ZigBee RF Module

ZigBee

- ZigBee is a technology standard to design for control and sensor network
- Based on IEEE 802.15.4 standard
- Ad-hoc and Mesh network creation
- Routing (pass messages on) and Self-healing
- Example of WPAN Technology
- Created by ZigBee Alliance
  - Global standards for reliable, cost-effective, low power wireless applications

ZigBee® Alliance

Radio Communication

- Electromagnetic Waves
- No medium required
- Modulation
- Wireless/Airwaves
- Inverse Square Law

$$\rho \propto \frac{1}{r^2}$$

r = distance, ρ= power.

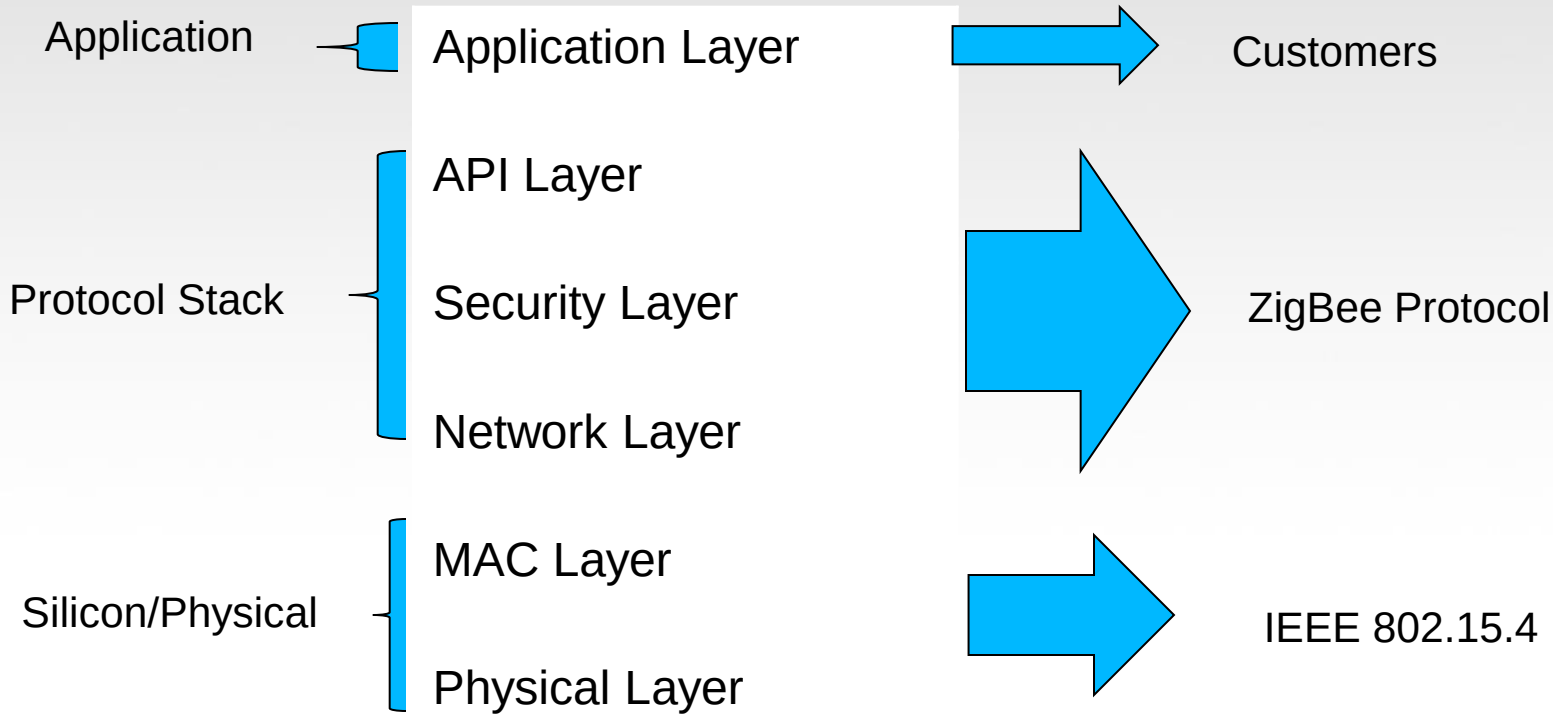
Need of ZigBee?

- Development started 1998, when many engineers realized that Wi-Fi and Bluetooth were going to be unsuitable for many applications as
- Direct /indirect communication between multiple machines
- Non standardized IoT devices
- Low power and small size devices
- Cost effective and security.

IEEE 802.15.4

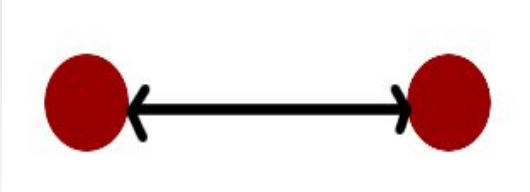
- Low Power consumption
- Low bandwidth
- Affordable
- Small
- Standardized
- Popular

