Proposed Enhancements to the IEEE 1451.2 Standard for Smart Transducers

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October 2, 2001

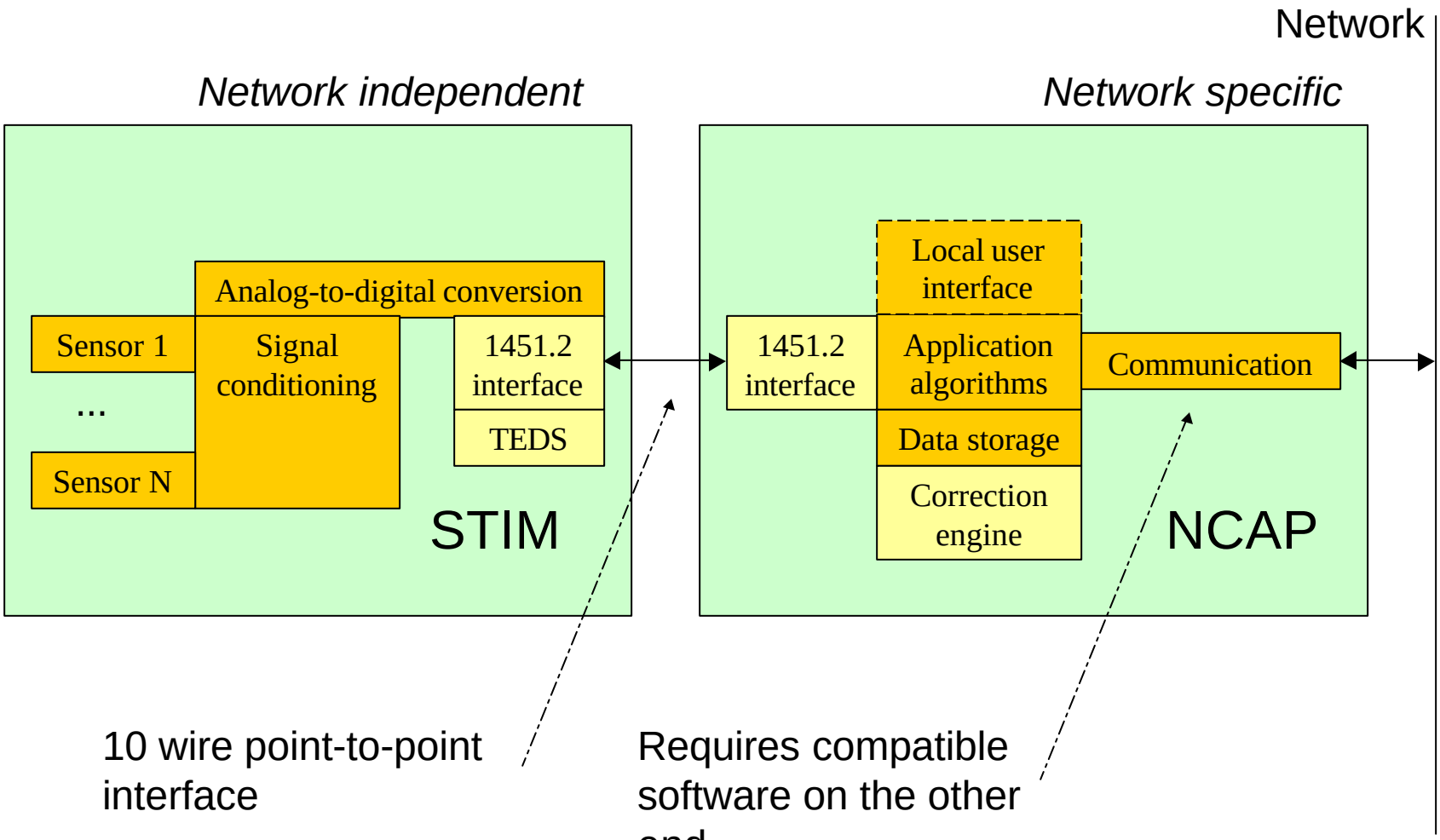
Introduction

- General benefits of smart sensors and of IEEE 1451.2 have been discussed in the previous presentations
- IEEE 1451.2-1997 was approved in September, 1997
- Defined terms and established basic principles of smart transducers and communications with transducers
- Received wide praise for technical accomplishments but has not enjoyed wide use
- Due for five-year review and vote on renewal next year
- This paper will discuss requested changes and proposed enhancements
- Workshop October 4, 2001 to discuss this in more detail
- Please attend the workshop! We want your feedback and support

What is a smart sensor?

- Several definitions of smart sensor; we will use the one from IEEE 1451.2-1997
- A Smart Transducer is “A transducer that provides functions beyond those necessary for generating a correct representation of a sensed or controlled quantity. This functionality typically simplifies the integration of the transducer into applications in a networked environment.”
- A Smart Sensor is “A sensor version of a smart transducer.”
- Key concept: A smart sensor adds value to the data to enable or support distributed processing and decision making

