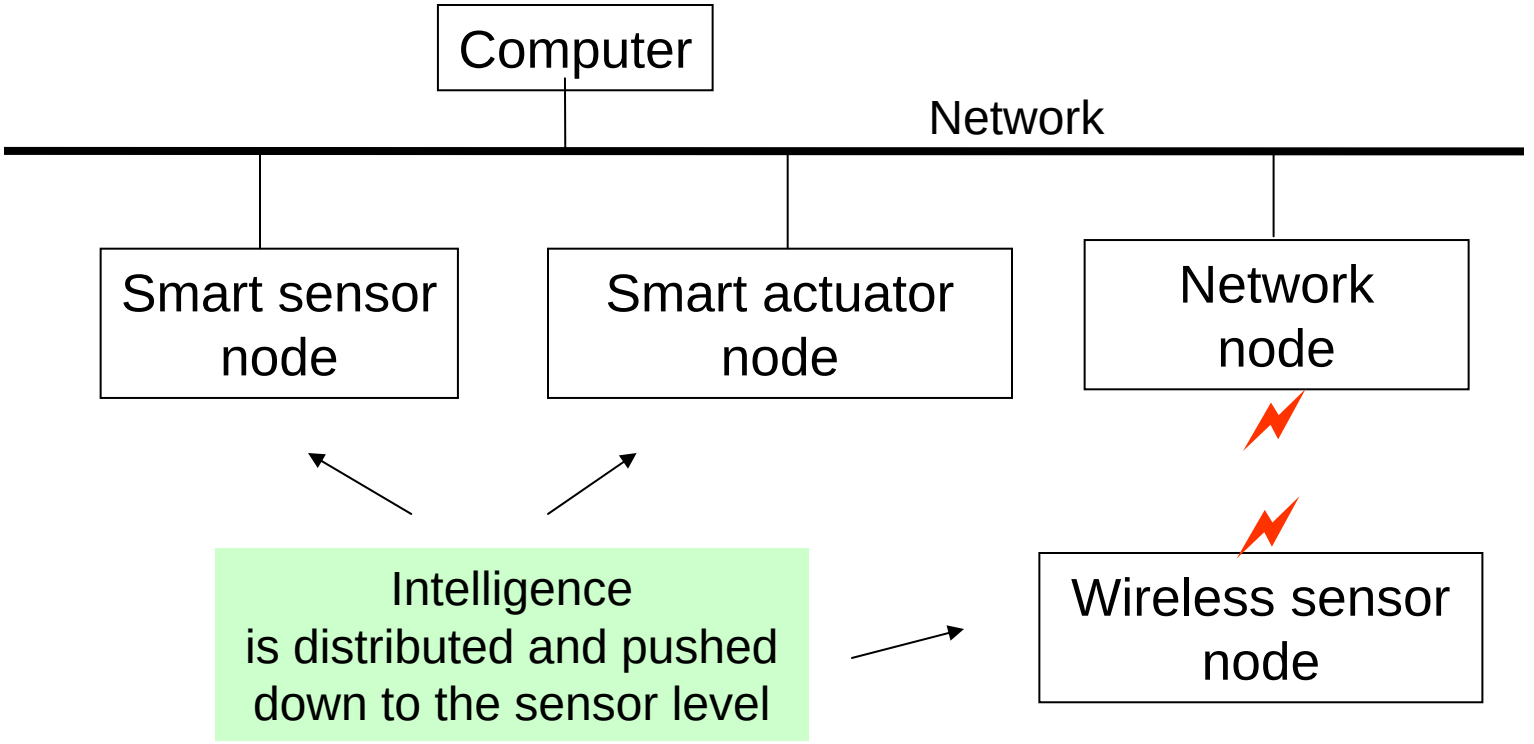
- **IEEE P1451.0,** Common Functions, Communication Protocols, and Transducer Electronic Data Sheet (TEDS) Formats -- *In progress, balloting in May 2005*

Physical Layers

- **IEEE Std 1451.2-1997,** Transducer to Microprocessor Communication Protocols and Transducer Electronic Data Sheet (TEDS) Formats -- *Published standard, being revised*
- **IEEE Std 1451.3-2003,** Digital Communication and Transducer Electronic Data Sheet (TEDS) Formats for Distributed Multidrop Systems -- *Published standard*
- **IEEE Std 1451.4-2004,** Mixed-mode Communication Protocols and Transducer Electronic Data Sheet (TEDS) Formats – *Published standard*
- **IEEE P1451.5,** Wireless Communication and Transducer Electronic Data Sheet (TEDS) Formats – *In progress, balloting in May, 2005*
- **IEEE P1451.6,** A High-speed CANopen-based Transducer Network Interface – *In progress*

