

Track: ZigBee

ZigBee™: Wireless Control Made Simple

Wireless & Mobile WorldExpo
NTC Toronto, Canada

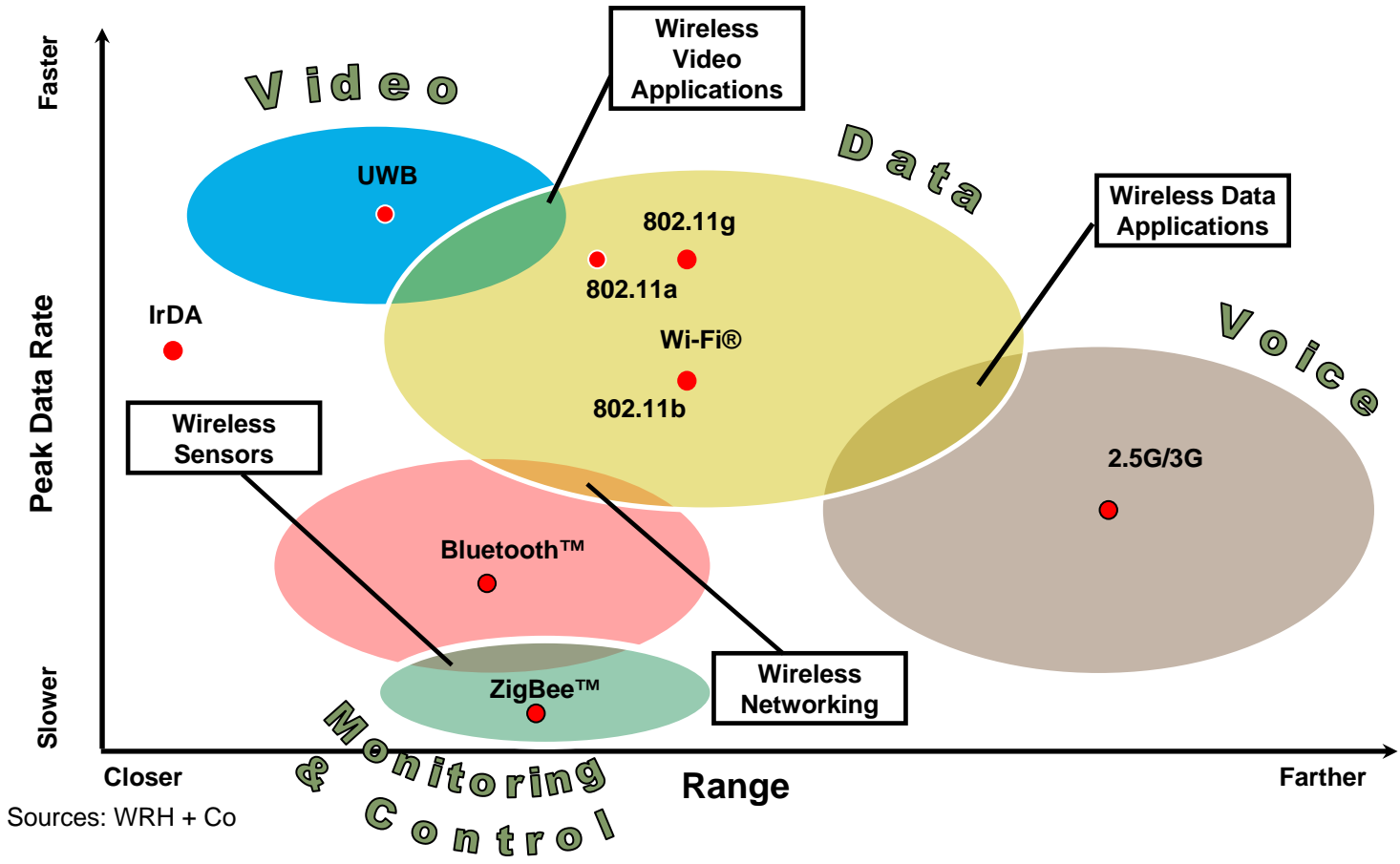
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- ZigBee Market Overview
 - Wireless Technology
 - Market Applications
 - Market Forecast
- IEEE® STD 802.15.4 Primer
 - Robust and Reliable, Standards-based radio and protocol
- ZigBee Overview
 - Mission and Objectives
 - Organization
 - Feature Set
 - Application Examples
- ZigBee Networking Basics

Where Does ZigBee Fit?





ZigBee Alliance

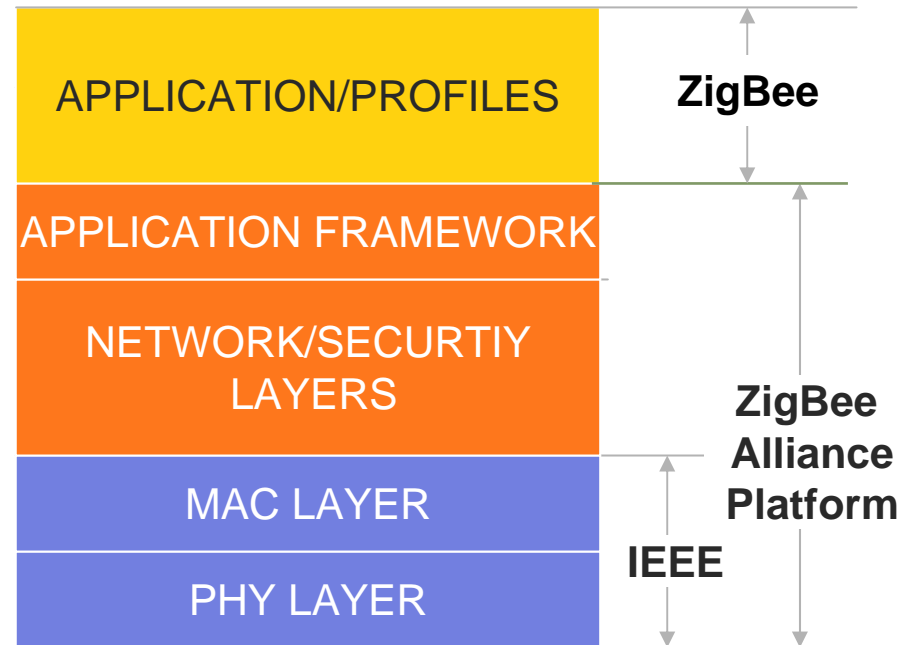
- The ZigBee Alliance is an association of companies working together to enable reliable, cost-effective, low-power, wirelessly networked, monitoring and control products based on an open global standard

