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ZigBee Security

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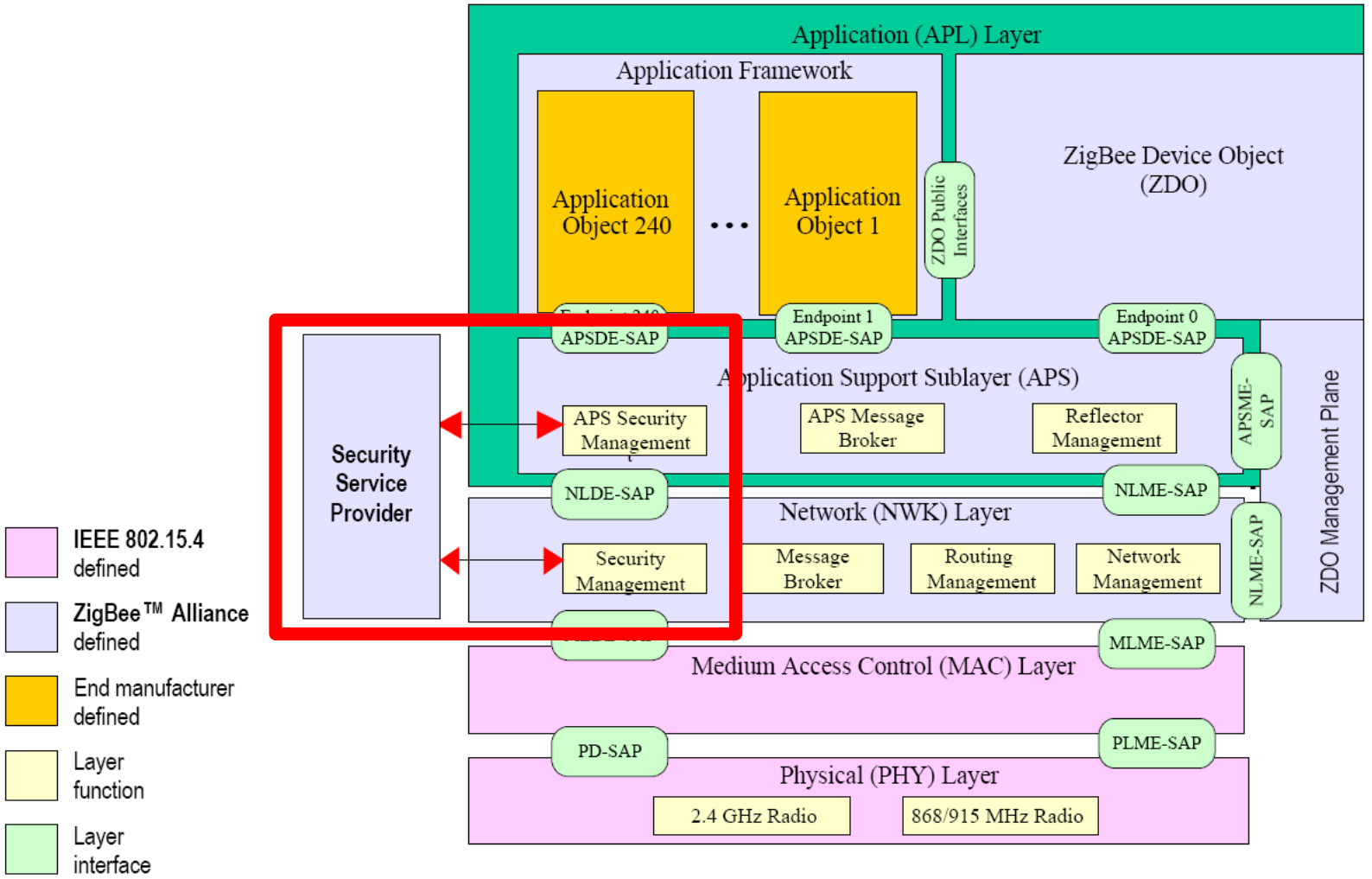
Security in the ZigBee stack



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Specification constraints

- The specification assumes an 'open trust' model where the protocol stack layers trust each other
  - This is not unreasonable for the type of devices ZigBee is aimed at, e.g. single-chip wireless microcontrollers executing the whole stack on a single CPU
- This implies that cryptographic protection only occurs between devices
- The same security suite level is used for all services

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Security services provided

- The ZigBee Security Services provided in the specification are:
  - Key establishment
  - Key transport
  - Frame protection
  - Device authorization

