



ZigBee and IEEE 802.15.4

Successful COTS standards
available today

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The next 20 minutes...

- Two Standards: IEEE 802.15.4 and ZigBee
- Topologies: Star, Tree, Mesh
- Delaminating the 802.15.4 / ZigBee Stack
- One COTS system: Ember EM250

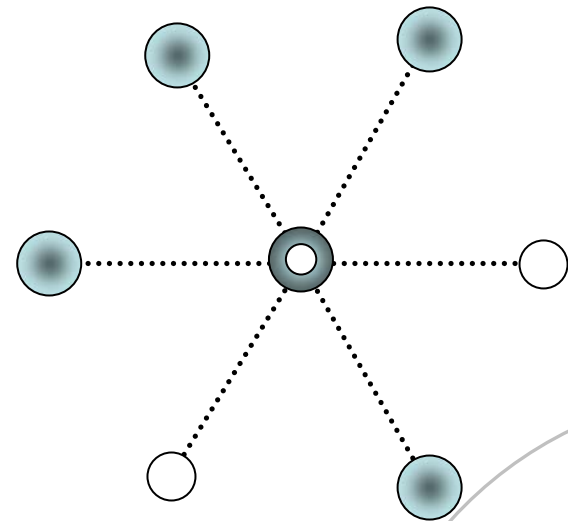
ember Specific to Wireless Sensor Networks

- Wireless Sensor Networks are not like WLANs:
 - Unattended operation with high reliability
 - Some applications require very long battery life
 - Some applications require short latency
 - Some applications require hundreds of endpoints

...one topology does not fit all

Network Topologies: Star

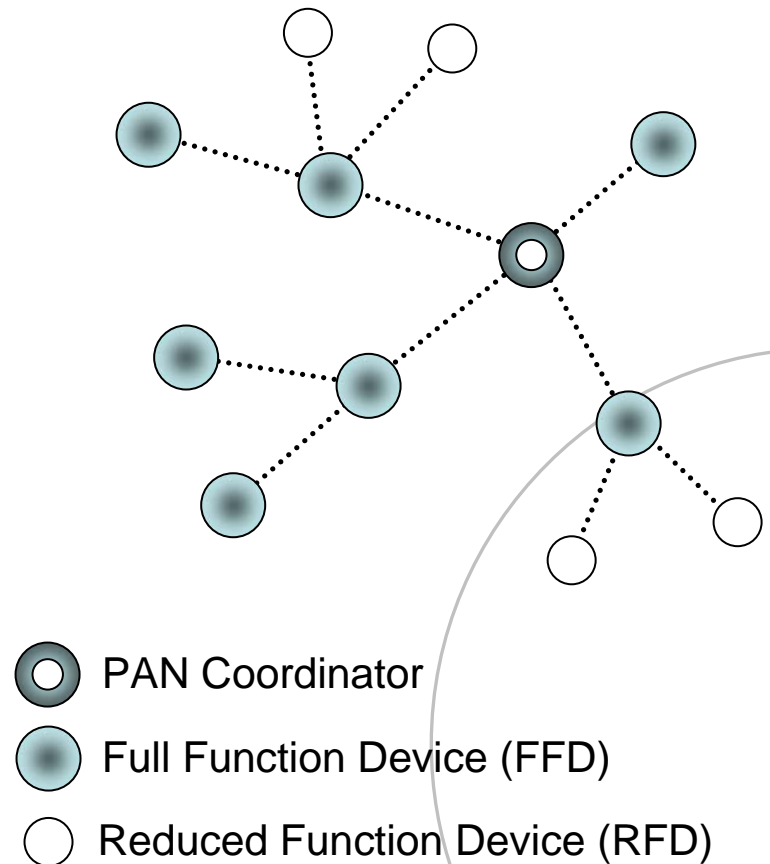
- Network controlled by ZigBee Coordinator
- End Devices communicate directly with Coordinator
- Up to 65,536 End Devices supported.
- Coordinator initiates and maintains network
- Simple layout
- Low latency



- PAN Coordinator
- Full Function Device (FFD)
- Reduced Function Device (RFD)