- ZigBee Alliance: Consortium of >150 companies
 - > Freescale is one of 8 World-Class Promoter Companies with a total market cap of more than US \$150B
 - > Over 140 Participant and adopter companies including over a dozen OEMs with a market cap of US \$200B
- Solid Hardware/Software Platform base available now
 - > Silicon ready for volume production
- 1.0 Specification approved in December
 - > Home Control Lighting Profile included
 - HVAC, security, home automation and industrial process control will follow
 - Specification available to public in April 2005
- Interoperability Program
 - > Freescale's product had passed compliance testing
- Certification Program ready in Q2 2005

- ZigBee is designed to be a low power, low cost, low data rate, wireless solution.
- ZigBee relies upon the robust IEEE 802.15.4 PHY/MAC to provide reliable data transfer in noisy, interference-rich environments
- ZigBee layers on top of 15.4 with Mesh Networking, Security, and Applications control
- ZigBee Value Propositions
 - Addresses the unique needs of most remote monitoring and control network applications
 - > Infrequent, low rate and small packet data
 - Enables the broad-based deployment of wireless networks with low cost & low power solutions
 - > Example: Lighting, security, HVAC,
 - > Supports peer-to-peer, star and mesh networks
 - Monitor and sensor applications that need to have a battery life of years on alkaline batteries
 - > Example – security systems, smoke alarms

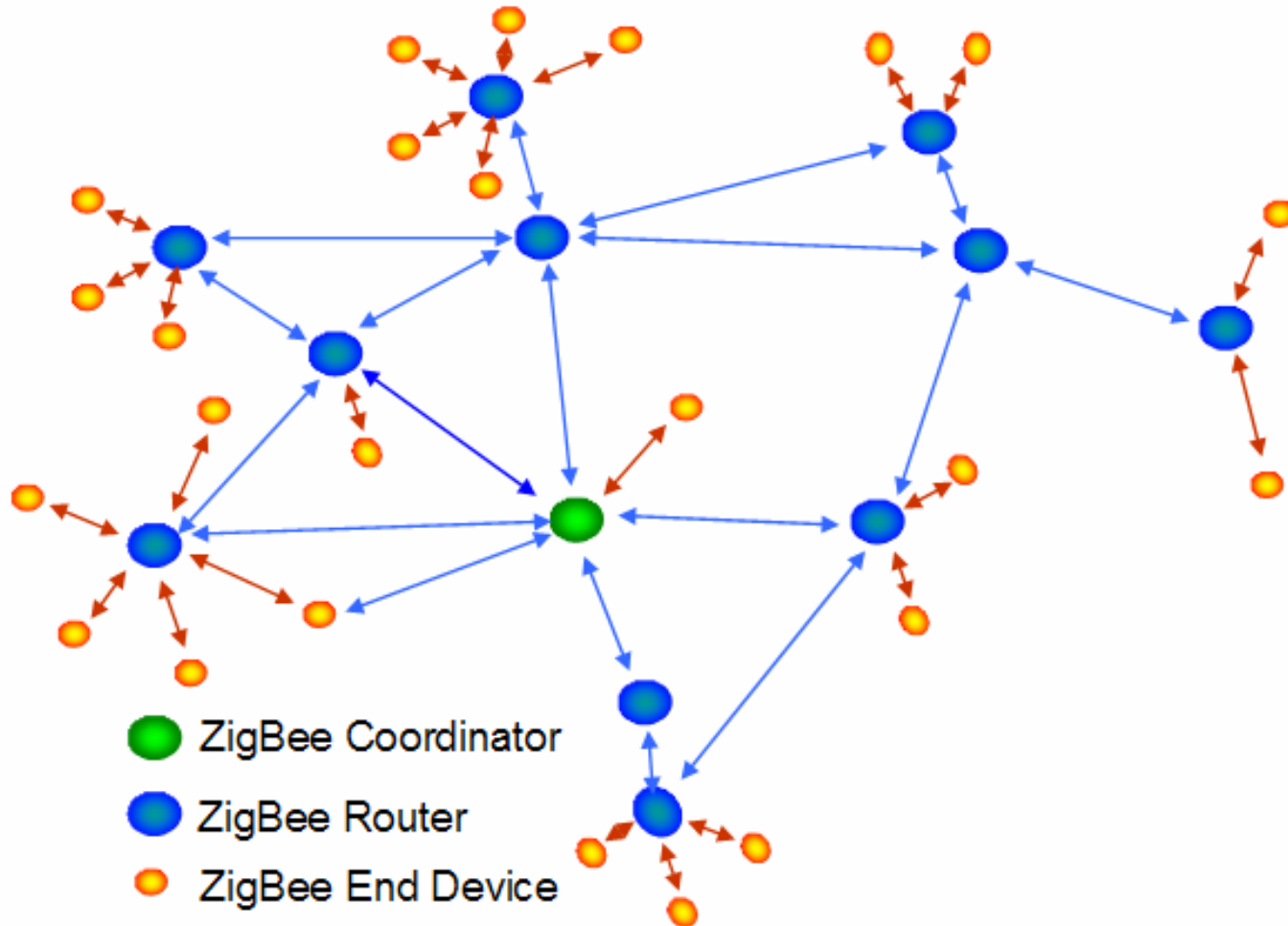
Protocol Stack Features

- ZigBee
 - Based upon the robust, reliable, international IEEE 802.15.4 standard
- IEEE STD 802.15.4[®]
 - Designed by Motorola, Philips and other companies to supply the radio and protocol, allowing the designer to concentrate on the application and their customers' needs