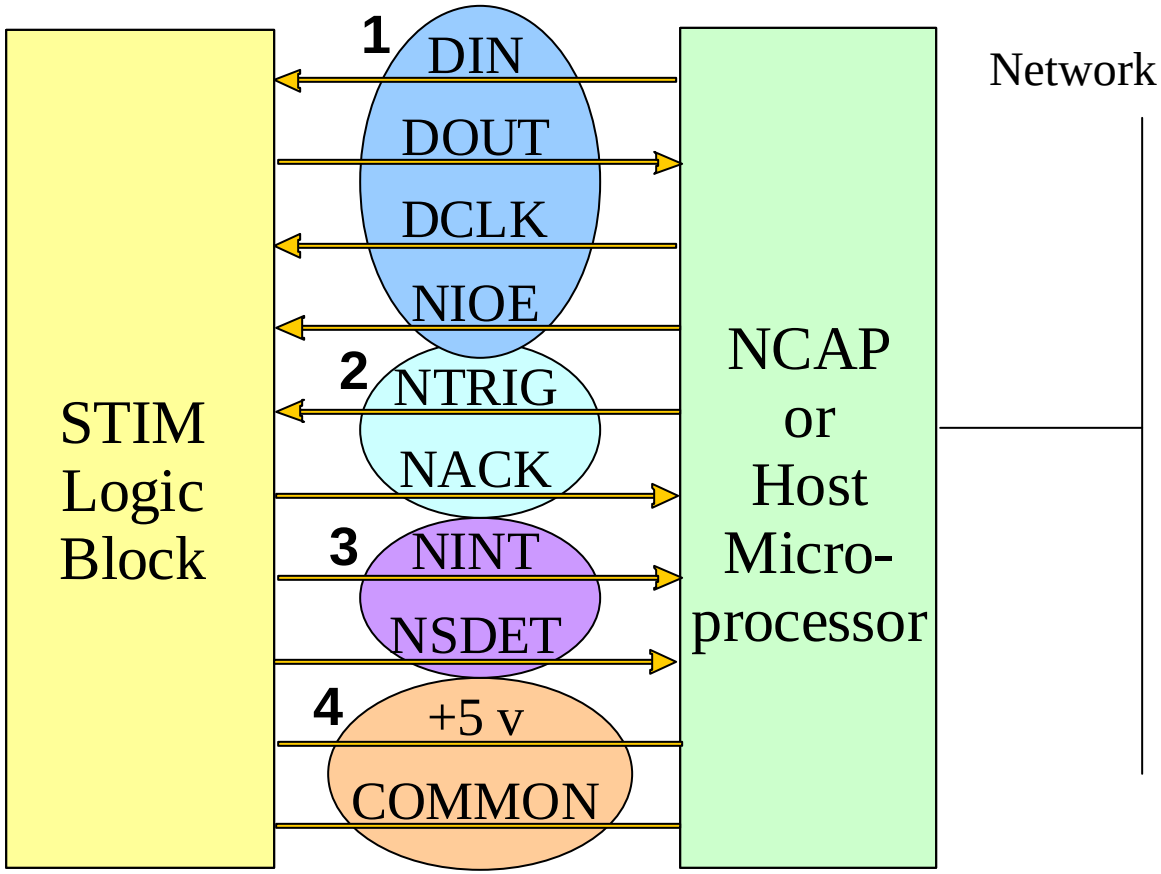
IEEE 1451.2 smart sensor model



IEEE 1451.2 hardware interface

1) Communication/framing
2) Triggering/handshaking
3) Interrupts and hot swap
4) Power

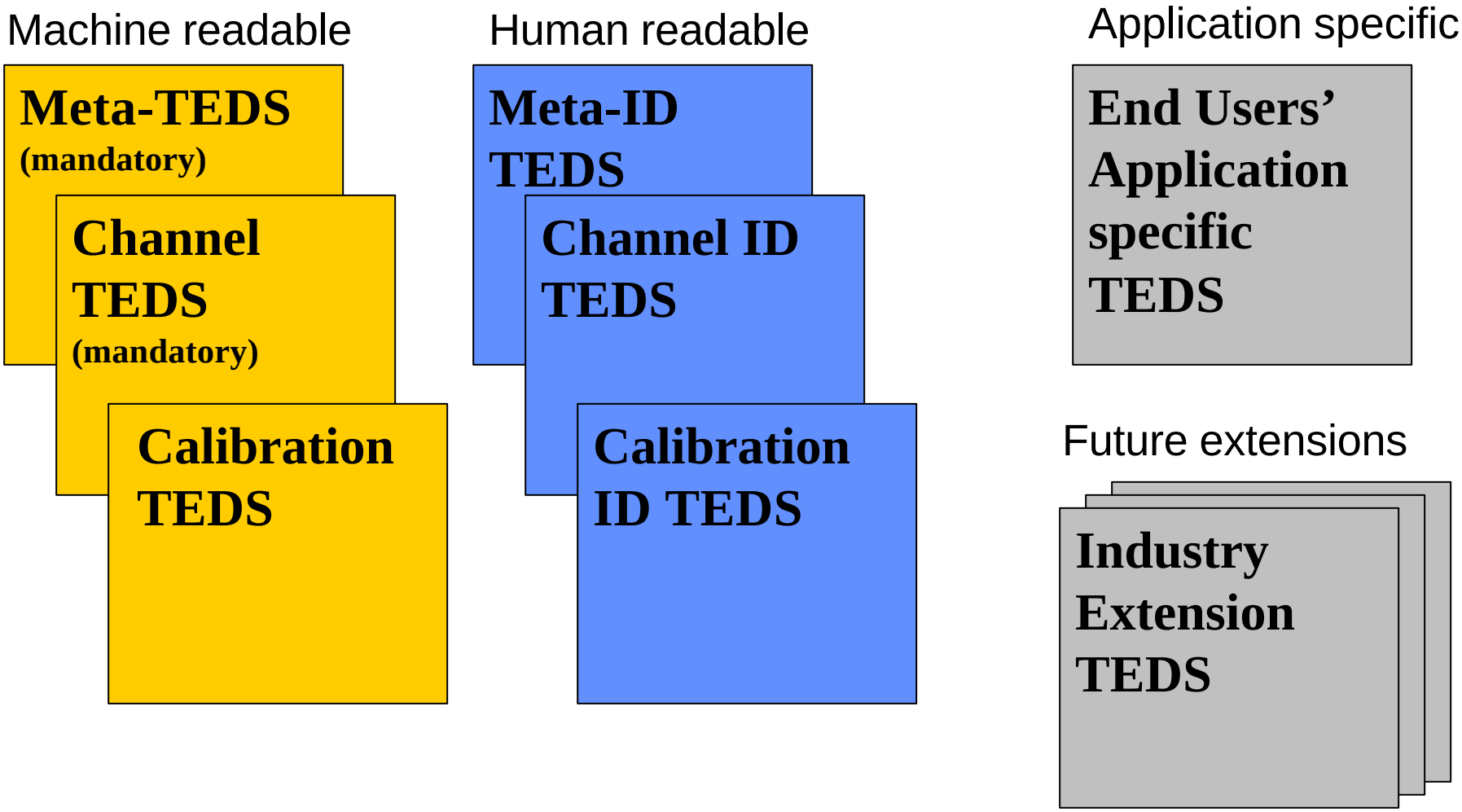
Intended for closely -coupled systems



IEEE 1451.2-1997 valuable features

- Extensible Transducer Electronic Data Sheet (TEDS)
- General calibration/correction model for transducers
- Physical units representation based on SI units
- Triggering and control model defines how channels are accessed
- All channels may be triggered simultaneously, timing parameters are used to indicate channel differences
- Models for different kinds of sensors
- Powerful concept/location of correction engine allows flexibility in system design

IEEE 1451.2 TEDS blocks



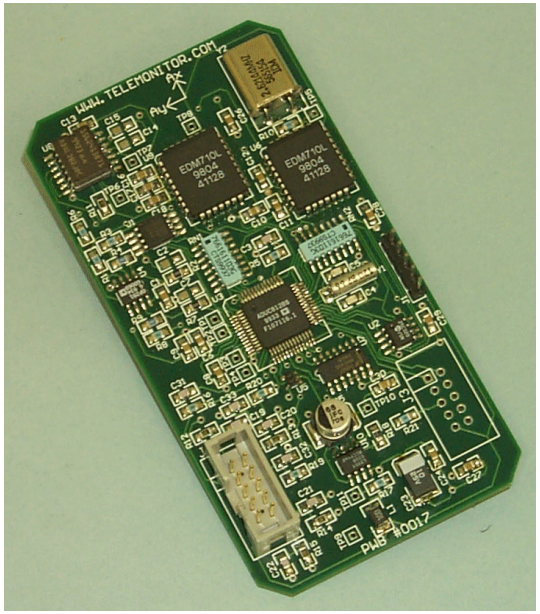
Power of TEDS plus correction engine

Multi-channel acceleration/tilt sensor:

- Hardware channels for temperature and acceleration
- Correction engine performs temperature compensation
- Virtual actuators for zero correction
- Virtual sensors for tilt (roll and pitch)
- Correction engine converts to angle
- Number order of channels is important

Data Channels

No.	Property	Type	Units	Minimum	Maximum
1	Temperature	Sensor	K	233.15 (-40° C)	358.15 (85° C)
2	Roll Zero	Actuator	radians	-1.57 (-90°)	1.57 (90°)
3	Pitch Zero	Actuator	radians	-1.57 (-90°)	1.57 (90°)
4	Roll Zero	Sensor	radians	-1.57 (-90°)	1.57 (90°)
5	Pitch Zero	Sensor	radians	-1.57 (-90°)	1.57 (90°)
6	X Acceleration	Sensor	m/s^2	-19.6 (-2 *g*)	19.6 (2 *g*)
7	Y Acceleration	Sensor	m/s^2	-19.6 (-2 *g*)	19.6 (2 *g*)
8	Roll (about X)	Sensor	radians	-1.31 (-75°)	1.31 (75°)
9	Pitch (about Y)	Sensor	radians	-1.31 (-75°)	1.31 (75°)



Most requested changes to IEEE 1451.2

- Make it easier to understand and implement
- Make the hardware interface faster
- Use less wires
- Pick a standard connector
- Provide for electrical isolation
- Allow real-time reconfiguration
- Add frequency response to TEDS and correction engine
- Make NCAPs readily available and compatible with existing systems
- Don’t add unnecessary expense to simple transducers
- Add security, timestamps, data logging, etc.

