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# Overview and Status Update for IEEE 1451.2

May 9, 2000  
Sensors Expo, Anaheim

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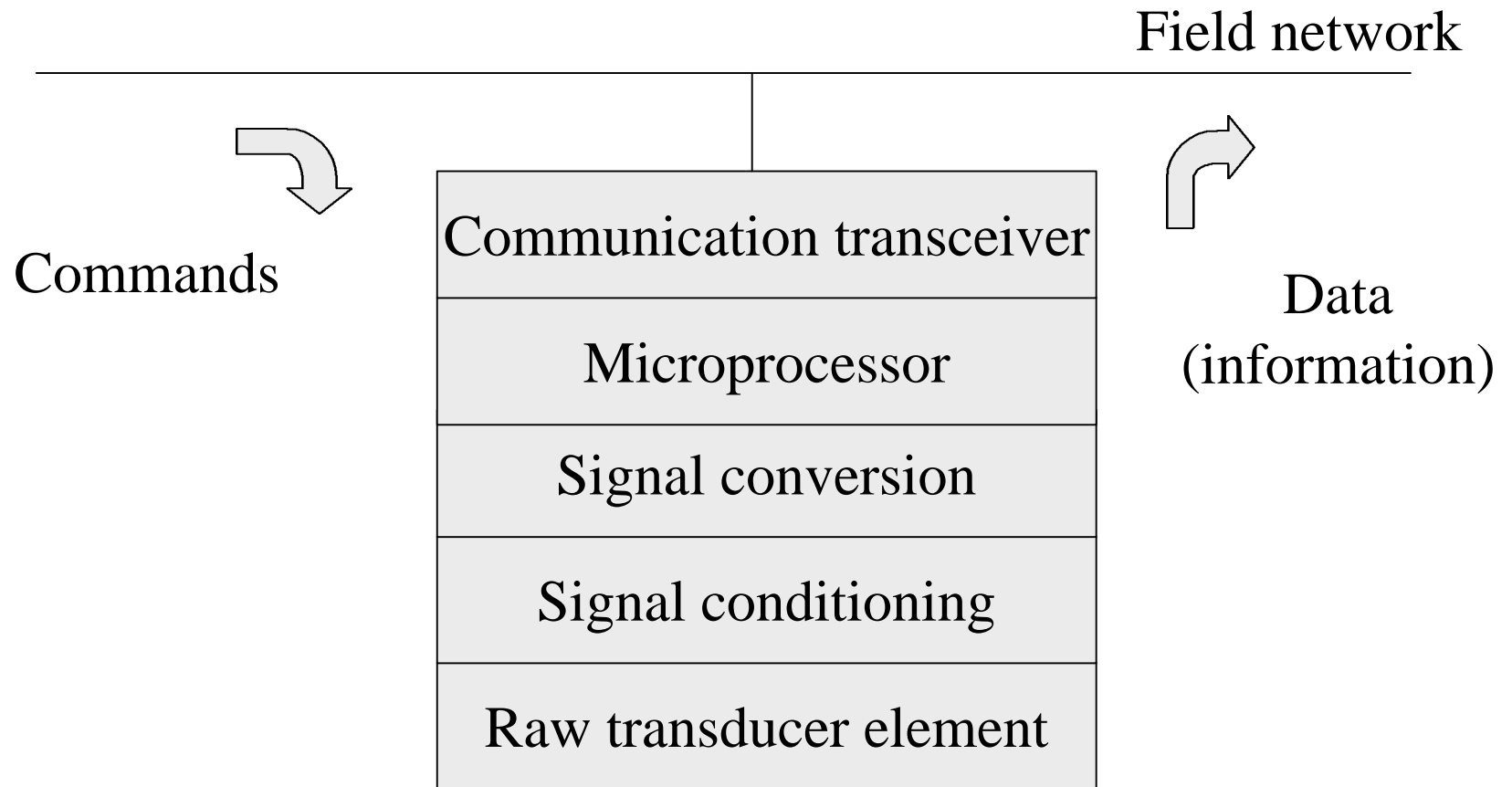
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# Agenda

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- Technical overview
- System issues
- Status

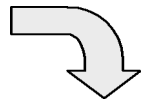
# Smart Transducer



# IEEE 1451.2

Field network

Commands



Communication transceiver

Microprocessor



Data  
(information)

•Creates a standard  
digital interface



•Defines a transducer  
electronic data sheet



Signal conversion

Signal conditioning

Raw transducer element



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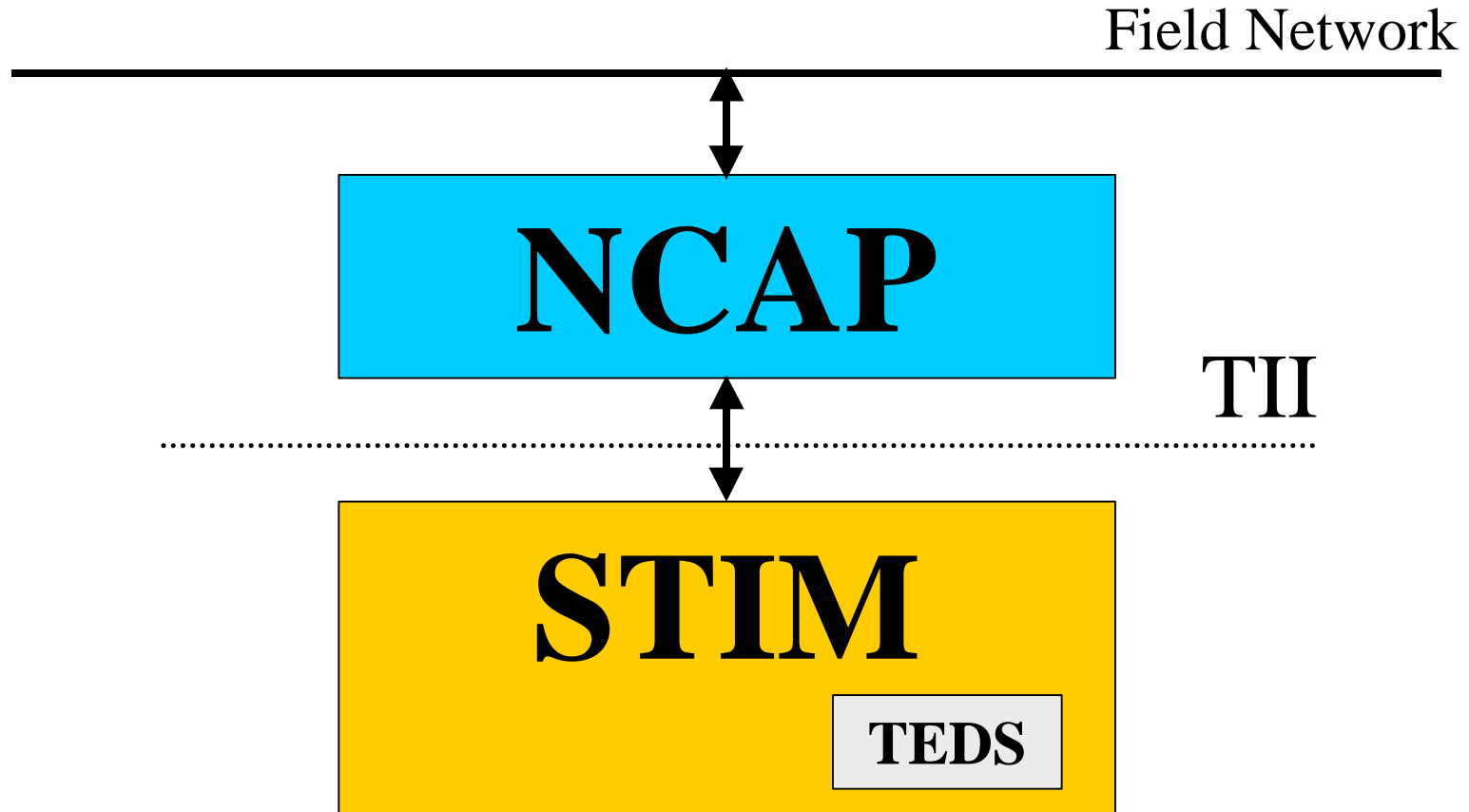
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# Vocabulary