Layering Architecture of ZigBee

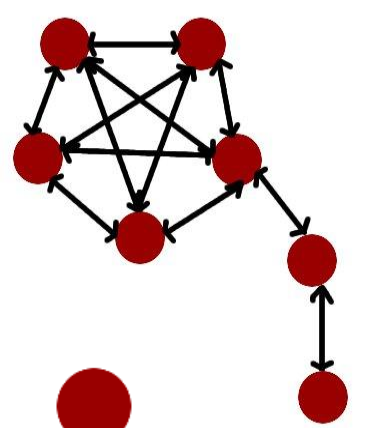


IEEE 802.15.4 Configurations

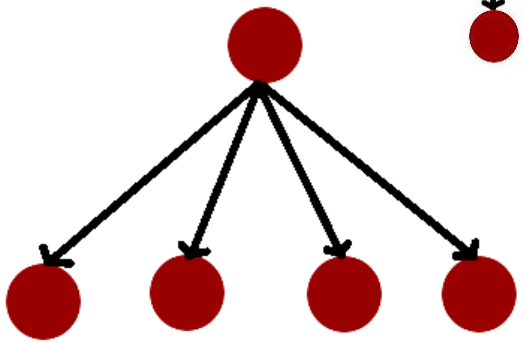
- Single Peer



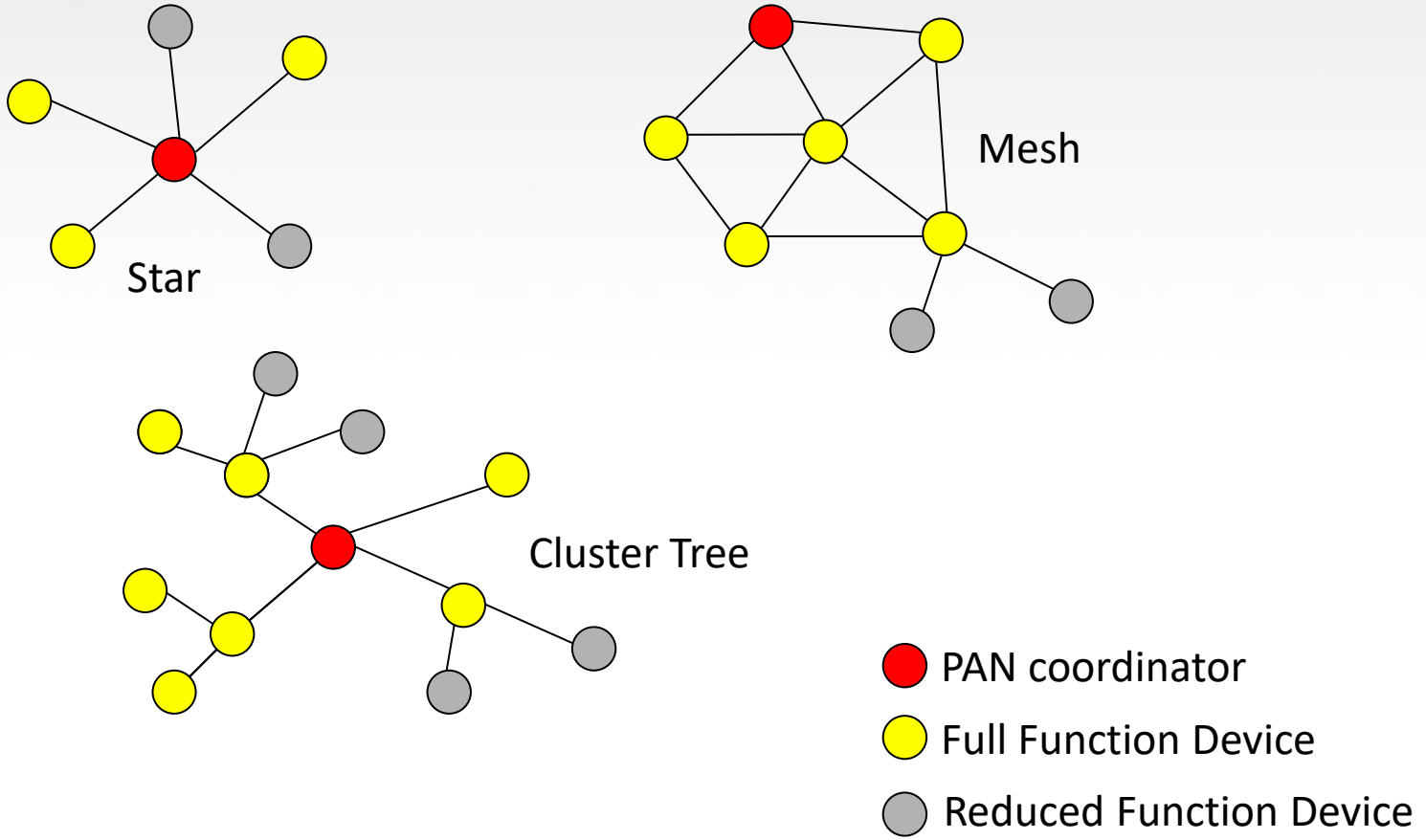
- Multi Peer



- Broadcast

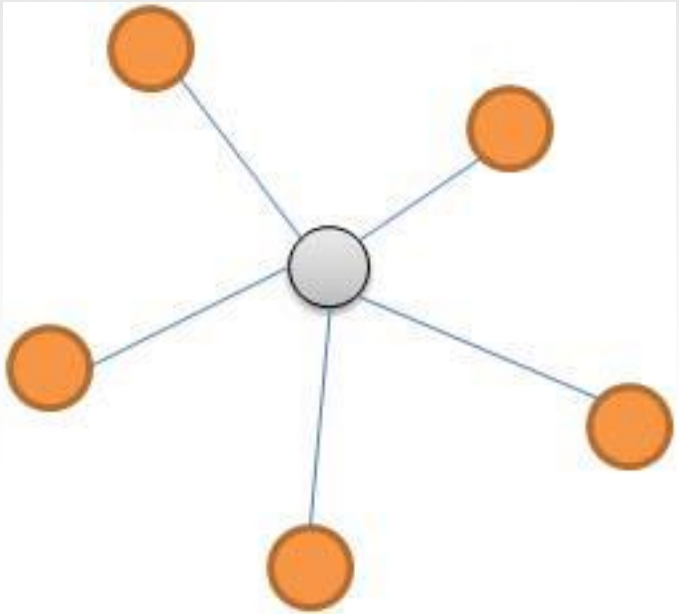


ZigBee Network Topologies



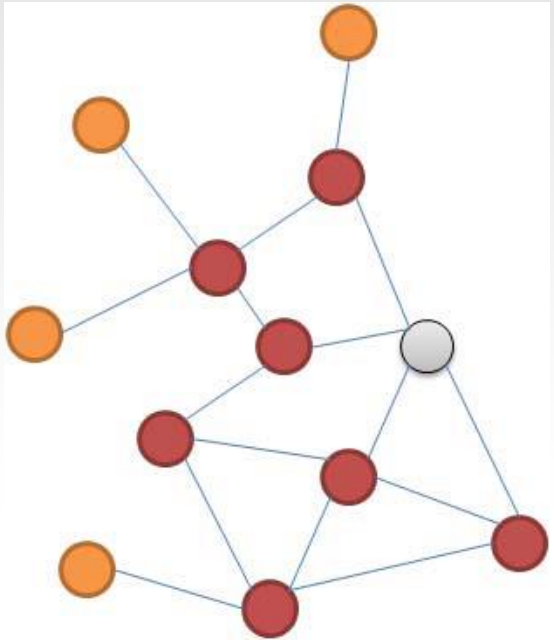
ZigBee Network Topologies

- Star Topology
  - Advantage
    - Easy to synchronize
    - Low latency
  - Disadvantage
    - Small scale



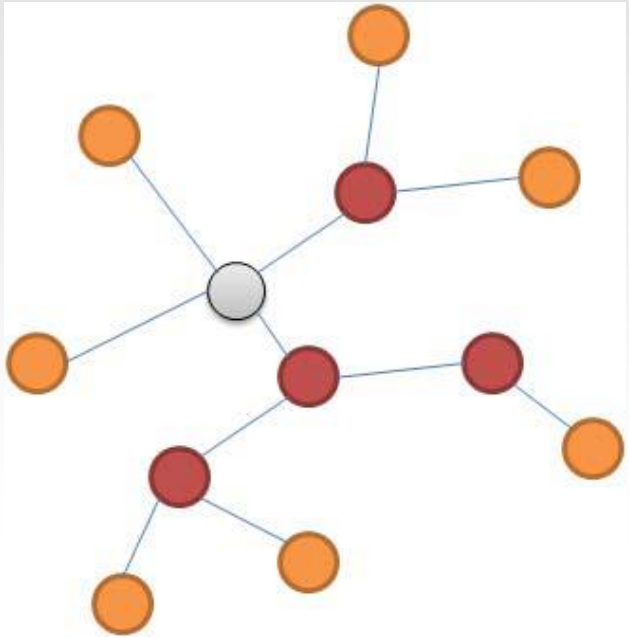
ZigBee Network Topologies

- Mesh Topology
  - Advantage
    - Robust multi-hop communication
    - Network is more flexible
    - Lower latency
  - Disadvantage