Most requested changes, con't.

- Make it easier to understand and implement
  - New, broad-reaching standard
  - Wide adoption will produce user guides, books, etc.
  - Not everyone must understand the details
  - OEMs can convert raw transducers to STIMs without having to design signal conditioning and conversion
- Make the hardware interface faster
  - Minimum of 6,000 bit/s supports inexpensive hardware
  - Maximum not specified; several million bit/s has been demonstrated
  - Digital interface may not be appropriate for all applications (*e.g.* IEEE P1451.4)

Most requested changes, con't.

- Use less wires
  - Originally for single close-coupled transducer to microprocessor
  - Based on SPI with hardware handshaking
  - Supports synchronized trigger and data acquisition
  - Simpler interfaces are appropriate for some uses
- Pick a standard connector
  - Connectors are very application-dependent
  - Started defining connectors for some applications
  - Alternate physical layers may include connectors
  - True "plug-and-play" requires connector definition

Most requested changes, con't.

- Provide for electrical isolation
  - Isolation less of an issue for close-coupled system
  - Using existing standard physical layers will help
- Allow real-time reconfiguration
  - STIM cannot tell NCAP that the TEDS has changed
  - No standard mechanism for selectable gain, sample rate, number of samples, etc.
- Add frequency response to TEDS and correction engine
  - Standard provides for extensions to TEDS but not to correction engine

Most requested changes, con't.

- Make NCAPs readily available and compatible with existing systems
  - Standard visualizes complete system including STIMs, NCAPs, network-level software
  - Need growth path to bring benefits of IEEE 1451 to existing systems
- Don't add unnecessary expense to simple transducers
  - Target is applications where interchangeable communicating smart transducers add value
  - Some applications are too cost-sensitive
  - Line between the two will shift over time

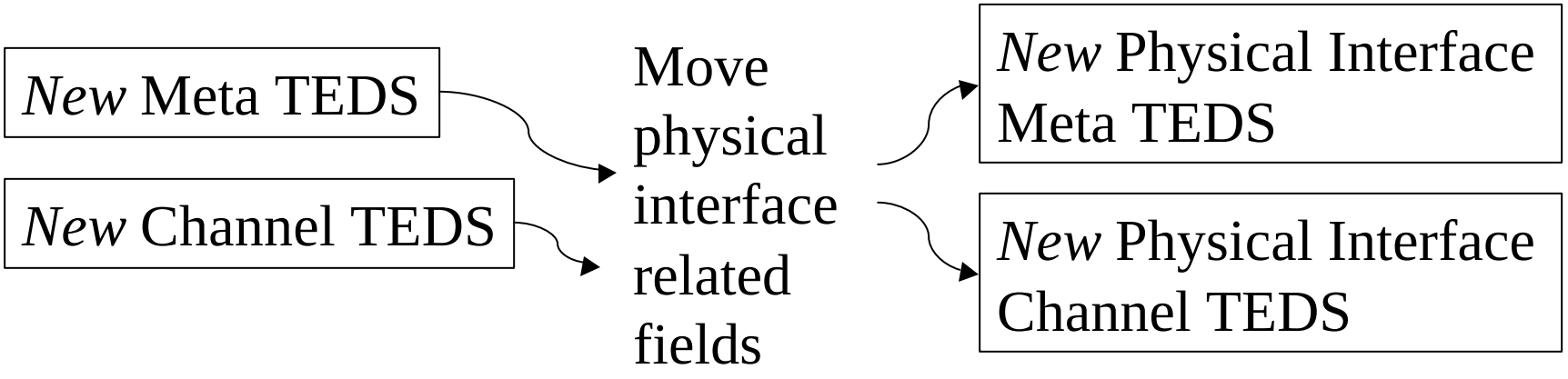
Most requested changes, con't.

- Add security, timestamps, data logging, etc.
  - Originally viewed as higher-level functions
  - Appropriate to consider for proposed enhancements
  - Will depend on the interests of the people who participate in the working group
  - Must avoid "rampant featuritis!"

Proposed enhancements to IEEE 1451.2

- Primary enhancements:
  - Partition the TEDS
  - Alternative physical layers
  - Partition the standard
- Secondary enhancements:
  - Enhance the TEDS
  - Add functions
  - Standalone function
  - Corrections and additions

