Proposed IEEE Standard P1451.0

Defining the Core Features of Smart Sensors to Facilitate Broader Adoption

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1. INTRODUCTION

There are several standards in the IEEE P1451 family that all share certain characteristics, but there exists no common set of functions, communications protocols, and TEDS formats that facilitate interoperability among these standards. This is viewed by the user community as an impediment to broad adoption of the standards. The proposed IEEE Standard P1451.0 provides that commonality and also simplifies the creation of future standards for different physical interfaces while maintaining interoperability among the family members.

2. BACKGROUND

Kang Lee, the Chairman of the IEEE TC9 Sensor Technology Committee, formed the IEEE 1451.0 Common TEDS Study Group in October of 2002. The charter of the Study Group was:

"The study group is charged to study the current state of the 1451 family of standards, and coordinate with the Chair of each of the P1451.X working groups, for the purpose of determining the possibility of an IEEE P1451.0 standard that will facilitate interoperability and compatibility among the family of P1451 standards, as well as for ease of application and integration of these standards by the sensor industry and user community."

Kang Lee appointed Robert Johnson as Study Group Chair, and Lee Eccles as the Study Group Secretary and Editor. Due to the need for close coordination with the other members of the IEEE P1451 family, the past and present chairs of the other working groups were automatically members of this study group. This effort included representatives from IEEE 1451.1, 1451.2, P1451.3, P1451.4, and P1451.5.

The study group met by telephone on several occasions during October, November, and December of 2002.

3. ACCOMPLISHMENTS

The study group developed and approved several items, including:

1. A definition/vision of what the IEEE P1451.0 standard should cover.
2. *Proposed IEEE P1451 Family Interoperability Guidelines*.
3. A series of block diagrams illustrating the IEEE P1451.0 concept and facilitating visualizing the resulting architecture.
4. An initial list of items to be considered for inclusion in the standard.
5. A Project Authorization Request (PAR) for submission to IEEE for formal approval of the IEEE P1451.0 standardization project.

4. IEEE P1451.0 DEFINITION/VISION

The Study Group approved the following definition of and vision for IEEE P1451.0:

"IEEE P1451.0 is a physical layer-independent NCAP-to-transducer module interface that includes the basic command set and communications protocol. All that is necessary to implement a new variety of IEEE P1451 is to define the physical layer, including the physical layer TEDS, plus any

specialized functions or commands necessary to support the selected physical layer."

5. PROPOSED IEEE P1451 FAMILY INTEROPERABILITY GUIDELINES

The Study Group proposed the guidelines shown attached to this paper in order to facilitate interoperability among the various member standards of the IEEE P1451 family.

6. BLOCK DIAGRAMS

Several block diagrams were prepared and discussed by the Study Group in order to evaluate the various options proposed for the scope and architecture of IEEE P1451.0. The block diagrams shown at the end of this paper were selected by the Study Group to illustrate the recommended architecture for IEEE P1451.0.

Figure 1 is a block diagam of an IEEE P1451.0 smart transducer system that illustrates the physical context and basic interfaces for the system. This block diagram applies to any IEEE P1451.0 system, regardless of the physical layer selected. The specific physical layer will be defined in one of the other member standards of the IEEE P1451 family.

Figure 2 illustrates the protocol stack for an IEEE P1451.0 smart transducer. The bottom two layers (1 and 2) will be defined in the IEEE 1451.X standard for that specific physical layer.

Similarly, figure 3 illustrates the protocol stack for a Network Capable Application Processor (NCAP) that supports IEEE P1451.0.

Figure 4 shows the overall protocol stack arrangement for the smart transducer system. This figure is particularly useful in that it illustrates the fact that the network supported by the NCAP is a separate protocol stack (TCP/IP, for example) and is not covered by the IEEE P1451 standards.

Figure 5 is an alternate version of the overall system showing how IEEE P1451.4 mixed-mode sensors might be used in an IEEE P1451.0 system.