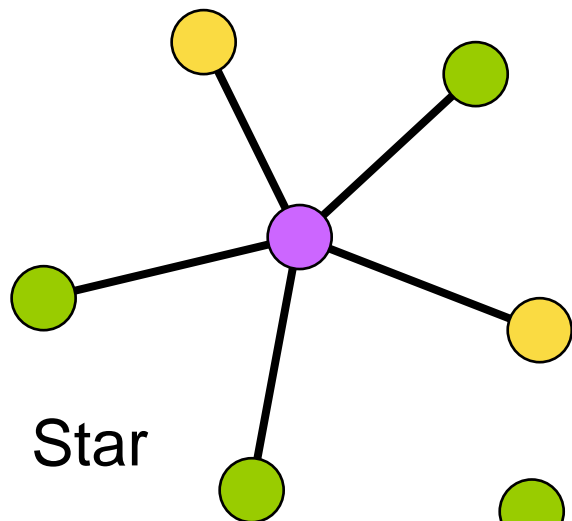


- Application
- ZigBee Platform Stack
- Silicon

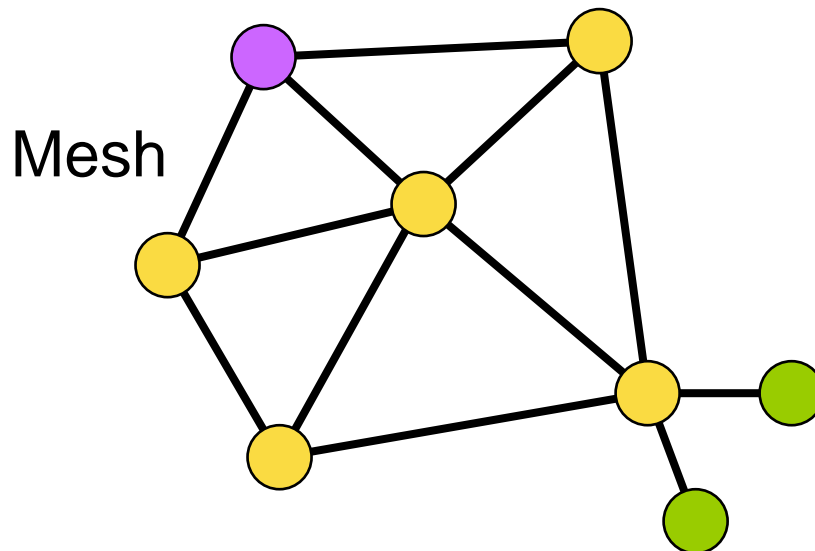
ZigBee is Mesh Networking



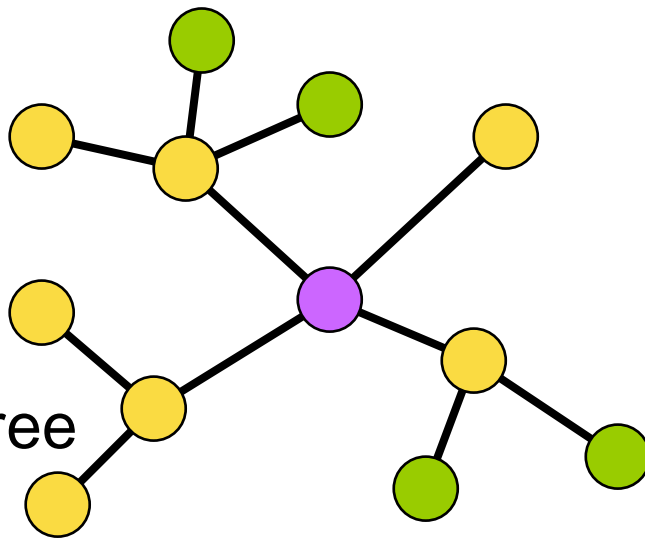
Network Topology Models






Star



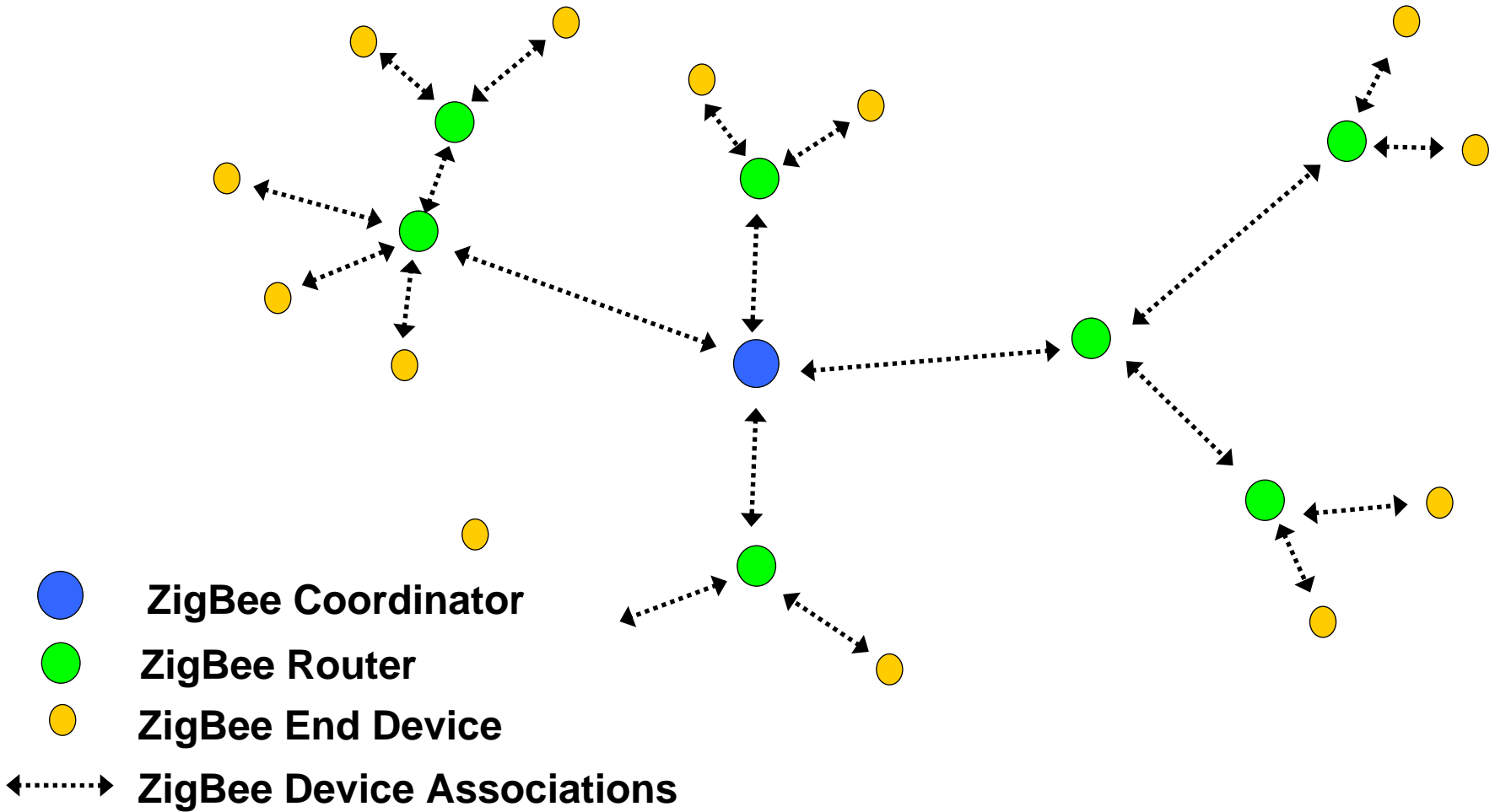
Mesh



Cluster Tree

-  PAN coordinator (PANC)
-  Full Function Device (FFD, Router)
-  Reduced Function Device (RFD)

