

**A Proposal for IEEE P1451.5, Standard for a Smart Transducer Interface for Sensors and Actuators - Wireless Communication Protocols and Transducer Electronic Data Sheets (TEDS) Formats**

**Submission Title:** [Link Adaptation and Management Protocol (LAMP)]

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**Re:** [Call for Proposals; Doc. <related doc #'s>]

**Abstract:** [We propose Link Adaptation and Management Protocol (LAMP), which includes autoconfiguration, session management, data transfer, reliable multicasting/broadcasting]

**Purpose:** [proposal and call for discussion]

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# < Link Adaptation and Management Protocol (LAMP) for IEEE 1451.5 >

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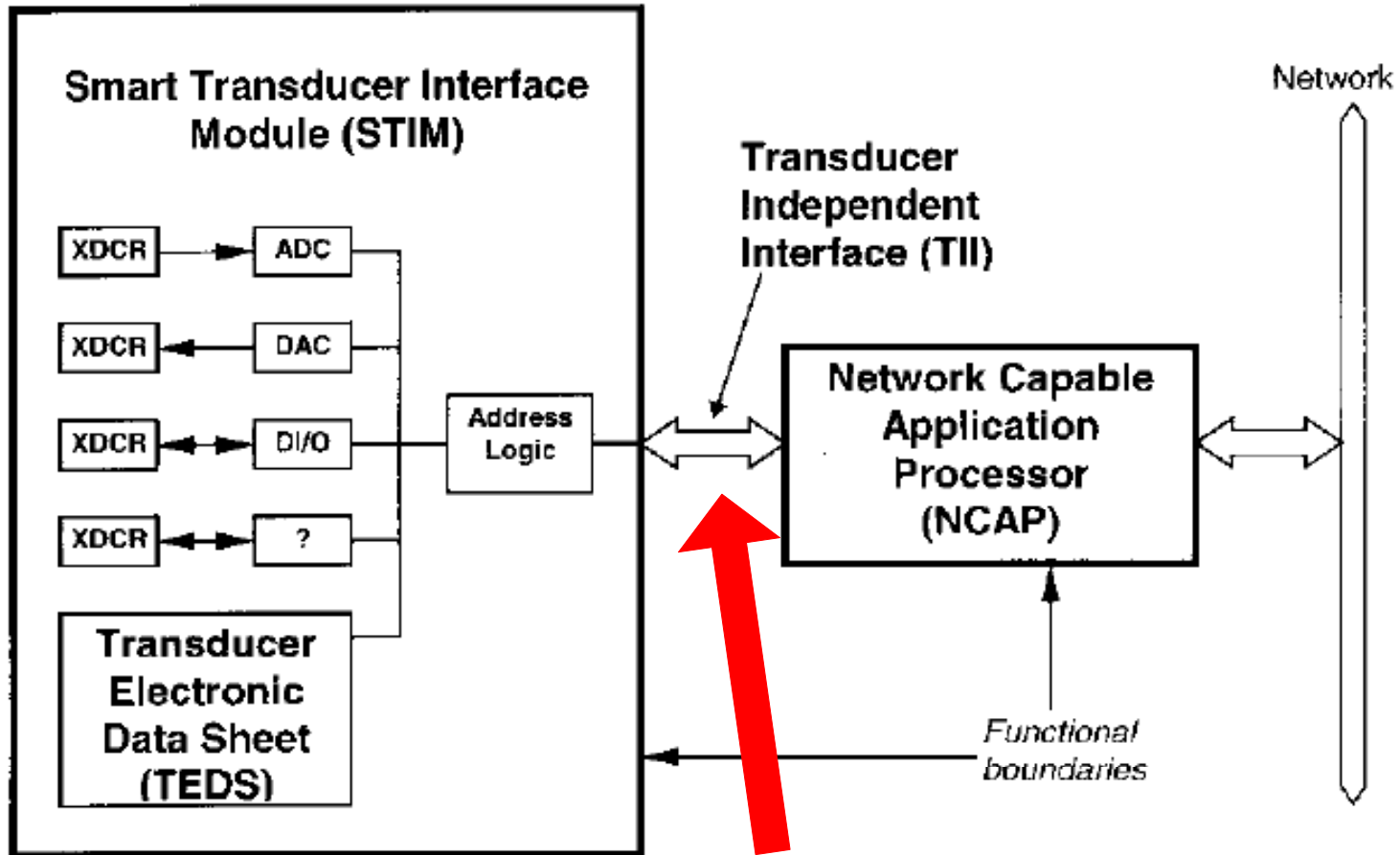
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# 1. Introduction

- Goal of our proposal
  - Providing reliable wireless communications between STIMs and NCAP for P1451.5 networks.
    - 1) auto-configuration,
    - 2) session management,
    - 3) data transfer,
    - 4) reliable multicasting/ broadcasting.
- The scope of this proposal
  - Defining the Link Adaptation and Management Layer between the Application Layer and the underlying wireless IEEE MAC Layers, including 802.15.4 and 802.11 families.