7. ITEMS INCLUDED IN THE PROPOSED STANDARD

The final attachment to this paper shows the list of items that the Study Group felt should be included in the IEEE P1451.0 standard. The final list of contents will be up to the Working Group to determine, in accordance with the approved IEEE Project Authorization Request (PAR).

8. IEEE P1451.0 STATUS

As of this writing, the IEEE standardization committee had not met to consider the IEEE P1451.0 PAR. It is anticipated that this will have occurred by the time of the Sensors Expo session at which this paper is presented. The scope of the submitted PAR is:

"This project develops a set of common functionality for the family of IEEE P1451 smart transducer interface standards. This functionality is independent of the physical communications media. It includes the basic functions required to control and manage smart transducers, common communications protocols, and media-independent Transducer Electronic Data Sheet (TEDS) formats. It defines a set of implementation-independent application programming interfaces (API). This project does not specify signal conditioning and conversion, physical media, or how the TEDS data are used in applications."

Once the PAR is approved, the IEEE P1451.0 Study Group will become a formal Working Group and can begin work on the actual draft standard. Active participation by and assistance from manufacturers, system integrators, and users of smart sensors is encouraged.

Robert N. Johnson is the Chair of the IEEE P1451.0 Study Group and participates in several of the other IEEE P1451 Working Groups. He is president of Telemonitor, Inc., a company that was spun off from Electronics Development Corporation (EDC) to pursue smart sensor and remote monitoring applications. He can be reached by voice at 410-312-6621, or by e-mail at robertj@telemonitor.com

PROPOSED IEEE P1451 FAMILY INTEROPERABILITY GUIDELINES VERSION 1.0

The following guidelines are proposed to facilitate interoperability among the various member standards of the IEEE P1451 family.

1. IEEE P1451 core values must be supported.

All of the IEEE P1451.X standards are members of the basic IEEE P1451 family. As such, they must support the underlying principles, core values, and requirements of that family. Each standard must define a mechanism to provide all data, specifically including the IEEE P1451.0 core TEDS, that are needed by other interfaces to meet their respective standards.

2. Interfaces are defined, not modules.

The standards describe the functional and physical *interfaces* between the modules, not the modules themselves. In order to accomplish this it is necessary for the standards to speak in terms of the behavior of the modules under certain conditions and the response of the modules to certain inputs, as perceived through the interfaces. However, the modules themselves may or may not exist as separate entities, as long as the interface requirements are met.

3. Partitioning is invisible beyond the immediate interface.

A module cannot tell if any of the individual interfaces exist beyond the one to which it is connected. An application using only the IEEE P1451.0 core information need not know or care which physical layer standard is used for the actual transducer.

4. Hot swaps must be allowed and passed on.

The capability for a “hot swap” (removing and inserting a STIM without removing power to the NCAP, to use the IEEE 1451.2 terminology) must be supported. If any link to any module or transducer is made or broken that can affect any of the TEDS data, then a hot swap must be simulated (or an appropriate message provided) to notify other users to update the TEDS data.