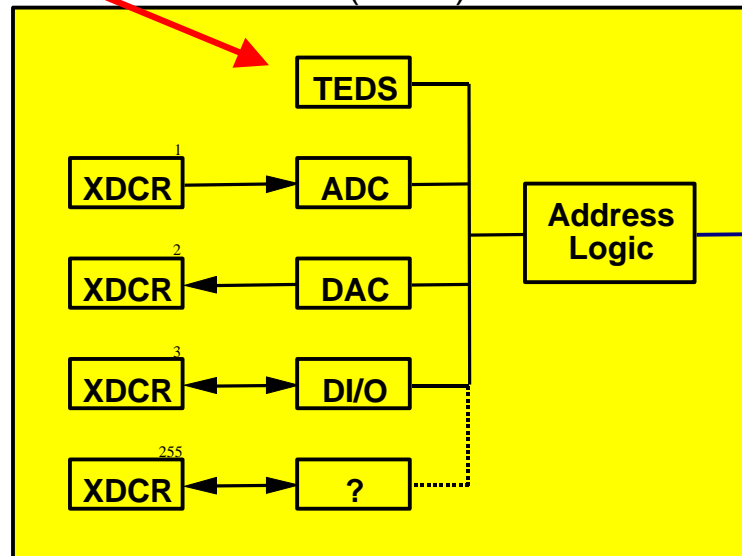
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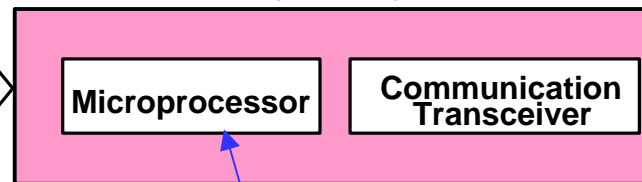
# IEEE 1451.2

- Not another field network; may be used with many networks.
- A transducer electronic data sheet.
- A standard digital interface.

Smart Transducer Interface Module (STIM)



Network Capable Application Processor (NCAP)



- Application firmware
- 1451.2 Interface Driver
- Correction Engine

Network

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# Technical Features

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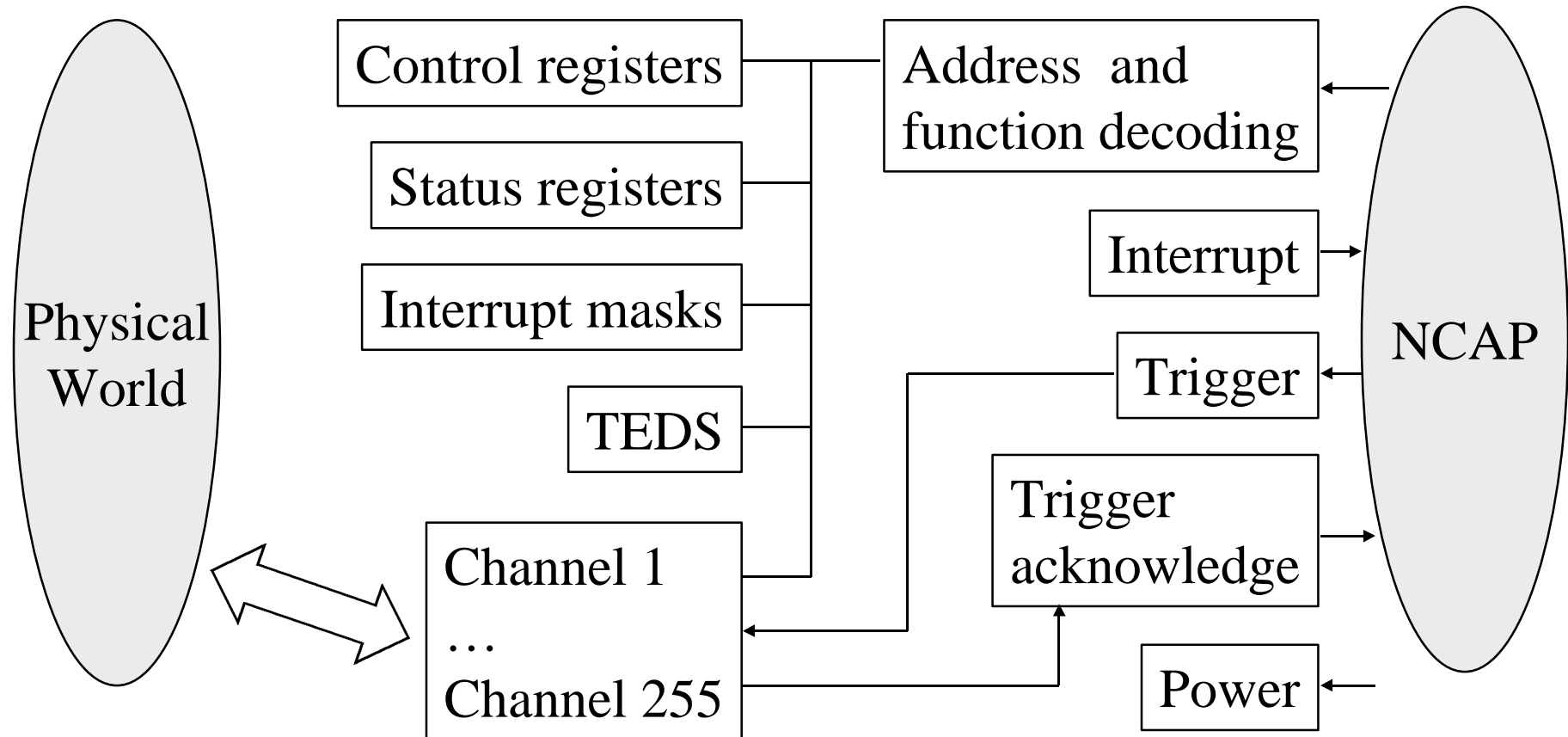
- Digital interface for measurement and control:
  - » Hardware lines, protocol, and timing
  - » Standard set of functionality: TEDS and channel addressing, triggering, interrupts, status and control, hot swap
  - » Communication rate is not fixed.
- Transducer Electronic Data Sheet:
  - » Required and optional data blocks
  - » Calibration/correction model for a wide variety of transducers
  - » Representation of physical units enables interoperability
  - » Support for multiple languages
  - » Extension mechanism
- Measurement and control model for transducers