    - Route discovery is costly
    - Needs storage for routing table



ZigBee Network Topologies

- Cluster Tree
  - Advantage
    - Low routing cost
    - Allow multihop communication
  - Disadvantage
    - Route reconstruction is costly
    - Latency may be quite long

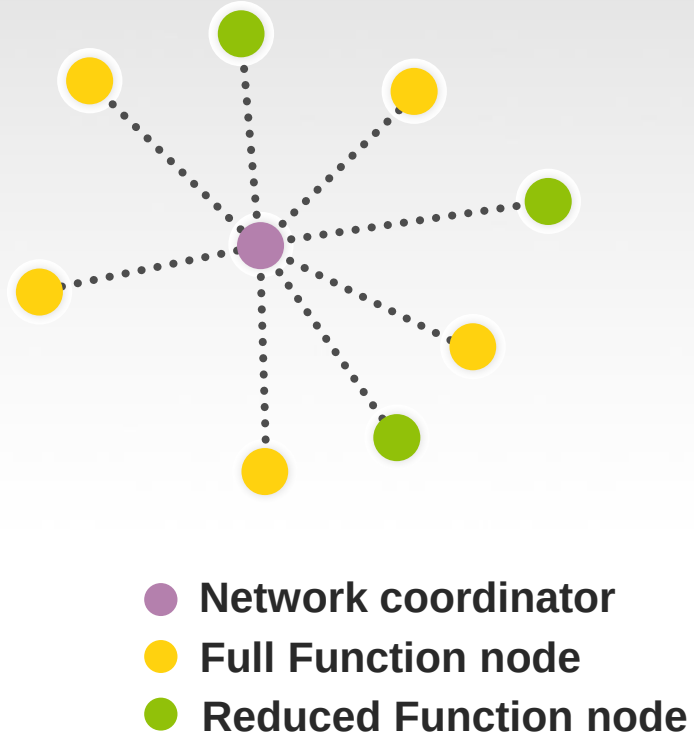


Sensor/Control Network Requirements

- Networks form by themselves, scale to large sizes and operate for years without manual intervention
- Extremely long battery life (years on AA cell),
  - low infrastructure cost (low device & setup costs)
  - low complexity and small size
- Low device data rate and QoS (Quality-of-Service)
- Standardized protocols allow multiple vendors to interoperate.