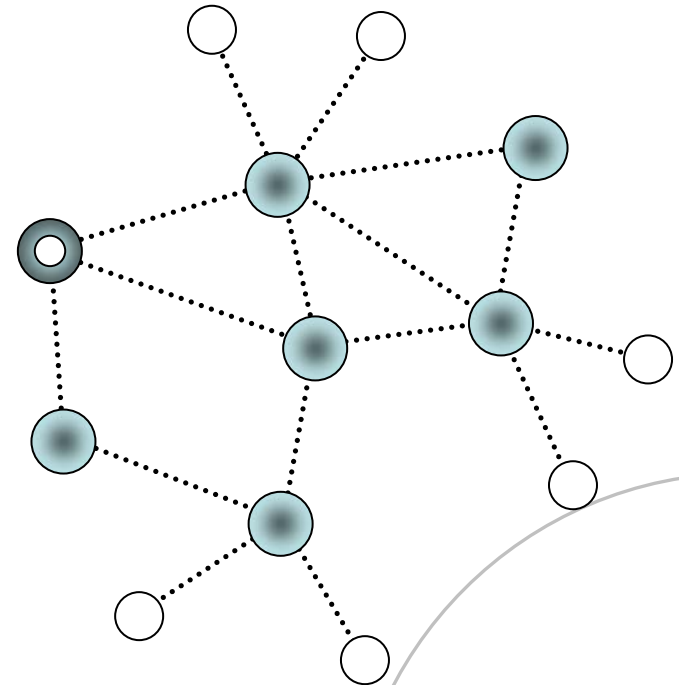
Network Topologies: Tree

- Tree structure rooted at the PAN coordinator
- Coordinator initiates network
- Children route through Parents in strict hierarchy.
- Multi-hop topology extends range of the network.
- Can use beacons to increase battery life.
- Not always appropriate for low-latency applications



Network Topologies: Mesh

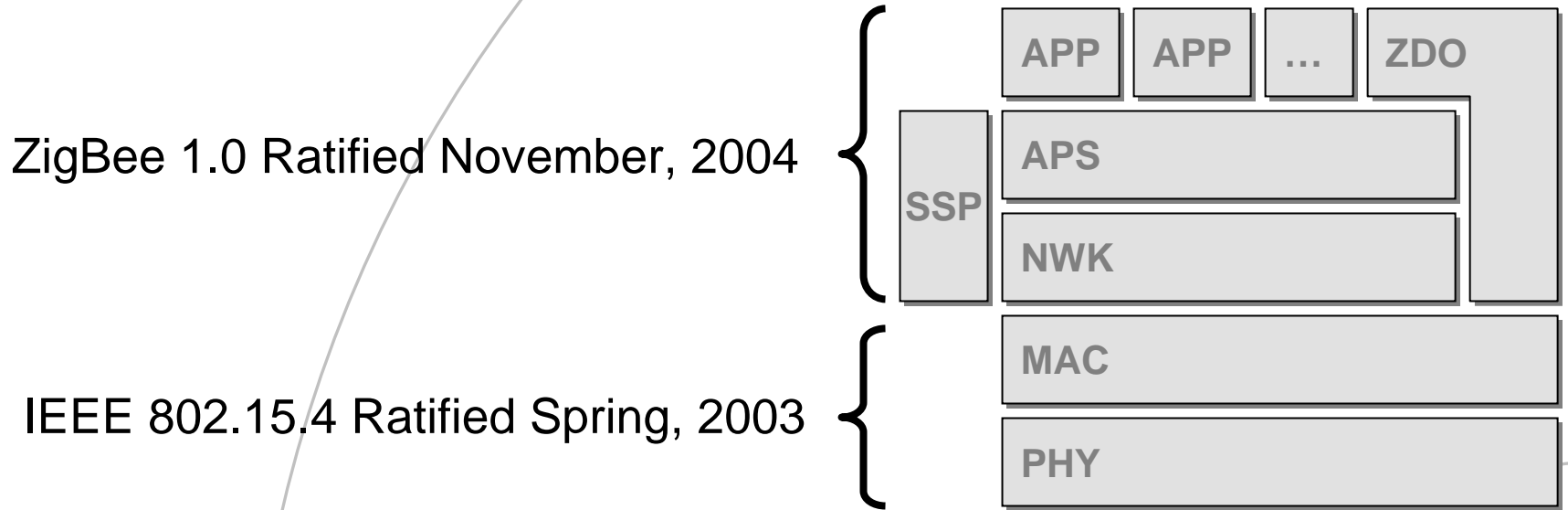
- Messages may be routed from any source to any destination -- every FFD is a router for its neighbors
- Uses variant of Ad Hoc On Demand Distance Vector Routing (AODV)
- Multi-hop topology extends range of the network.
- Highly reliability through multiple paths.
- Self-configuring, ease of build-out
- Not always appropriate for battery powered applications.



