IEEE P1451.5 Framework

Presented by 3eTI

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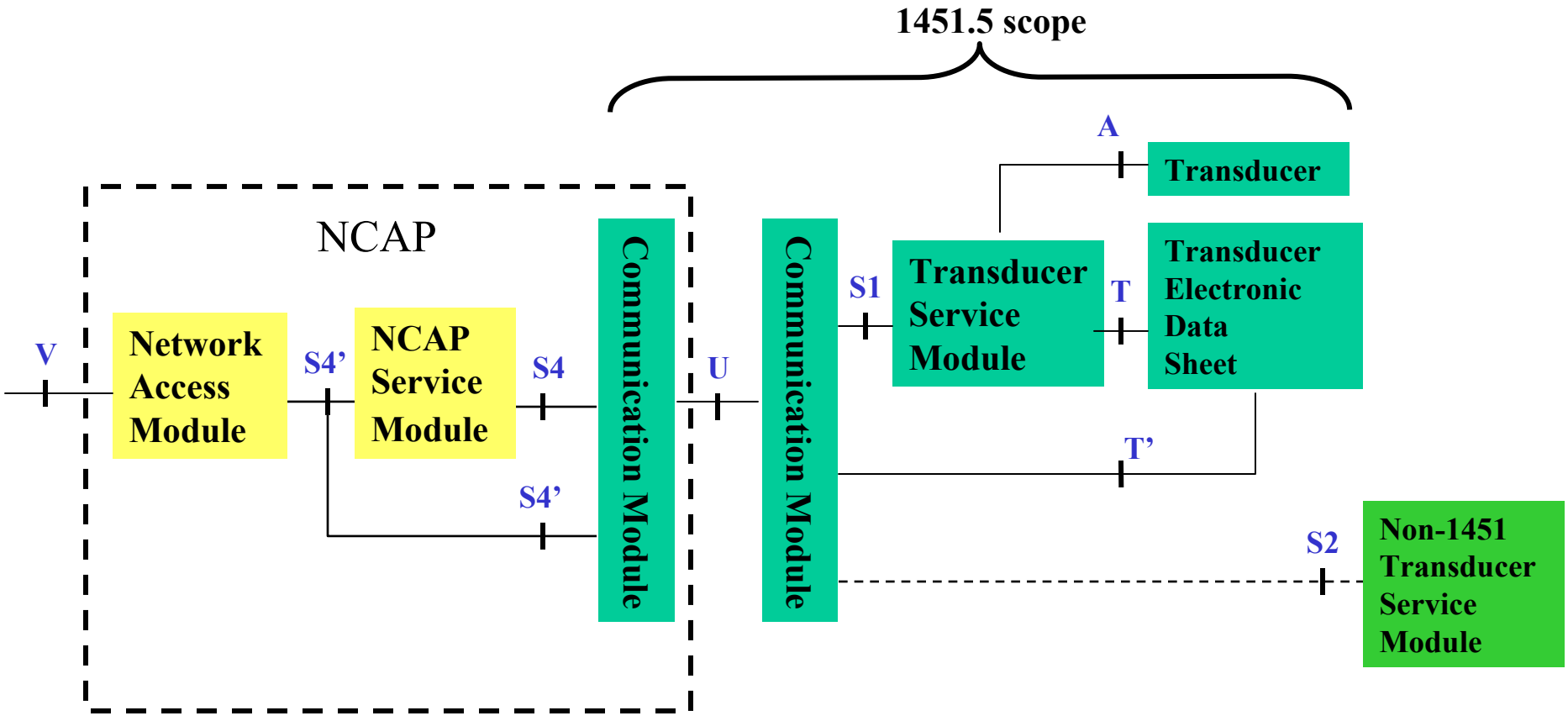
Anaheim, CA

IEEE P1451.5 Framework



Reference Model and P1451.5 Framework

- IEEE P1451.5 framework is consistent with the IEEE P1451.0 reference model.
- IEEE P1451.5 framework covers the following scope:
  - Wireless communication and interface between NCAP and transducer(s),
  - Transducer service and interface,
  - Transducer electronic datasheet and interface.

Terminology of Requirements

- **SHALL** this word, or **REQUIRED, or MANDATORY** means that the requirement is fundamental to this specification.
- **SHALL NOT** means prohibition is absolute.
- **RECOMMENDED** this word, or **SHOULD**, means that there may exist valid reasons in particular circumstances to ignore this requirement, but the full implications must be understood and carefully weighed before choosing a different course.
- **MAY** this word, or **OPTIONAL or (O)**, means this requirement is one of an allowed set of alternatives. An implementation that does not include this option MUST be prepared to inter-operate with another implementation that does include the option.