Partition the TEDS



Meta-ID TEDS

Channel-ID TEDS

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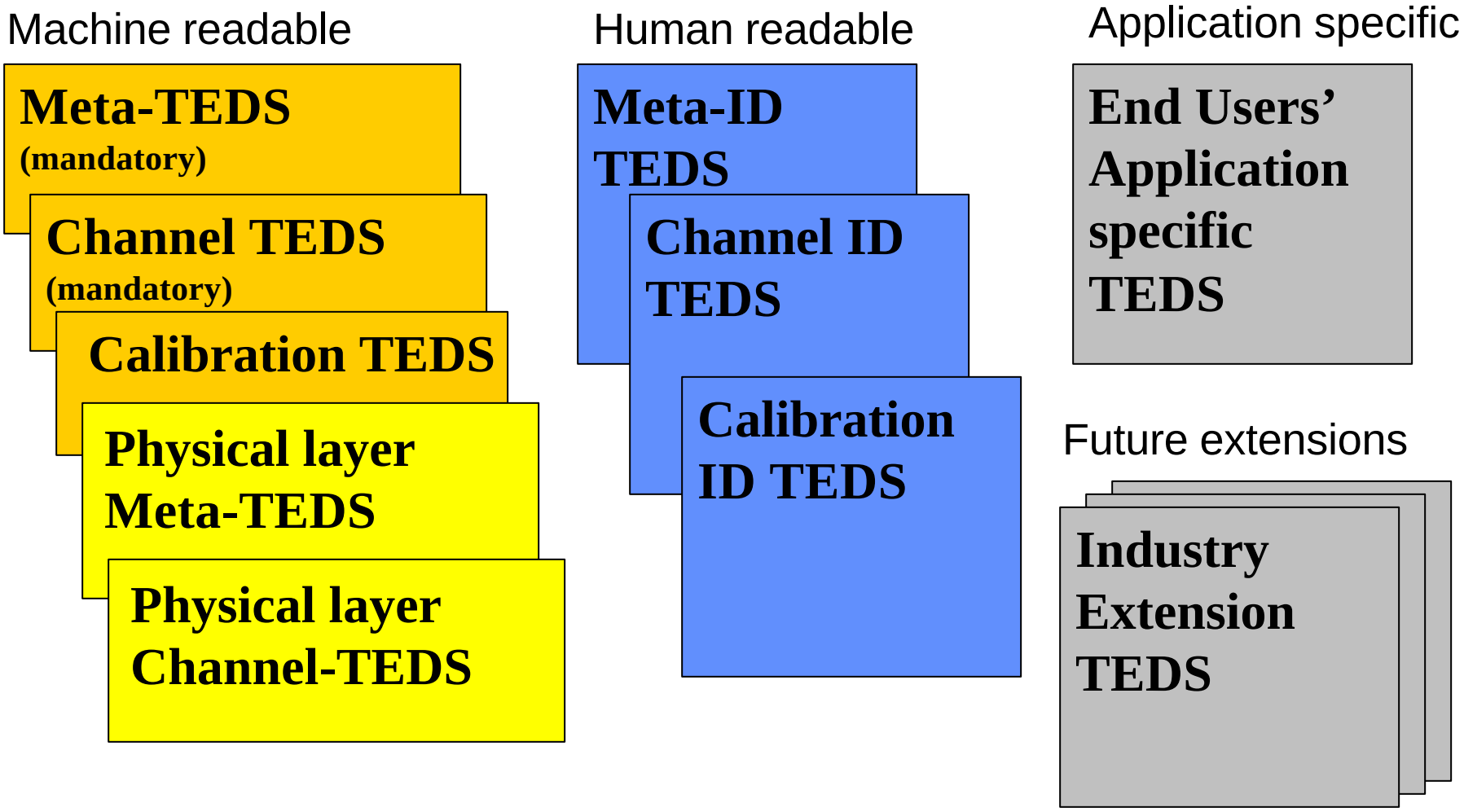
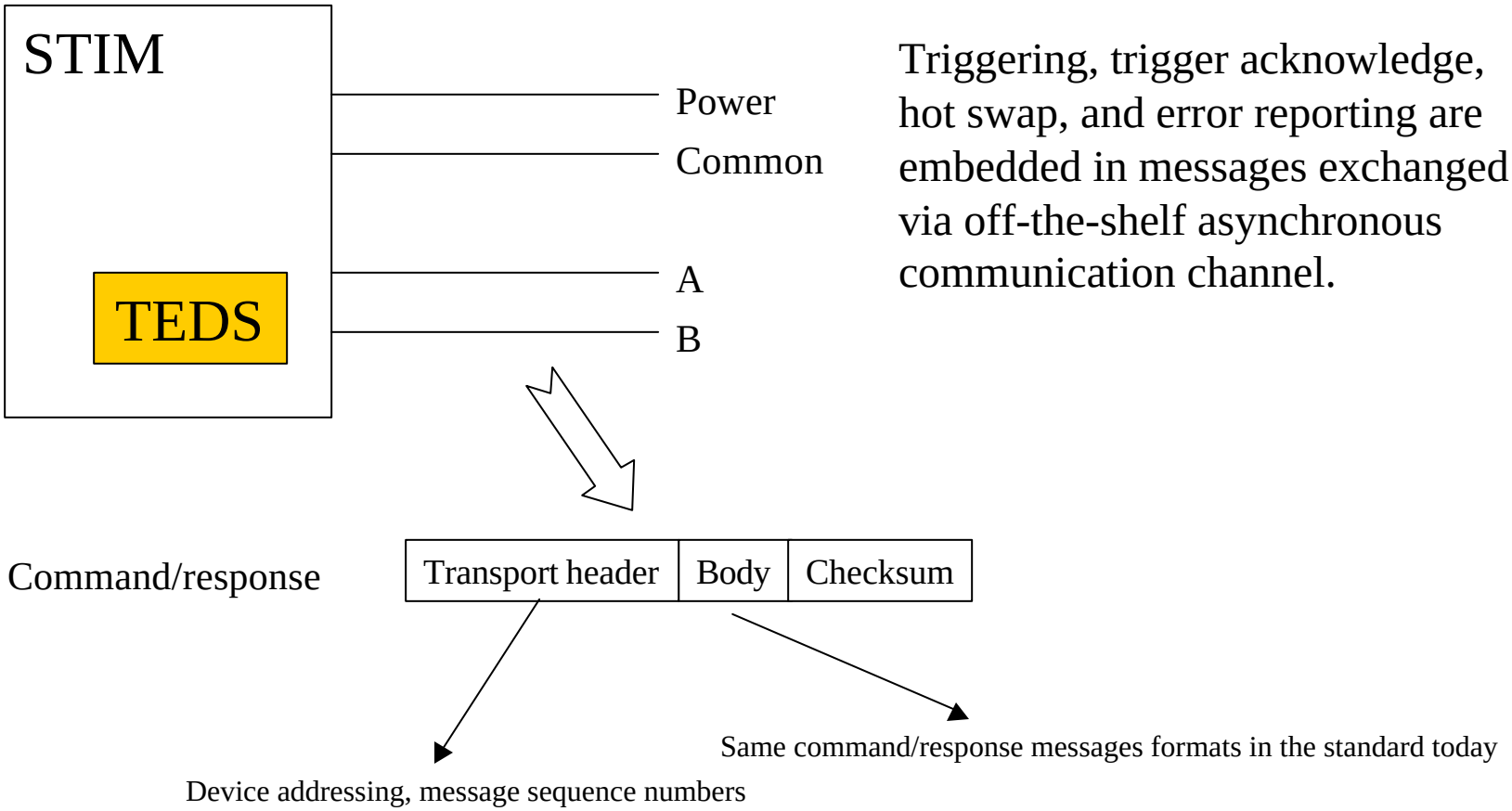
Other TEDS blocks can remain the same.

Supports use of different physical layers.