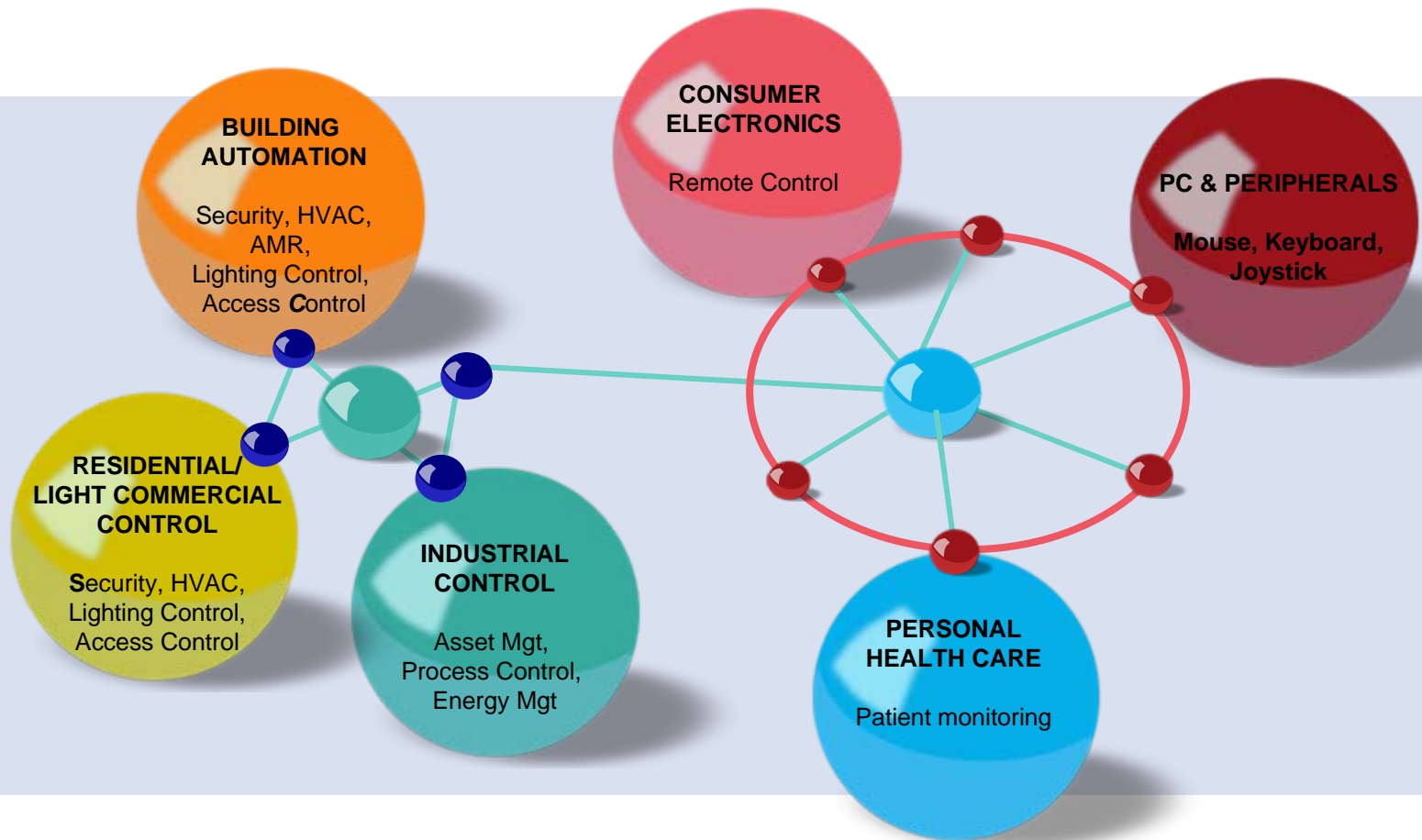
ZigBee is Mesh Networking





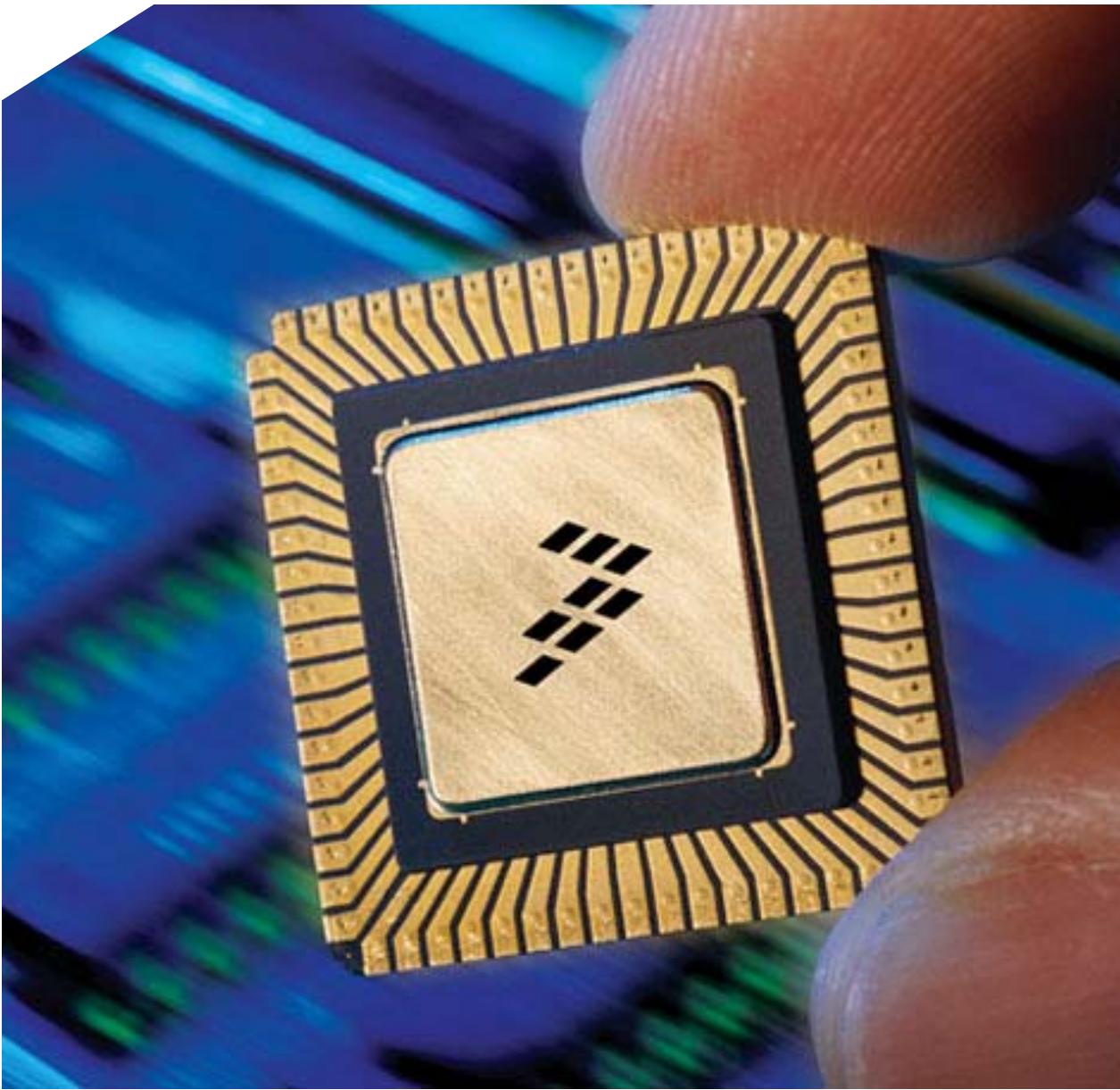
ZigBee Markets and Applications

ZigBee Wireless Markets and Applications



802.15.4/ZigBee Market Size

- Strong growth in areas such as wireless sensors will help fuel the growth of 802.15.4 and ZigBee
 - Harbor Research reports that by 2008, 100 million wireless sensors will be in use
 - *On World reports that by 2010, more than 500 million nodes will ship for wireless sensor applications*
- ABI Research forecasts shipments of ZigBee devices in 2005 at about 1 million, growing to 80 million units by the end of 2006
- In-Stat 2004 report has an aggressive forecast of over 150 million annual units of 802.15.4 and ZigBee chipsets by 2008