# Standard Functions

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- Addressing – functional and channel
- Data transport – data read from and written to the STIM
- Triggering – global or channel
- Interrupts – masks, status registers
- Control – STIM or channel
- Optional functionality – e.g. self calibration

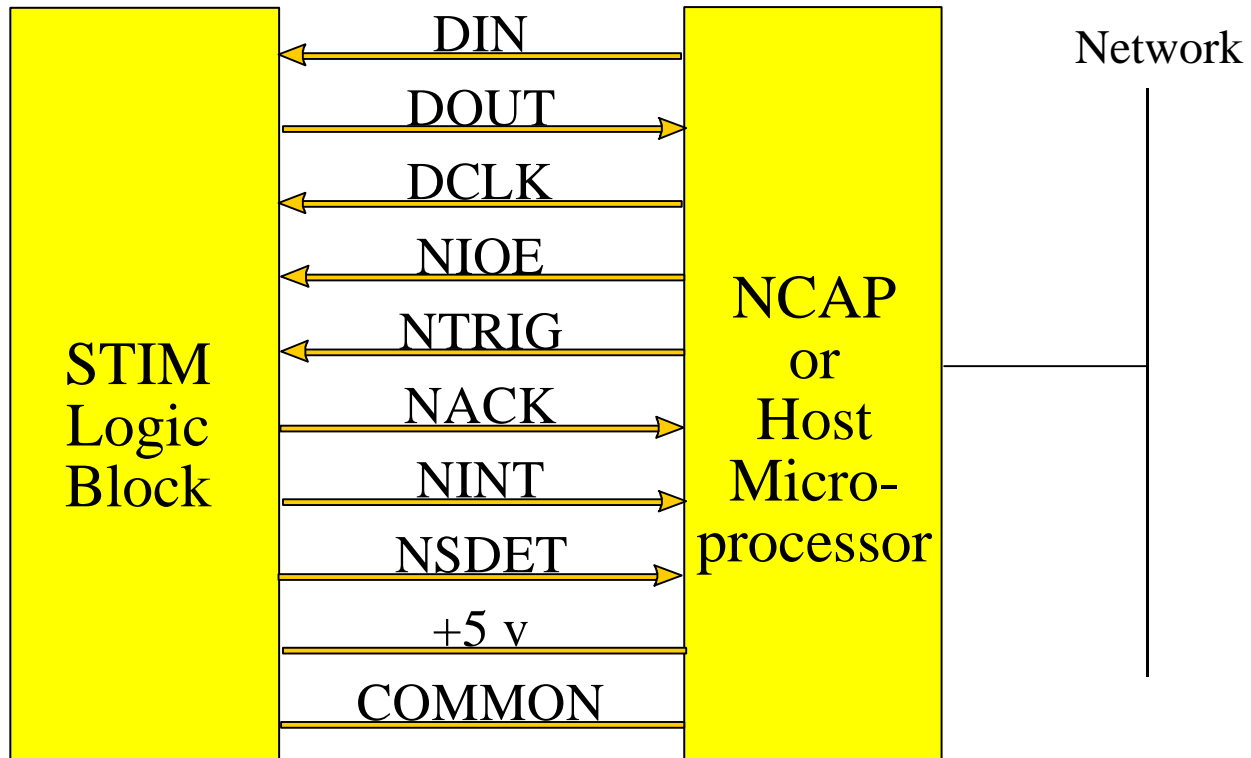
# 1451.2 STIM Model



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# The 1451.2 Digital Interface



## TII Signal and Control Lines

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# TII Signal and Control Lines