Proposed new IEEE 1451.2 TEDS blocks

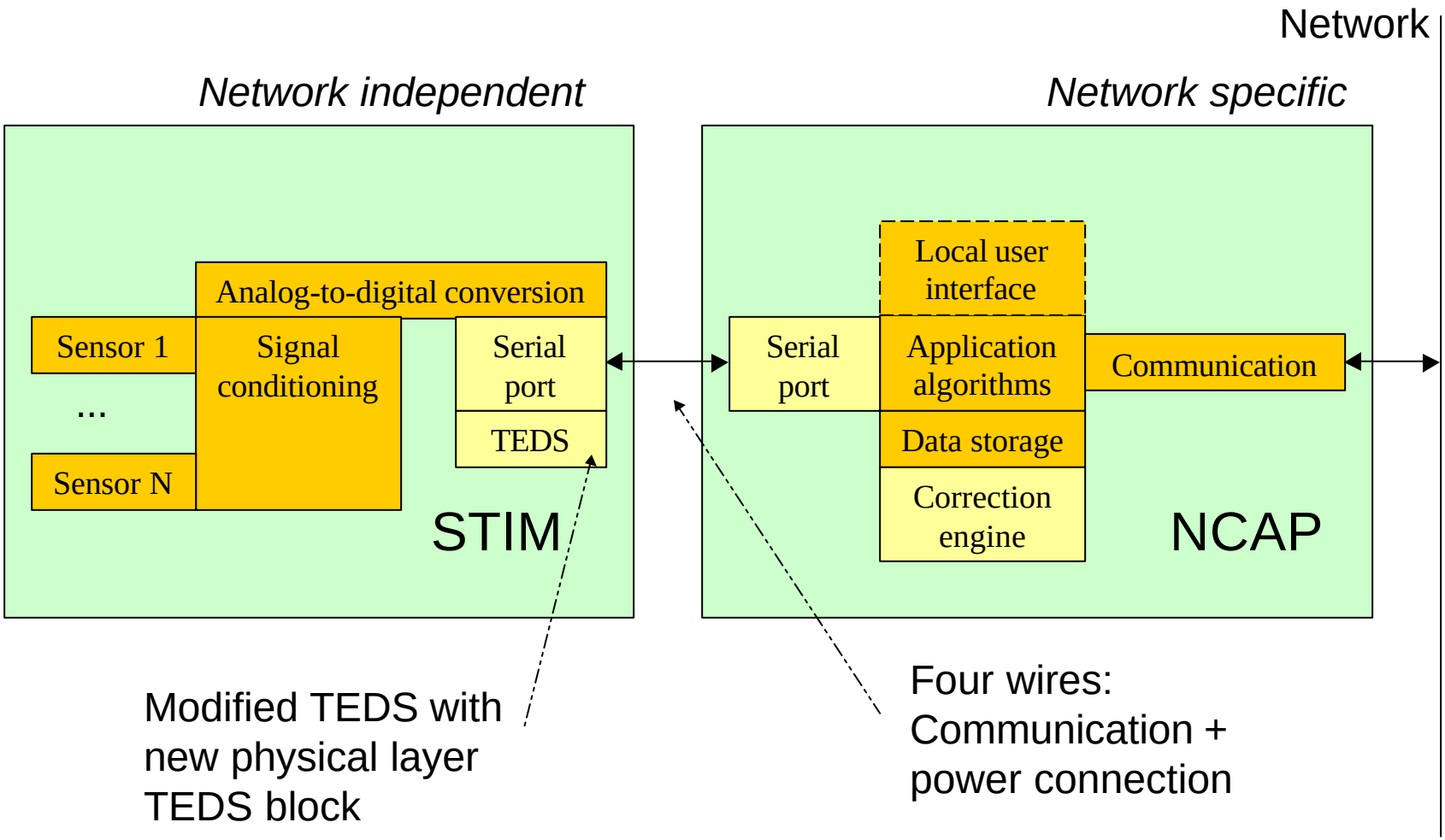


Alternate physical layers



Triggering, trigger acknowledge, hot swap, and error reporting are embedded in messages exchanged via off-the-shelf asynchronous communication channel.