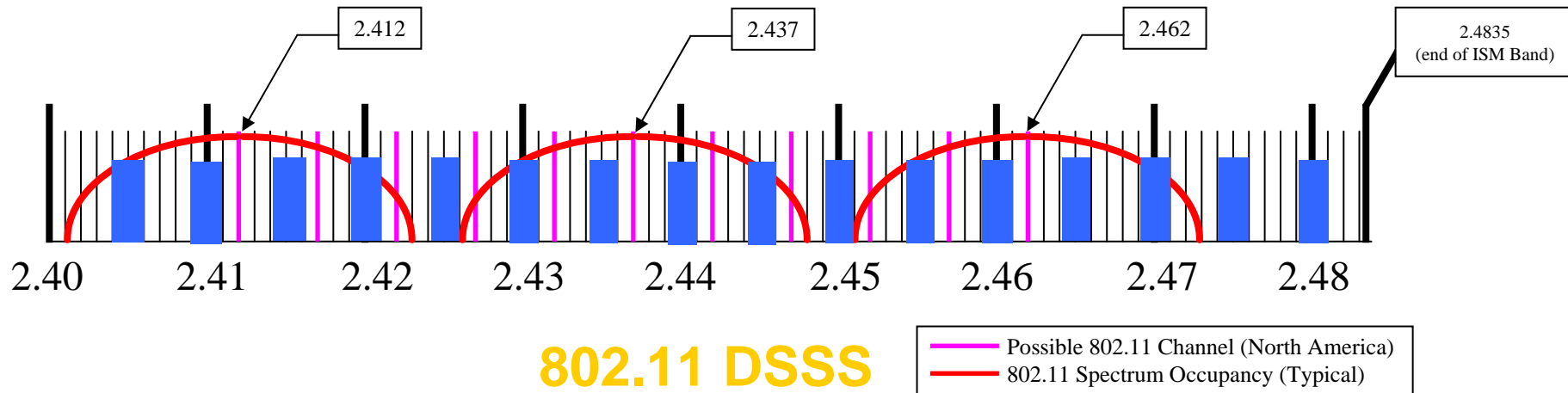


IEEE 802.15.4 Overview

- Simple packet data protocol for lightweight wireless networks
 - Released in May 2003
 - Channel Access is via Carrier Sense Multiple Access with collision avoidance and optional time slotting
 - Message acknowledgement and an optional beacon structure
 - Multi-level security
 - Works well for
 - > Long battery life, selectable latency for controllers, sensors, remote monitoring and portable electronics
 - Configured for maximum battery life, has the potential to last as long as the shelf life of most batteries

Frequency Band	License Required?	Geographic Region	Data Rate	Channel Number(s)
868.3 MHz	No	Europe	20kbps	0
902-928 MHz	No	Americas	40kbps	1-10
2405-2480 MHz	No	Worldwide	250kbps	11-26

Normal Channel Occupancy

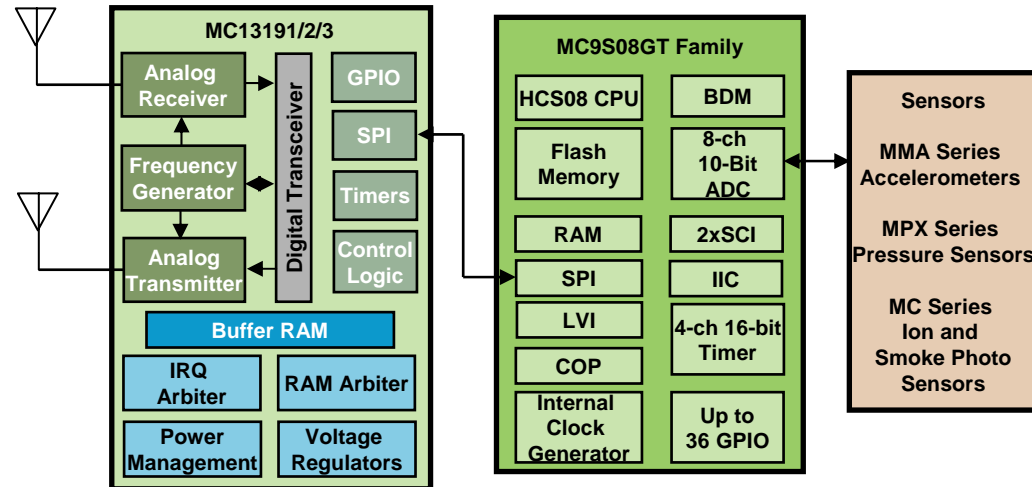


- Employs 64-bit IEEE & 16-bit short addresses
 - Ultimate network size can be >> nodes (more than we'll probably need...)
 - Using local addressing, simple networks of more than 65,000 (2^{16}) nodes can be configured, with reduced address overhead
- Three devices specified
 - Network Coordinator
 - Full Function Device (FFD)
 - Reduced Function Device (RFD)
- Simple frame structure
- Reliable delivery of data
- Association/disassociation
- AES-128 security
- CSMA-CA channel access
- Optional superframe structure with beacons
- Optional GTS mechanism

Freescal 802.15.14 Radio Example

• Key Features

- IEEE® 802.15.4 Compliant
 - > 2.4GHz
 - > 16 selectable channels
 - > 250Kbps Data Rate
 - > 250Kbps 0-QPSK DSSS
- Multiple Power Saving Modes
 - > Hibernate 2.3uA
 - > Doze 35uA
 - > Idle 500uA
- RF Data Modem
- Up to 7 GPIO
- SPI Interface to Micro
- Internal Timer comparators (reduce MCU resources)
- -16.6dBm to +3.6dBm output power
 - > Software selectable
 - > On-chip regulator
- Up to -92 Rx sensitivity at 1% PER



- 2V to 3.4 operating voltage
- -40°C to +85°C operating temperature
- Low external component count
 - > Requires single 16Mhz Xtal (Auto Trim)
- 5mmx5mm QFN-32
 - > Lead-Free



ZigBee Technology Overview

- Enables cost-effective, low power, reliable devices for monitoring and control
- ZigBee's architecture developed to target environments and applications best suited to the technology
- Provide a platform and implementation for wirelessly networked devices
- Ensure interoperability through the definition of application profiles
- Define the ZigBee network and stack models
- Provide the framework to allow a separation of concerns for the specification, design, and implementation of ZigBee devices
- Allow future extension of ZigBee

- ZigBee V1.0
 - Ad-hoc self forming networks
 - > Mesh, Cluster Tree and Star
 - Logical Device Types
 - > Coordinator, Router and End Device
 - Applications
 - > Device and Service Discovery
 - > Messaging with optional responses
 - > Home Controls Lighting Profile
 - > General mechanism to define private Profiles
 - Security
 - > Symmetric Key with AES-128
 - > Authentication and Encryption at MAC, NWK and Application levels
 - > Master Keys, Network Keys and Link Keys
 - Qualification
 - > Conformance Certification (Platform and Profile)
 - > Interoperability Events