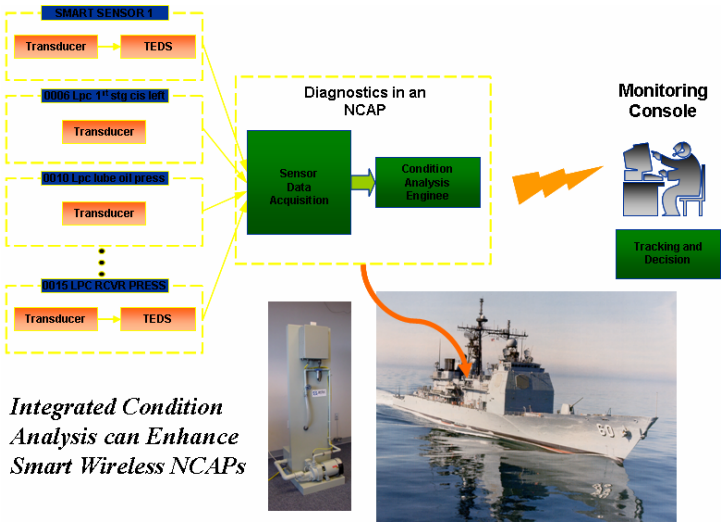
IEEE 1451 Enables

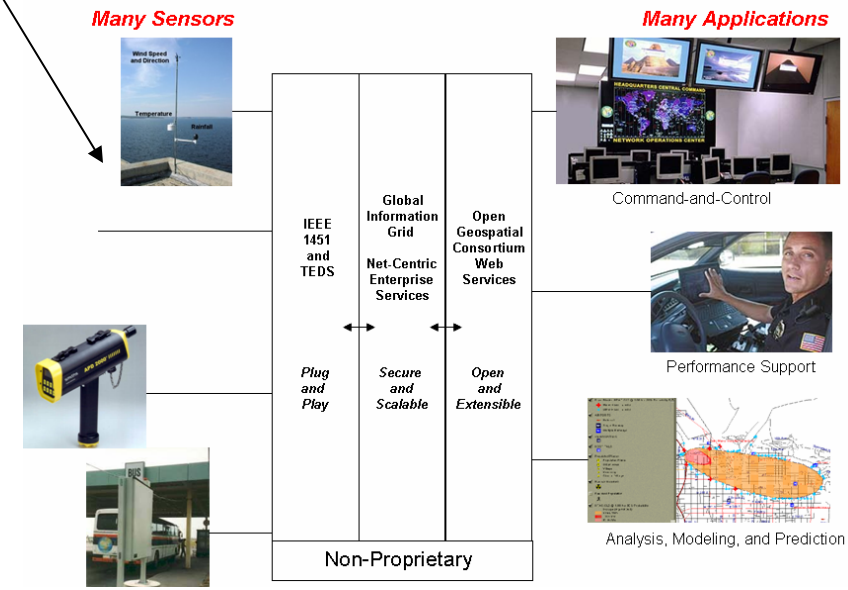
- users to build “Distributed Smart Sensor/Actuator Systems”.
- users to access the sensors in wired or wireless network using a common command set.