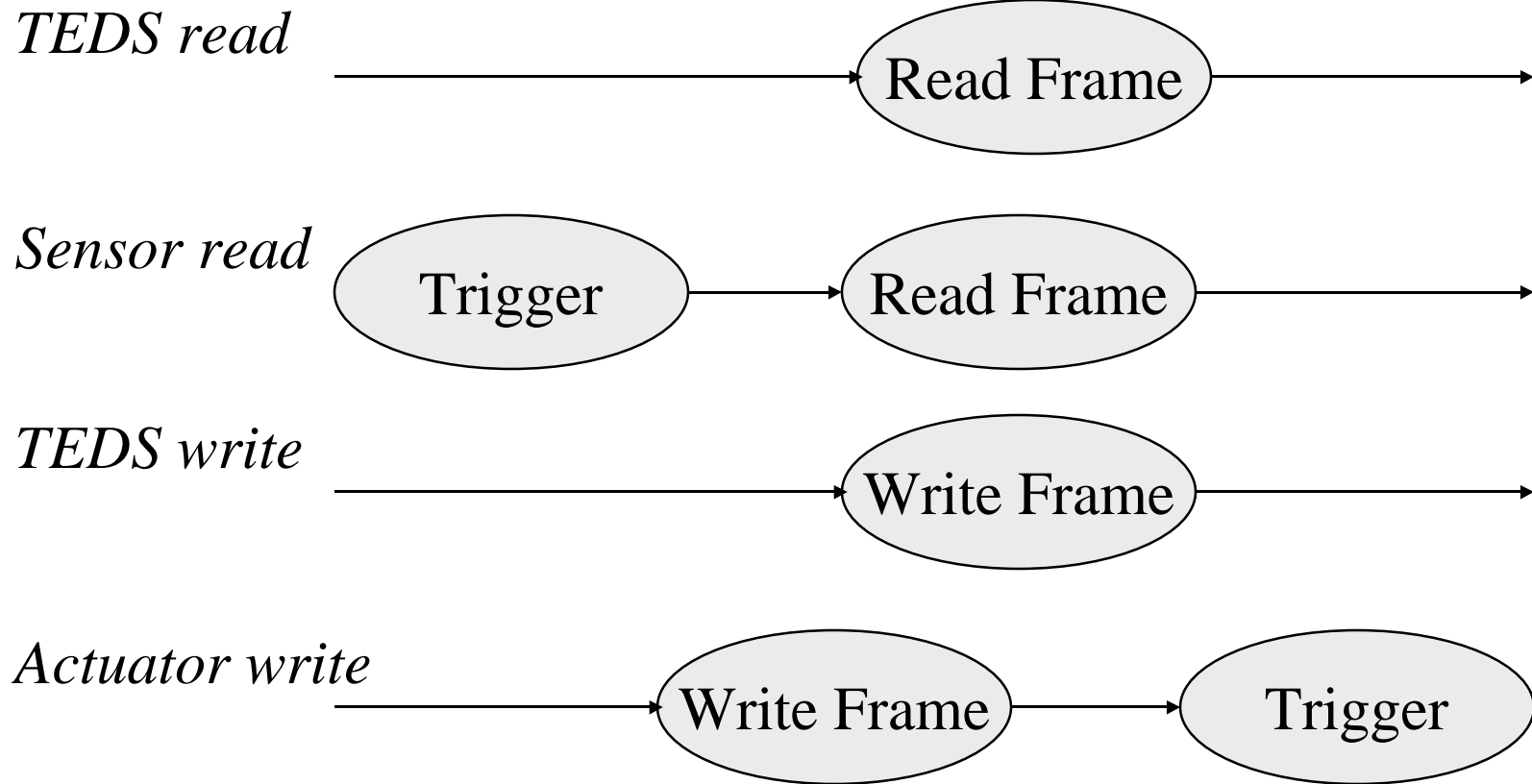
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<b>Line</b>	<b>Driven By</b>	<b>Function</b>
DIN	NCAP	Address and data transport from NCAP to STIM
DOUT	STIM	Data transport from STIM to NCAP
DCLK	NCAP	Positive-going edge latches data on both DIN and DOUT
NIOE	NCAP	Signals that the data transport is active and delimits data-transport framing
NTRIG	NCAP	Performs triggering function
NACK	STIM	Serves as both trigger and data-transport acknowledge
NINT	STIM	Used by the STIM to request service from the NCAP
NSDET	STIM	Grounded in the STIM and used by the NCAP to detect the presence of a STIM
POWER	NCAP	Nominal 5-V power supply
COMMON	NCAP	Signal common or ground

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# Digital Interface Operations

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# Transducer Types

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- Sensor
- Actuator
- Buffered Sensor
- Data Sequence Sensor
- Buffered Data Sequence Sensor
- Event Sequence Sensor

# Sensor

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- NCAP triggers
- STIM begins sensor reading
- When done, STIM asserts Trigger Acknowledge
- NCAP reads value(s)

# Actuator

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- NCAP writes value(s)
- NCAP triggers STIM
- STIM begins actuation
- When done, STIM asserts Trigger Acknowledge

# Buffered Sensor

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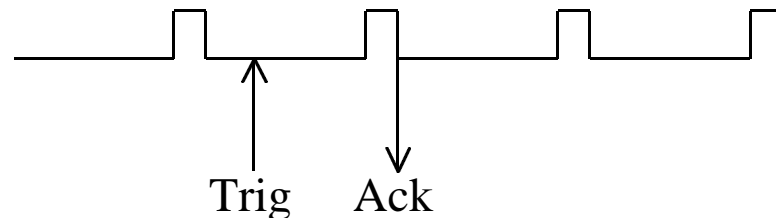
- Same as sensor, but value returned is from *previous* trigger
  - » Immediate response
  - » Uncertain time of reading



# Data Sequence Sensor

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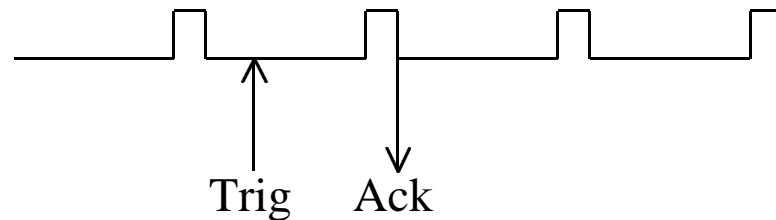
- Samples at its own choice of time, typically synchronized with physical world
- After trigger, waits until next sample time, then returns Ack and reading is available



# Event Sequence Sensor

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- Similar to Data Sequence Sensor, but does not return any data
- The *time* of the event is the relevant information



# TEDS Overview

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- Fully describes the type, operation, and attributes of the transducer.
- Is always connected to the transducer no matter the location. The TEDS moves when the transducer moves.

# TEDS Contents

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## Mandatory TEDS

- Meta TEDS
- Channel TEDS

## Optional TEDS

- Calibration TEDS
- Meta ID TEDS
- Channel ID TEDS
- Calibration ID TEDS
- End User Application Specific TEDS
- Extension TEDS



# Format of a TEDS Section

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- Length
- Languages & String Codes  
(human-readable sections)
- Section Body
- Checksum

# Overall Description (Meta TEDS)

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- Data about the TEDS itself
- Data about the overall transducer
- Timing information
- Relationships among channels

# Channel Description (one per channel)

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- Physical properties of the transducer
- Type of correction
- Type & format of data returned
- Timing information

# Calibration Model

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- Can be as simple as a linear relationship.
- Supports multi-variable, piecewise polynomial with variable segment widths and variable segment offsets.
- Expects the NCAP to have a general correction engine that understands the calibration scheme no matter which transducer is attached.