- PAN Coordinator
- Full Function Device (FFD)
- Reduced Function Device (RFD)



IEEE 802.15.4 and ZigBee



IEEE 802.15.4 PHY

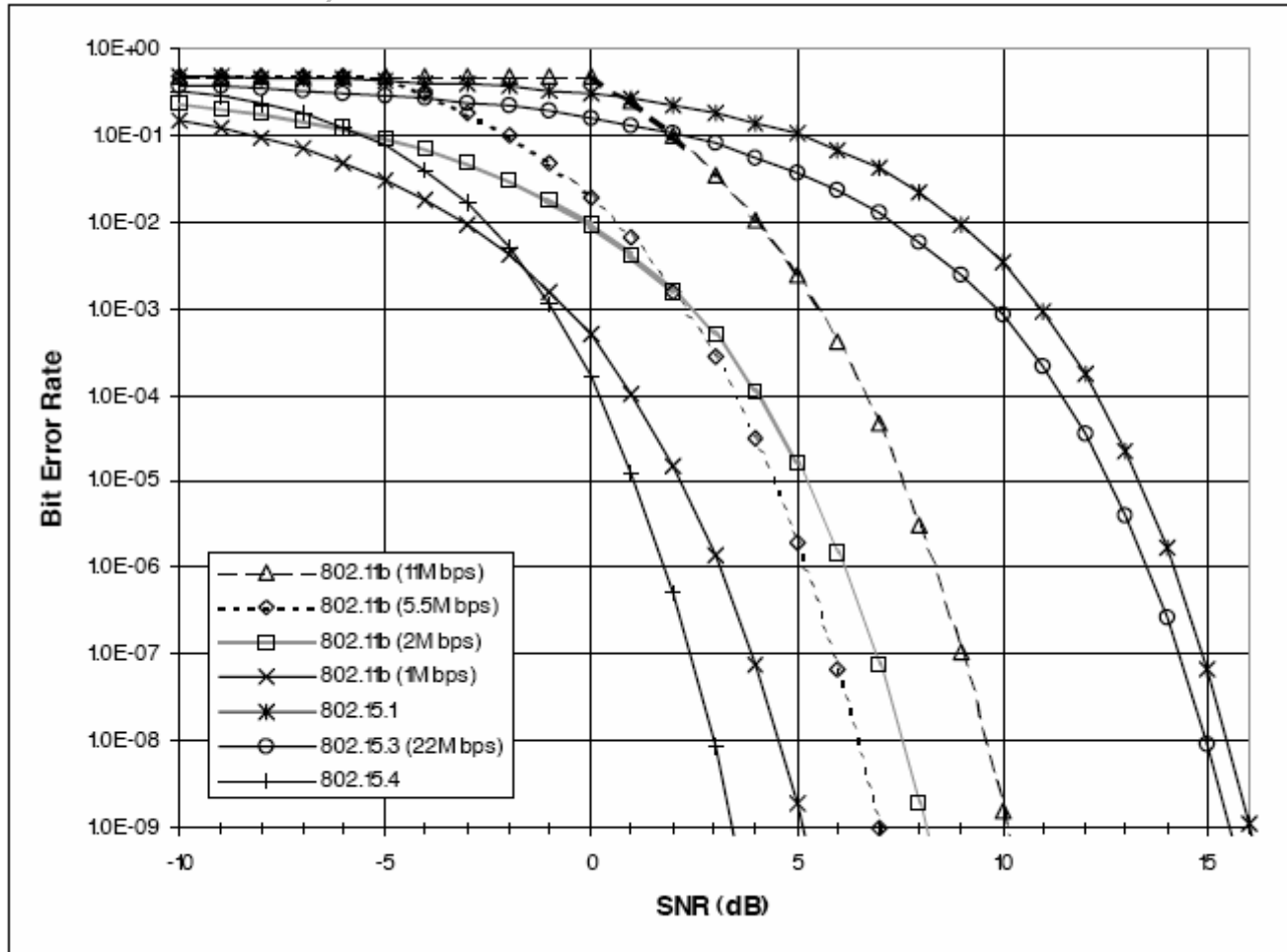
- 802.15.4 defines three PHYs:
 - 2.4GHz Global ISM Band: DSSS, 250kb/s, 16 channels
 - 915MHz North American ISM Band: DSSS, 40kb/s, 10 channels
 - 868MHz European ISM Band: DSSS, 20kb/s, 1 channel