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The Trust Center

- To function securely in a network, a device must have a counterpart device which it can trust to obtain keys and which controls access
- ZigBee therefore introduces the concept of the Trust Center, which
  - Stores the keys for the network
  - Uses the security services to configure a device with its key(s)
  - Uses the security services to authorize a device onto the network
- The ZigBee Coordinator is usually designated the Trust Center

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Symmetric key distribution

- ZigBee security is based on symmetric keys
- Both originator and recipient of a protected transaction need to share the same key
- That key is used directly in the security transformation
- How does this key get to both ends?
- Three basic methods
  - Pre-installation
  - Transport
  - Establishment

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Distribution methods

- Pre-installation is where keys are placed into device using out-of-band method, e.g. commissioning tool
- Transport is where the Trust Center sends the key (securely wherever possible) to the device
- Establishment is where the device negotiates with the Trust Center and keys are established at either end without being transported
  - SKKE (Symmetric Key Key Establishment)
  - CBKE (Certificate-based Key Establishment)
  - ASKE (Alpha-secure Key Establishment)

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Key types

- There are three key types:
  - Master key
    - Shared key for SKKE only
  - Link key
  - Network key

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Link key

- Key which is uniquely shared between two and only two devices for protecting frames at the APS layer
- One of those devices is normally the Trust Center
- Usually dynamically established using key establishment service
- Can also be pre-installed or transported from the Trust Center

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Network key

- Global key which is used by all devices in the network
- A set of network keys is held by the Trust Center and current network key is identified by a key sequence number
- Usually transported from the Trust Center
- Can also be pre-installed
- Two stage update mechanism
  - Update new key and associated key sequence number
  - Switch to new key sequence number

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Common Security Model

- Some confusion due to flexibility in specification
- A *common security model* was developed
- Use of network key with pre-configured Trust Center link keys
- Pre-configured TC link key protects the transport of the network key
- Additional link keys can be transported or established using higher-layer mechanism
  - Secure communication cluster in SE/HC profile

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Frame protection

- The security suite used is AES-CCM*
- The security level used in ZigBee (level 5) means AES_CCM* is the same as AES-CCM
- AES-CCM is NIST special publication 800-38C
- Low-cost implementation in terms of resources
- Some wireless microcontrollers have hardware support for AES-CCM or AES-CCM*
- Two parts to protection
  - Encryption
  - Integrity protection
- ZigBee security uses level 5 in the AES-CCM* suite
  - Encrypted
  - MIC length 4 octets