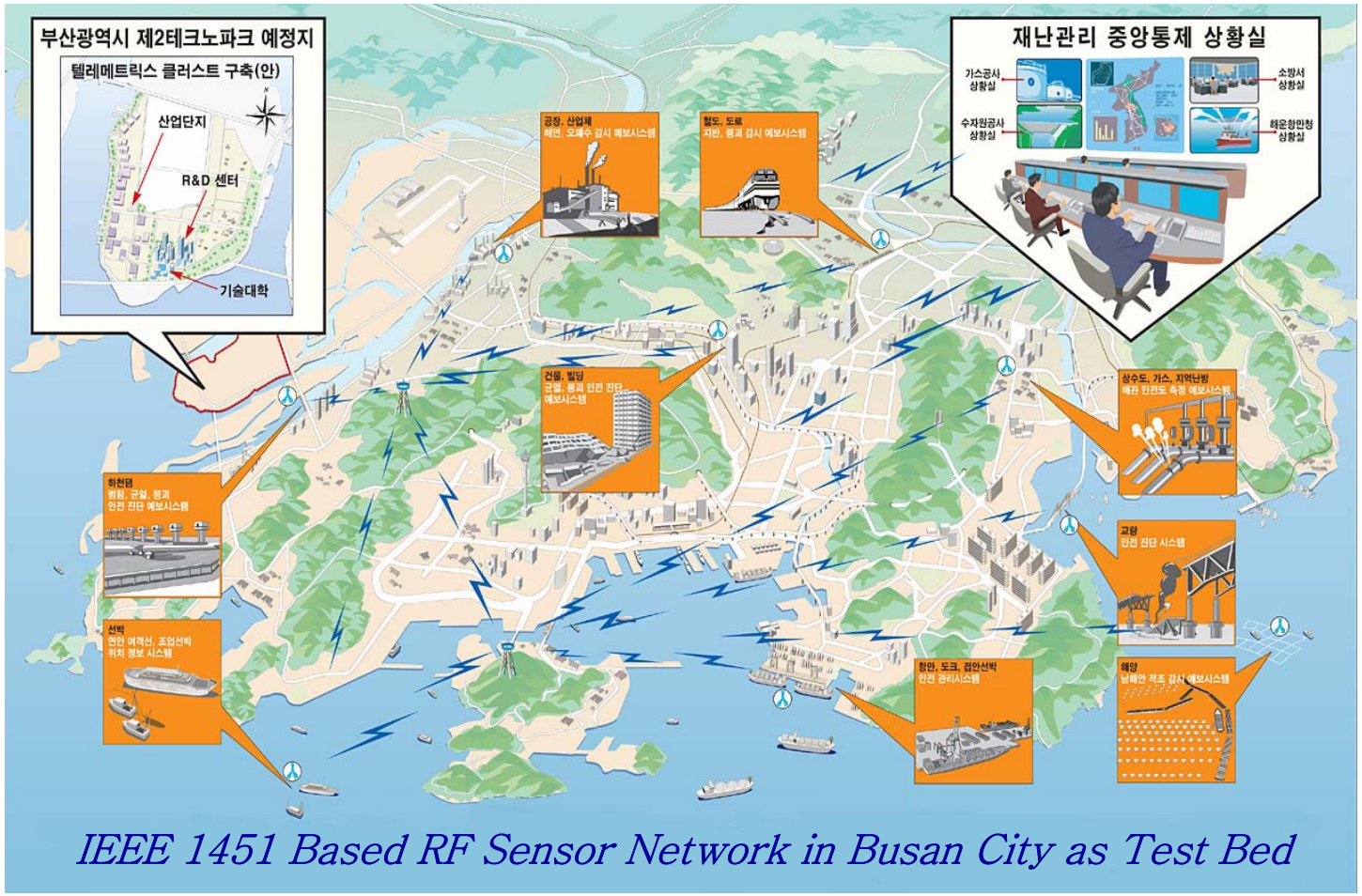
Examples of IEEE 1451 Applications

- NI LabVIEW integrated with IEEE 1451.4 interfaces.
- EDC applies IEEE 1451.2 in oil drilling monitoring.
- ORNL applies 1451 in SensorNet.
- 3eti applies 1451 in naval vessels for CBM.





Telemetrics Test Bed - applying IEEE 1451 Standard in South Korea supported by the Ministry of Commerce, Industry, and Energy (MOCIE)



Courtesy of KDnet

Collaboration – IEEE TC-9, OGC and ORNL

- OGC president Mark Reichardt visited the IEEE 1451 Committee at their meeting in Dec 2004.
- IEEE 1451 Committee addressed the OGC Committee at their meeting in Jan 2005.
- Common interest in working together to advance open standards to enable sensor interconnection, discovery, access, integration, and usage within and across systems, networks, and enterprises.
- Excellent opportunity to bring IEEE 1451-based sensor data and information to the geospatial applications.
- MOU was signed in April 2005 between IEEE I&MS and OGC.

Key points of IEEE 1451 Standard

- Develop network-independent and vendor-independent transducer interfaces
- Define standardized Transducer Electronic Data Sheets (TEDS) that contain manufacture-related data
- Support a general model for transducer data, control, timing, configuration, and calibration
- Eliminate error prone, manual entering of data and system configuration steps, ultimately achieving Plug and Play
- Allow transducers (sensors or actuators) to be installed, upgraded, replaced or moved with minimum effort
- Be able to get wired or wireless sensor data and information seamlessly from a host system or network anywhere in the world.

For More Information About TC-9 Sponsored IEEE Standards

- **Contact: Kang Lee at kang.lee@nist.gov**
- **IEEE standards can be purchased at http:// ieee.org**
- **IEEE 1451 websites:**
  - **1451: http://ieee1451.nist.gov**
  - **1451.4: http://grouper.ieee.org/groups/1451/4**
  - **1451.5: http://grouper.ieee.org/groups/1451/5**
  - **1451.6: http://grouper.ieee.org/groups/1451/6**
- **IEEE 1588 website: http://ieee1588.nist.gov,** Standard for a Precision Clock Synchronization Protocol for Networked Measurement and Control Systems