# What we are addressing?



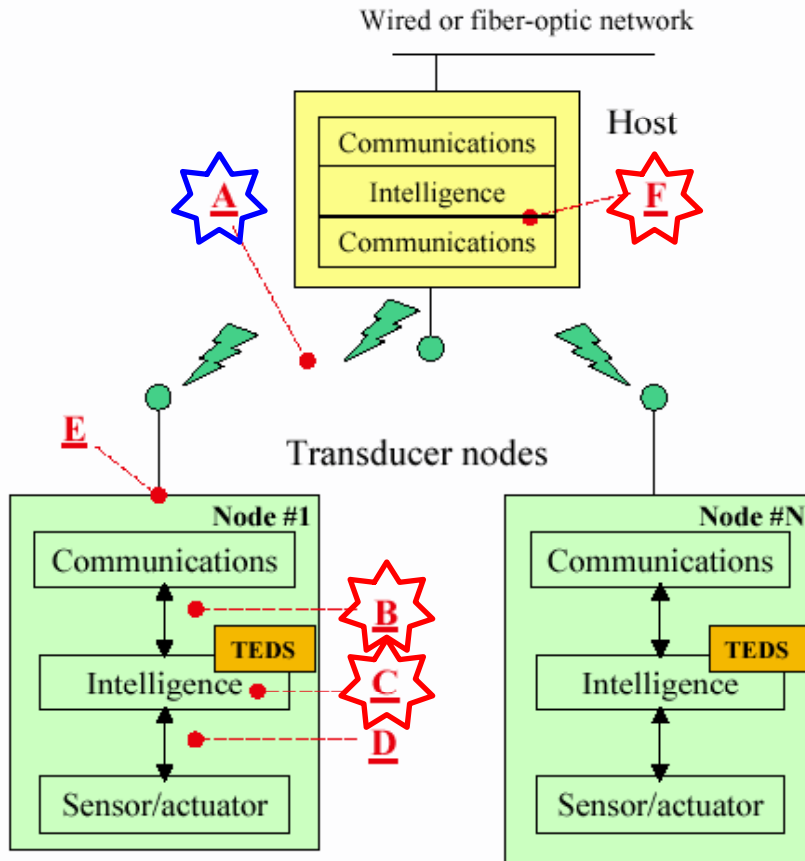
Replacing the Interface with Wireless Interface

# Difference between TII and P1451.5

	Transducer Indep. Interface	Wireless Interface (P1451.5)
Association (NCAP-to-STIM)	One-to-one (physical)	One-to-many (logical)
Addressing (in module level)	No	Yes
Channel Reliability	High	Low
Power Supply	Mains powered	Battery powered
Transmission Mechanism	Bit level	Packet level
Sleeping Mode	No	Yes
Bandwidth	No constraint	Limited

# What we are defining?

## P1451.5 Standardization Options



**Standardization options** (modified based on discussion at P1451.5 meeting on 5/7/02 )

**A- HW** - RF spectrum, wireless protocol (Adopt an industry standard, data format), could do Appendix X, each with profile to address.

★ **A- SW** - Wireless message formats, data/control model, security model (Part of an industry standard)

**B- HW** - Interface between intelligence and wireless transceiver (Do not standardize)

★ **B- SW** - Message formats (Define or adopt from P1451.3)

★ **C- SW** - TEDS (Contents and size - define or adopt from P1451.3), data/control models (Define or adopt from P1451.3)

**D- HW** - Low level wired interface (Do not standardize)

**E- HW** - Packaging, antennas (Do not standardize)

**F- HW** - Interface between host intelligence and wireless transceiver (Do not standardize)

★ **F- SW** - API between host intelligence and wireless transceiver (Define or adopt from P1451.3)

**In general, the objectives are:**

- Interoperable in spectrum level.
- Don't want to lock on a specific vendor HW, but has profiles for Bluetooth, 802.11b, 802.15.4, and others protocols, etc.
- Define message passing format, specify host API, Java, DCOM, and COM++, etc., and have a few reference implementations.
- Transducer nodes = STIM
- Host = NCAP.