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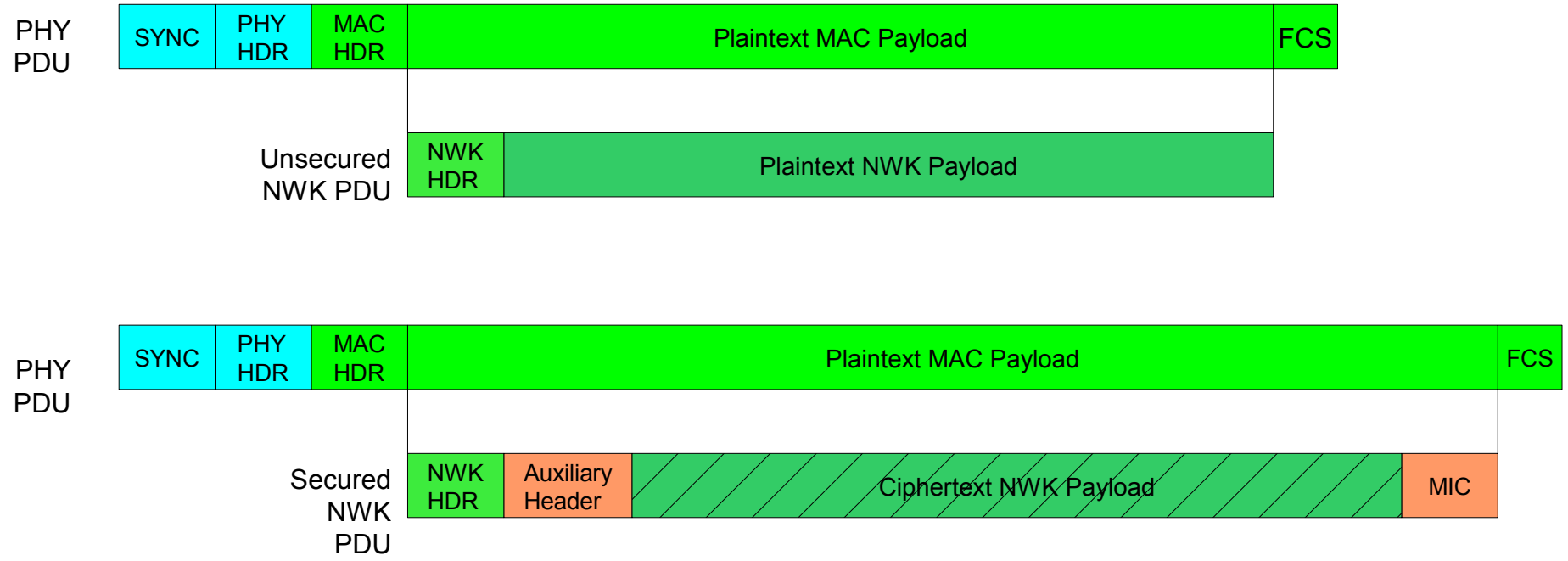
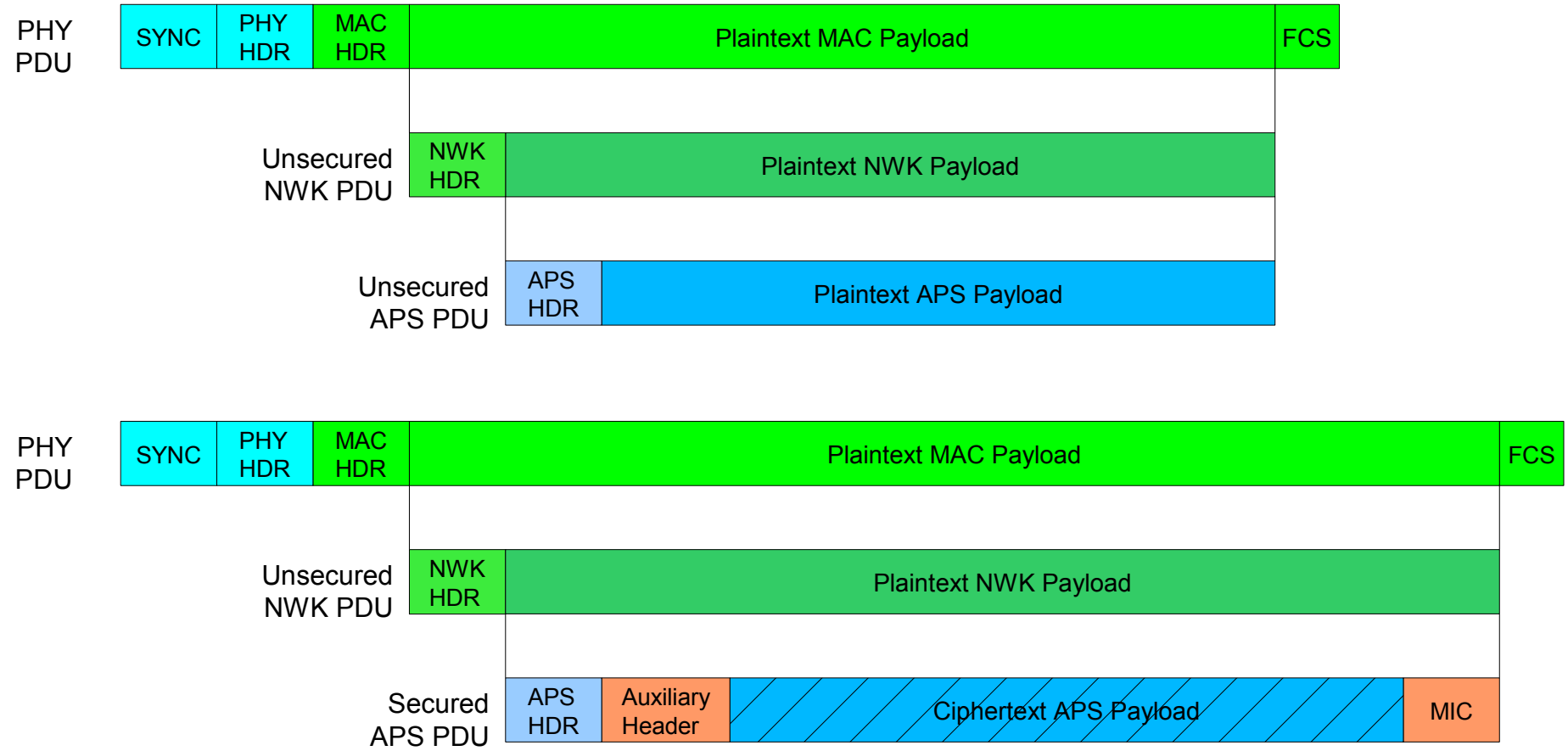
Encryption and Integrity protection

