ZigBee™ Alliance

Wireless Control That Simply Works

Application Framework Overview

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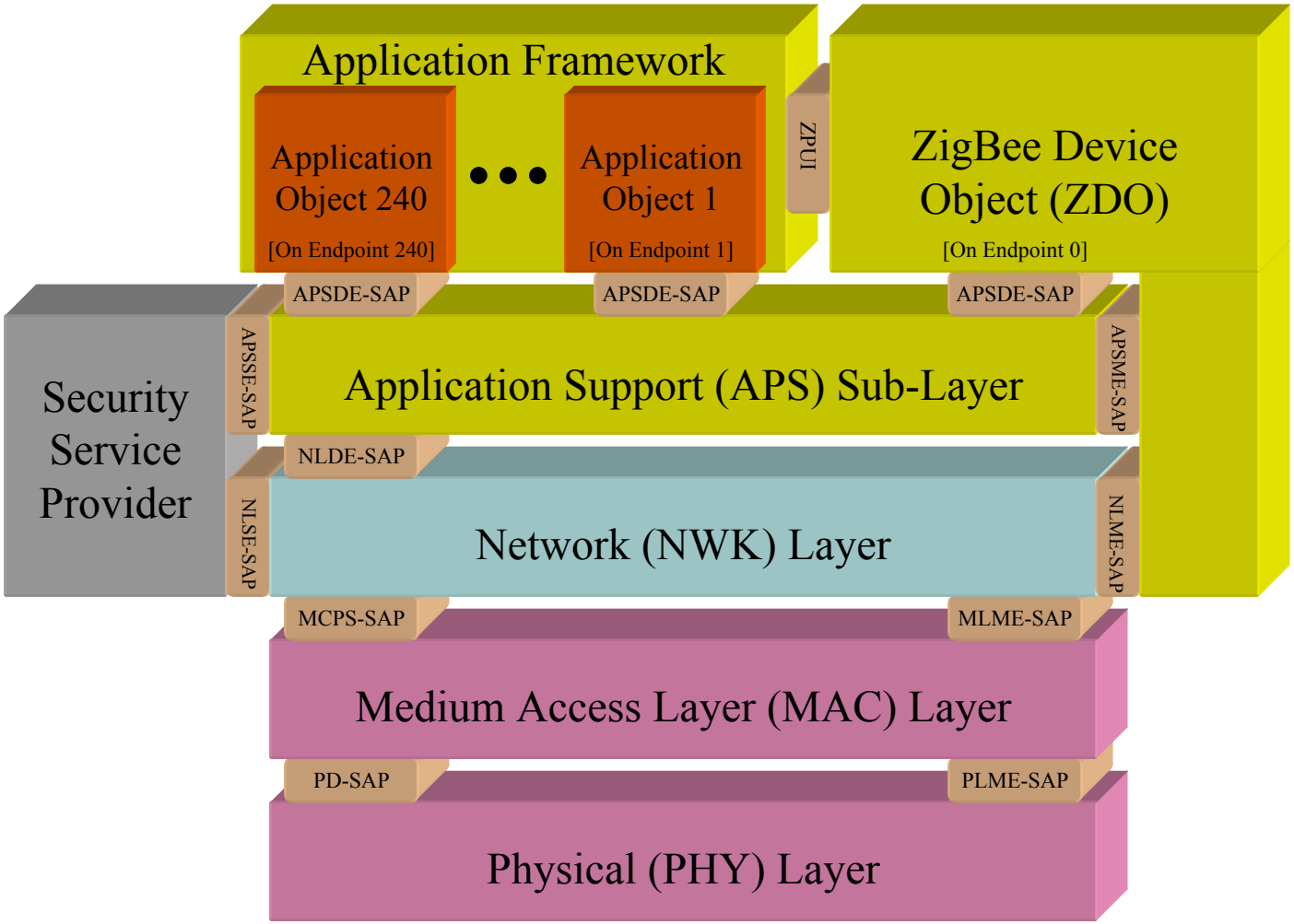
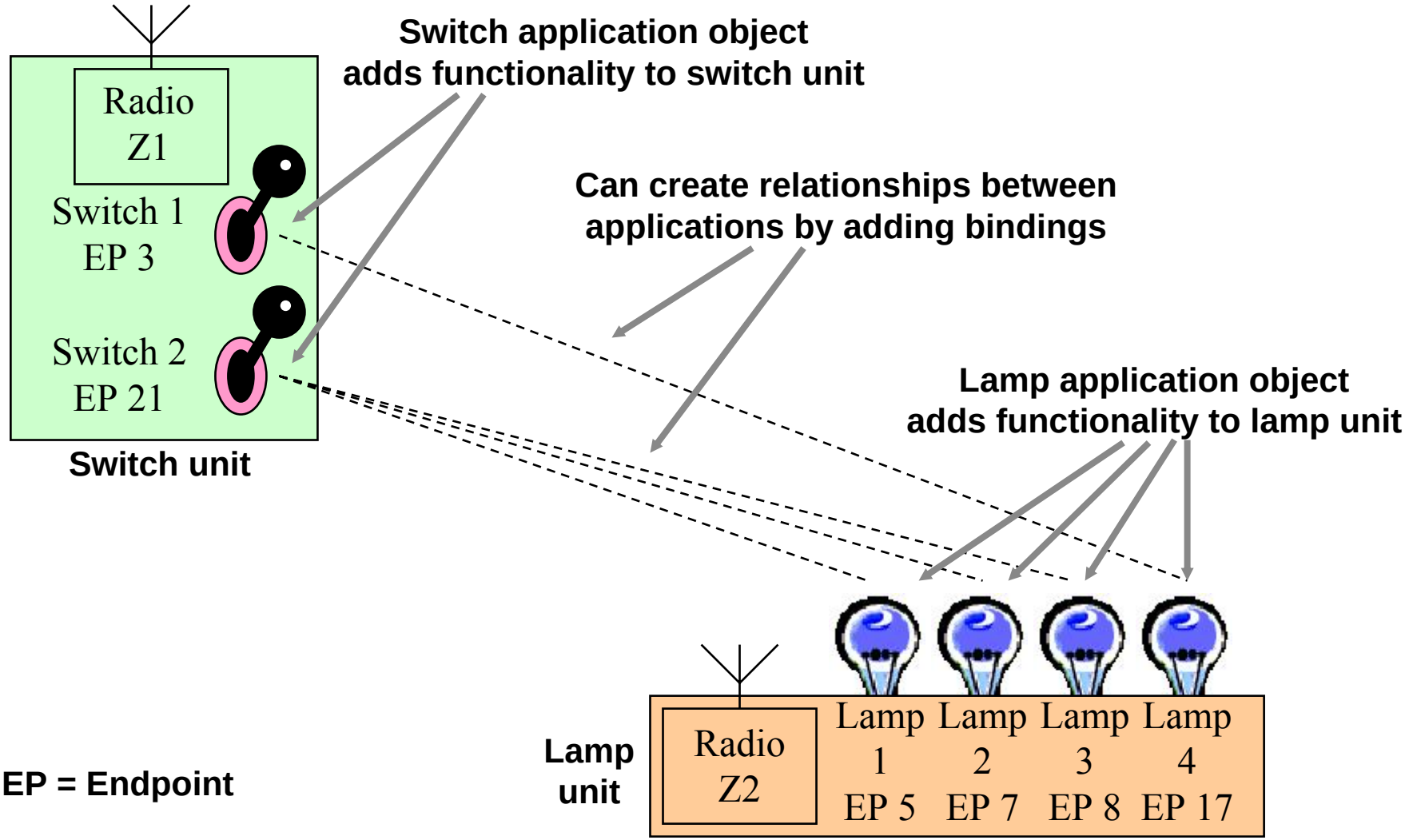
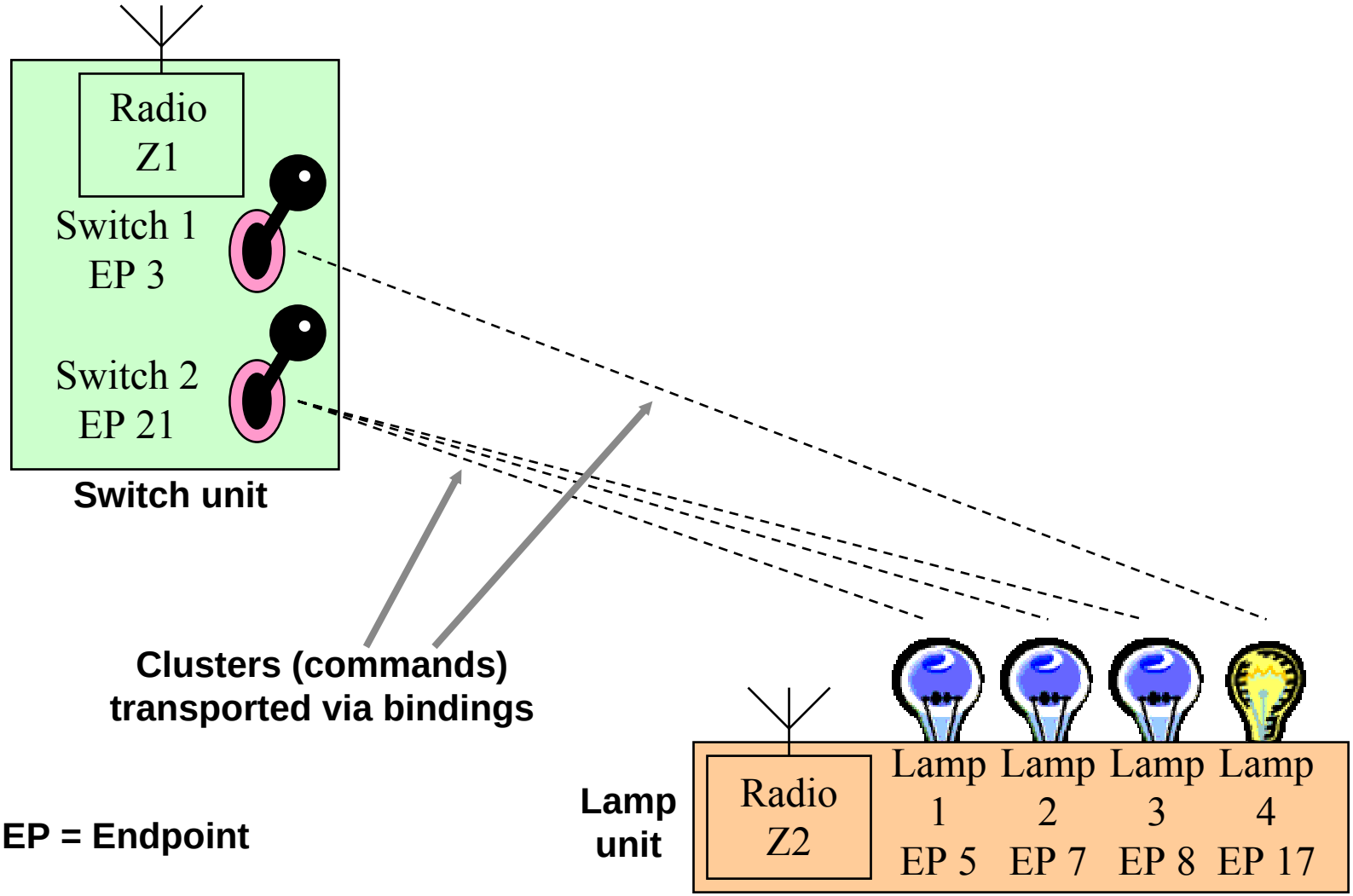
The ZigBee Stack