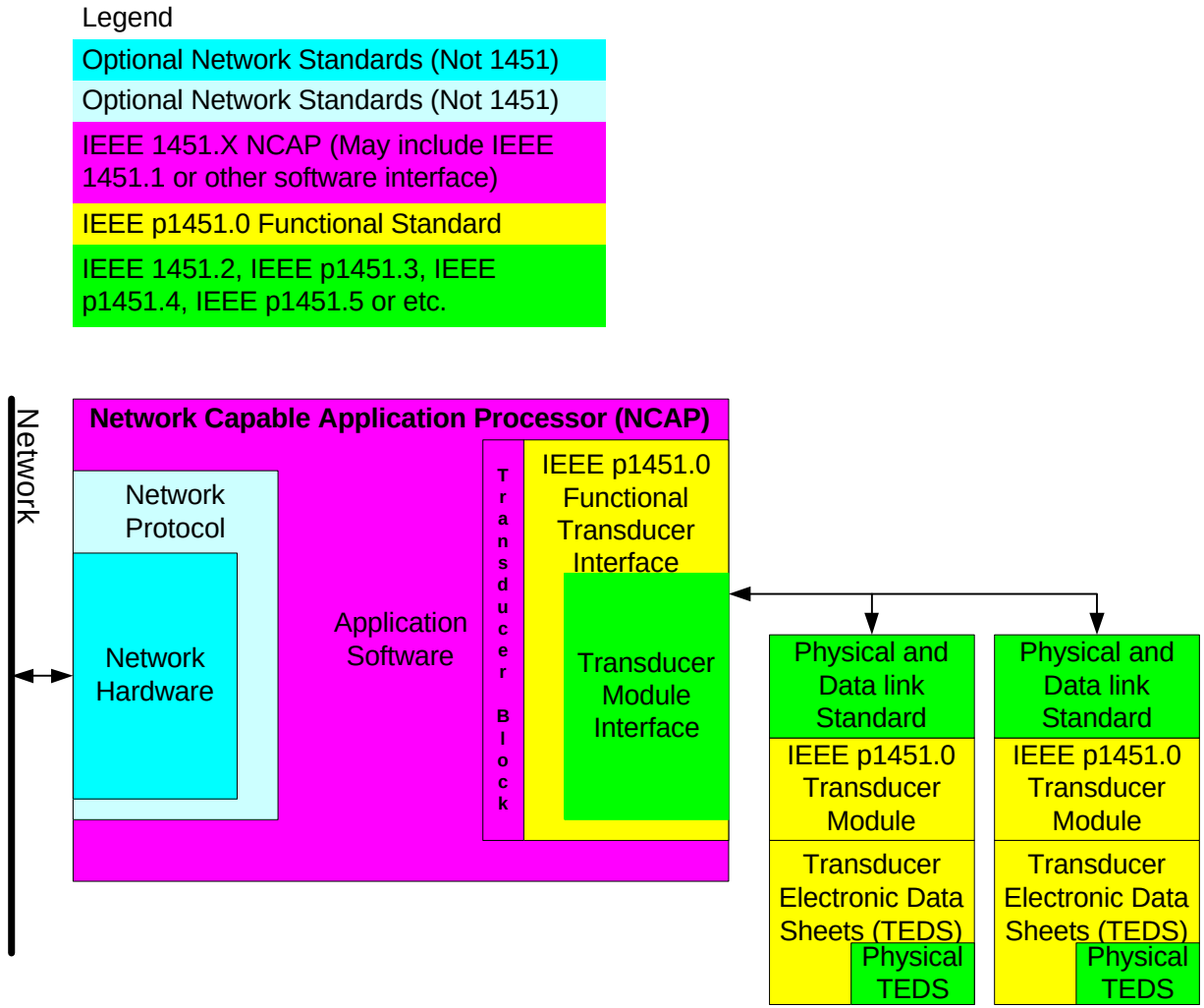

Figure 1 IEEE P1451.0 Block Diagram

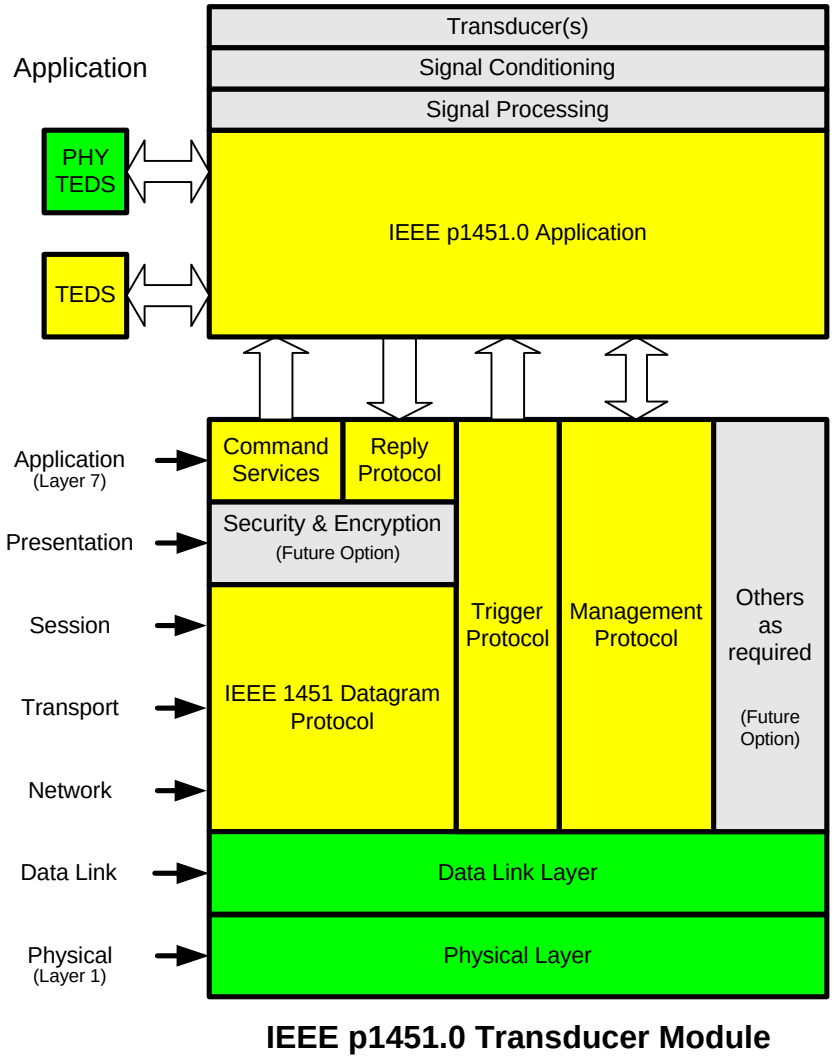

Figure 2 IEEE P1451.0 Protocol Stack in a Transducer Module

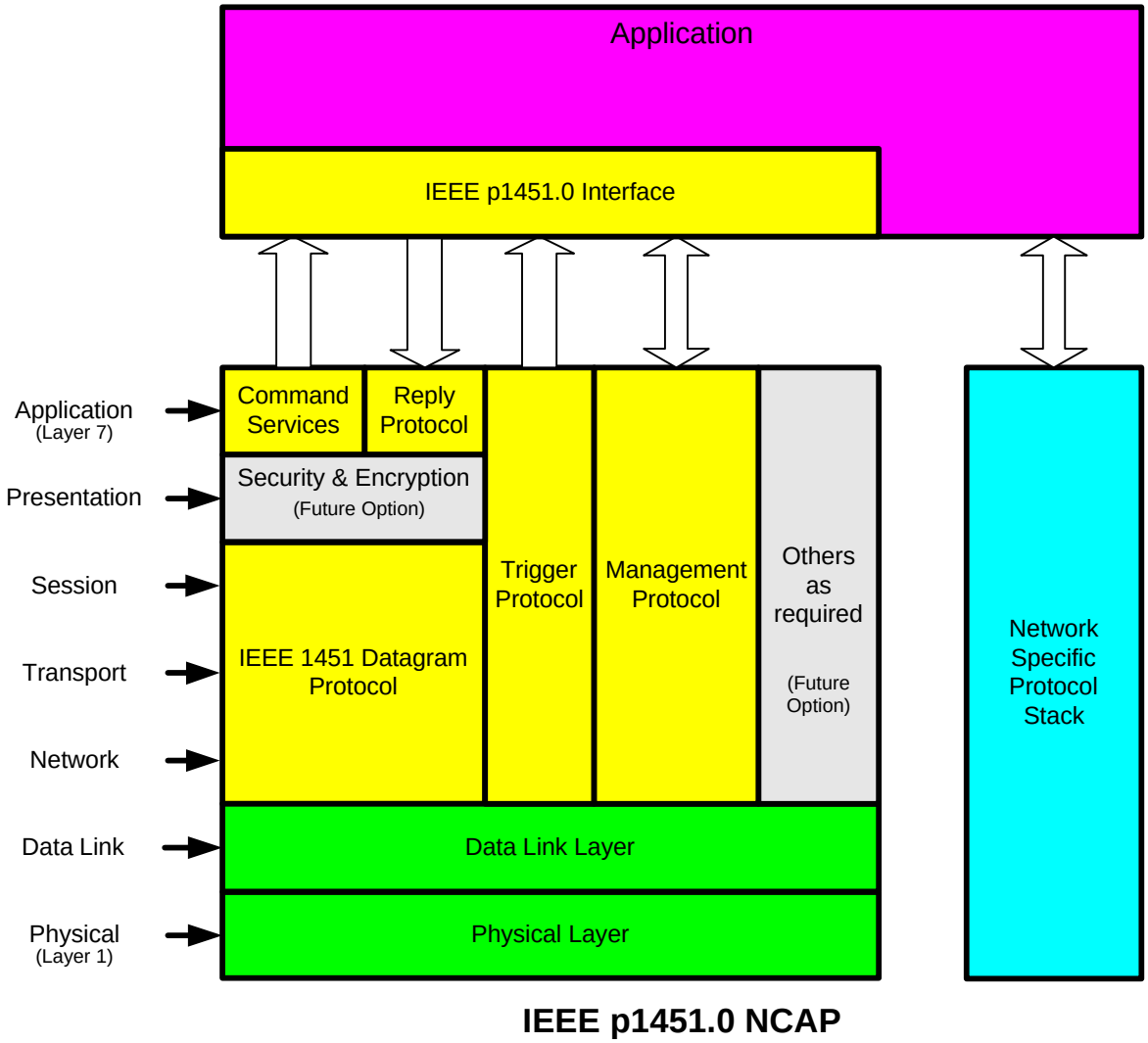

Figure 3 IEEE P1451.0 Protocol Stack in an NCAP

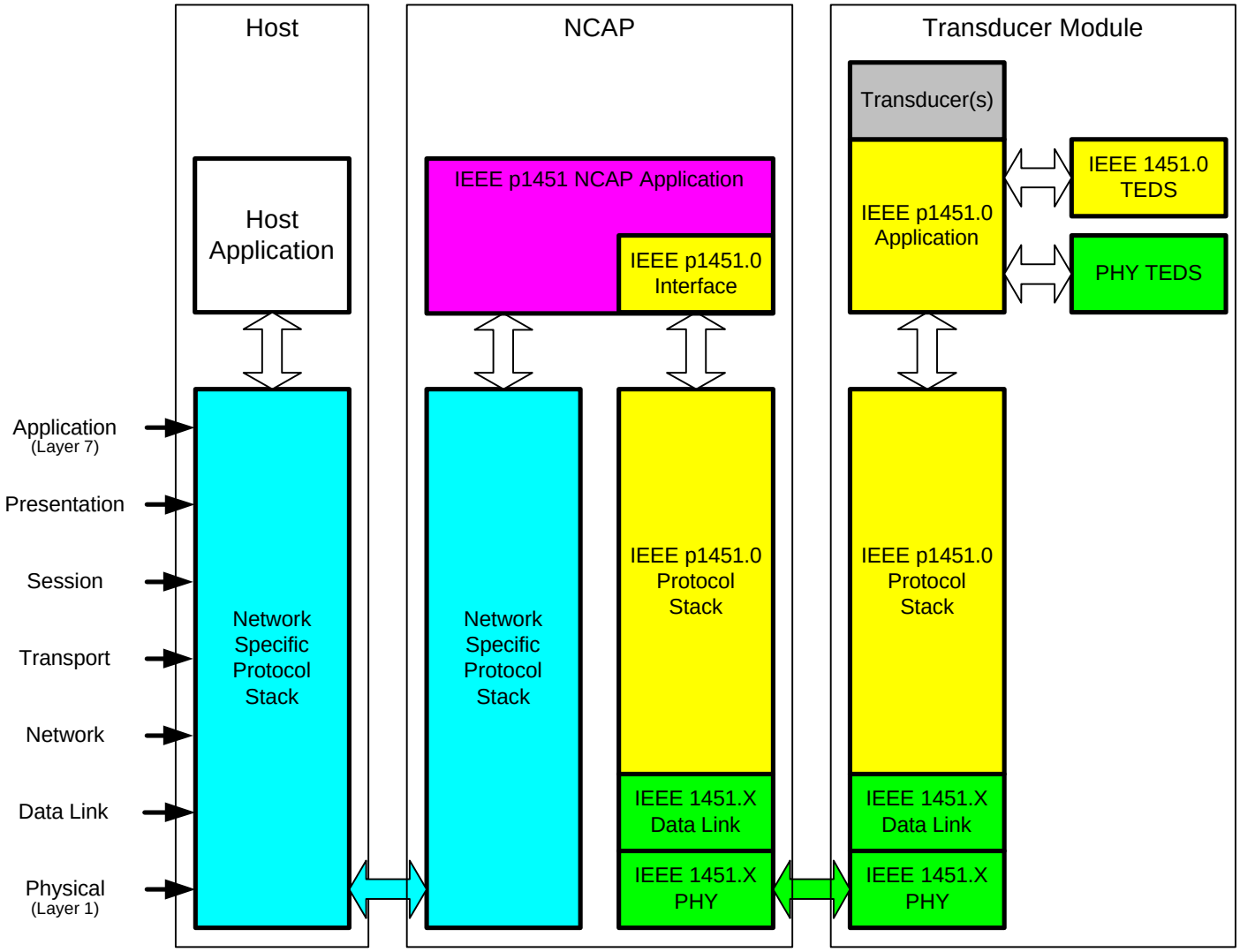

Figure 4 End-to-end application

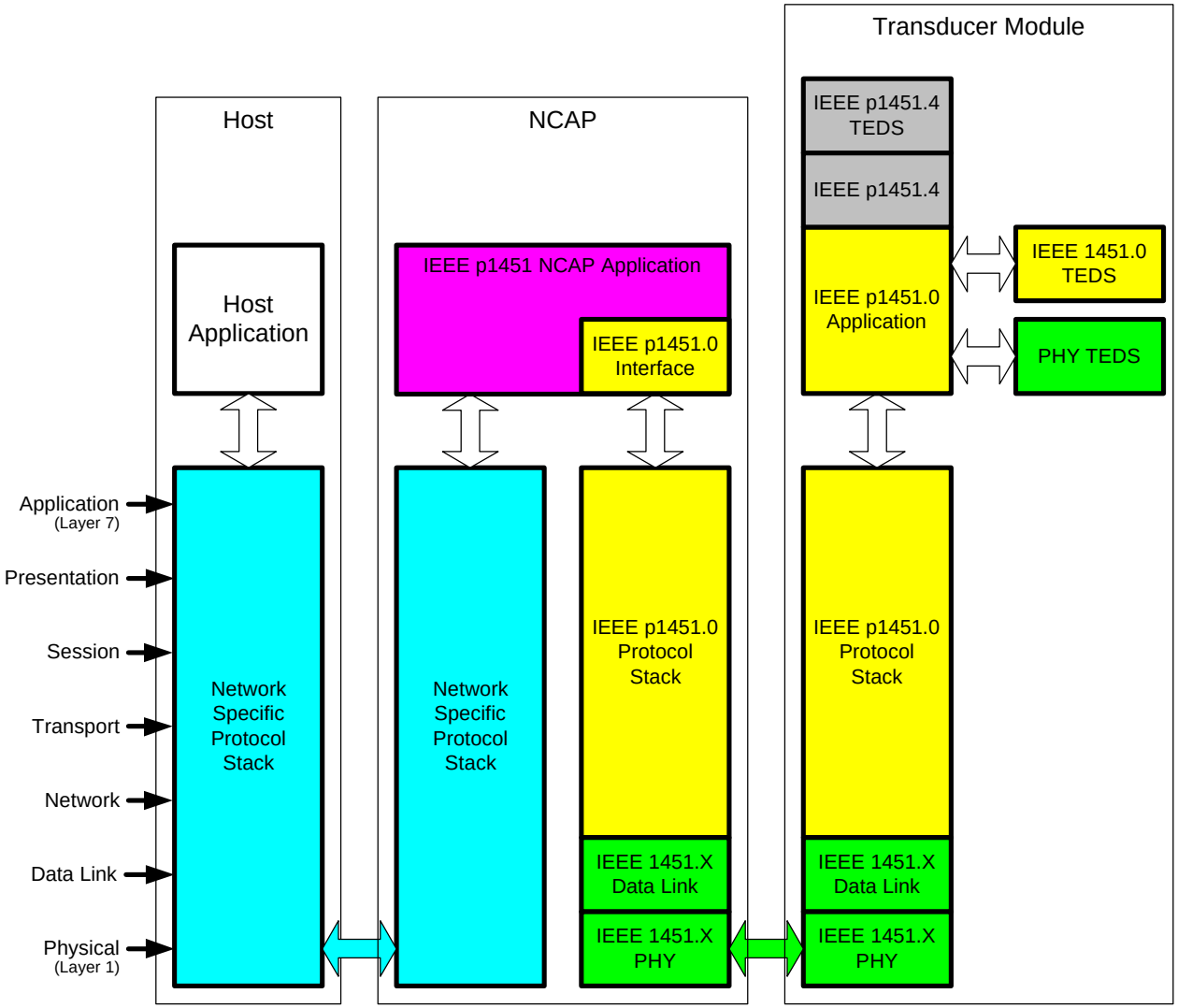

Figure 5 End- to-end application with IEEE P1451.4 in the Transducer module