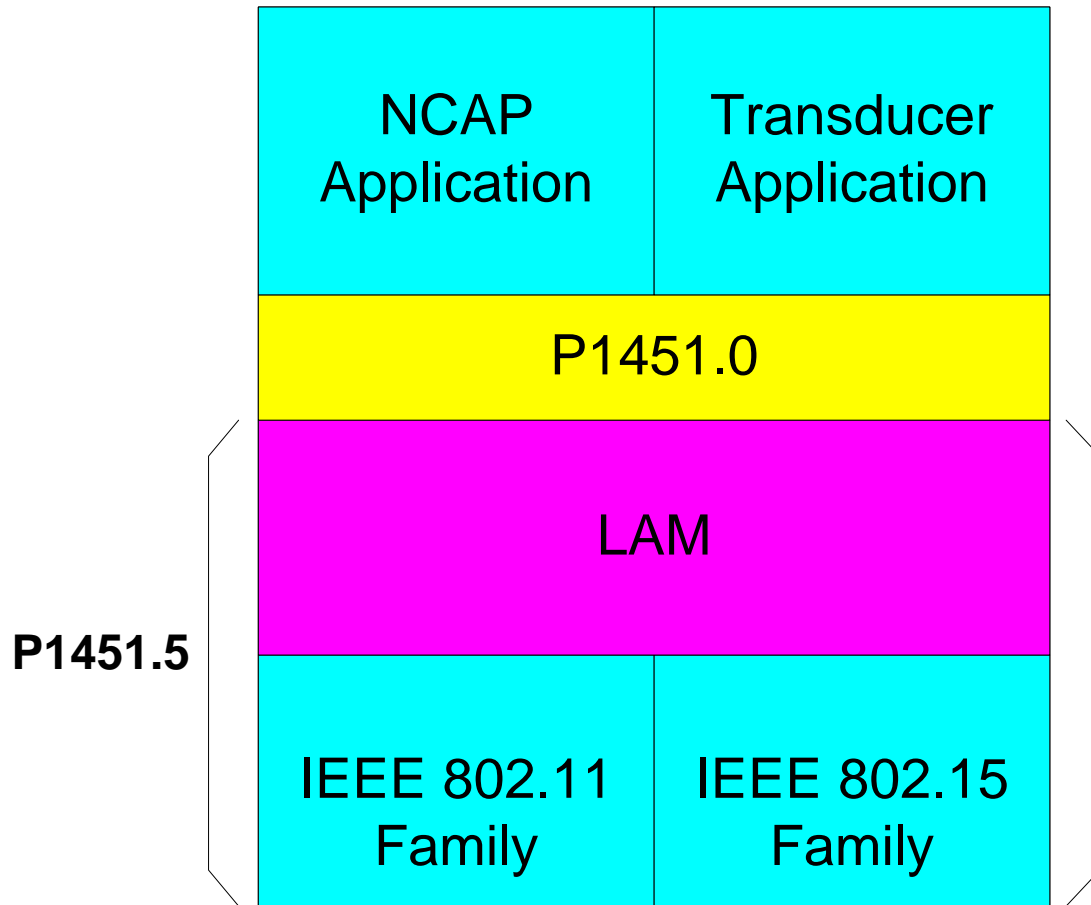


Standard we adopted (HW + SW)



Standard we proposed (SW only)