Application Overview: Addressing & Binding

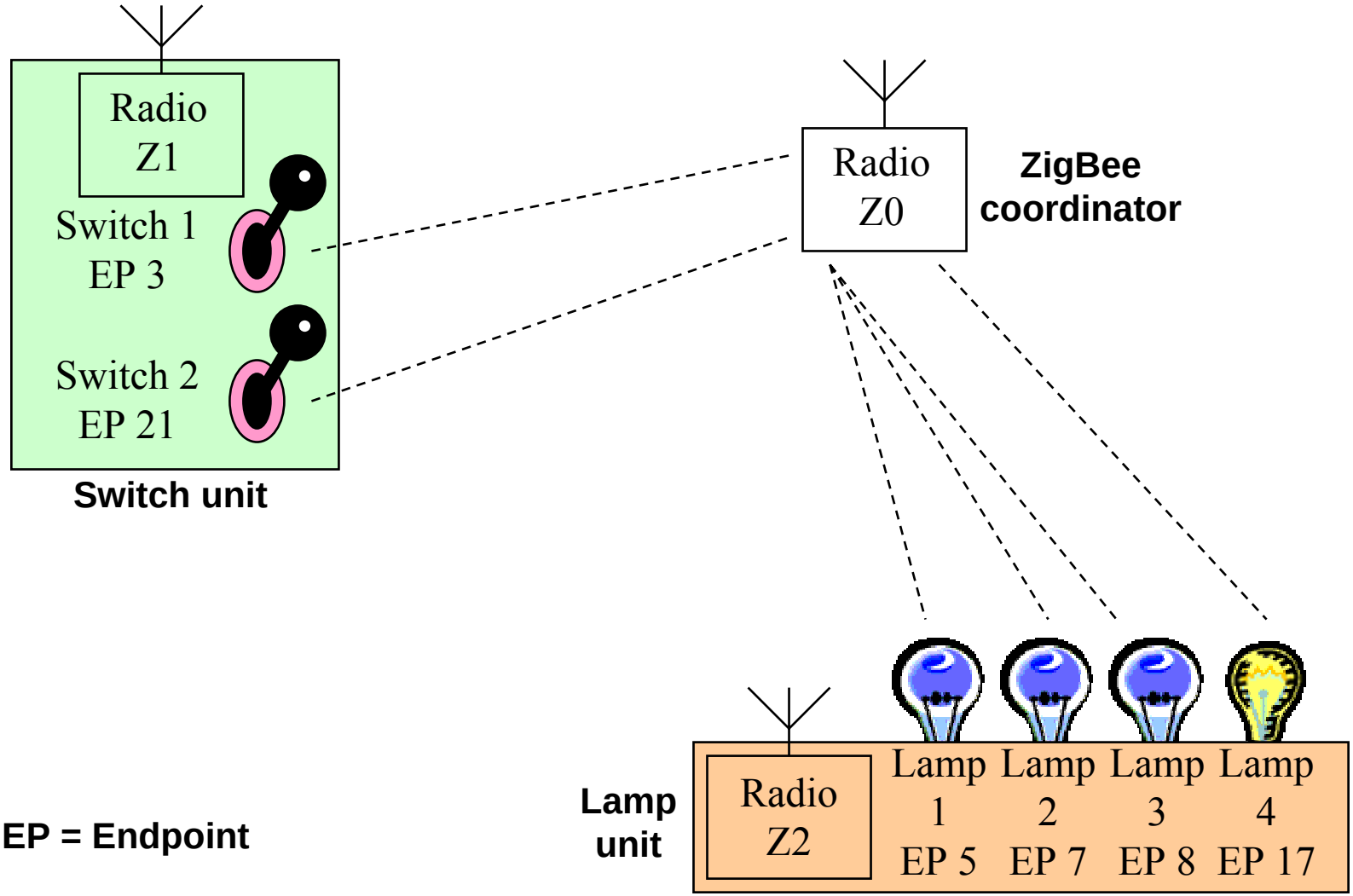


Application Overview: Transporting Clusters



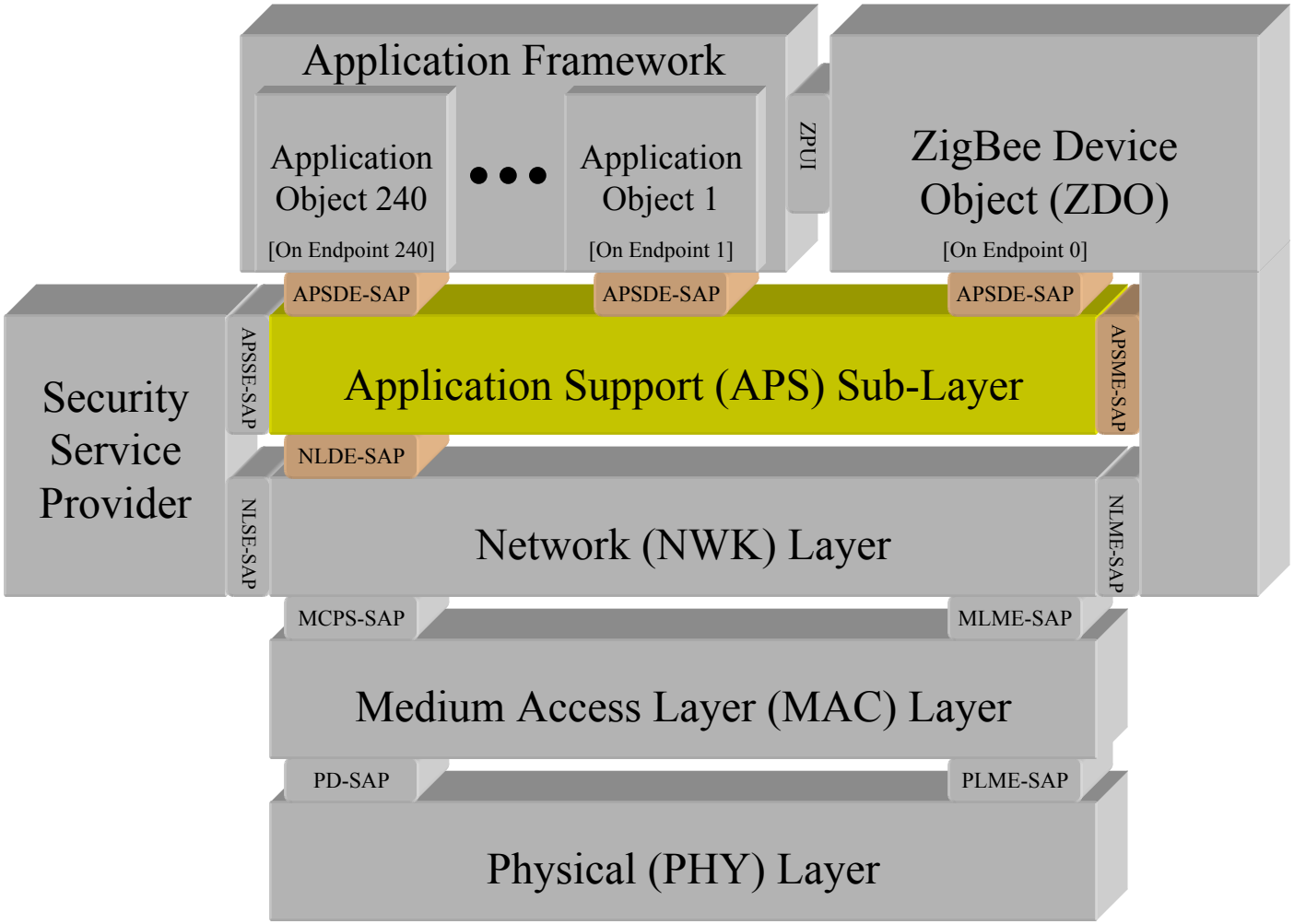
EP = Endpoint

Application Overview: Indirect Transmission



EP = Endpoint

The Application Support Sub-Layer



APS Service Primitives

- Data service
  - APSDE-DATA.request
  - APSDE-DATA.confirm
  - APSDE-DATA.indication
- Management service
  - APSME-BIND.request
  - APSME-BIND.confirm
  - APSME-UNBIND.request
  - APSME-UNBIND.confirm