The Proposed IEEE p1451.0 Functional Standard Should Cover:

- Transducer Types
- Transducer Modes of Operation
- High Level Addressing Technique
- Trigger/Trigger Acknowledgement
- Commands
- Standard TEDS
- Communications Protocols (Level 3 and up)

Transducer Types and Modes

- Transducer Types
  - Sensor
  - Event Sensor
  - Actuator
- Transducer Modes of Operation and Attributes
- Combining these three types with Attributes covers all transducer types.

High Level Addresses

- High Level Addressing Technique
  - A common set of addresses independent of the address used on the physical communications link.
  - Conceptually similar to IP addresses over Ethernet but significantly less capability is required.

Trigger and Trigger Acknowledgement

- The IEEE p1451.0 Functional Standard should define
  - The high level function of a trigger
  - A method of requesting trigger acknowledgement
  - The relationship between a trigger and data
- How the trigger is implemented at the physical layer should not be defined.

Commands

- A general set of commands should be defined
- Additional commands can be specified
  - By a revision to the IEEE p1451.0
  - By including them in individual standards
- A method of adding manufacturer unique commands should be included.

TEDS

- The IEEE p1451.0 should contain
  - The general structure of all TEDS
  - Most TEDS definitions
  - The method of accessing TEDS including the Physical Layer TEDS

Communications Protocols

- Should be patterned after the ISO/OSI model
- Layers 3 and higher should be covered in the IEEE p1451.0 Functional Standard
- The Data Link Layer (layer 2) and the Physical Layer (layer 1) should be covered by the individual standards.