# Our View



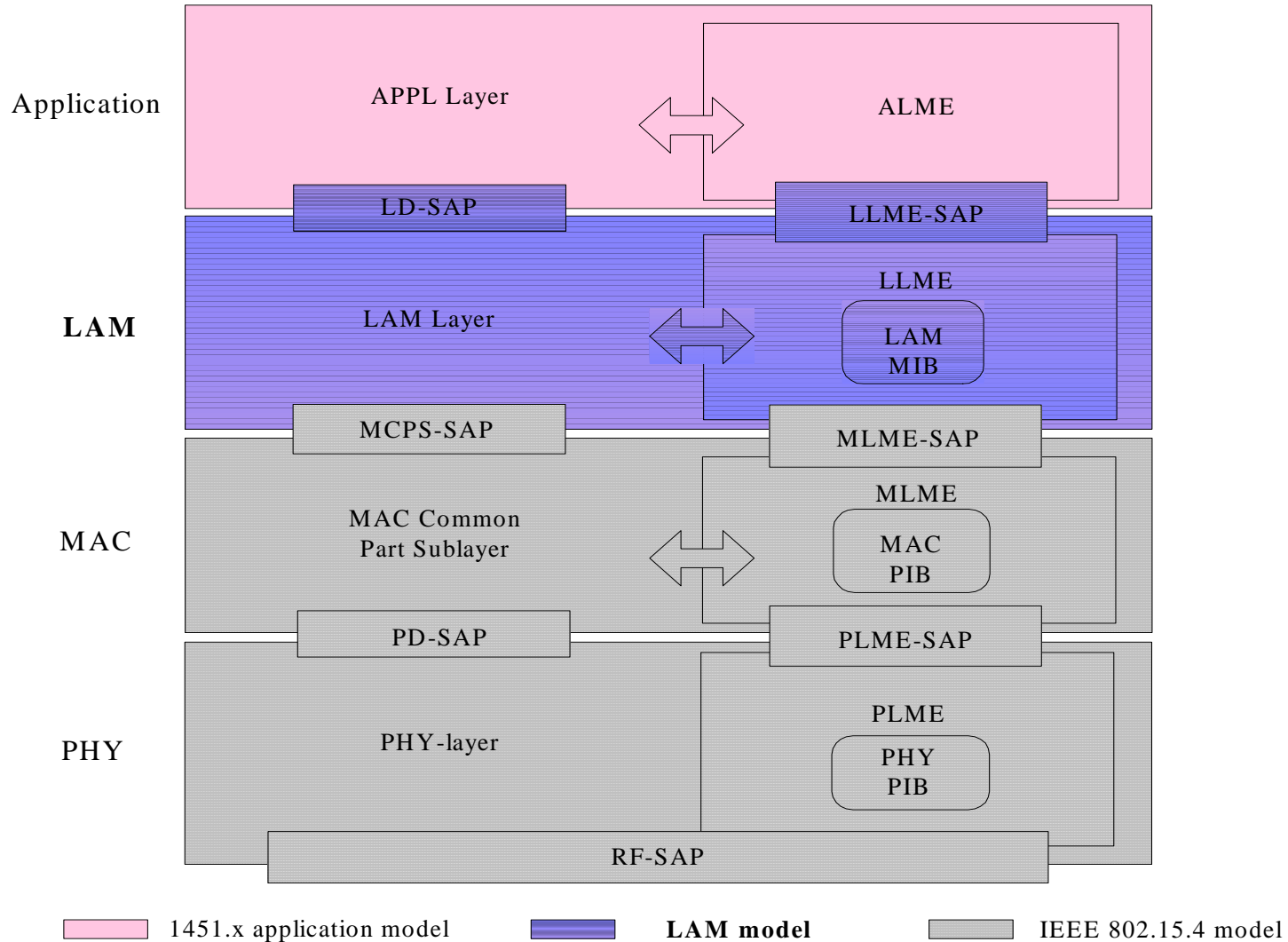
# LAM vs. ZigBee

- ZigBee:
  - ZigBee standard defines a protocol suite/profile from network layer to application layer.
  - ZigBee is an ongoing project, the first draft is expected to be available in August, 2003
  
- What LAM has and ZigBee does not in current version:
  - Multiple MAC support (e.g. IEEE 802.11 and 802.15.4)
  - Reliable end-to-end transmission
  - Reliable broadcast/multicast support
  - Sleeping mode support
  - Differentiated service
  - Data aggregation support

# IEEE 802.11b vs. IEEE 802.15.4

	IEEE 802.15.4	IEEE 802.11b
<b>Contention-free Mechanism</b>	Superframe with GTS - Coordinator pulls Device for data transfer	Point Coordination Function - PC polls STA for data transfer
<b>Contention-based Mechanism</b>	CSMA/CA	CSMA/CA
<b>Communication Range</b>	Short	Long
<b>Power Consumption</b>	Low	High
<b>Cost</b>	Low	High
<b>Battery Life</b>	Long	Short
<b>Bandwidth</b>	Small	Large
<b>Freq. Band</b>	2.4GHz/900MHz/800MHz	2.4GHz