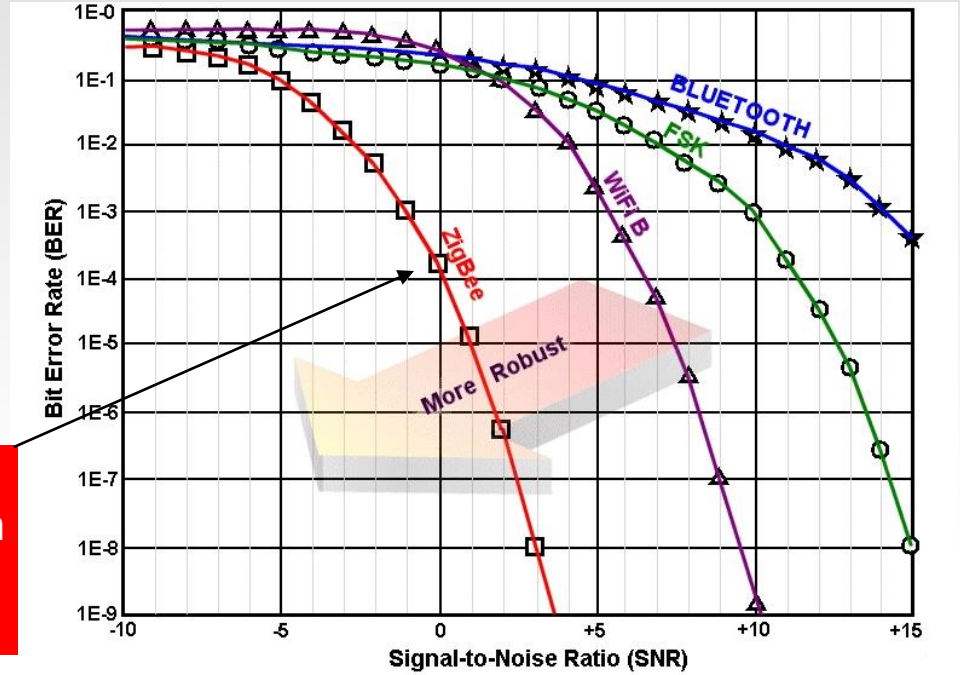
Basic Network Characteristics

- 65,536 network (client) nodes
- 27 channels over 2 bands
- 250Kbps data rate
- Optimized for time-critical applications and power management
- Full mesh networking support



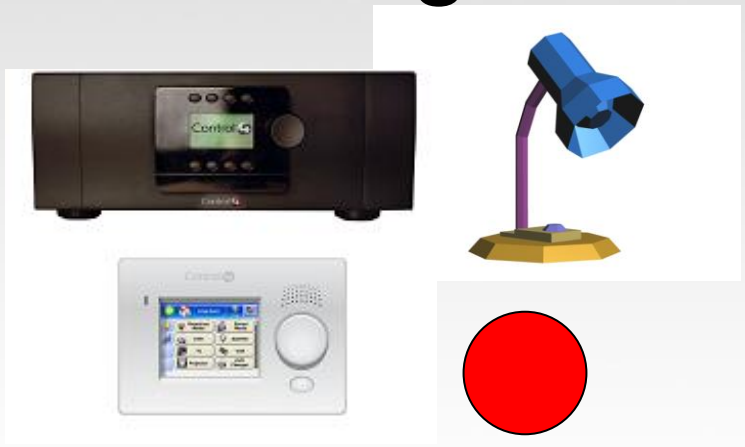
Basic Radio Characteristics

ZigBee technology relies upon IEEE 802.15.4, which has excellent performance in low SNR environments



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

ZigBee Mesh Networking



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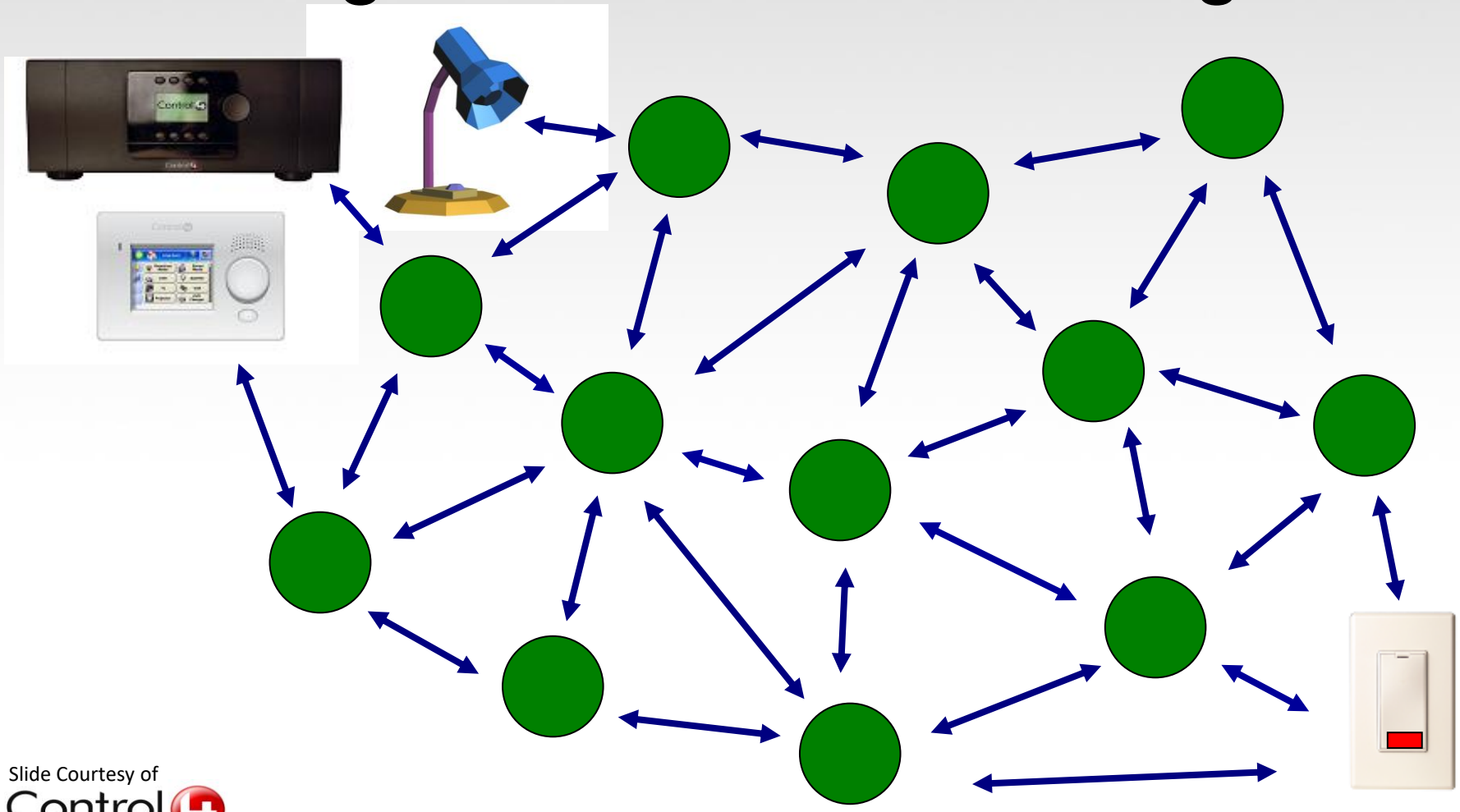
Control 4