# Correction Description (one per channel)

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- Date/Time of last calibration
- Rated time between calibrations
- Which channels have input to correction function
- Degree and segmentation of correction functions
- Correction function coefficients

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# System Issues



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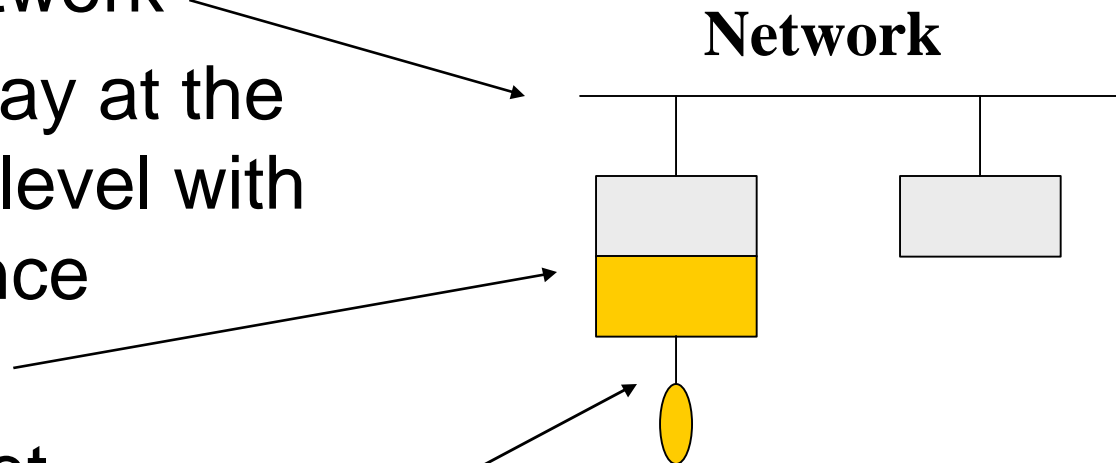
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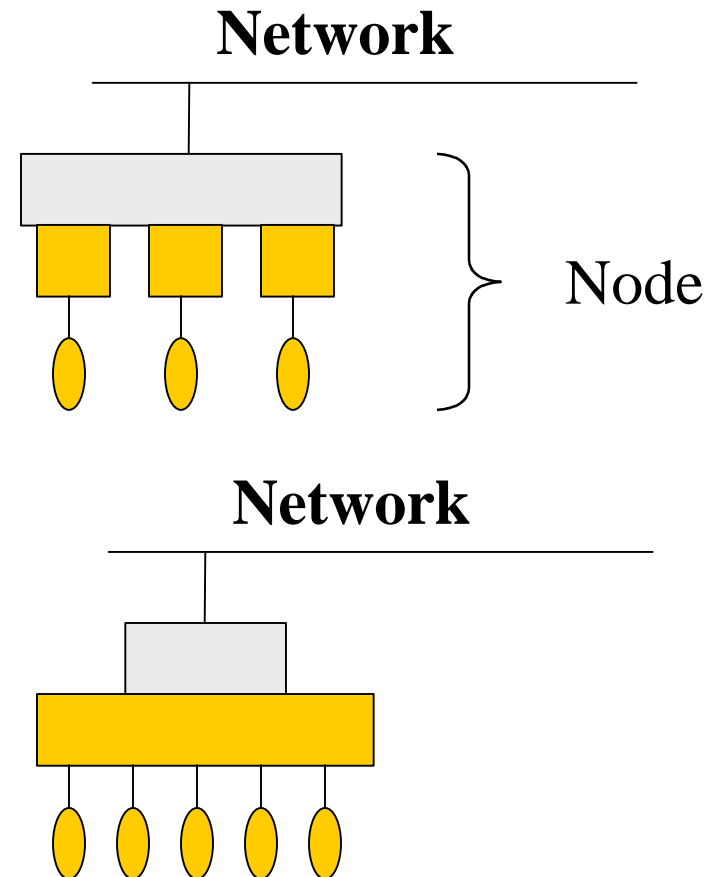
# 1451.2 Architecture

- Distance is achieved with the network
- Plug and play at the transducer level with short distance interface.
- Last few feet achieved with analog wiring.