# IEEE P1451.5 Protocol Reference Model



## 2. LAM Management Service

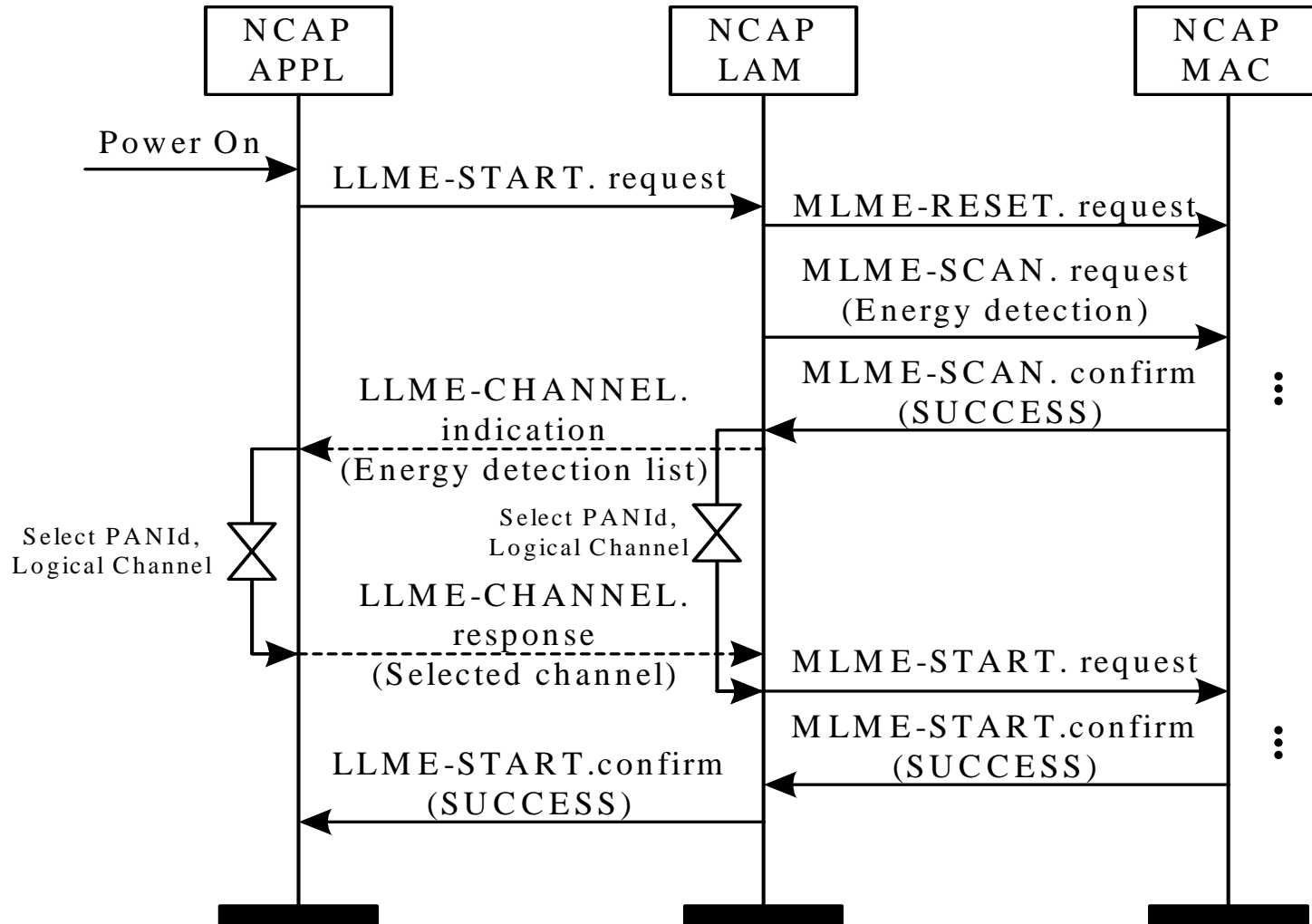
The LLME provides a complete set of management services to support “plug and play” configuration of the network. These services include:

- NCAP Startup
- STIM Startup and Addressing
- Service Discovery
- STIM Disassociation/Detach
- STIM Orphan
- Unexpected STIM Detach
- Dynamic Channel Adaptation

# LAM Management Primitives

Name	Request	Indication	Response	Confirm
LLME-START	X			X
LLME-CHANNEL		X	X	
LLME-INITIATE	X			X
LLME-ADDRESS	X	X	X	X
LLME-SERVICE	X	X	X	X
LLME-DISASSOCIATE	X	X		X
LLME-TEARDOWN		X		
LLME-GET	X			X
LLME-SET	X			X
LLME-DCA	X	X		X
LLME-REPORT	X			X

# Example: NCAP Startup

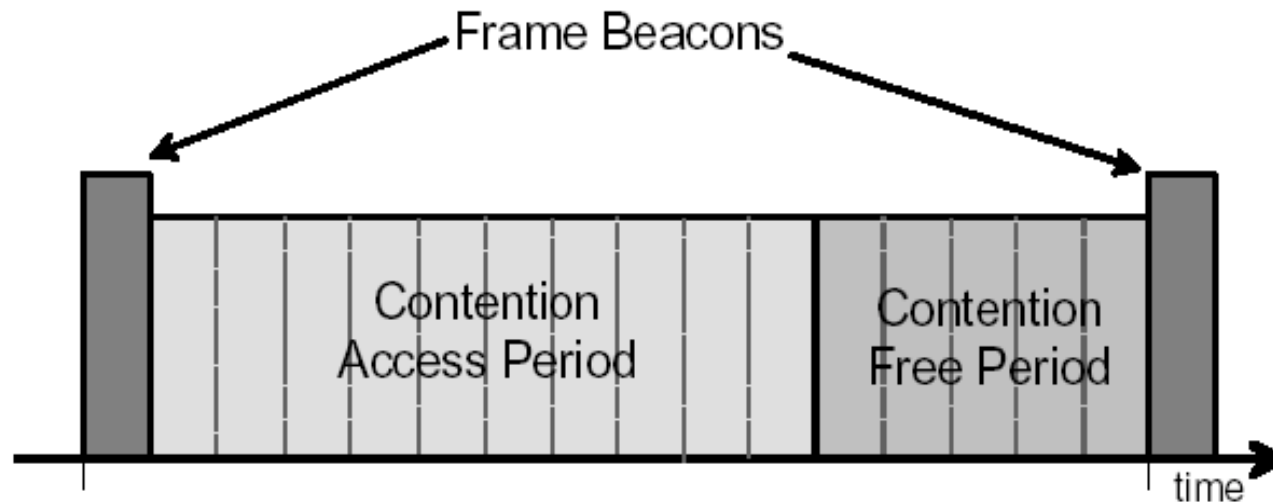


## 3. LAM Data Service

- 3.1 Review of IEEE 802.15.4 Data Transmission Mechanism
- 3. 2 Application Functions Supported
- 3. 3 Data Scheduling
- 3. 4 Reliable Broadcasting/Multicasting