How A ZigBee Network Forms

- Devices are pre-programmed for their network function
 - Coordinator scans to find an unused channel to start a network
 - Router (mesh device within a network) scans to find an active channel to join, then permits other devices to join
 - End Device will always try to join an existing network
- Devices discover other devices in the network providing complementary services
 - Service Discovery can be initiated from any device within the network
- Devices can be bound to other devices offering complementary services
 - Binding provides a command and control feature for specially identified sets of devices

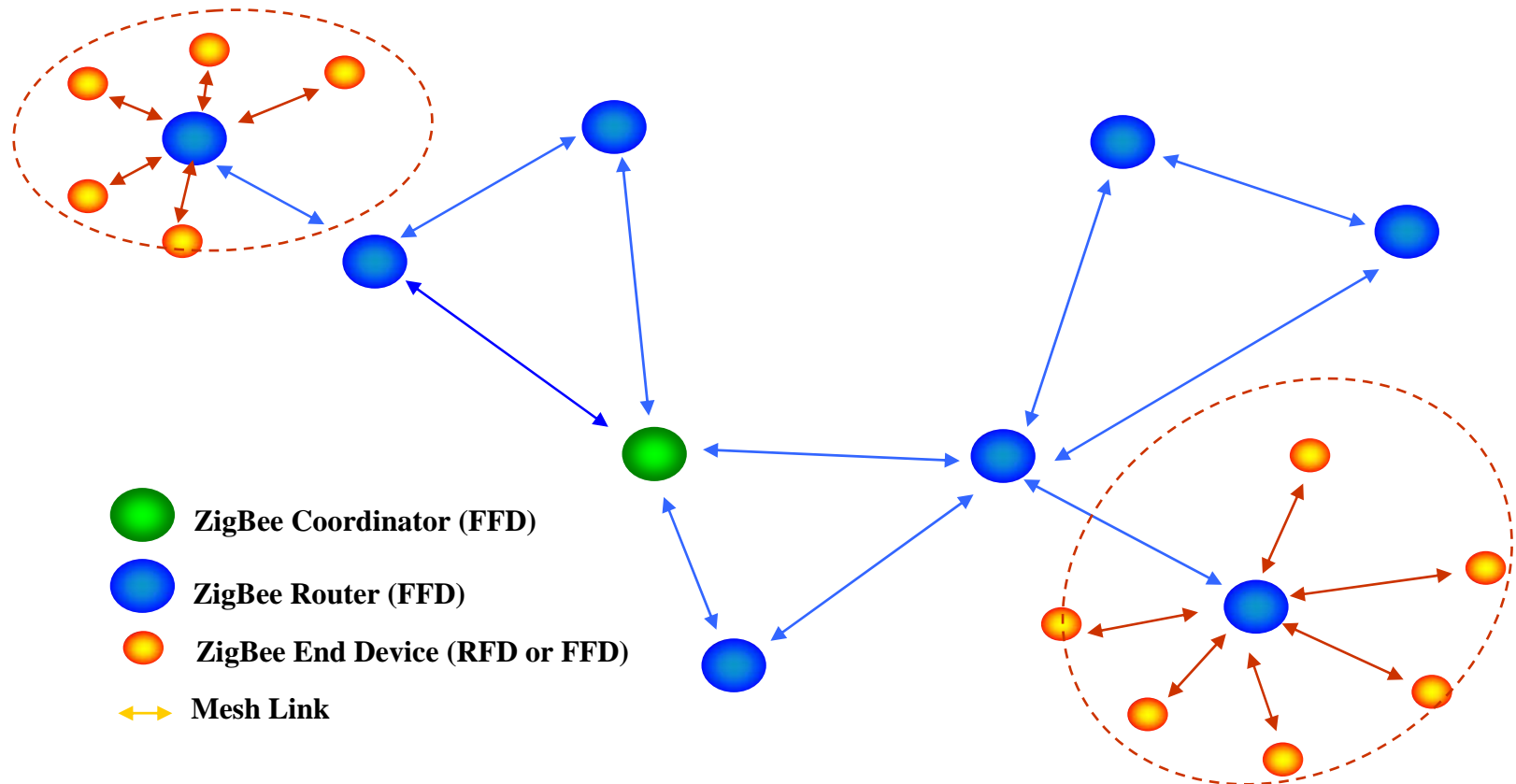
ZigBee Stack Architecture Basics

- Addressing
 - Every device has a unique 64 bit MAC address
 - Upon association, every device receives a unique 16 bit network address
 - Only the 16 bit network address is used to route packets within the network
 - Devices retain their 16 bit address if they disconnect from the network, however, if they LEAVE the network, the 16 bit address is re-assigned
 - NWK broadcast implemented above the MAC:
 - > NWK address 0xFFFF is the broadcast address
 - > Special algorithm in NWK to propagate the message
 - > “Best Effort” or “Guaranteed Delivery” options
 - > Radius Limited Broadcast feature



How a ZigBee Network Forms?

ZigBee Network Model



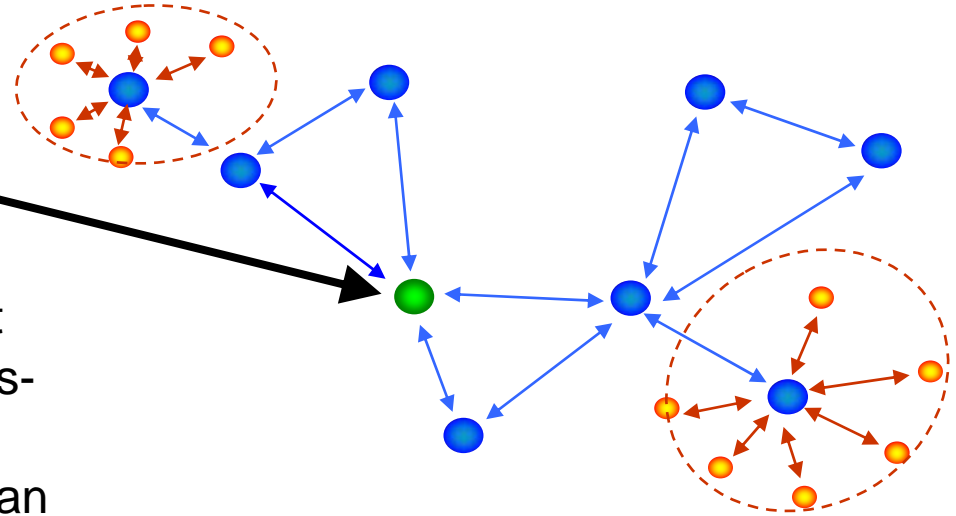
- Star networks support a single ZigBee coordinator with one or more ZigBee End Devices (up to 65,536 in theory)
- Mesh network routing permits path formation from any source device to any destination device