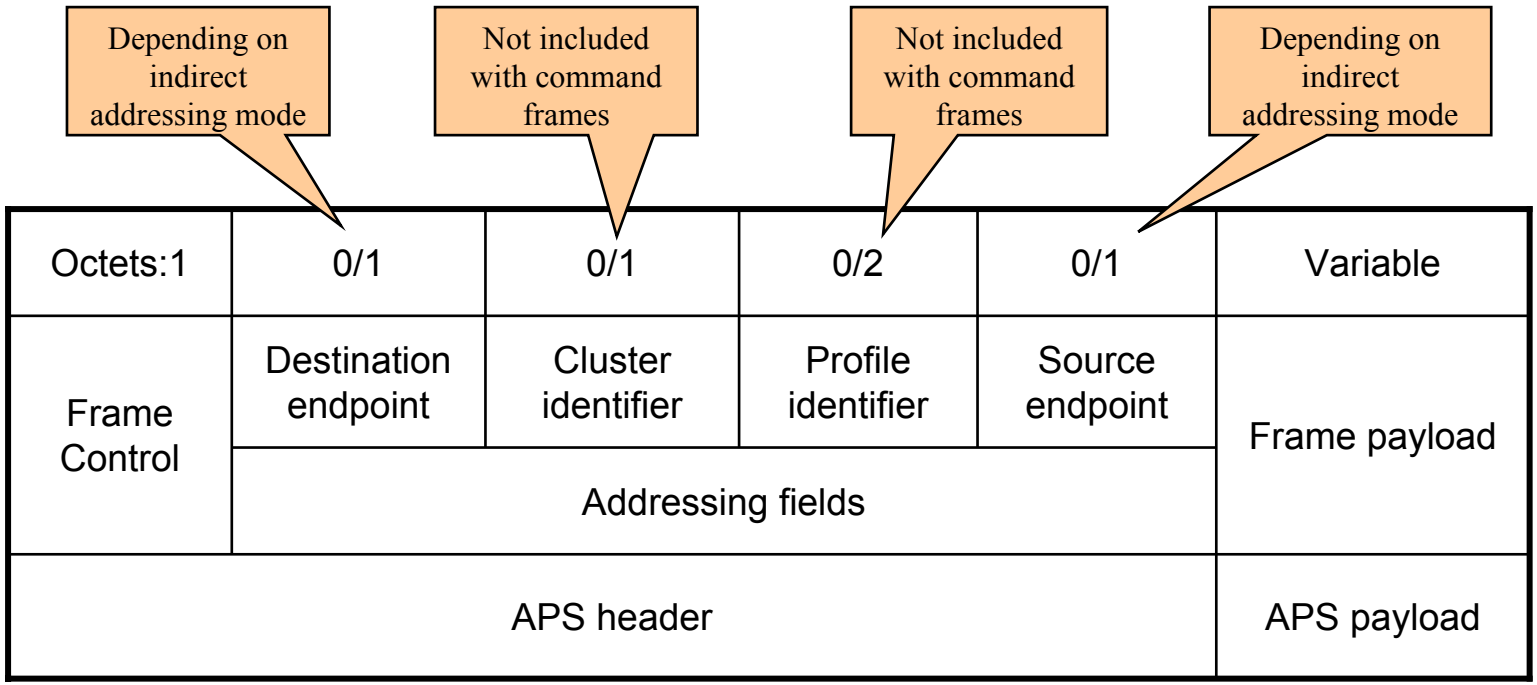
Request to Transmit Data

APSDE-DATA.request (	
DstAddrMode,	Not present, 16-bit or 64-bit
DstAddress,	According to DstAddrMode
DstEndpoint,	Target endpoint: 0x00-0xff
ProfileId,	Profile to which this command belongs
ClusterId,	Cluster being transported
SrcEndpoint,	Source endpoint: 0x00-0xfe
asduLength,	The length of asdu
asdu,	The application data
TxOptions,	Security, NWK key, acknowledgement select
DiscoverRoute,	Route discovery override
RadiusCounter	Broadcast radius (broadcast transmissions only)
)	

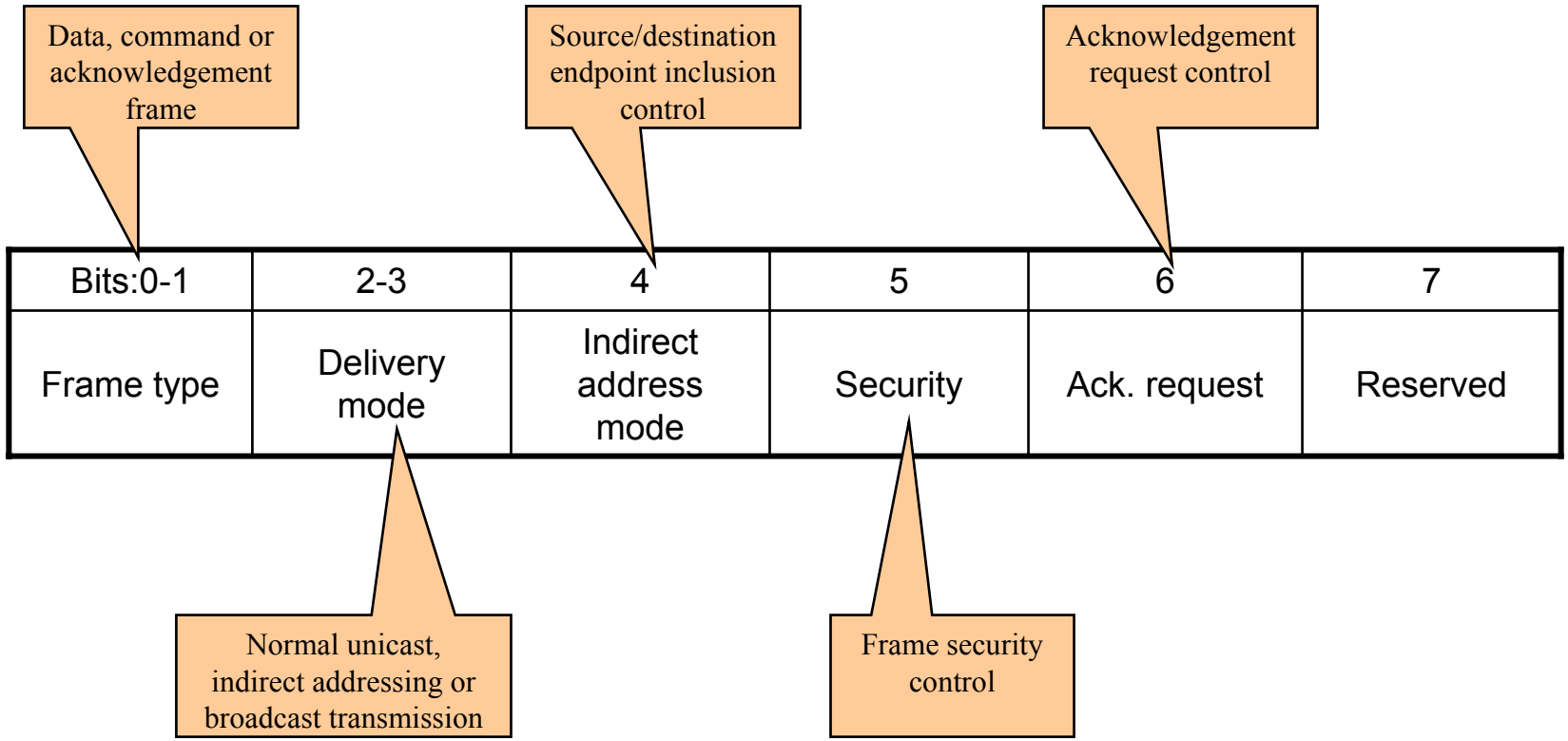
Notification of the Arrival of Data

APSDE-DATA.indication	(	
	DstEndpoint,	Target endpoint on this device: 0x00-0xfe
	SrcAddrMode,	Not present, 16-bit or 64-bit
	SrcAddress,	According to SrcAddrMode
	SrcEndpoint,	Originator endpoint: 0x00-0xff
	ProfileId,	Identifier of the profile from which the frame originated
	ClusterId,	Cluster being received
	asduLength,	The length of asdu
	asdu,	The application data
	WasBroadcast,	Whether the transmission was broadcast
	SecurityStatus	Unsecured, NWK key or link key
	)	

General APDU Frame Format



Frame Control Field



Binding Link Creation/Removal

APSME-(UN)BIND.request (

SrcAddr,	64-bit IEEE address
SrcEndpoint,	Source endpoint: 0x01-0xff
ClusterId,	Source cluster to (un)bind with destination
DstAddr,	64-bit IEEE address
DstEndpoint	Destination endpoint: 0x01-0xff

)