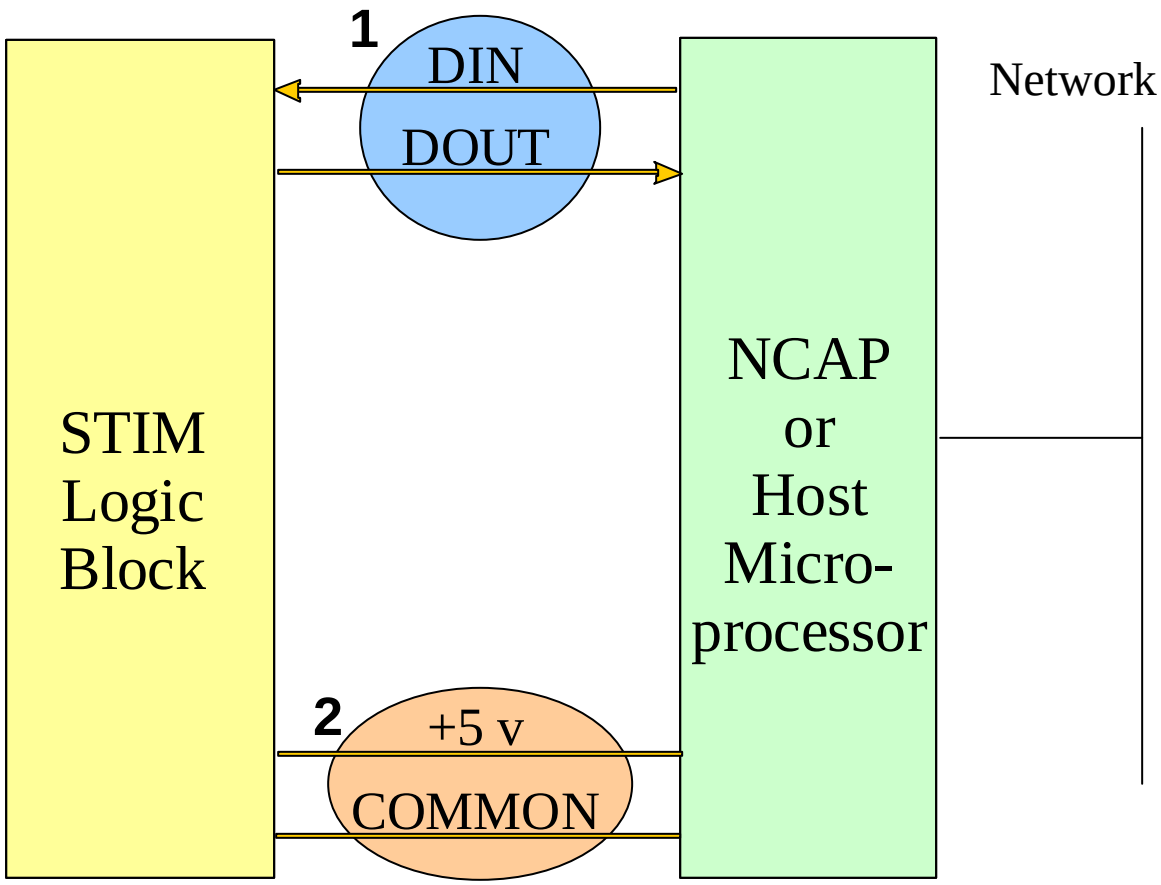
Proposed serial version of IEEE 1451.2



Proposed IEEE 1451.2 serial interface

1) Communication, triggering, error reporting
2) Power

Signal names for 1) will depend on particular physical layer



Support for serial IEEE 1451.2

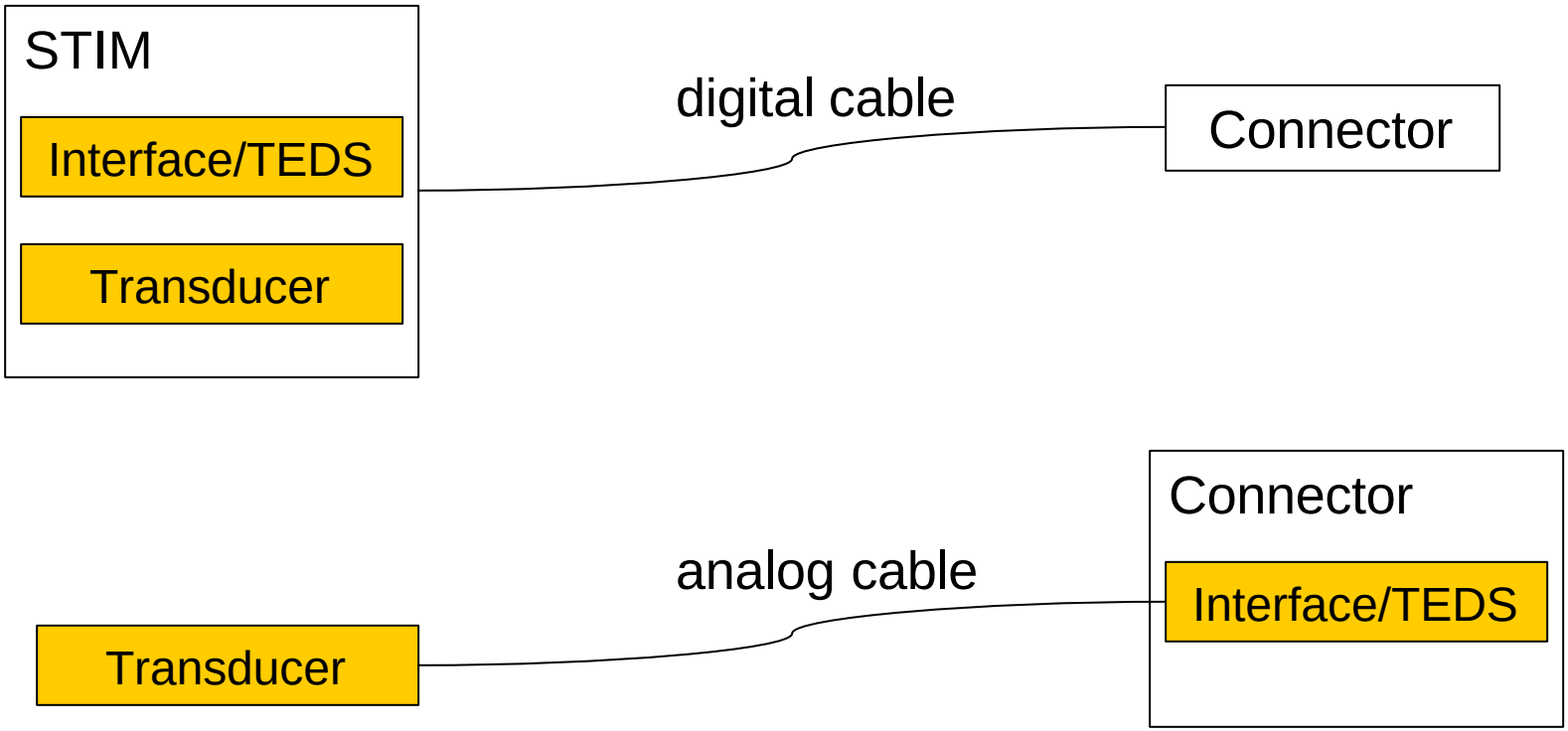
Trends in UART support:

- present on most microprocessors
- chips have become smaller, less expensive, more robust
- multi-port UARTs
- supported in ADI Microconverter family

Where can we plug into serial ports?

- Instruments
- I/O cards
- Computers
- “Slot 0” controllers in VME, VXI, CPCI, PXI card cages
- Handhelds, PDAs

Where to put the STIM interface electronics?



Partition the Standard

- Organize the standard around the OSI information model
- Separate sections for major functions:
  - TEDS
  - Correction engine
  - Physical layer

Partition the standard (allow TEDS only)

New Meta TEDS

New Channel TEDS

No physical interface related fields

Meta-ID TEDS

Channel-ID TEDS

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Other TEDS blocks can remain the same.

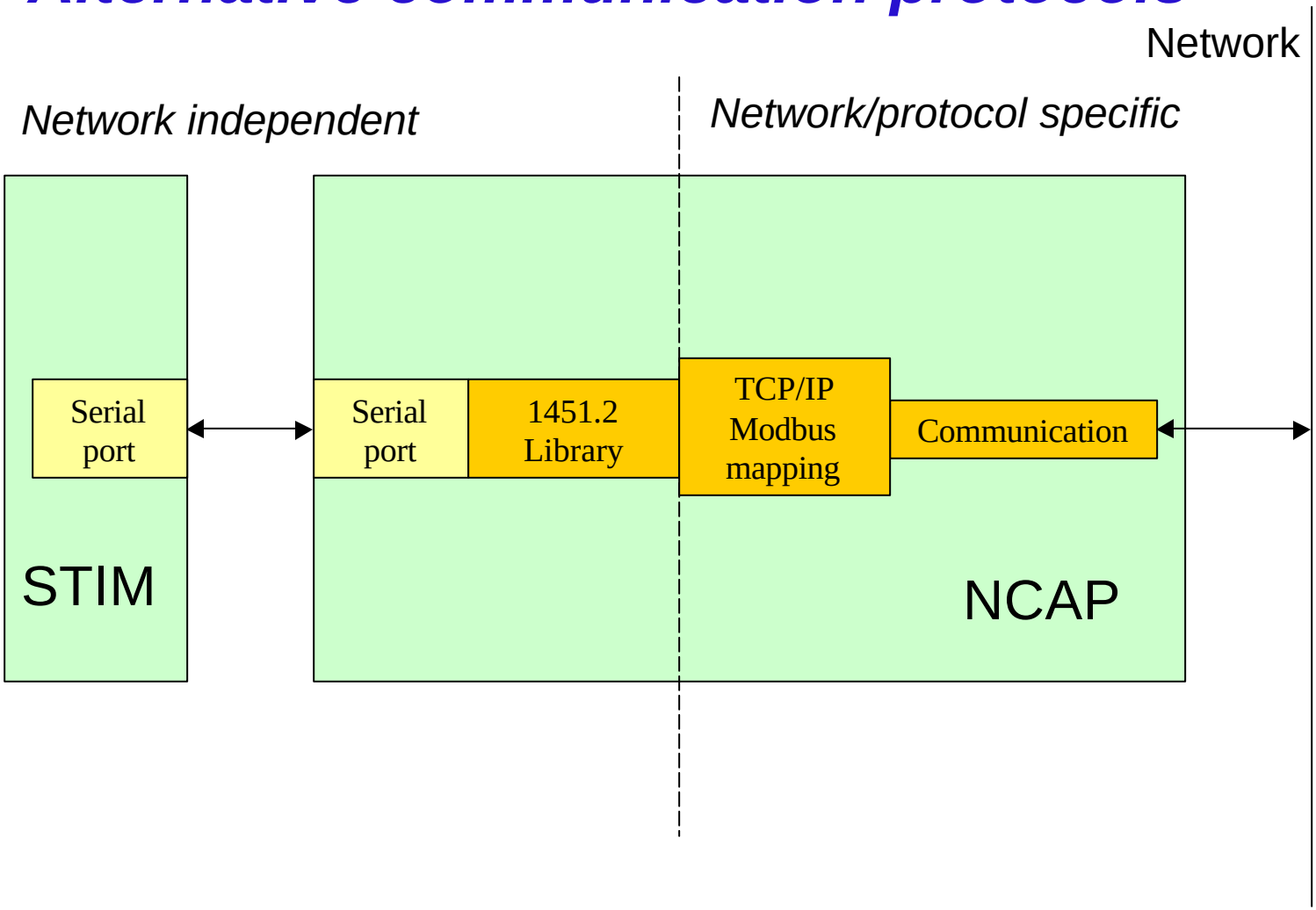
Secondary enhancements

- Enhance the TEDS
  - Add features from IEEE P1451.3 and IEEE P1451.4
    - Bandwidth
    - Frequency response
    - XML format
    - Etc.
- Add functions
  - Control function to tell NCAP to reload TEDS
  - Support STIM reconfiguration:
    - Gain, bandwidth, etc.
    - Changes in channels due to hot-swap in local sub-net, including IEEE P1451.3 or IEEE P1451.4