ZigBee Mesh Networking



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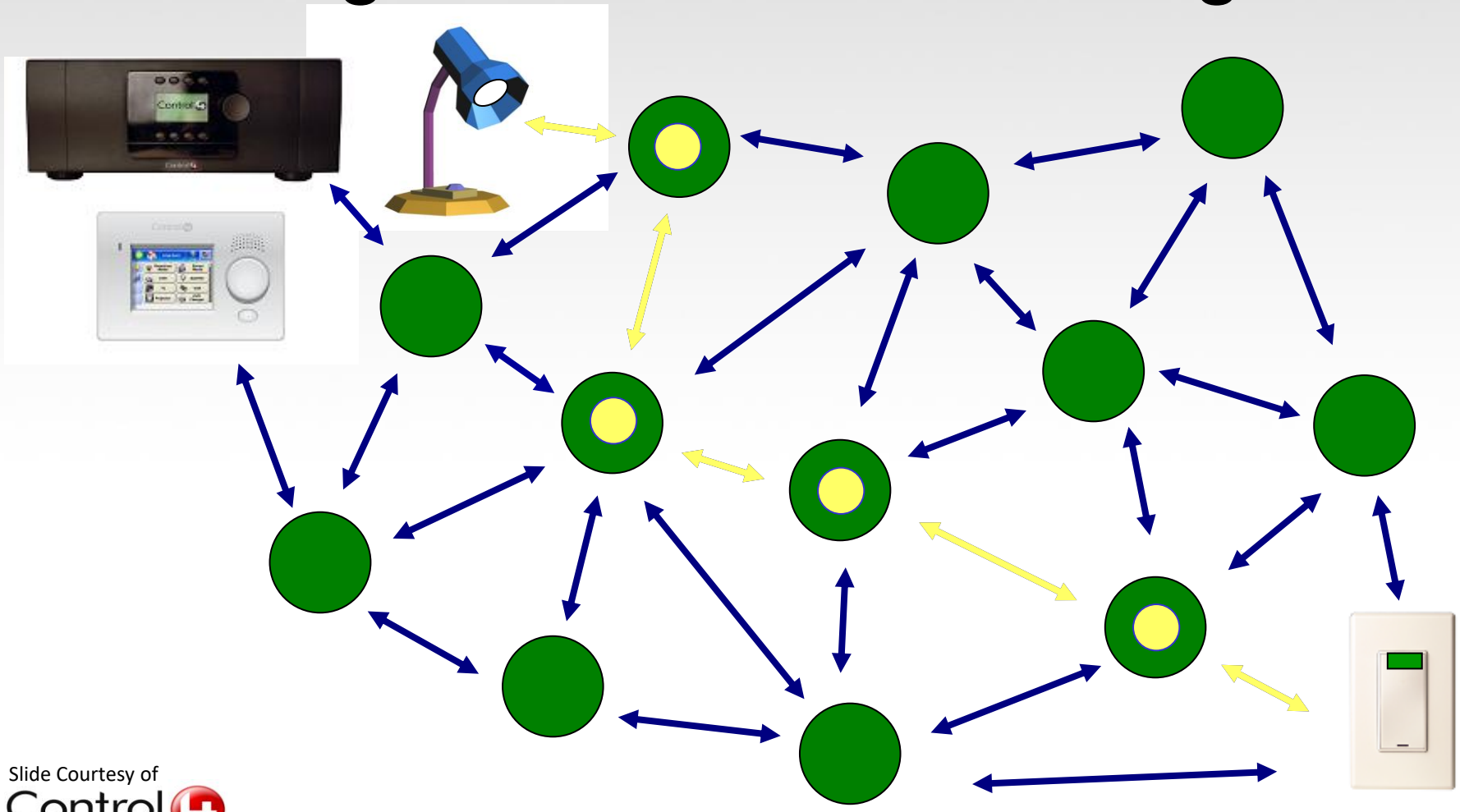
ZigBee Mesh Networking