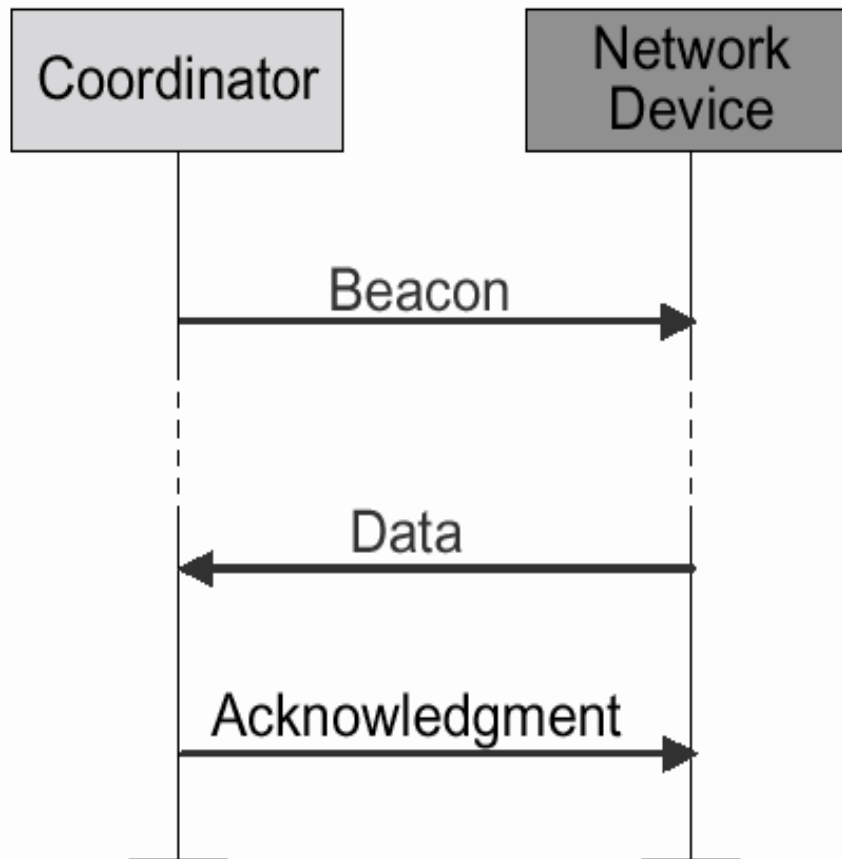
# 3.1 IEEE 802.15.4 Data Transmission Mechanism

# Data Transmission Mechanism



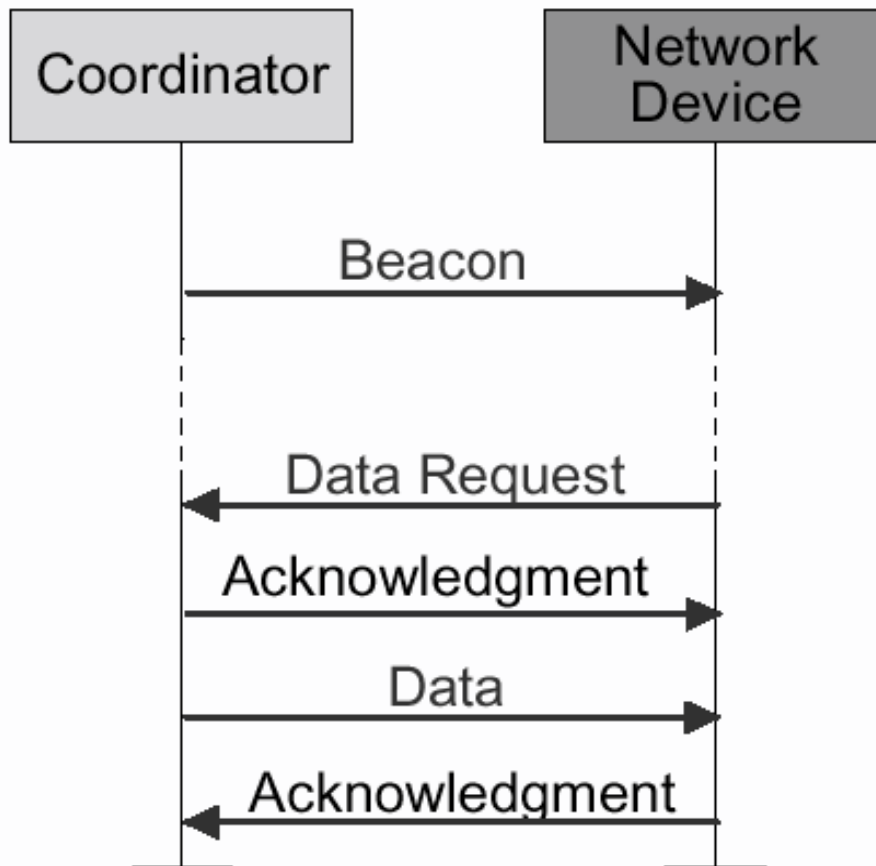
- Star topology network with centralized control at the coordinator
- A well-defined superframe structure supporting both contention-based and contention-free medium access
- Beacon based channel synchronization mechanism