The Binding Table

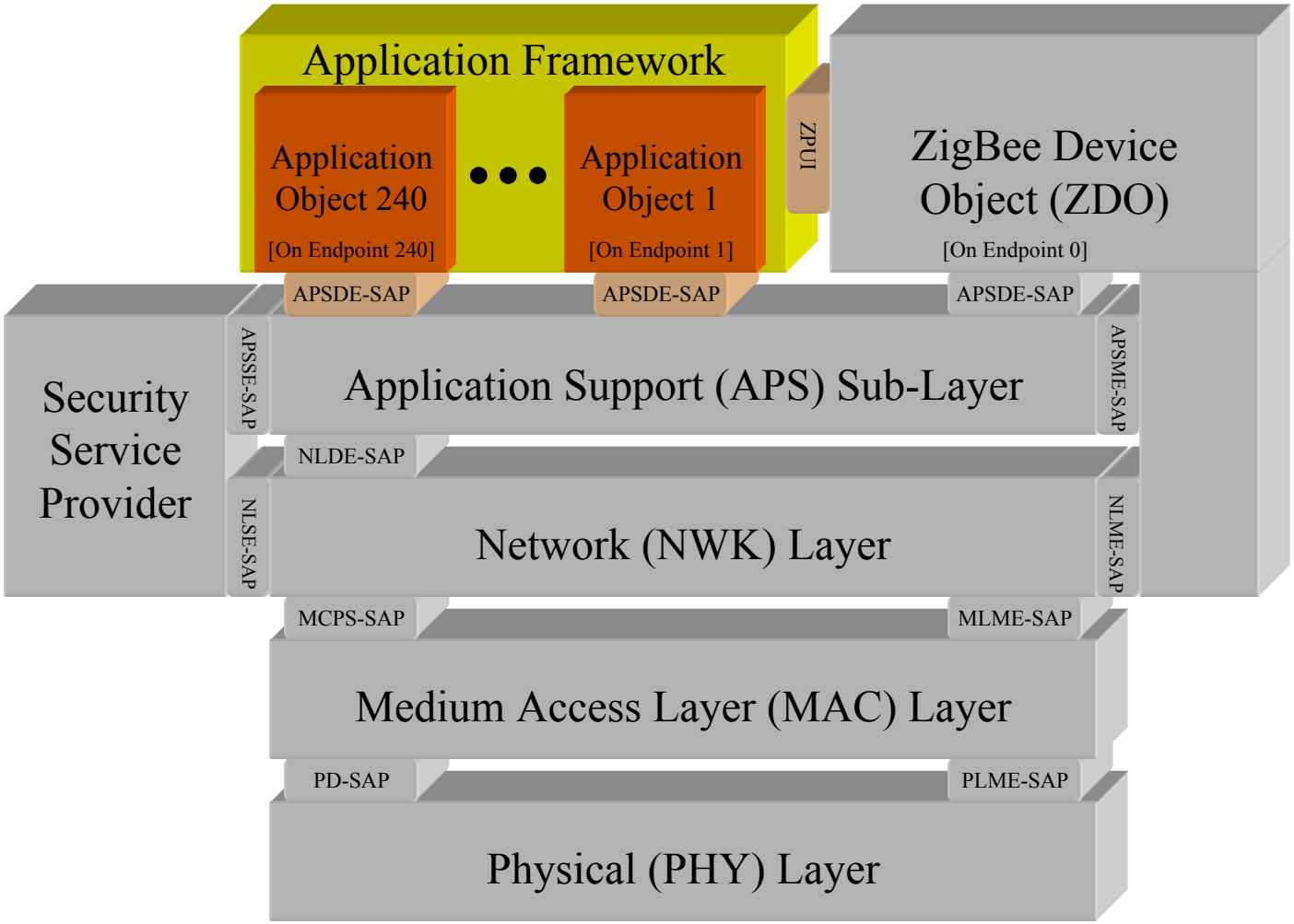
The binding table forms the mapping:

$$(a_s, e_s, c_s) = \{ (a_{d1}, e_{d1}), (a_{d2}, e_{d2}), \ldots, (a_{dn}, e_{dn}) \}$$

Where

- a_s = the address of the device as the source of the binding link
- e_s = the endpoint identifier of the device as the source of the binding link
- c_s = the cluster identifier used in the binding link
- a_{di} = the i^{th} address of the device as the destination of the binding link
- e_{di} = the i^{th} endpoint identifier of the device as the destination of the binding link

The Application Framework



Data Types

Data type	Data length (octets)
No data	0
Unsigned 8-bit integer	1
Signed 8-bit integer	1
Unsigned 16-bit integer	2
Signed 16-bit integer	2
Semi-precision	2
Absolute time (s)	4
Relative time (ms)	4
Character string	Defined in 1st octet
Octet string	Defined in 1st octet

Descriptors

Name	Mandatory/ Optional	Description
Node	M	Type and capabilities of the node (one per device)
Node power	M	Node power characteristics (one per device)
Simple	M	Device descriptions contained in the node (one per active endpoint)
Complex	O	Further information about the device descriptions (one per active endpoint)
User	O	User-definable information

Node Descriptor

Field name	Length (bits)	Description
Logical type	3	ZigBee coordinator, router, end-device
Frequency band	5	868MHz, 915MHz, 2.4GHz
MAC capability flags	8	Alternative PAN coordinator, MAC logical device type, power source, receiver on when idle, security capability
Manufacturer code	16	Allocated by the ZigBee Alliance
Maximum buffer size	8	Max size of data passed to application

Simple Descriptor

Field name	Length (bits)	Description
Endpoint	8	The endpoint to which this descriptor refers
Application profile ID	16	The profile implemented on this endpoint
Application device ID	16	The device description implemented on this endpoint
Application device version	4	Version 1.0
Application flags	4	Complex, user descriptor available
Application input cluster count	8	Number of input clusters
Application input cluster list	8**i*	List of supported input clusters
Application output cluster count	8	Number of output clusters
Application output cluster list	8**o*	List of supported output clusters

General AF Frame Format

Number of transactions, *n*, included in the frame

Key Value Pair (KVP) or Message (MSG)

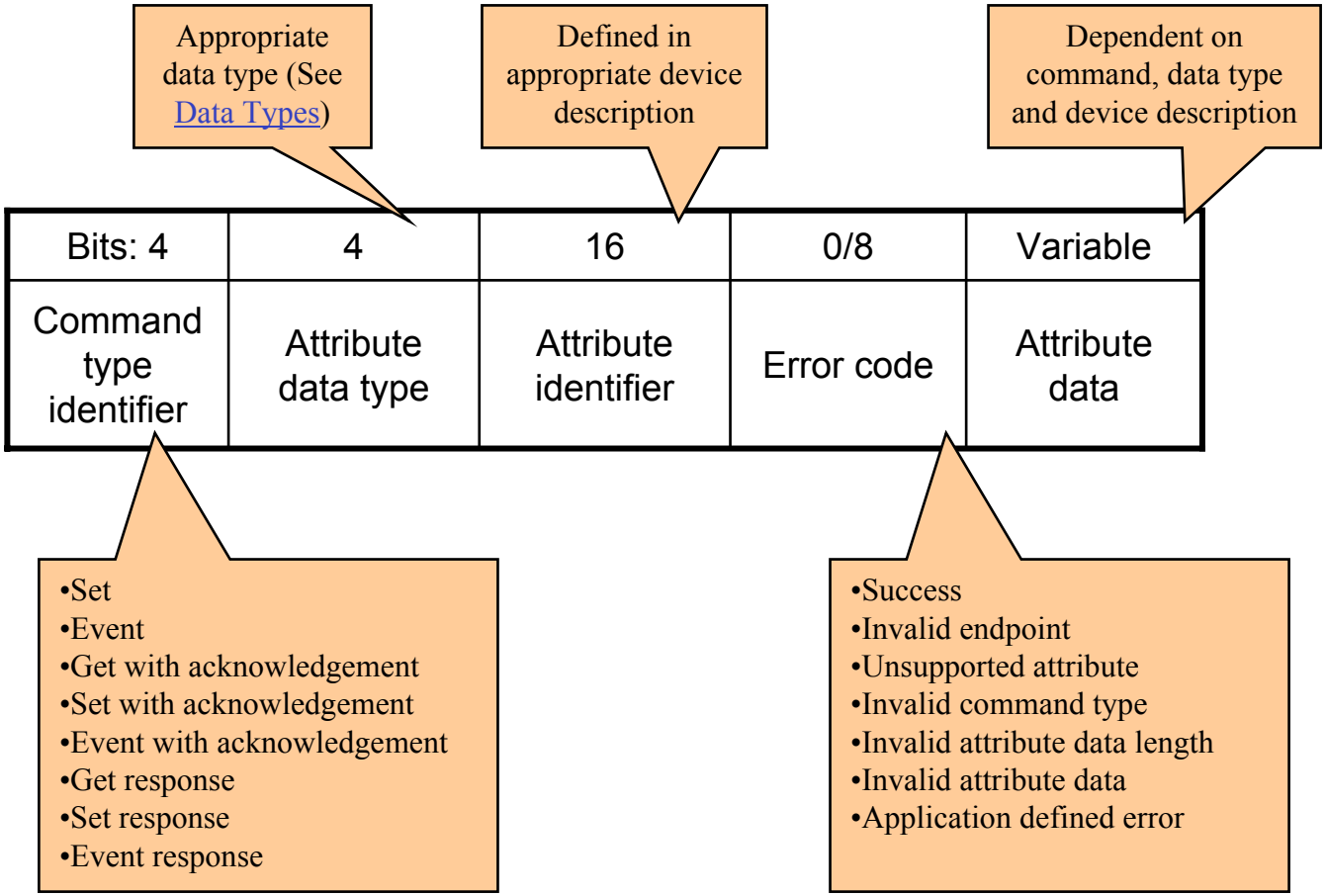
Bits:4	4	Variable	Variable	Variable
Transaction count	Frame type	Transaction 1	…	Transaction *n*