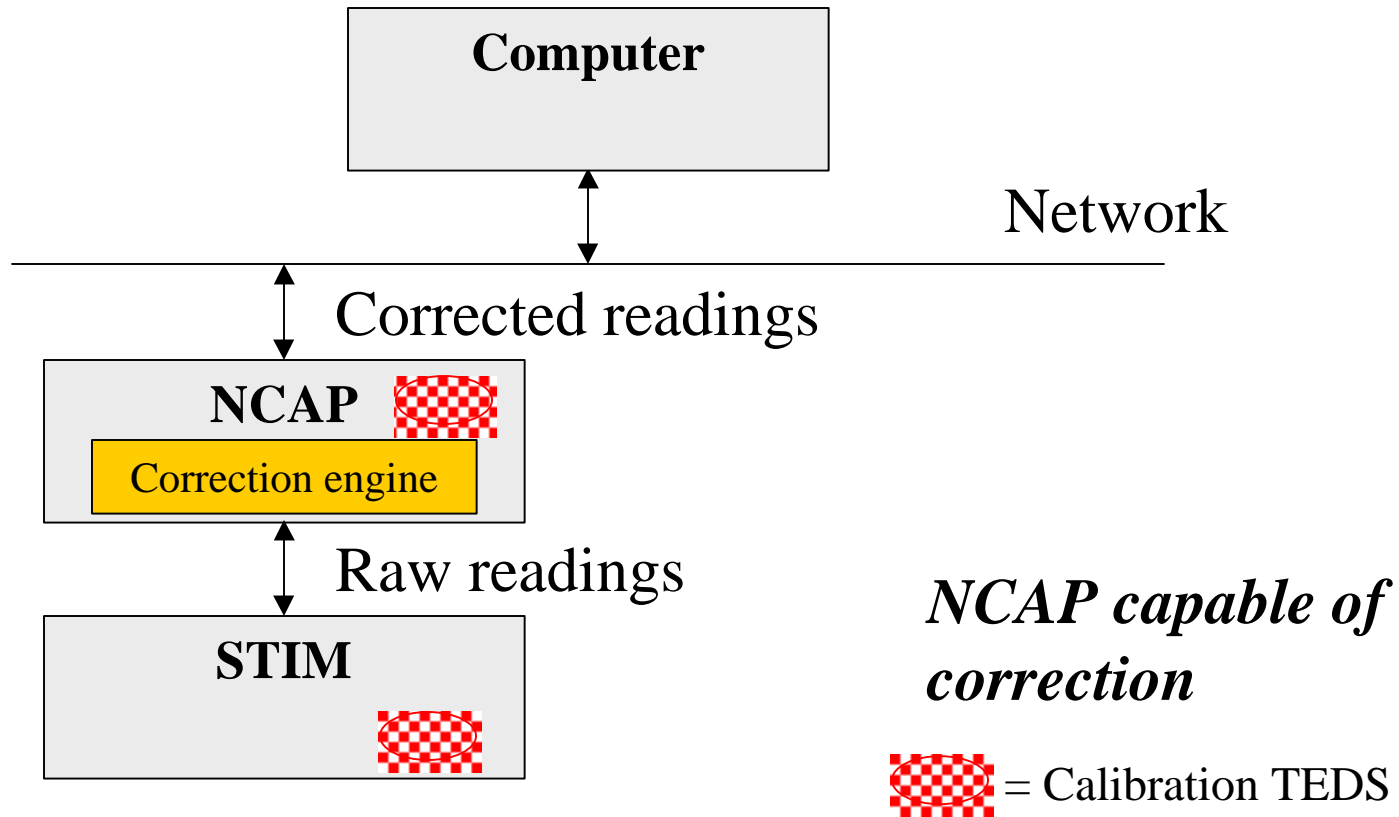
# Node Design Tradeoffs

- Big NCAP and little STIMs: e.g. NCAPs with multiple 1451.2 ports.
- Little NCAP and big STIMs: e.g. STIMs with many channels.
- Scalability
  - » type of network
  - » processing power
  - » type of processor
  - » number of channels
  - » types of sensors and actuators
  - » hardware interface speed
  - » connectors or PCB traces