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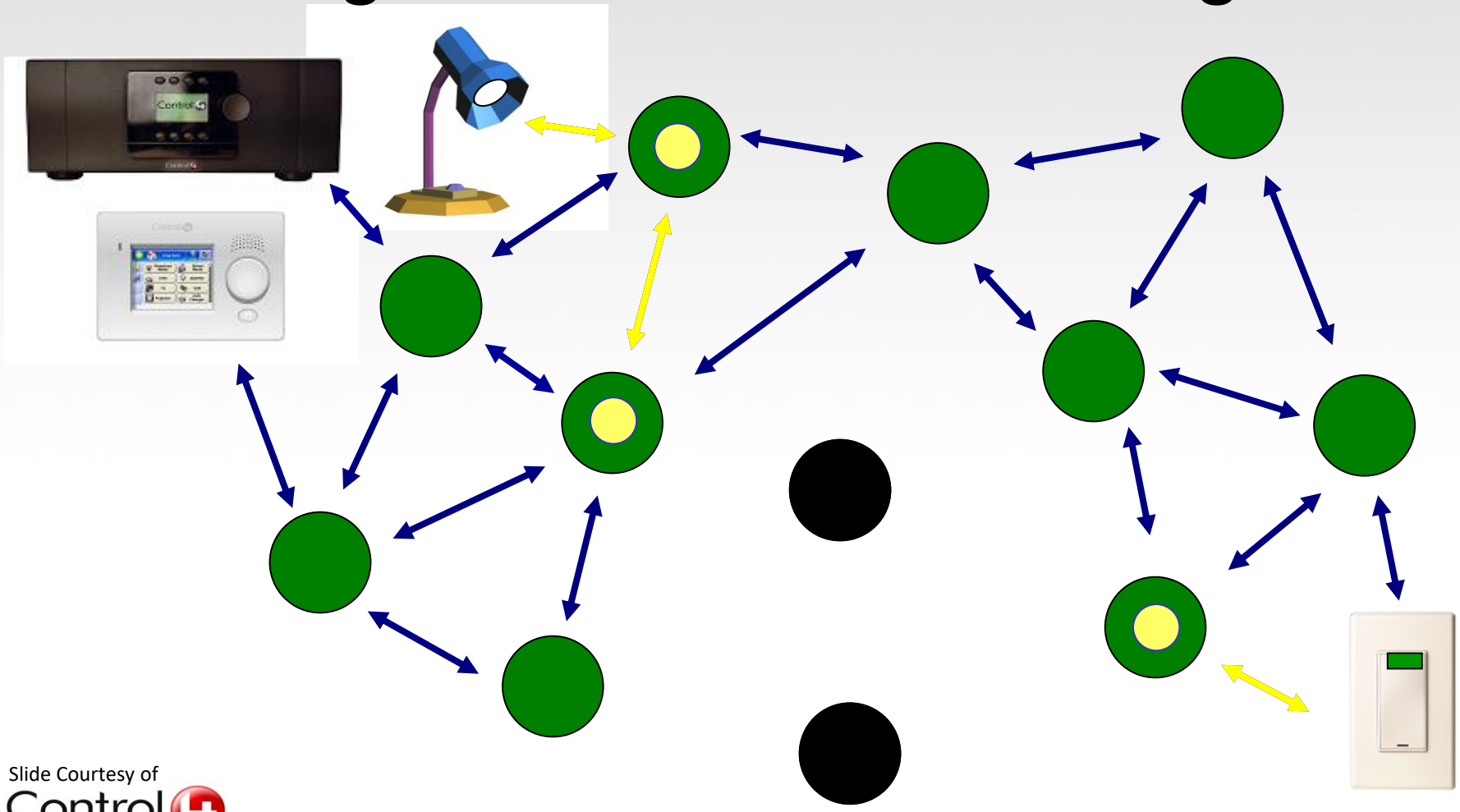
ZigBee Mesh Networking



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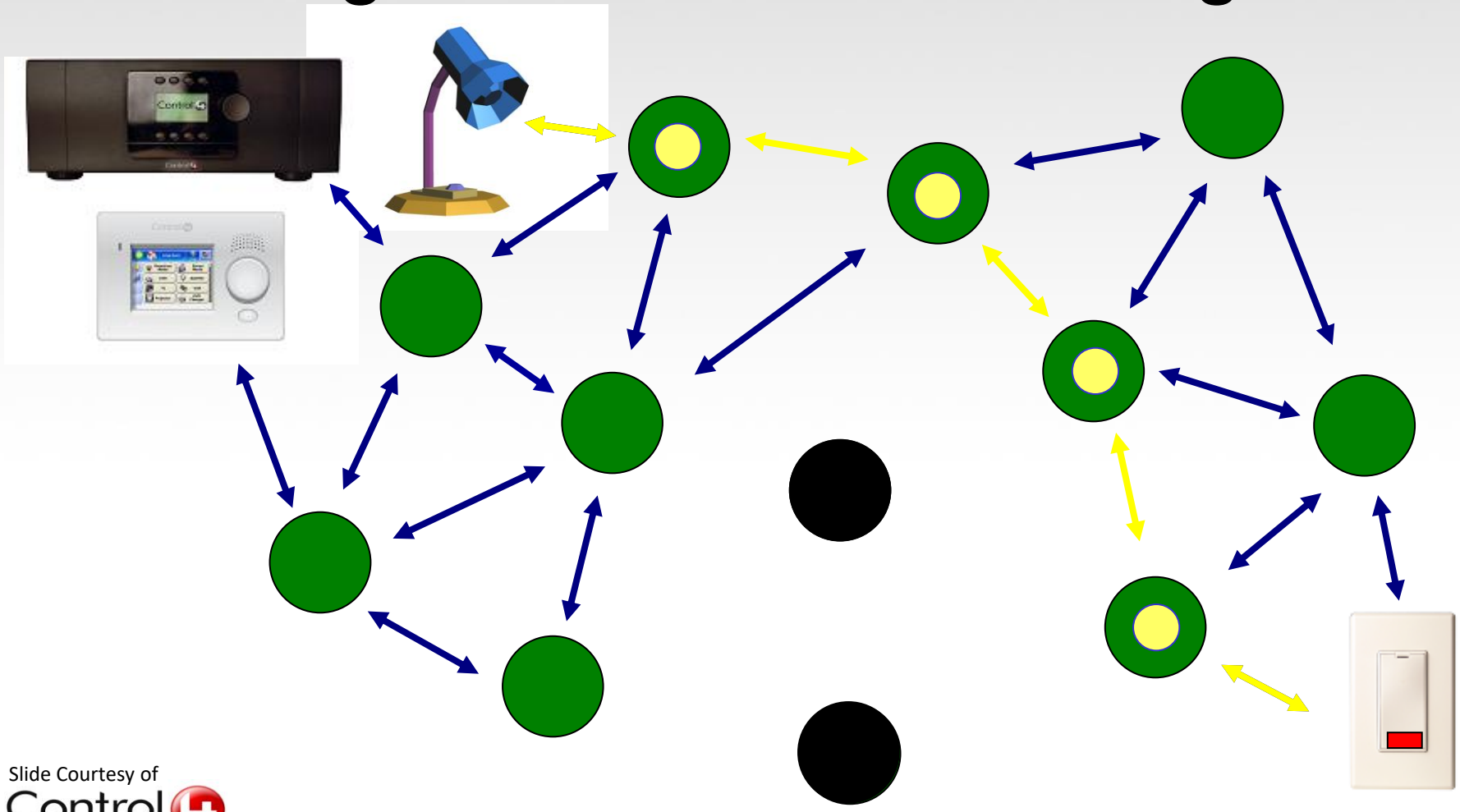
ZigBee Mesh Networking