# Data Transfer TO a Coordinator in a Beacon-Enabled Network



- When a device wishes to transfer data to a coordinator in a beacon-enabled network, it first listens for the network beacon.
- When the beacon is found, the device synchronizes to the superframe structure.
- At the appropriate point, the device transmits its data frame, using slotted CSMA-CA, to the coordinator.

# Data Transfer FROM a Coordinator in a Beacon-Enabled Network



- An “indirect” data transfer scheme
  - Coordinator must send a beacon to “pull” a Device to request for the data.
  - Five steps for one data transmission.
- It is designed to handle the Devices in sleeping state

# Beacon Frame

Octets: 2	1	4/10	2	variable	variable	variable	2
Frame control	Sequence number	Addressing fields	Superframe specification	GTS fields	Pending address fields	Beacon payload	Frame check sequence
MAC header			MAC payload				MAC footer

- Pending address fields
  - An address list which can accommodate up to 7 short addresses or 64-bit IEEE addresses
- Beacon payload
  - Contents in this field will be sent to the next higher layer for processing

## 3.2 Application Functions Supported

- From P1451.2 standard
  - 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
- From P1451.3
  - Support of multiple STIMs

## 3.3 Data Scheduling

- Packet Pending Queue (PPQ)
  - If the NCAP needs to send data to more than seven STIMs, it has to put the packets into the PPQ.
- Differentiated Services
  - High priority: packet content in beacon payload;
  - Medium priority: STIM addresses in beacon payload (without waiting in PPQ);
  - Low priority: packets wait in the PPQ.
- Data Aggregation
  - When NCAP has more than one packets from the application layer destined to the same STIM, LAM can assemble these packets into one LAM layer packet and send it only once.

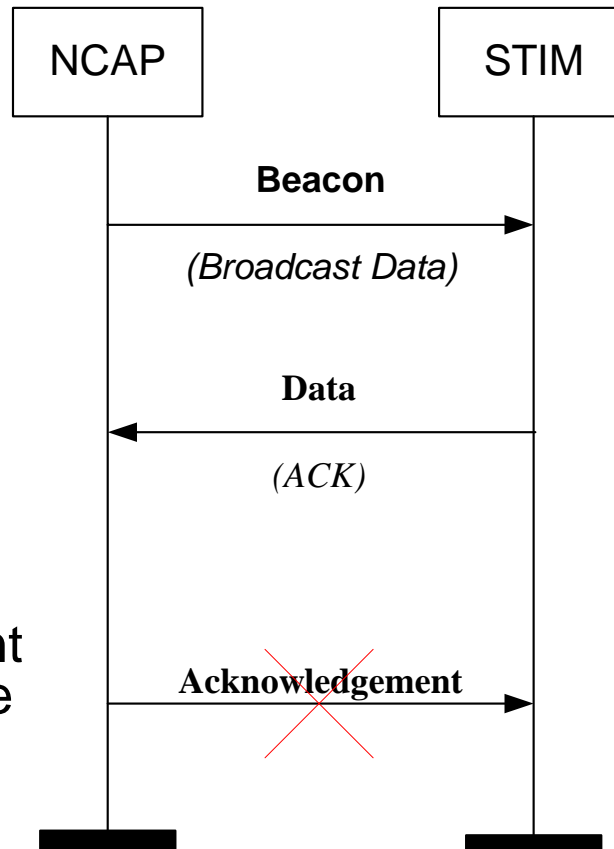
# 3.4 Reliable Broadcasting /Multicasting

# Applications of Reliable Broadcast/Multicast

- NCAP sending global triggers, controls and commands to all/multiple STIMs;
- NCAP sending re-programming files to all/multiple STIMs.