Band	Coverage	Data Rate	# of channels
2400MHz	worldwide	250kb/s	16
915MHz	Americas	40kb/s	10
868MHz	Europe	20kb/s	1

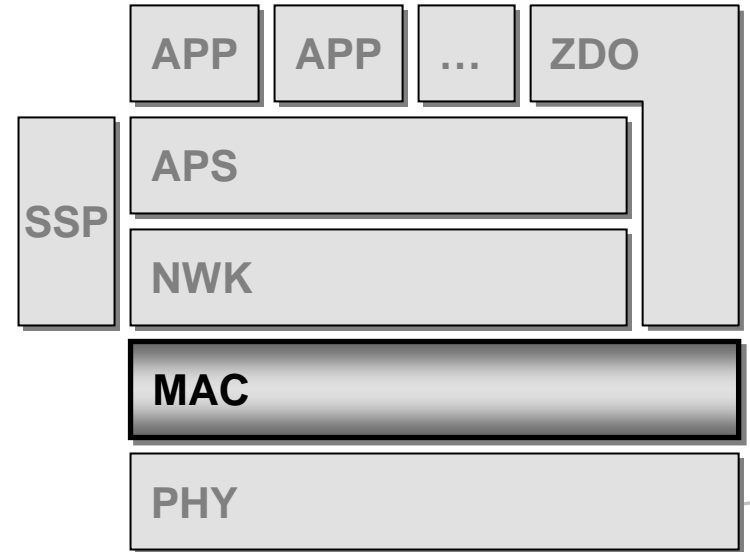


802.15.4 PHY Performance



IEEE 802.15.4 MAC

- The MAC provides:
 - CRC16 to verify data integrity
 - CSMA-CA to share airwaves
 - AES128 symmetric key encryption
 - Address filtering
 - Timed beacons
 - Guaranteed time slots (not used in ZigBee)



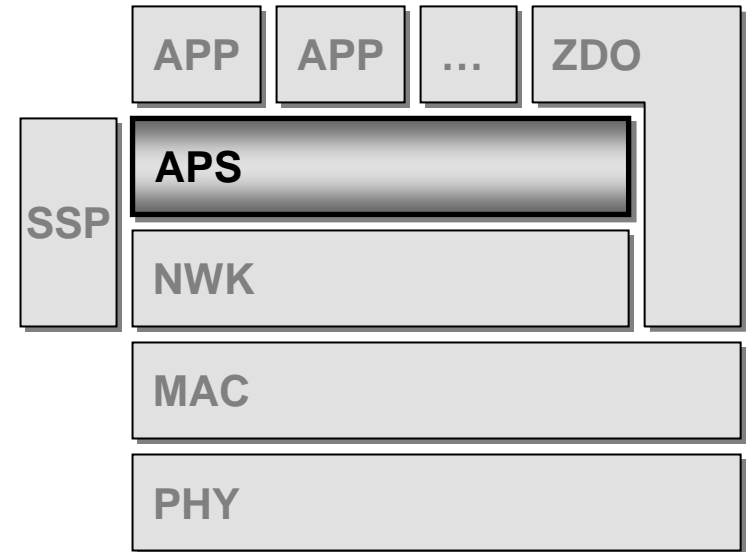
ZigBee NWK

- The ZigBee Network (NWK) Layer supports:
 - Mechanisms to join and leave a network.
 - Routing of frames to their intended destinations
 - Star, Tree and Mesh topologies
 - Discovery and maintenance of routes
 - Neighbor discovery
 - Address Assignment
 - Frame Security



ZigBee APS

- The ZigBee Application Support Sublayer (APS) provides:
 - Binding tables (to match devices based on services and needs)
 - Forwarding messages between bound devices