Where each transaction, Transaction *i*, has the format:

Bits:8	Variable
Transaction sequence number	Transaction data
Transaction header	Transaction payload

Transaction sequence number used to tie response frames to request frames

General KVP Command Frame Format



MSG Frame Format

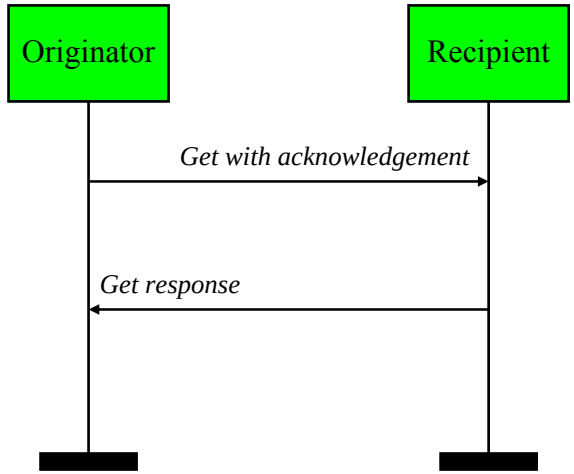
Bits: 8	Variable
Message length	Message data

- Designed for commands which do not fit into the KVP structure
- Free form data
- No response support
- All transactions must be defined in the device description

KVP: Get Command Frames

Get with acknowledgement frame format

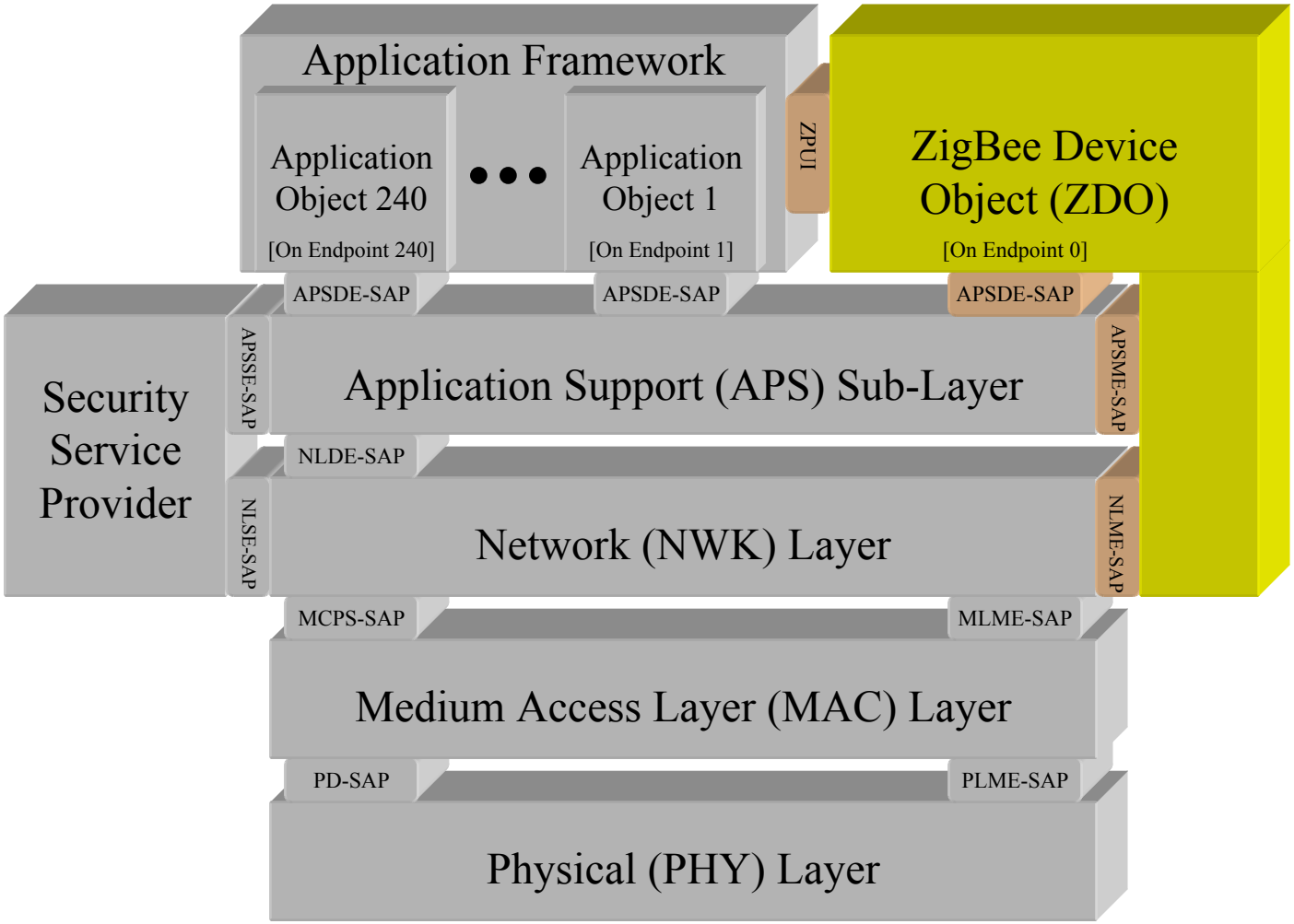
Bits: 8	4	4	16
Transaction sequence number	Command type identifier	Attribute data type	Attribute identifier
Transaction header	Transaction payload		



Get response frame format

Bits: 8	4	4	16	8	Variable
Transaction sequence number	Command type identifier	Attribute data type	Attribute identifier	Error code	Attribute data
Transaction header	Transaction payload				

The ZigBee Device Object



Device & Service Discovery Commands

Command	Addressing	
	Request	Response
NWK address	Broadcast	Unicast
IEEE address	Unicast	Unicast
Node descriptor	Unicast	Unicast
Power descriptor	Unicast	Unicast
Simple descriptor	Unicast	Unicast
Active endpoint	Unicast	Unicast
Match descriptor	Broadcast/unicast	Unicast
Complex descriptor	Unicast	Unicast
User descriptor	Unicast	Unicast
End device announce	Unicast to ZC	Unicast

ZC = ZigBee Coordinator

NWK Address Command Frames

Get the NWK address of a device given its IEEE address

NWK address request command frame format (Cluster identifier=0x00)

Octets: 8	1	1
IEEE address	Request type	Start index

- Of target address
- Single (this device) or extended (this device & associated devices) response
- Extended response only

NWK address response command frame format (Cluster identifier=0x80)