- Encryption scrambles the original data (called *plaintext* in 'security speak') into *ciphertext*
- Encryption prevents an eavesdropper from being able to interpret frame payload
- Integrity protection adds a Message Integrity Code (MIC) to be transported along with the data to be protected
- The MIC 'signs' the data and allows the recipient to verify that the data has not been tampered with
- The MIC is also bound to the identity (IEEE address) of the originator and thus provides origin authenticity
- Without integrity protection, a rogue device could modify a transmitted frame and the modification may not be detected by the recipient

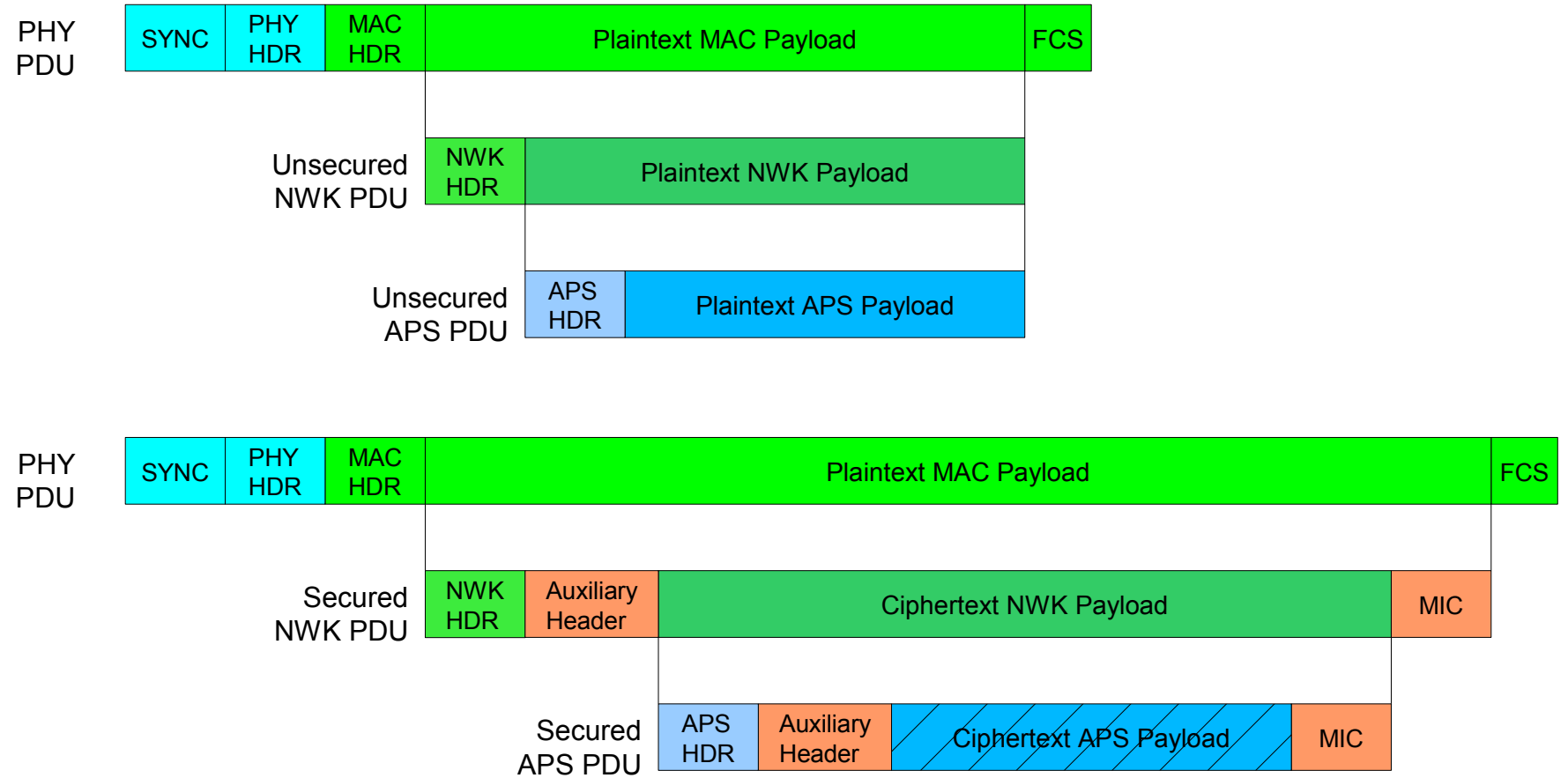
Protecting at NWK layer



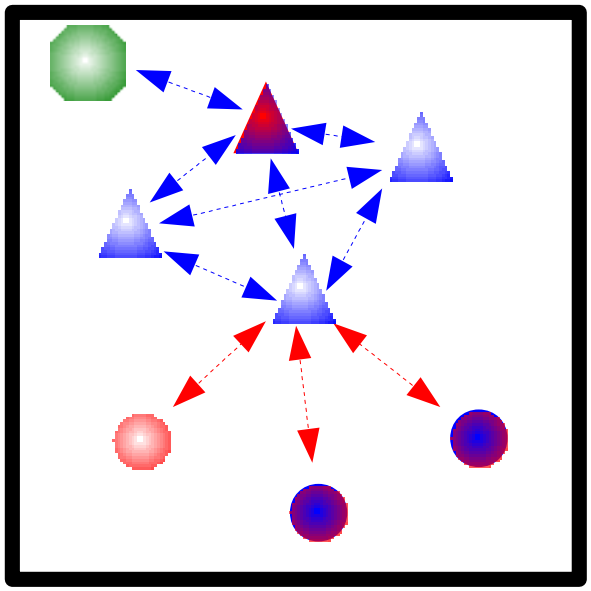
Protecting at APS layer

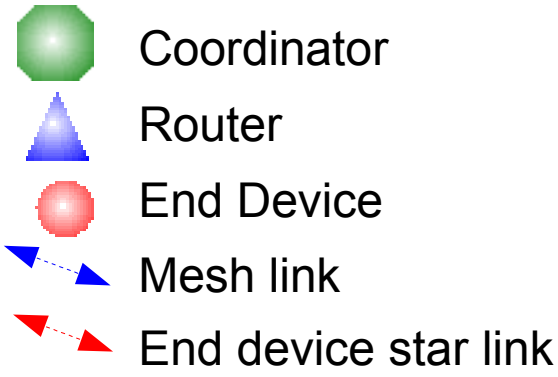


Protecting at NWK and APS layer



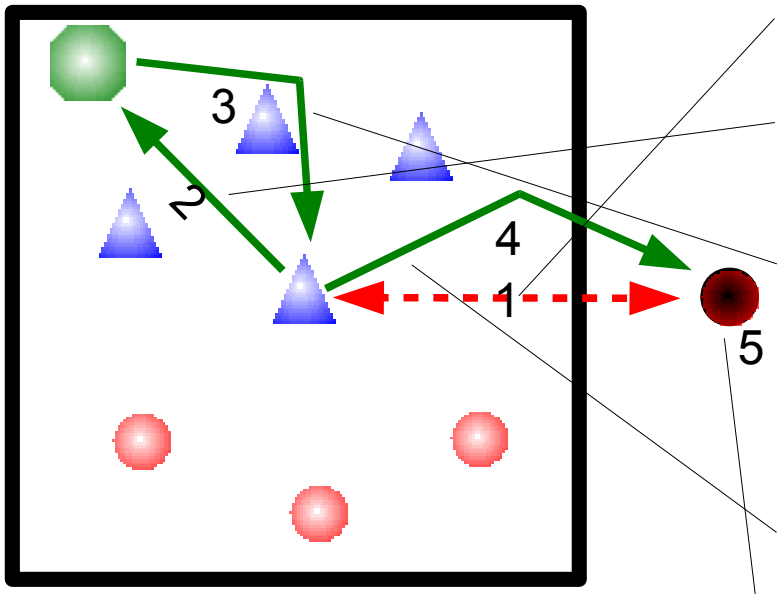
Joining scenario





- ZigBee Coordinator normally acts as Trust Center
- Walk through device without network key and with pre-configured TC link key
  - Common security model

Joining scenario walkthrough



Trust Center

Router

End Device

Mesh link

End device star link

APSME commands

1: Device does unsecured join

2: Router sends device update to TC for authorization

3: TC prepares network key transport for joining device secured with pre-configured TC link key shared between TC and joining device and tunnels it to router

4: Router unpacks tunneled network key transport and sends to device unsecured at network layer

5: Device retrieves network key from network key transport using pre-configured TC link key

ZigBee SE 2.0 security requirements

- SE 2.0 requires a more flexible security implementation
- Both federated and end-to-end models need to be considered
- Existing standards from IETF, IEEE, IEC etc. need to be used
- Multiple sources for implementation and multiple CAs required

ZigBee SE 2.0 security initial technical requirements

- Link layer security provided by 802.15.4-2006 frame protection
- EAP (Extensible Authentication Protocol) used for network admission
  - Certificates
  - Passphrases
  - PINs
- TLS (Transport Layer Security) used for secure associations at application level
  - Locally within HAN
  - Across the wider network to utility
- TRD available on ZigBee/ Homeplug document server