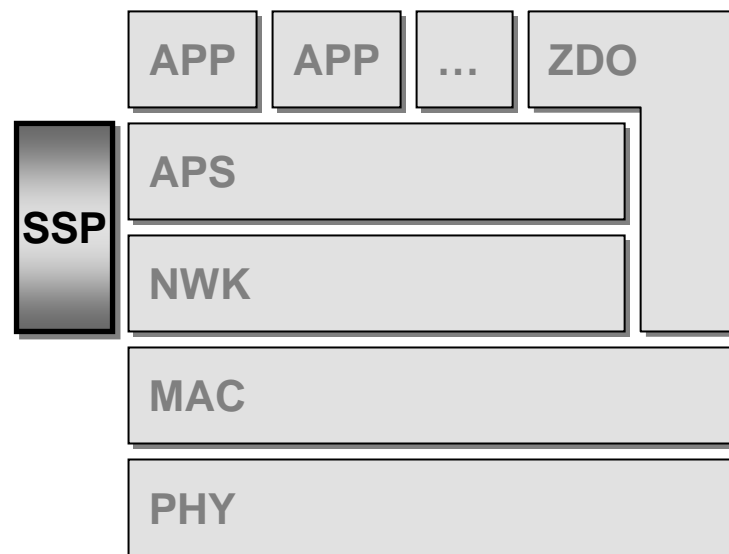
The ZigBee Stack: ZDO

- The ZigBee Device Object (ZDO):
 - Defines the role of the node in the network (e.g. Coordinator or End Device)
 - Initiates or responds to Binding requests.
 - Establishes secure connections among network devices.
 - Discovers devices and applications services in the network.



The ZigBee Stack: SSP

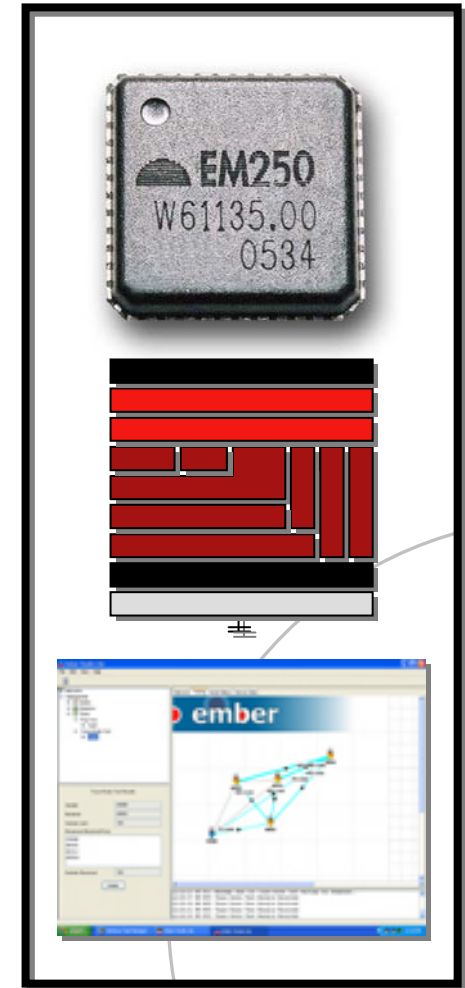
- The ZigBee Security Services Provider (SSP) manages:
 - MAC security for MAC-only frames
 - NWK security for NWK command frames (route request and route reply)
 - APL security for APS frames
- Features:
 - Authentication and Encryption
 - Freshness (frame counters)
 - Message Integrity
- Two Security Modes
 - Residential – Single NWK key, APL security via NWK key
 - Commercial – Two NWK keys, separate Link Keys for pairs of communicating devices at APL. Master Keys with the Trust Center for key exchange.





One COTS System: Ember EM250

- EM250: SOC 16-bit processor + IEEE 802.15.4 compliant Radio
 - Sensitivity > -94 dBm
 - Adjacent channel rejection > 30 dB
 - Low power: 29mA active, < 1uA sleep
- Choice of Stacks:
 - EmberZNet 2.0 HCL
 - EmberZNet 2.0 Mesh
- Power Tools: Ember WorkBench
 - Ember Developer Kit
 - EmberScope
 - EmberPeek
- Training & Support



Resources and Links

- For IEEE 802.15.4 specification:
<http://standards.ieee.org/getieee802/download/802.15.4-2003.pdf>
- For ZigBee 1.0 specification:
<http://www.zigbee.org>

...thank you

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