Octets: 1	8	2	1	1	Variable
Status	Remote device IEEE address	Remote device network address	Number of associated devices	Start index	Associated devices network address list

Simple Descriptor Command Frames

Get the simple descriptor for an endpoint of a device

Simple descriptor request command frame format (Cluster identifier=0x04)

Octets: 2	1
Network address	Endpoint

1-240

Simple descriptor response command frame format (Cluster identifier=0x84)

Octets: 1	2	1	Variable
Status	Remote device network address	Simple descriptor length	Simple descriptor

Binding Commands

Command	Addressing	
	Request	Response
End device bind	Unicast to ZC	Unicast
Bind	Unicast to ZC or Src	Unicast
Unbind	Unicast to ZC or Src	Unicast

ZC = ZigBee Coordinator

End Device Bind Command Frames

Bind an endpoint/profile/cluster configuration on an end device

End device bind request command frame format (Cluster identifier=0x20)

Octets: 2	1	2	1	1*i	1	1*o
Binding target	Endpoint	Profile identifier	Number of input clusters, *i*	Input cluster list	Number of output clusters, *o*	Output cluster list

End device bind response command frame format (Cluster identifier=0xa0)

Octets: 1
Status

Network Management Commands

Command	Addressing	
	Request	Response
Network discovery	Unicast to ZC/router	Unicast
Neighbour table	Unicast to ZC/router	Unicast
Routing table	Unicast to ZC/router	Unicast
Binding table	Unicast to ZC/router	Unicast
Leave network	Unicast	Unicast
Direct network join	Unicast to ZC/router	Unicast

ZC = ZigBee Coordinator

Network Discovery Command Frames

Perform a network scan by a remote device

Network discovery request command frame format (Cluster identifier=0x30)

Octets: 4	1	1
Scan channels	Scan duration	Start index

Network discovery response command frame format (Cluster identifier=0xb0)

Octets: 1	1	1	1	Variable
Status	Network count	Start index	Network descriptor list count	Network descriptor list

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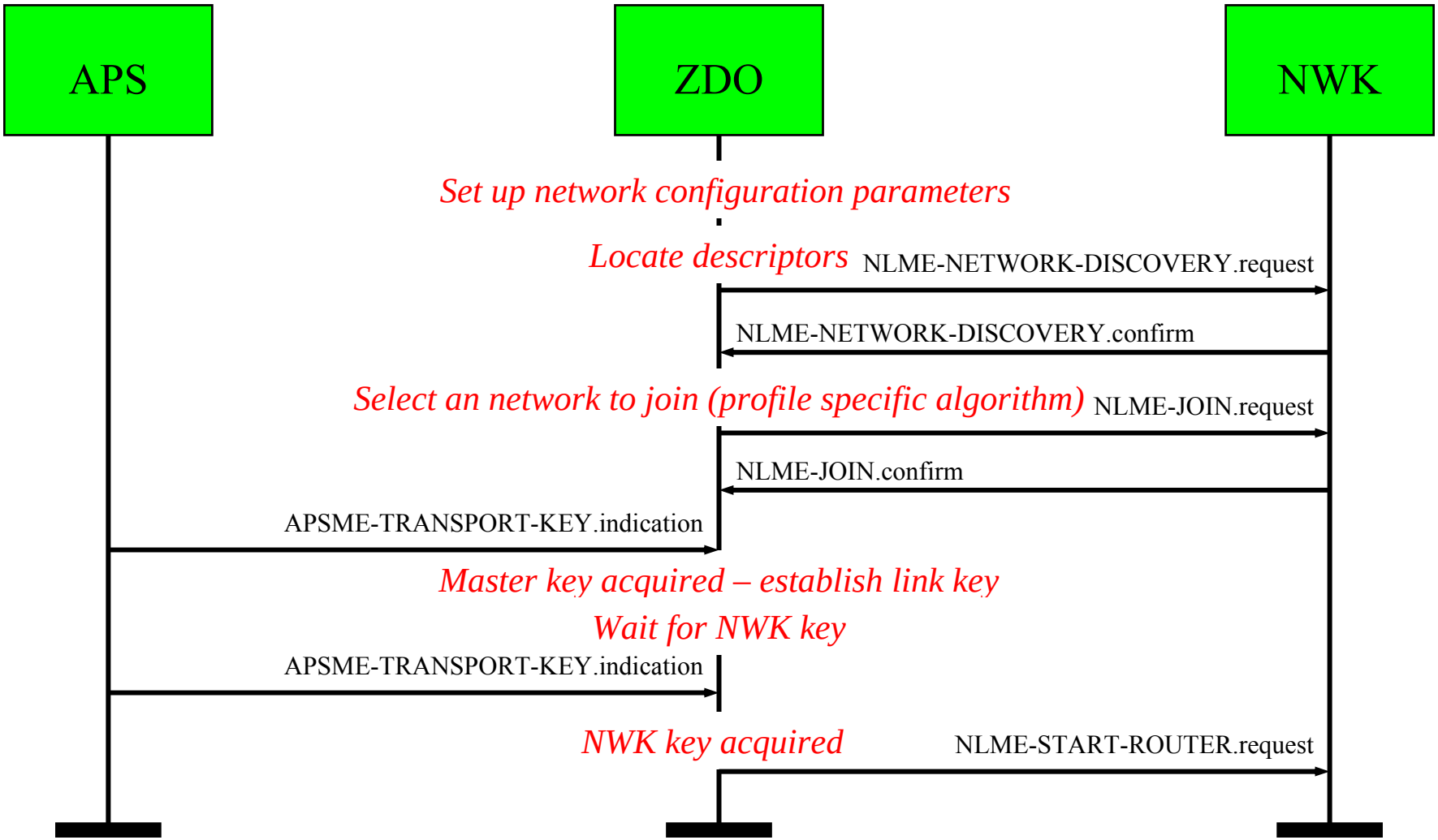
Logical Device Types

- State machine description for each device type
  - ZigBee Coordinator
  - ZigBee Router
  - ZigBee End Device
- Device initialisation
- Device normal operating state