Wireless Networking Basics

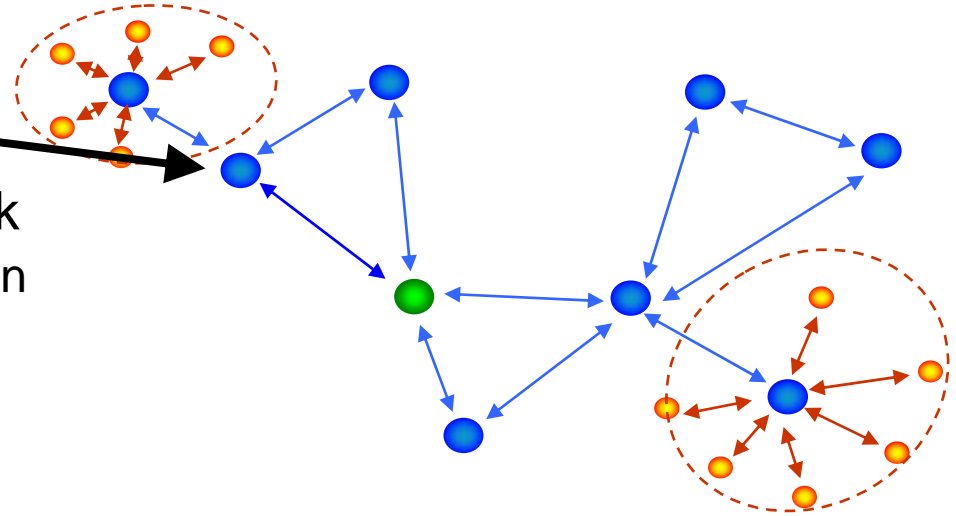
- Network Scan
 - Device scans the 16 channels to determine the best channel to occupy.
- Creating/Joining a PAN
 - Device can create a network (coordinator) on a free channel or join an existing network
- Device Discovery
 - Device queries the network to discover the identity of devices on active channels
- Service Discovery
 - Device scans for supported services on devices within the network
- Binding
 - Devices communicate via command/control messaging

Network Pieces –PAN Coordinator

- PAN Coordinator
 - “owns” the network
 - > Starts it
 - > Allows other devices to join it
 - > Provides binding and addressable services
 - > Saves messages until they can be delivered
 - > And more... could also have i/o capability
 - A “full-function device” – FFD
 - Mains powered

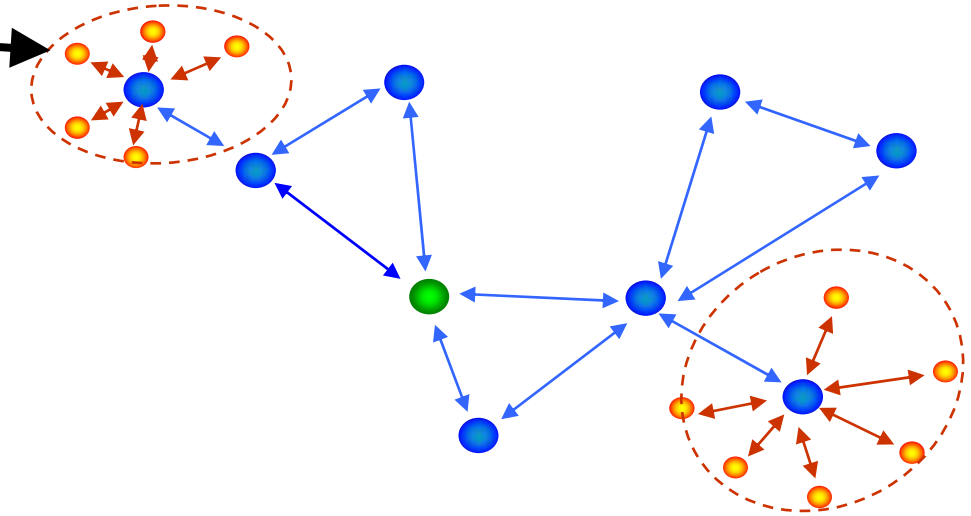


- Routers
 - Routes messages
 - Does not own or start network
 - > Scans to find a network to join
 - Given a block of addresses to assign
 - A “full-function device” – FFD
 - Mains powered depending on topology
 - Could also have i/o capability



Network Pieces – End Device

- End Device
 - Communicates with a single device
 - Does not own or start network
 - > Scans to find a network to join
 - Can be an FFD or RFD (reduced function device)
 - Usually battery powered





Summary

- IEEE 802.15.4 and ZigBee
 - Allows Designer to concentrate on end application
 - > Silicon vendors and ZigBee Alliance take care of transceiver, RF channel and protocol, ZigBee “look and feel”
 - Reliable and robust communications
 - > PHY and MAC outperform all known non-standards-based products currently available
 - Flexible network architectures
 - Very long primary battery life (months to years to decades)
 - Low system complexity for the OEM
- More Information
 - Freescale: www.freescale.com/zigbee
 - ZigBee: www.zigbee.org