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Wireless Connectivity Comparison				
Category	**BLE**	**Bluetooth Classic**	**ZIG-BEE**	**Wi-Fi**
				
IEEE Standard	802.15.1	802.15.1	802.15.4	802.11 (a, b, g, n)
Frequency (GHz)	2.4	2.4	0.8, 0.9, 2.4	2.4 to 5
Bandwidth (Mbps)	Low (1)	Medium (1 to 3)	Very low (0.25)	High (54-a, 11-b, 54-g, 600-n)
Power Consumption	Very Low	Medium	Very low	High
Battery Life	Months to Years	Days	Months to Years	Hours
Network Size	Undefined	7	64,000 +	255
Range	Short to Medium	Short	Medium	Medium to Long
Ease of use	Simple to use	Fairly simple to use	Fairly simple to use, but not yet adopted in mobiles and computers	It is more complex and requires configuration of Hardware and Software
Adaptability	High	High	Low	High
Primary Applications	Wearables, Mobile phones	Mobile Phones, mouse, keyboards, office and industrial automation devices	Industrial Automation, Home Automation, Smart metering	Notebook computers, desktop computers, servers.

XBee as a Coordinator

- Each network has 1 coordinator
- Coordinator selects channel and Create PAN ID
- Other devices then join the PAN ID
- Usually powered by something stable
- 16-bit network address is always 0
- Assigns 16-bit address for the router and end devices

XBee as a Routers

- Router as Optional
- Often powered by something stable
- Can have as many as you want
- Issues a request on start to find a coordinator/network so it can join
- Can talk to any device
- Coordinator can act as a “super router”

XBee as End Devices

- End devices as Optional
- Usually, battery powered
- Can have as many as you want
- Issues a request on start to find a network, it can join a parent device (router or coordinator)
- Can only communicate with its parent

XBee ZB S1 Vs XBee ZB S2 Vs XBee s2c

Specification	XBee ZB S1	XBee ZB S2	XBee ZB S2C
Indoor/Urban range	up to 100 ft. (30m)	up to 133 ft. (40m)	up to 200 ft (60 m)
Outdoor RF line-of-sight range	up to 300 ft. (100m)	up to 400 ft. (120m)	up to 4000 ft (1200m)
Transmit Power Output	1 mW (0dbm)	2 mW (+3dbm)	6.3mW (+8dBm) Boost mode
			3.1mW (+ddBm) Normal mode
RF Data Rate	250 Kbps	250 Kbps	250 Kbps
Receiver Sensitivity	-92dBm (1% PER)	-98dBm (1% PER)	-102dBm (1% PER) Boost mode
			-100dBm (1% PER) Normal Mode