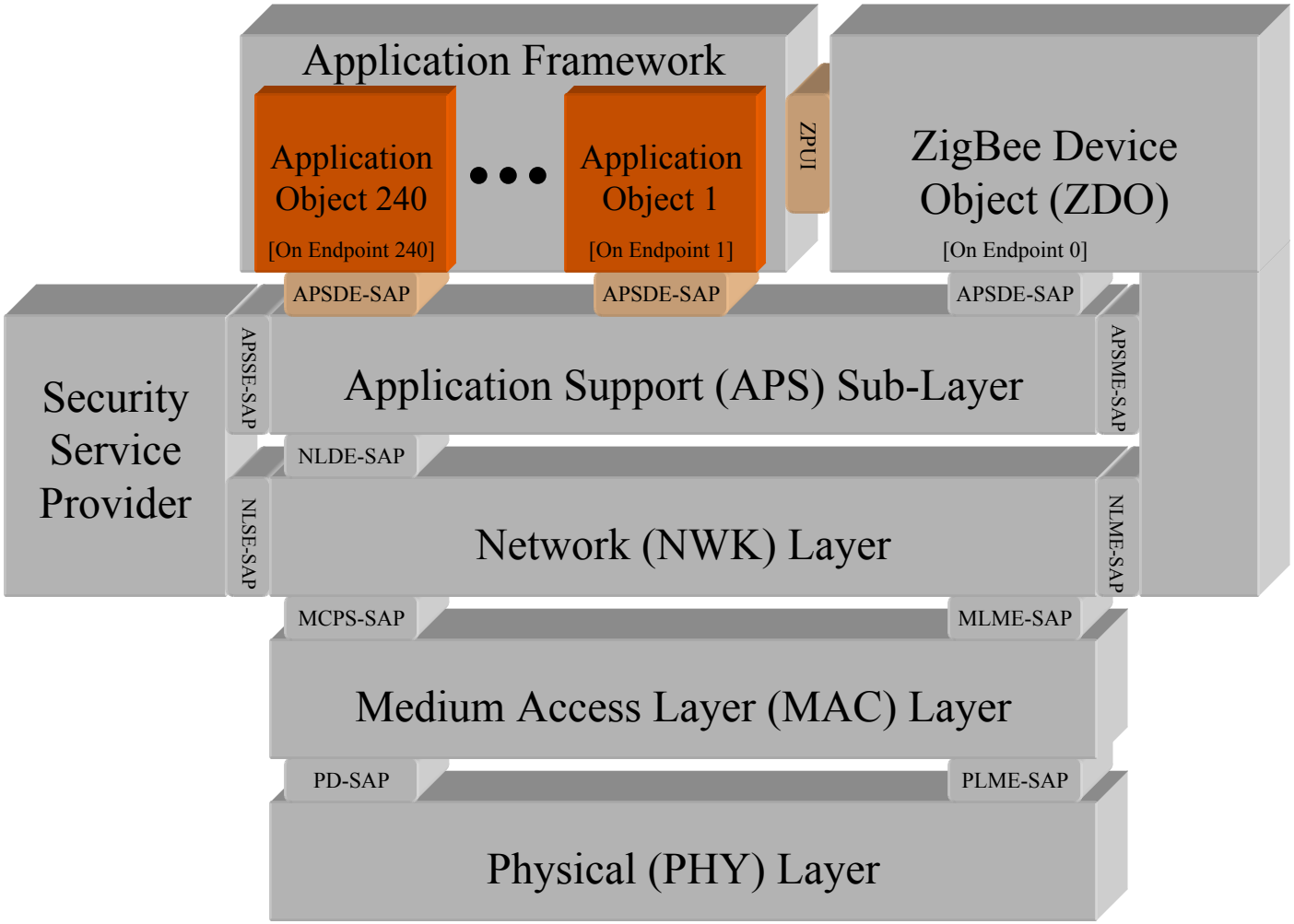
ZigBee Router Initialisation



ZigBee Router
Normal Operating State

- Accept new devices on the network through NLME-JOIN primitives
- Respond to device or service discovery operations requested of its device or any end devices
- If security is enabled:
  - Employ the master key in link key establishment
  - Support the transport of keys from the trust centre
  - Support the secure storage and removal of keys
- Allow devices to leave the network through NLME-LEAVE primitives
- Allow devices to be joined directly to the network
- Process end device bind requests
- Process end device announce requests

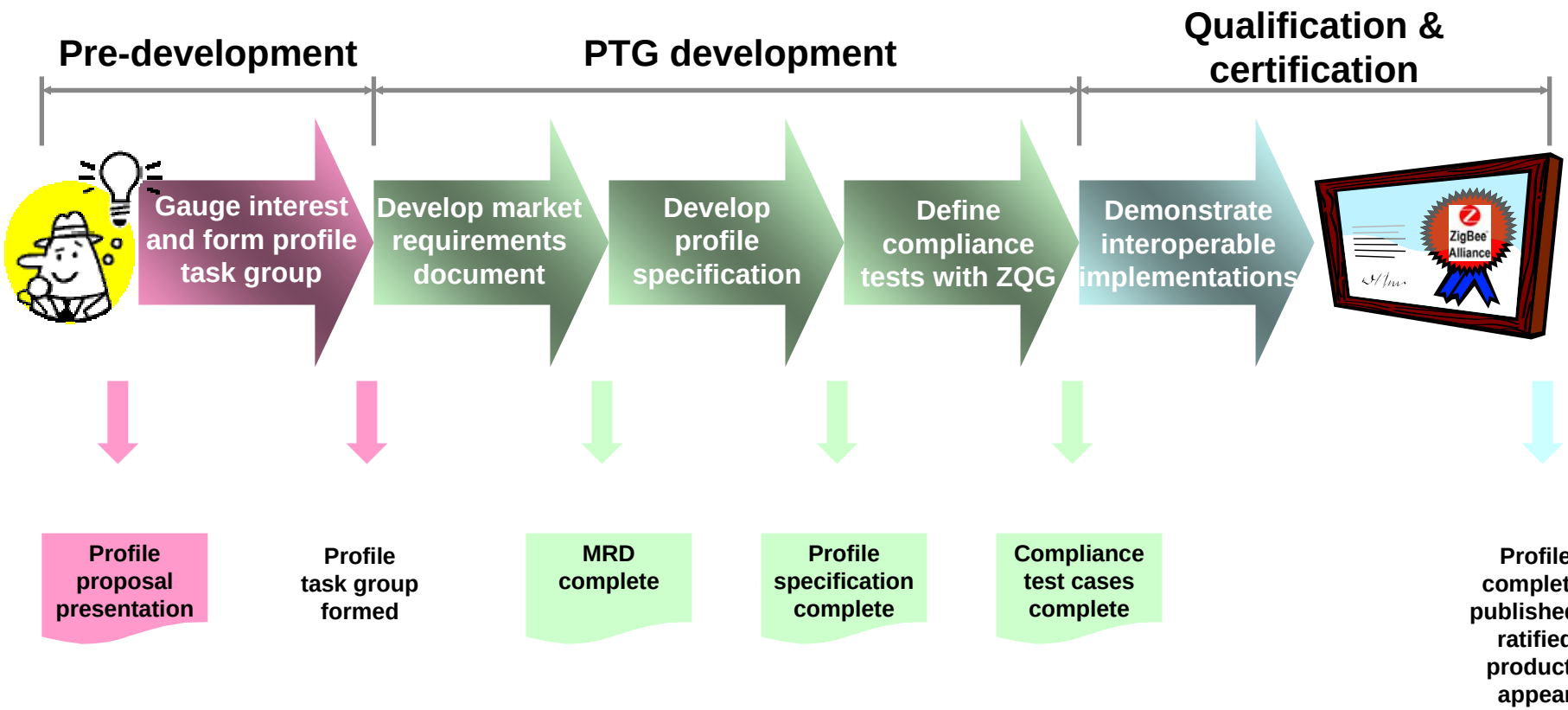
Profiles



Why Do We Need Profiles?

- Need a common language for exchanging data
- Need a well defined set of processing actions
- Device interoperability across different manufacturers
- Allows solid conformance test programmes to be created
- Simplicity and reliability for the end users
- Realistic application specifications developed through OEM experience

Profile Development Lifecycle



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Active Profiles

- Commercial building automation
  - Complete building control, monitoring and energy management
- Heating, ventilation, air conditioning
  - HVAC systems for improved efficiency and lower installation cost
- Home automation
  - Low to high end residential systems for control of devices around the home
- Home control, lighting
  - Residential lighting control allowing basic control and dimming
- Industrial plant monitoring
  - Monitoring time varying attributes related to operating environment and machinery conditions

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Future Profiles

- Automatic Meter Reading
  - Residential & commercial utility systems
- Personal health care
  - Body area networks
  - Fitness monitoring: home, gym, on-the-move
- Hospital & institutional
  - Patient monitoring
  - Cable replacements
- Automotive
  - In vehicle control: vehicular & entertainment
  - Status monitoring
- Others identified by ZigBee members

Any Questions

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