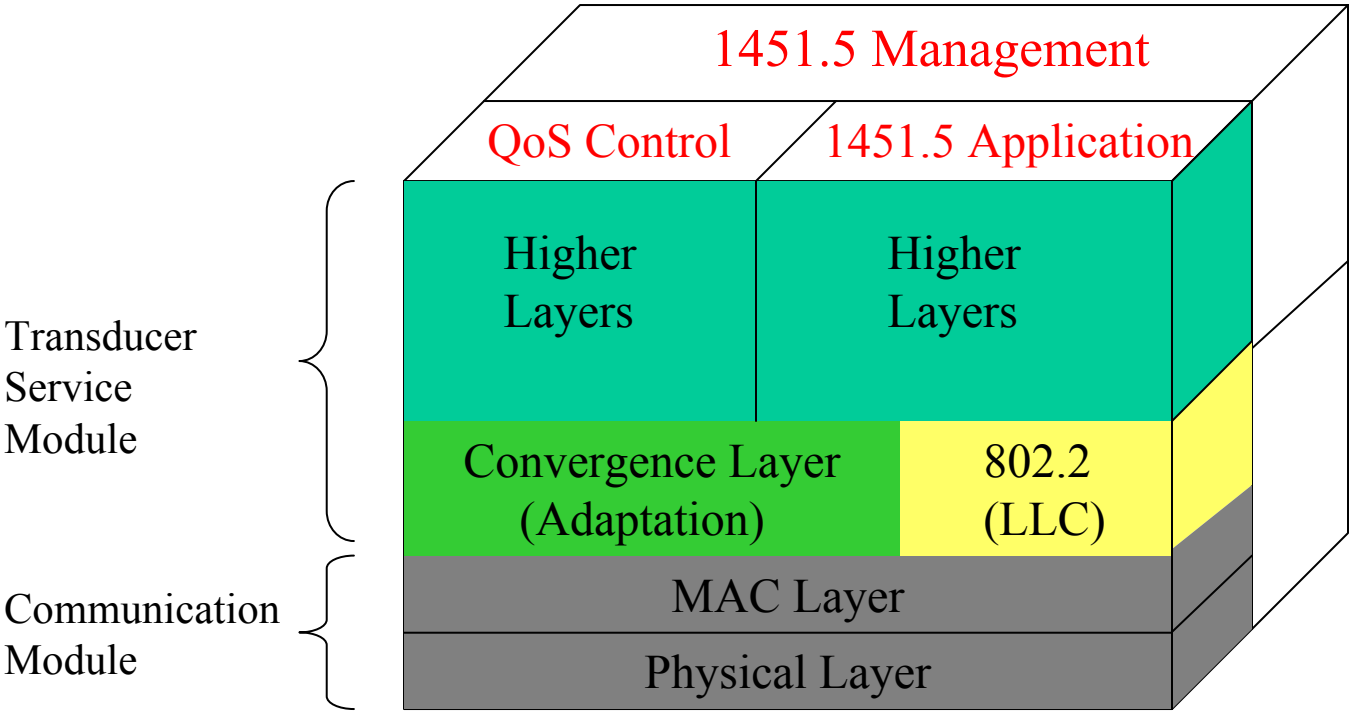
IEEE P1451.5 Functional Requirements

1. ∀ < SHALL, SHALL NOT, SHOULD, MAY > support coexist of multiple wireless technologies;
2. ∀ <SHALL, SHALL NOT, SHOULD, MAY> support 1451-compliant and non-1451 transducers;
3. ∀ < SHALL, SHALL NOT, SHOULD, MAY > support 1451-compliant and non-1451 transducer simultaneously;
4. ∀ < SHALL, SHALL NOT, SHOULD, MAY > have the ability to transport one or more network layer protocols;
5. ∀ < SHALL, SHALL NOT, SHOULD, MAY > transport different network protocols simultaneously;
6. ∀ < SHALL, SHALL NOT, SHOULD, MAY > support *Infrastructure* operation mode (1451.5 between NCAP and wireless transducers);