# Broadcasting by using the Beacon frame

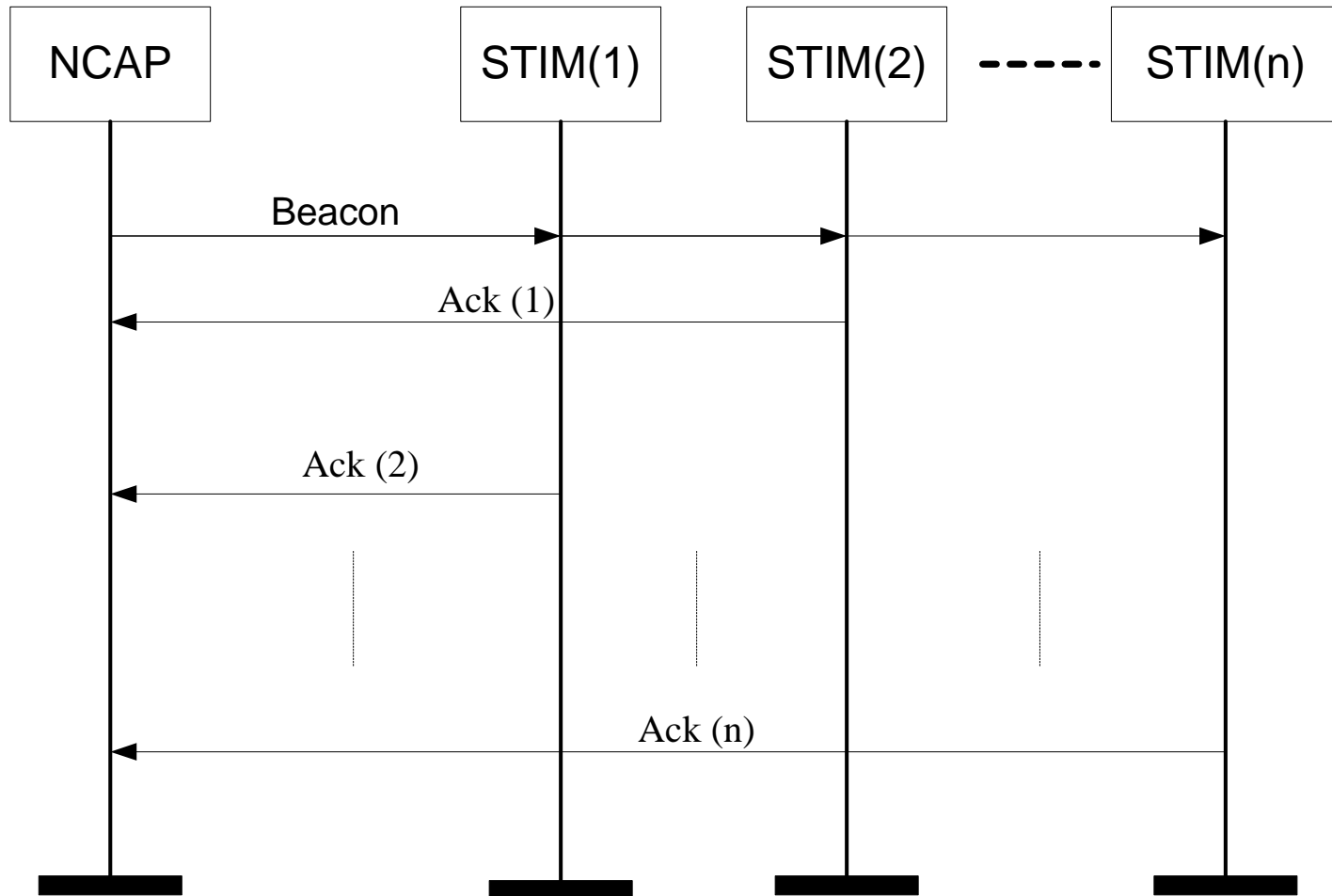
1. Packets is broadcasted using the payload field of beacon



2. The ACK of broadcast packet can be treated as "Data" (with "ack.req" bit set to "0")

3. The Acknowledgment from coordinator can be saved

# Message Sequence of Broadcast Packet



# Multicasting

- Transmitting messages from the NCAP to a group of STIMs.
- Example: a trigger signal needs to be sent to all STIMs which contain temperature sensors.
- Only considering multicasting among homogeneous STIMs/Sensors (i.e. only STIMs contain same kinds of sensors can be in the same group).
- Multicasting = broadcasting + attribute (e.g. temperature)

# 4. Extending the Coverage

- Two ways of doing it:
  - Repeater/Bridge
    - No routing is needed, less control overhead
    - Low latency (route discovery takes time)
    - No extra hardware requirement (e.g. more memory space for routing table at every node)
    - No sleeping-mode effect
  - Multihop Routing
    - More capable (e.g. multiple paths, route recovery)
    - More scalable (e.g. grouping into multiple clusters)
    - Better support for node mobility

# 5. Conclusion

- Link Adaptation and Management Protocol
  - Defined between Application layer and underlying IEEE wireless MAC layers, including 802.15.4 and 802.11 families for IEEE1451.5
  - To provide reliable wireless services between NCAP and STIM in a star topology
  - Services include autoconfiguration, session management, data transfer, and reliable multicasting/ broadcasting.

# Questions ?