XBee ZB S1 Vs XBee ZB S2 Vs XBee s2c

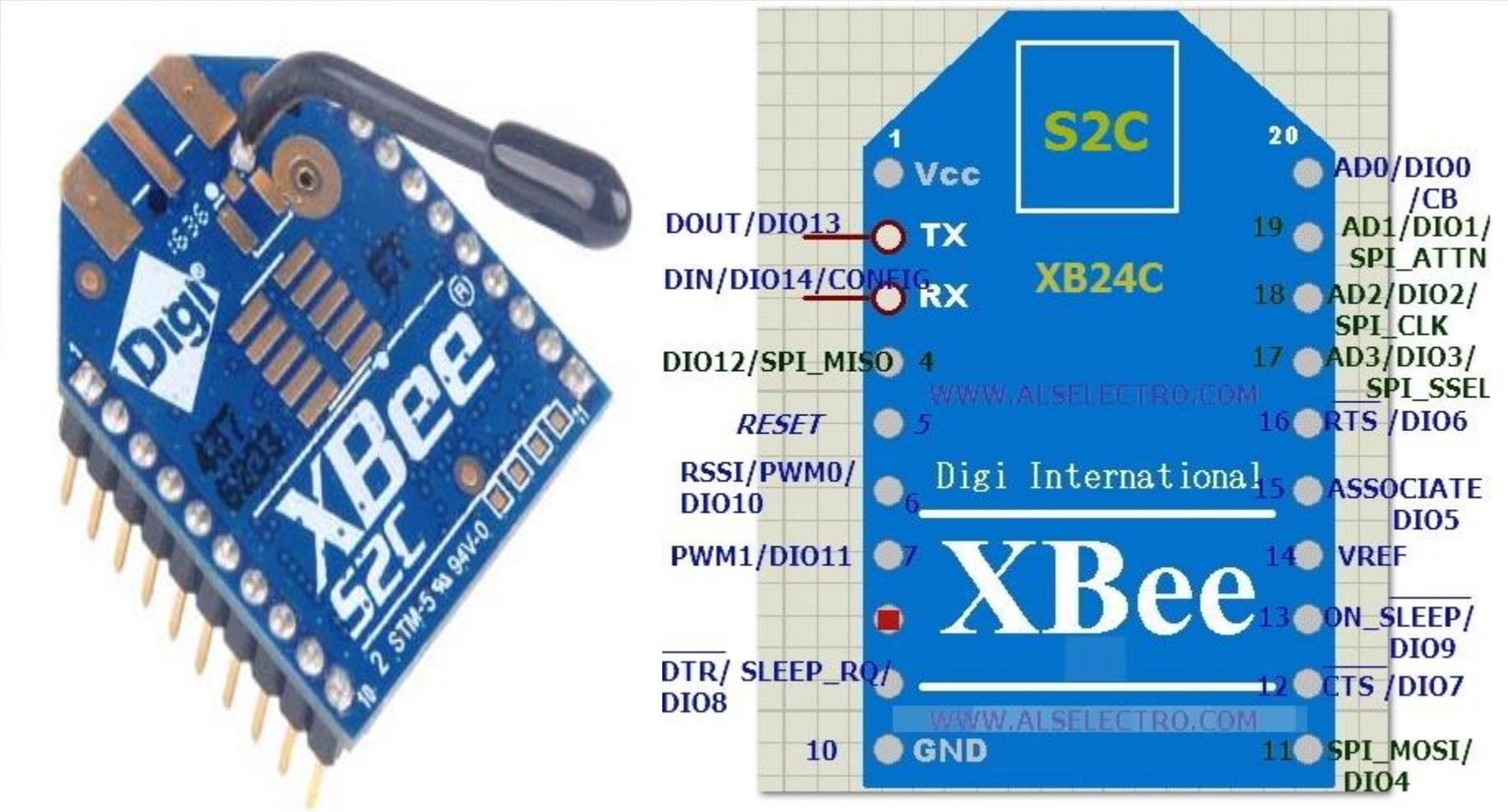
Supply Voltage	2.8 - 3.4 V	2.8 - 3.6 V	2.1 - 3.6V
Transmit Current (typical)	45 mA (@ 3.3 V)	40 mA (@ 3.3 V)	45 mA (+8dBm) Boost Mode
			33 mA (+5dBm) Normal Mode
Idle/Receive Current (typical)	50 mA (@ 3.3 V)	40 mA (@ 3.3 V)	31 mA (+8dBm) Boost Mode
			28 mA (+5dBm) Normal Mode
Power-down Current	10 uA	1 uA	<1uA
Frequency	ISM 2.4 GHz	ISM 2.4 GHz	ISM 2.4 GHz

XBee ZB S1 Vs XBee ZB S2 Vs XBee s2c

Network Topologies	Point to point, Star, Mesh (with DigiMesh firmware)	Point to point, Star, Mesh	Point to point, Star, Mesh
Number of Channels	16 Direct Sequence Channels	16 Direct Sequence Channels	16 Direct Sequence Channels
Filtration Options	PAN ID, Channel & Source/Destination	PAN ID, Channel & Source/Destination	PAN ID, Channel & Source/Destination

https://www.digi.com/support/knowledge-base/the-major-differences-in-the-xbee-series-1-vs-the

XBee s2c Pin out Diagram



Pin signals for XBee s2c

Pin	Name	Direction	Description
1	VCC		Power supply
2	DOUT	Output	UART data out
3	DIN/CONFIG	Input	UART data In
4	DIO12/SPI_MISO	Both	Digital I/O 12 / Serial Peripheral Interface (SPI) Data Out
5	RESET	Input	Module reset (reset pulse must be at least 200 ns). This must be driven as an open drain/collector. The device drives this line low when a reset occurs. Never drive this line high.
6	DIO10/PWM0/RSSI PWM	Both	Digital I/O 10 / PWM output 0 / RX signal strength indicator
7	DIO11/PWM1	Both	Digital I/O 11 / PWM output 1
8	[Reserved] - Do not connect		
9	DIO8/SLEEP_ RQ/DTR	Both	Digital I/O 8 / Pin sleep control line
10	GND		Ground
11	DIO4/SPI_MOSI	Both	Digital I/O 4 / SPI Data In
12	DIO7/CTS	Both	Digital I/O 7 / Clear-to-send flow control
13	ON/SLEEP	Output	Device sleep status indicator
14	VREF		Feature not supported on this device. Used on other XBee devices for analog voltage reference.

Pin signals for XBee s2c Cont..

Pin	Name	Direction	Description
15	DIO5/ASSOC	Both	Digital I/O 5 / Associated indicator
16	DIO6/RTS	Both	Digital I/O 6 / Request-to-send flow control
17	DIO3/AD3/SPI_ SSEL	Both	Digital I/O 3 / Analog input 3 / SPI select
18	DIO2/AD2/SPI_CLK	Both	Digital I/O 2 / Analog input 2 / SPI clock
19	DIO1/AD1/SPI_ ATTN	Both	Digital I/O 1 / Analog input 1 / SPI Attention
20	DIO0/AD0	Both	Digital I/O 0 / Analog input 0

Troubleshooting

- Only use 3.3V, more than 5V will release magic smoke
- Use decoupling capacitors with a voltage regulator
- TX->RX
- RX->TX
- Don't overwhelm them, try putting in a small delay

Firmware

- Must install with X-CTU (on Windows)
- API firmware
- Coordinator, Router, End Device
- Each Firmware has different settings

Thank You

https://www.robolab.in/zigbee-xbee-s2c-how-to-configure-as-coordinator-router-end-device/