IEEE P1451.5 Functional Requirements

7. ∀ < SHALL, SHALL NOT, SHOULD, MAY > support *ad hoc* operation mode (1451.5 between wireless transducers);
8. ∀ < SHALL, SHALL NOT, SHOULD, MAY > incorporates authentication and data encryption algorithms for secured wireless communications;
9. ∀ < SHALL, SHALL NOT, SHOULD, MAY > have priority scheduling at a "higher layer" if no QoS is supported at PHY/MAC layer;
10. ∀ < SHALL, SHALL NOT, SHOULD, MAY > support simultaneous multiple class of service or QoS support;
11. ∀ < SHALL, SHALL NOT, SHOULD, MAY > be dependent upon higher layer protocols whether they are Internet standard- or non-standard based;

P1451.5 Protocol Architecture



1. Management-plane provides management functions and capability to exchange information between 1451Application and QoS control.
2. Application-plane provides for the transfer of sensor application information.
3. QoS Control-plane deals with QoS associated connection establishment and release and other control functions necessary for providing quality of service.

Communication Module

- IEEE P1451.5 communication module *SHALL or MAY* provide high reliability, error checking, user-selectable authentication and security algorithm, prioritized wireless communication services between NCAP and transducer(s) through physical (PHY) and media access control (MAC) layers
- IEEE P1451.5 communication module (PHY and MAC) *SHALL or MAY* provide the ability to offer a classification of quality of services (QoS) for transducer advanced applications.

Wireless Technologies

- IEEE 802.15.1 (Bluetooth v1.1)
- IEEE 802.15.4 (ZigBee)
- IEEE 802.15.4a
- IEEE 802.15.3
- IEEE 802.15.3a
- IEEE 802.11b/a/g/e

	802.15.4	802.15.1	802.11b	802.11g	802.11a	802.15.3	802.15.3a
Standard Version/status	IEEE approved	V1.1 (Low-rate)	IEEE approved	IEEE approved	IEEE approved	Draft	Draft IEEE 802.15.3a
Max. data rate	250 kbps 40 kbps 20 kbps	1 Mbps	11 Mbps	54 Mbps	24 Mbps mandatory; 54 Mbps optional	11 Mbps (QPSK) 55 Mbps	110 Mbps (10m) 200 Mbps (4m)
Avg. distance	10-30 m	10 m	100 m	100 m	50 m	10 m	10 m
Frequency allocation	868-868.6 MHz; 902-928 MHz; 2400-2483.5 MHz	2.4 GHz (ISM)	2.4 GHz (ISM)	2.4 GHz (ISM)	5 GHz UNII (5.15-5.35 + 5.725 – 5.825) GHz	2.4 GHz (ISM) 2.4 – 2.4835 GHz	3.1 – 10.6 GHz
Channel bandwidth	0.3 MHz; 0.6 MHz (2 MHz spacing); 2 MHz	1 MHz	25 MHz	25 MHz	20 MHz	15 MHz	Min. 500 MHz Max. 7.5 GHz
Number of RF channels	1; 10; 16	79	3	3	12 US. 8 EU 4 Japan	5	1 – 15
Modulation type	BPSK; OQPSK	GFSK	11 Mbaud QPSK	OFDM (64+CCK (legacy)	COFDM PSK QPSK, 16 QAM	DQPSK 16/32/64 QAM	BPSK, QPSK
Spreading	DS-SS	DS-FH	CCK	OFDM	OFDM		Multiband
Maximum allowed RF power	US: 1W+6dB antenna gain (FCC 15.247); EU: (868 MHz) ERC70-03E: 25mW if duty cycle < 1% in 1 hour.	0 dBm 20 dBm	US: 30 dBm EU: 20 dBm Japan: 10 dBm	US: 30 dBm EU: 20 dBm Japan: 10 dBm	50 mW; 250 mW; 1-watt (depending on the used channels within the band)	US: 50 mV/m EU: 100 mW[2] EIRP (ETS 300-328) Japan: 10 mW (ARIB STD-T66)	-41.3dBm/MHz (Max average EIRP over entire band = 0.562 mW) (FCC First Report and Order: Part 15 ET Docket 98-153)
Required receiver sensitivity	-85 dBm PER < 1%	-70 dBm BER < 10^{-3}	–76 dBm	From –76 dBm to –74 dBm	From –82 dBm (6 Mbps) to –65 dBm (54 Mbps)	From –82 dBm (DQPSK) to –68 dBm (64 QAM)	
Approx. power consumption	< BT	BT (~40 – 100mW)	~4BT	~4BT	~6BT		(~2-3BT)
Approximate cost	~ 0.5 BT	BT (~ $5)	~ 4BT	~4BT	~5BT		~1 to 2 BT