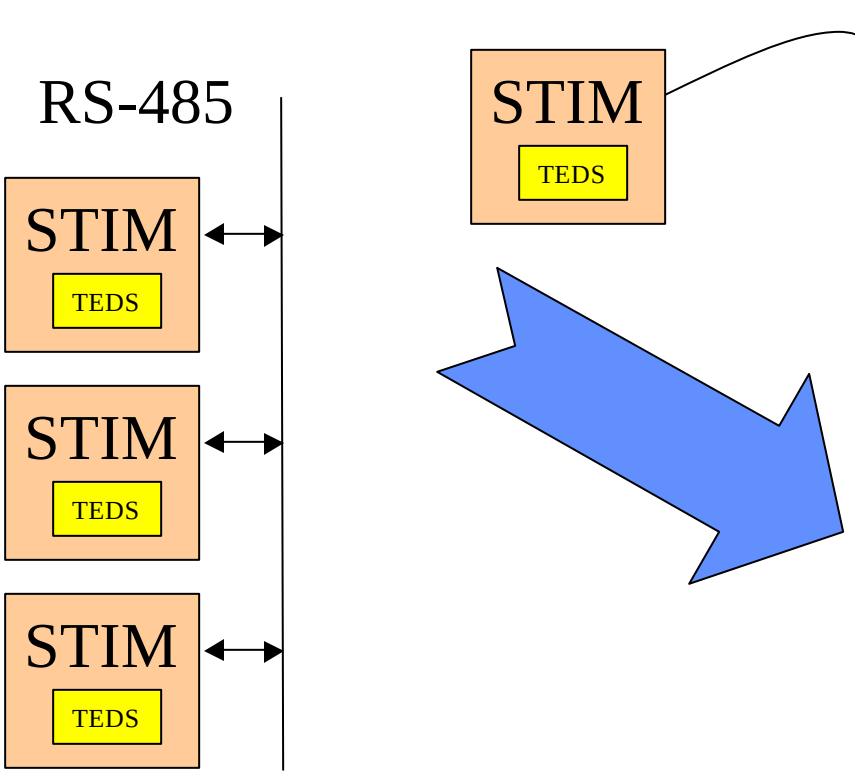
Secondary enhancements, con't.

- Standalone function
  - Support use with existing data and control systems
  - Map IEEE 1451.2 functions to existing protocols:
    - Modbus RTU
    - Modbus/TCP
    - ProfiBus
    - HTTP URL-based
    - XML
    - Etc.
- Corrections and additions
  - Miscellaneous comments received since publication
  - Others identified during review and updating process

Alternative communication protocols



New connectivity enabled by enhancements

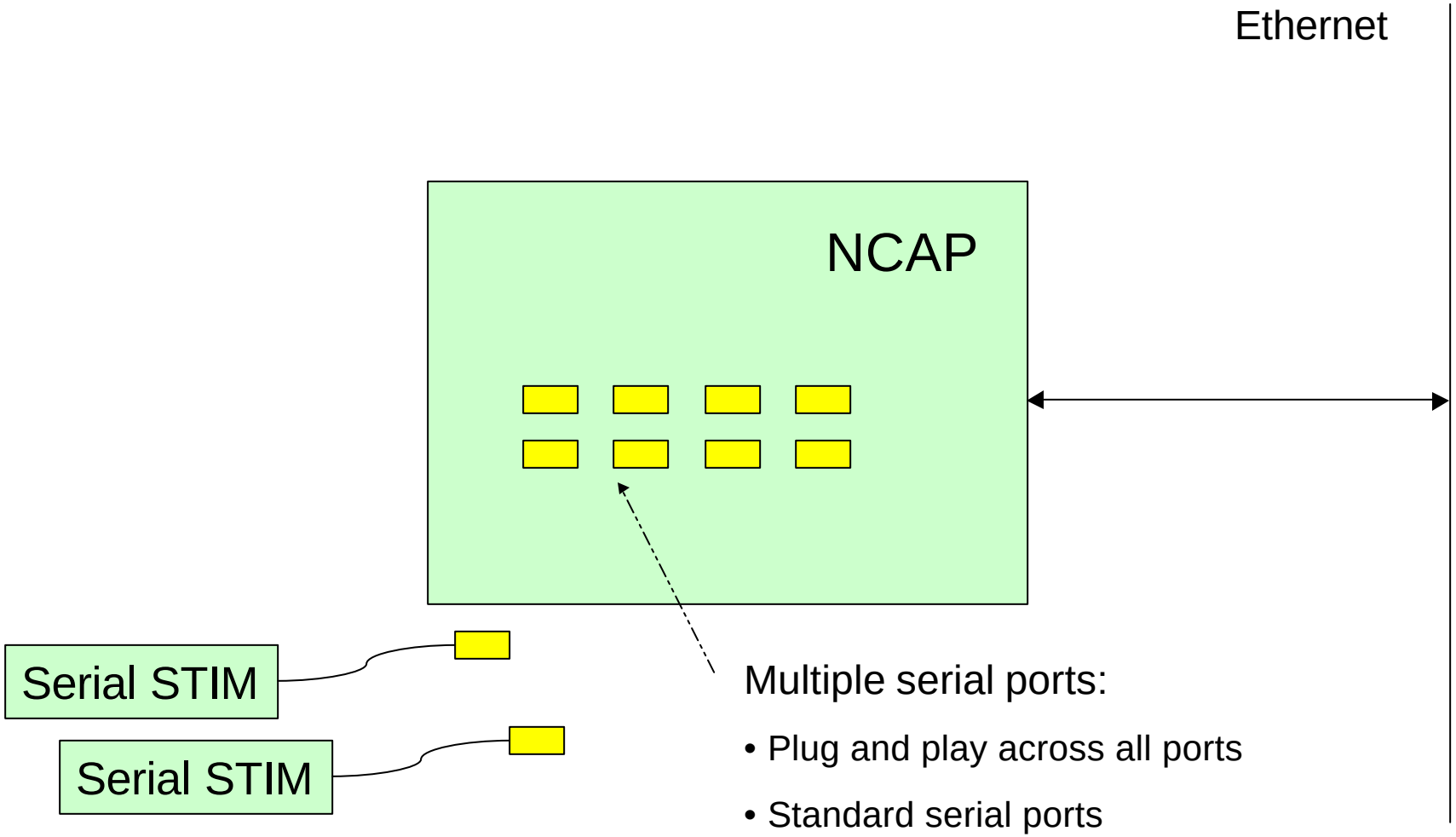


Connectivity to existing communication ports:

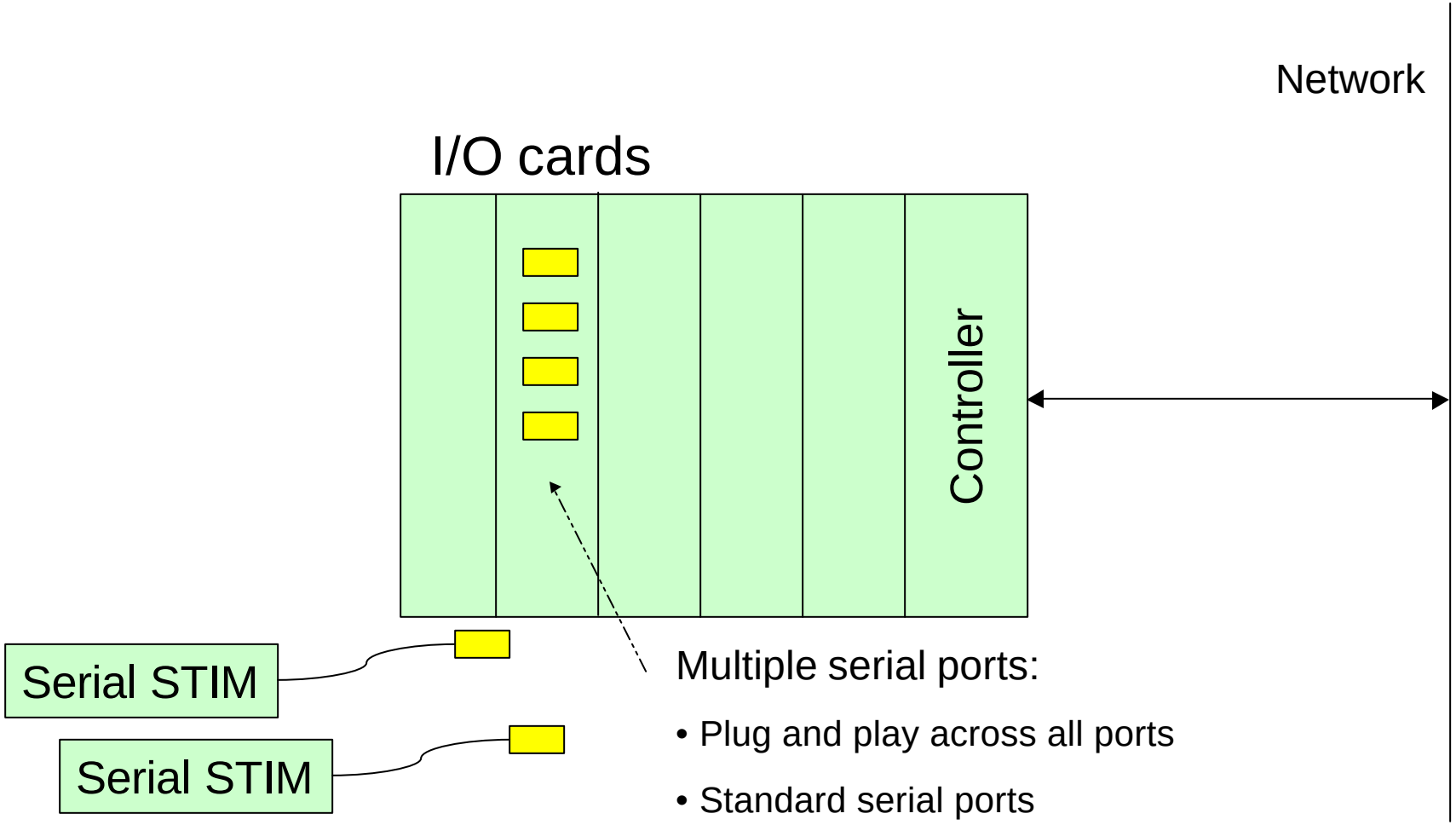
- Computers
- Programmable logic controllers
- PC plug-in cards
- Instruments
- NCAPs

Applications for serial IEEE 1451.2

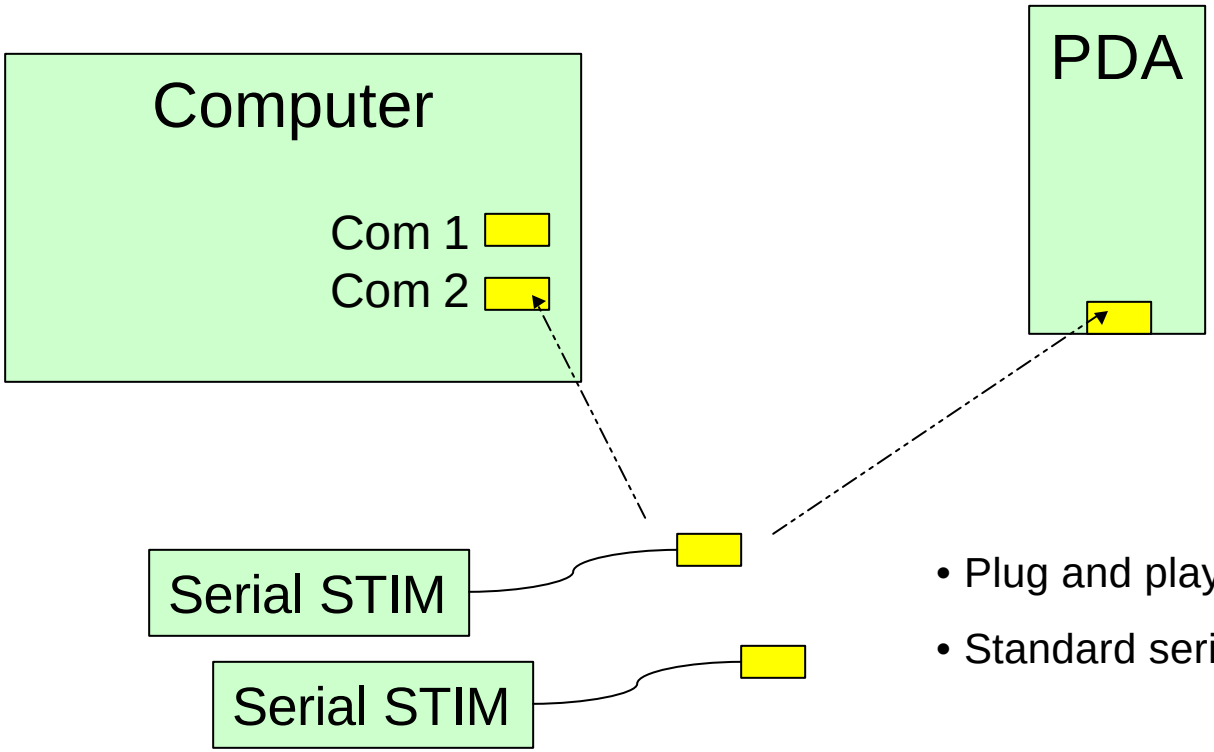
Multi-port serial NCAP



Industrial card cage I/O card



Computers and PDAs



- Plug and play across serial ports
- Standard serial ports

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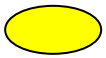
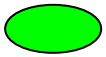


Addressed by going to serial interface



Addressed by other proposed enhancements

Conclusions

- IEEE 1451.2 established several valuable basic principles of smart transducers
- The most important of these is the TEDS
- We need to keep the best parts of the original standard while addressing the current needs of the marketplace
- The proposed enhancements will address the major requested changes and will result in:
  - More flexibility
  - Lower cost
  - Improved connectivity
- We need user comments and feedback on the proposed enhancements

Please attend the IEEE 1451.2 workshop on October 4, 2001!