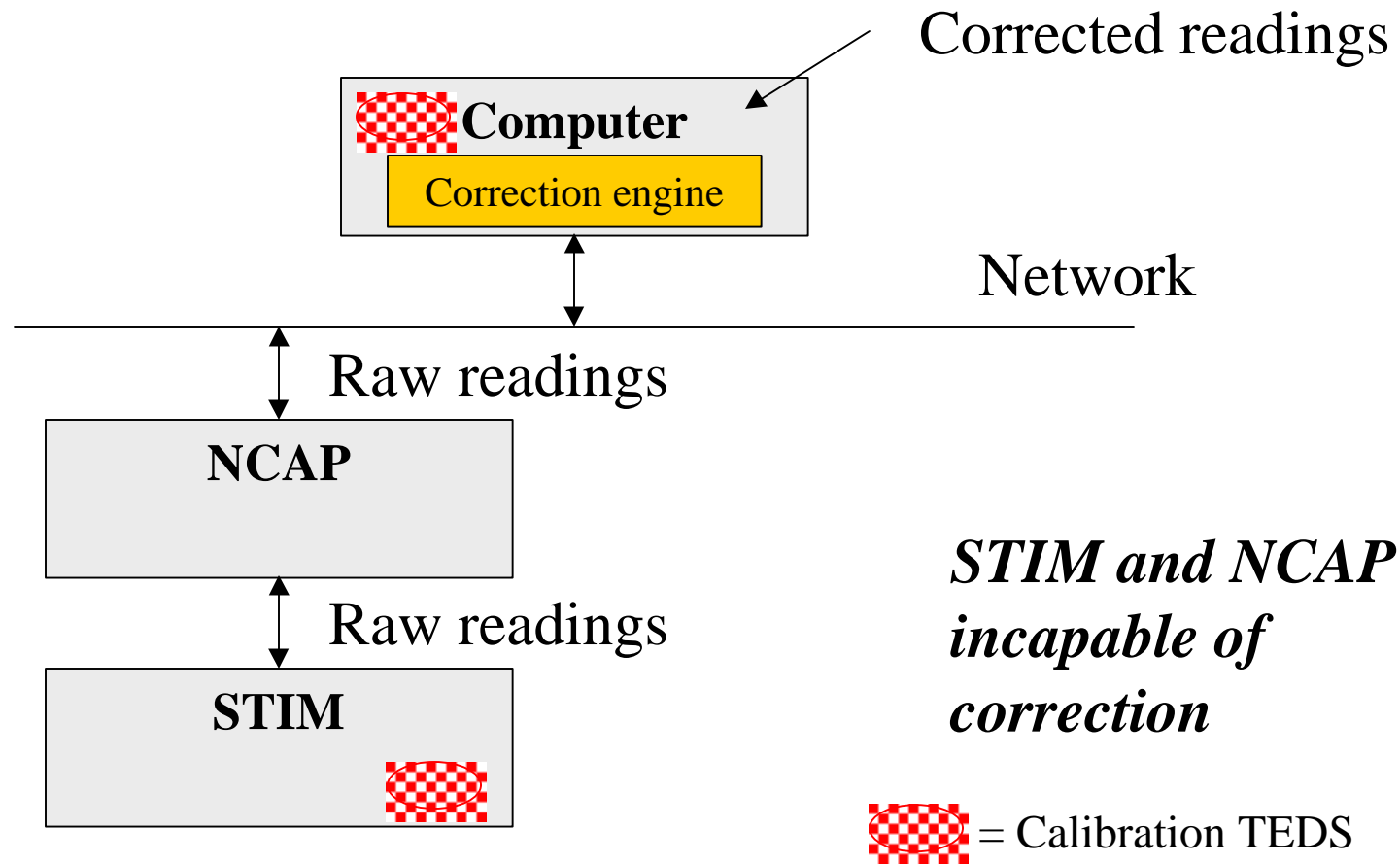




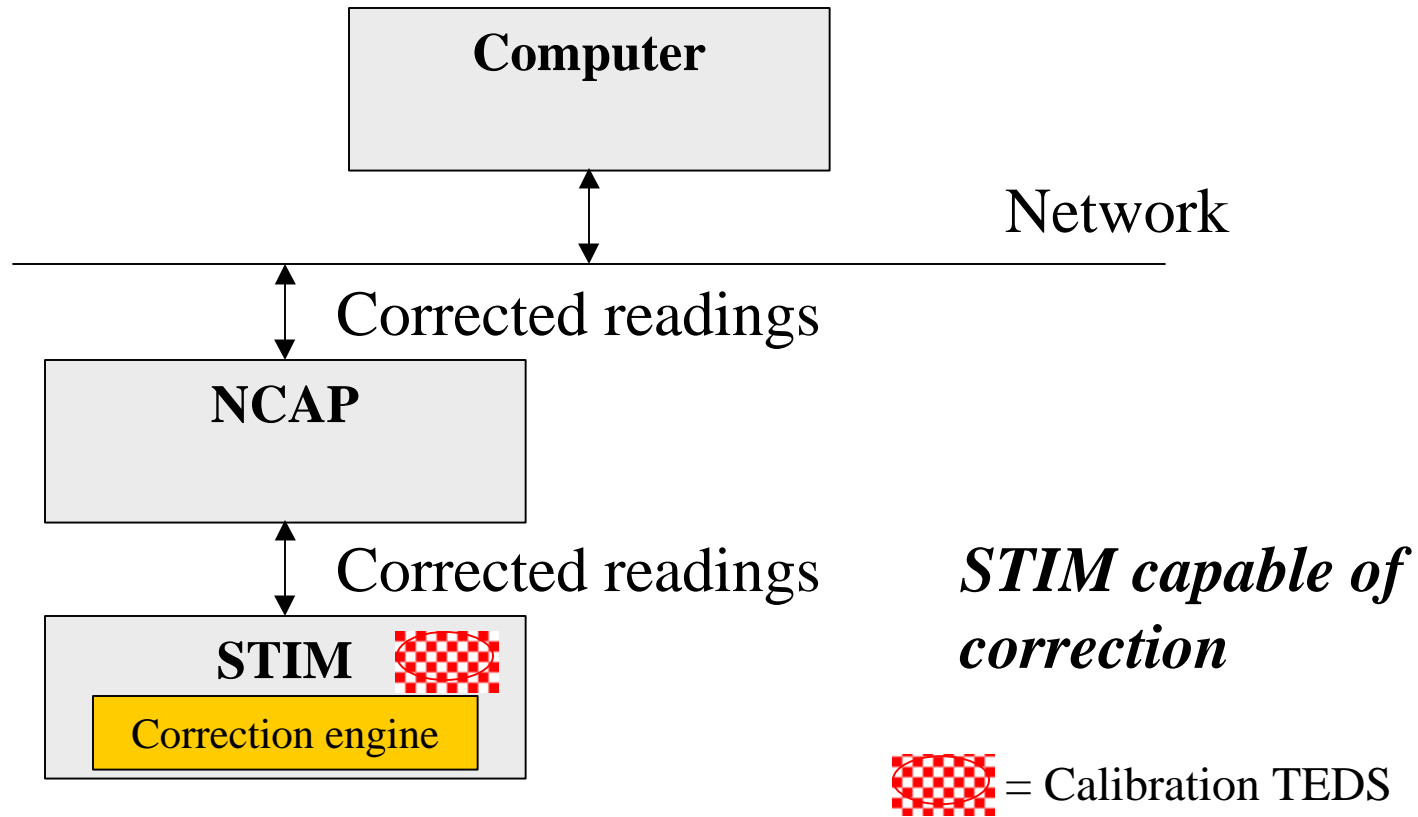
# 1451.2 Correction Engine in the NCAP



# 1451.2 Correction Engine Elsewhere in the System

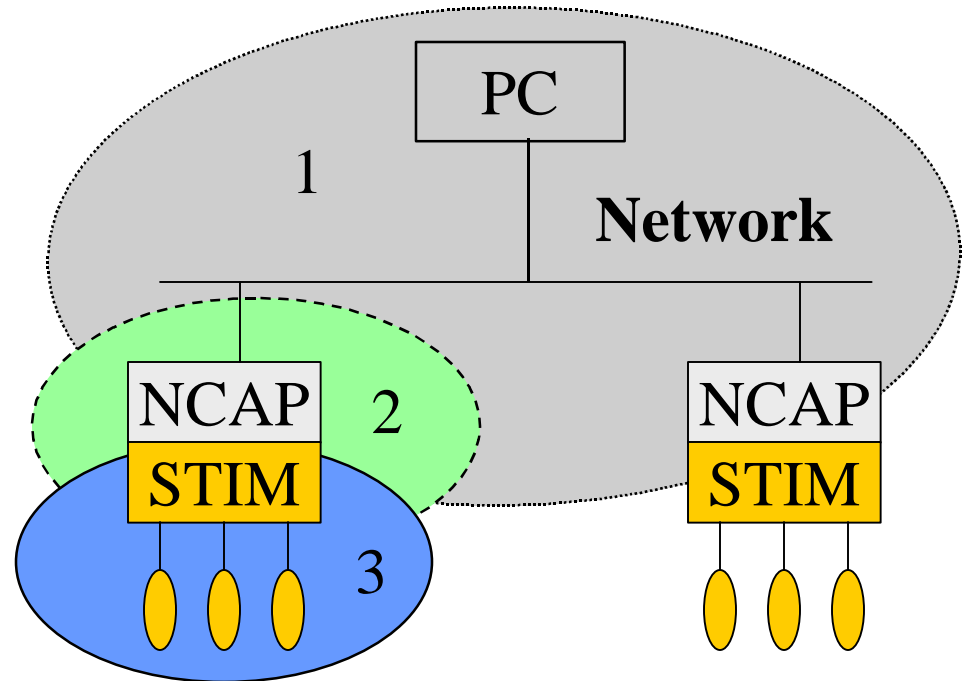


# 1451.2 Correction Engine in the STIM

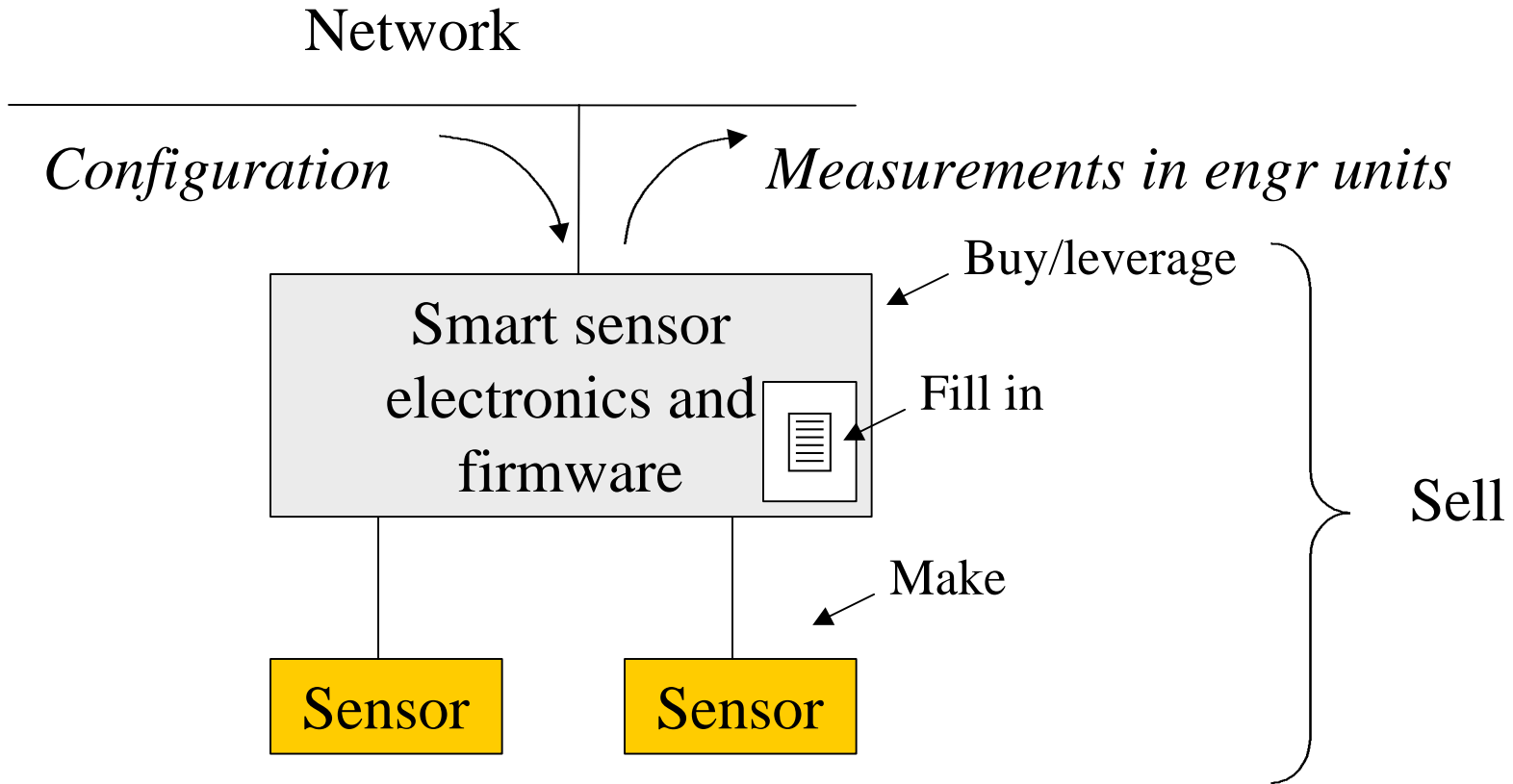


# Measurement/Control Loops

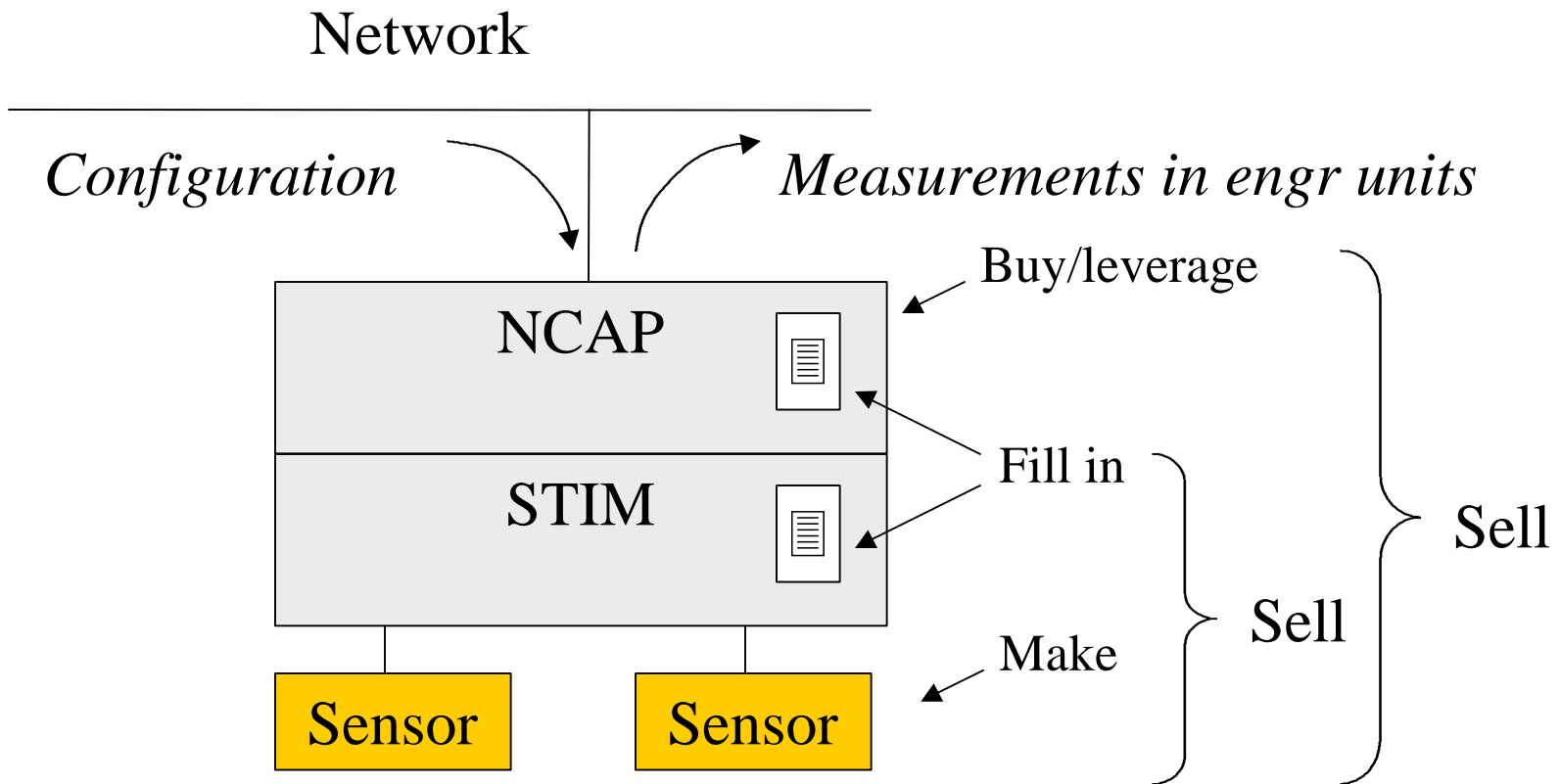
- With the network / 1451.2 architecture there are three loops which may be used for measurement and control.
  - » 1) Control by layers above the NCAP
  - » 2) NCAP based control of STIM channels
  - » 3) Control based within a STIM
- Control may be:
  - » Client/server (poll/set, 'pull', tightly coupled)
  - » Publish/subscribe ('push', loosely coupled)



# What Does Easier Connectivity Mean?



# What Does Easier Connectivity Mean Using 1451.2?



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# Status

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- Approved September 1997 as IEEE Std 1451.2-1997.
- Published September 1998 and available from the IEEE.

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# Questions?



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