	AXONN
Standard Version/status	AXONN LLC own technology
Max. Data rate	Standard Rate – OOK or BPSK: Approximately 19.4 Kb/s High Rate – BPSK only: Approximately 58.2 Kb/s Maximum Data Rate – BPSK only: Approximately 116 Kb/s
Avg. distance	
Frequency allocation	905.58 MHz, 908.58 MHz, 911.58 MHz, 914.58 MHz, 917.58 MHz, 920.58 MHz, 923.58 MHz, 926.58 MHz
Channel bandwidth	3 MHz
Number of RF channels	Eight RF channels shall be supported, each spaced 3 MHz apart, from 905.58 MHz to 926.58 MHz.
Modulation type	Direct Sequence, Binary Phase Shift Keying (BPSK) modulation and On-Off Keying (OOK) or BPSK
Spreading	DS-SS
Maximum allowed RF power	US: EU: Japan:
Required receiver sensitivity	
Approximate # PHY power consumption	
Approximate cost	

Proposed Classification of QoS

Attributes	Class#1	Class#2
Timing between source and destination	Related	Not Related
Bit rate	Constant	Variable
Connection mode	COM	CLM

QoS Parameters (Example)

- Timing
  - Frame or packet transfer delay (TD) in µs
  - Frame or packet delay variation (DV) in µs
  - Guaranteed vs. best effort transfer
- Bit rate
  - bps (bits per sec): constant bps and average bps
- Bit error rate (BER)
  - Class#1: BER <= 10^{-10} (example)
  - Class#2: BER <= 10^{-7} (example)

Transducer Service Module

- Transducer service module *SHALL or MAY* provide the sensor adaptation, network, transport, session, (presentation and application) layers above the communication module (PHY and MAC layers). This high-layer services should support standard-based wireless network platform optimized for wireless monitoring and control applications. Network layer architectures supported by the transducer service module *SHALL or MAY* include star, mesh, or a hybrid star/mesh topologies.

P1451.5 TEDS

(In addition to 1451.3 meta-TEDS and transducer channel TEDS)

- A table of parameters that identify the transducer and are held in the transducer on a storage (e.g., E^2PROM) for interrogation by external electronics physically accessible. The parameters stored on a E^2PROM must be retrievable and modifiable. Hence, the structure of the TEDS organizes, names, and describes information (or managed object) so that logical access can occur. The information (or managed object) must have a name, a syntax, and an encoding. The name, an object identifier (OID), uniquely identifies the information (object). The syntax defines the data type, such as integer or a string or octets. The encoding describes how the information associated with the managed object is serialized for transmission.

P1451.5 TEDS Elements

1. TEDS Syntax (use Abstract Syntax Notation One, ASN.1). ASN.1 syntax is a presentation layer (layer 6) function.
2. TEDS Encoding rules
3. Parameter Name (or Object Identifier)

These three elements can provide a building block for presenting and accessing sensor management information through standard-based SNMP and web-based management station.

"U" Reference Point

- The "U" reference point embraces the logical and physical characteristics of the interface between the communication modules:
  - ✓ Point-to-Point Link e.g., wireless bridge, or to replace a single communications cable.
  - ✓ Point-to-Multipoint Links e.g., IEEE 802.11 and Bluetooth when operated in the infrastructure mode have one access point to control communications with all other wireless nodes in the network.
  - **?** Wireless mesh network topology for industrial control and sensing is a point-to-point, or peer-to-peer, system called an ad hoc or multi-hop network. A node can send and receive messages in a mesh network. A node also functions as a router and can relay messages for its neighbors. Through the relaying process, a packet of wireless data will find its way to its destination, passing through intermediate nodes with reliable communication links.

“S1” Reference Point

- “S1” reference point describes the logical and physical characteristics of the interface between communication module and transducer service module.
  - Protocol Service Access Point (SAP)
  - Physical interface e.g., a serial point-to-point link

“T” Reference Point

- “T” reference point describes the logical and physical characteristics of the interface between transducer service module and transducer electronic datasheet.

T’ Reference Point

- T’ reference point describes the logical and physical characteristics of the interface between communication module and transducer electronic datasheet.

“A” Reference Point

- “A” reference point describes the logical and physical characteristics of the interface between transducer service module and analog-based transducer.