



SNS COLLEGE OF TECHNOLOGY

Coimbatore-35
An Autonomous Institution



Accredited by NBA – AICTE and Accredited by NAAC – UGC with 'A++' Grade
Approved by AICTE, New Delhi & Affiliated to Anna University, Chennai

DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING

19ECT312 – EMBEDDED SYSTEM DESIGN

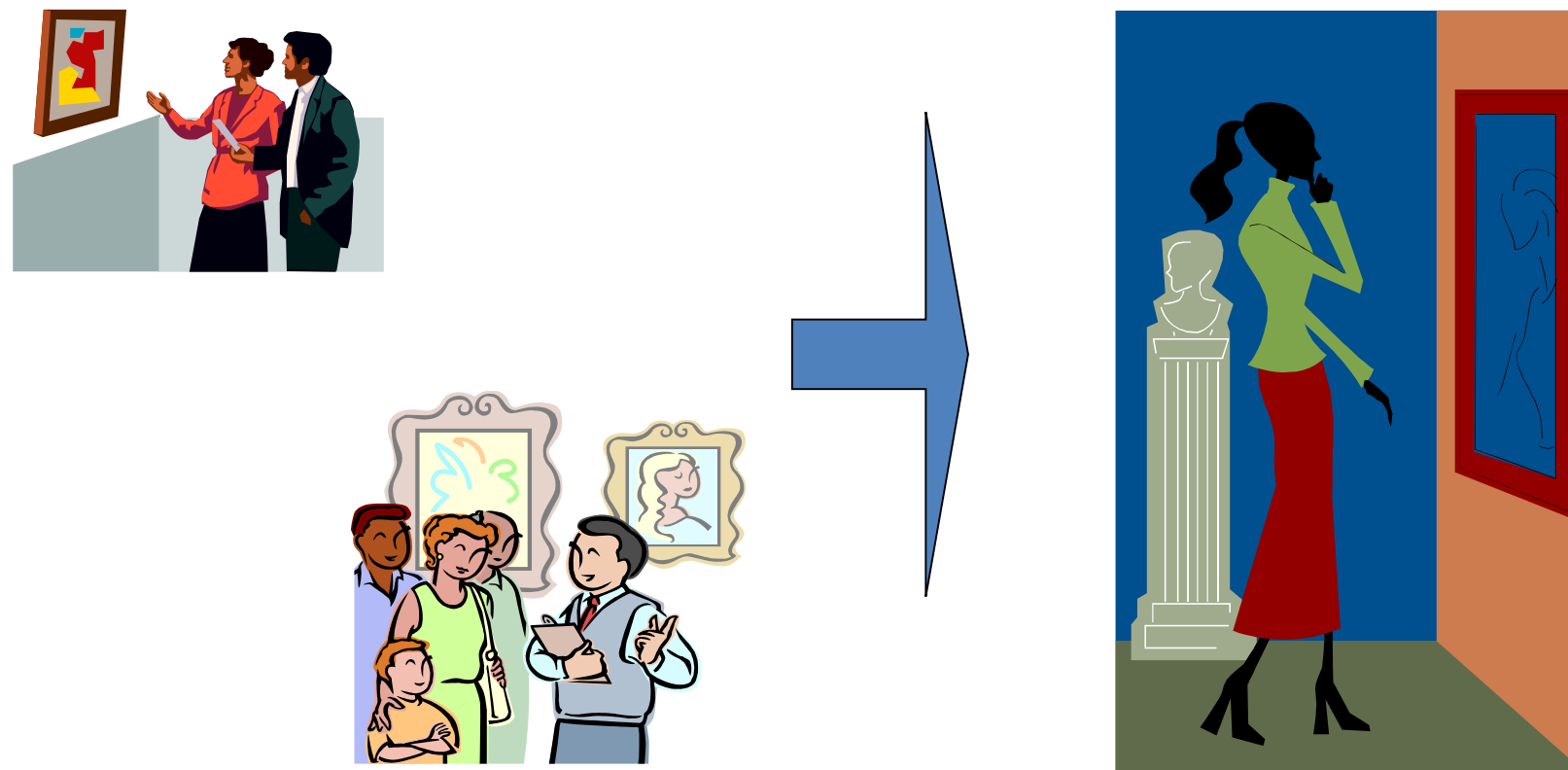
III YEAR/ VI SEMESTER
1

UNIT 2 :DEVICES AND EMERGING BUS STANDARDS

TOPIC 2.8 & 9 - Bluetooth & Zigbee



BLUETOOTH & ZIGBEE





BLUETOOTH



- Radio band: 2.4-2.48 GHz
- Average 1 Mbps - Up to 3 Mbps
- Supports point-to-point and point-to-multipoint
 - Creates personal area networks (PANs/Piconets)
 - Connects up to 8 devices simultaneously
- Minimal interference between devices
 - **Devices alter frequencies arbitrarily after packet exchanges -up to 1600 times/second - frequency hopping**
- 3 classes of Bluetooth transmit power

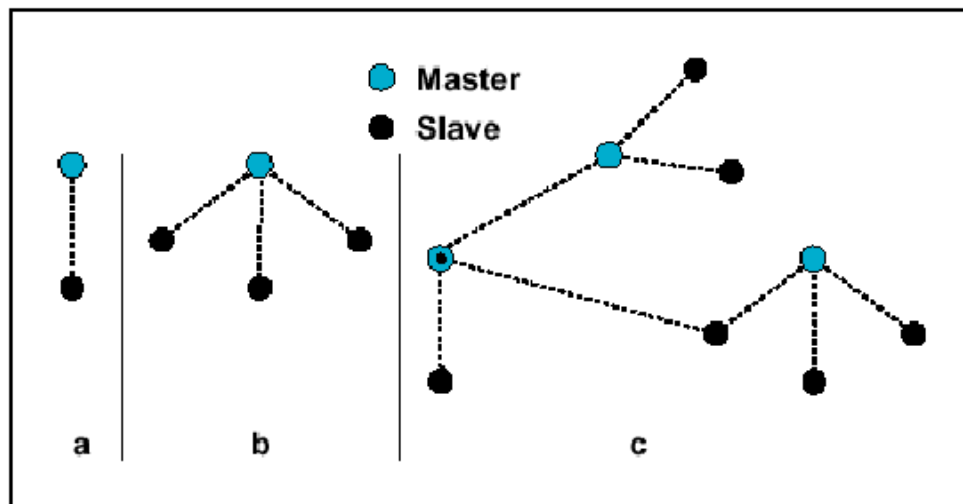


Figure 1.2: Piconets with a single slave operation (a), a multi-slave operation (b) and a scatternet operation (c).

Class	Maximum Power	Operating Range
Class 1	100mW (20dBm)	100 meters
Class 2	2.5mW (4dBm)	10 meters
Class 3	1mW (0dBm)	1 meter



BLUETOOTH



- Alternatives to cables
- IEEE 802.15.1 standard (2002)
- “Short range” and “Mobile products”
- POS of 10m radius, with mobility
- Ad-hoc connections between devices

- Network topology
- # of devices
- Scalability / Extendibility
- Flexibility
- Resilience / Reliability



BLUETOOTH

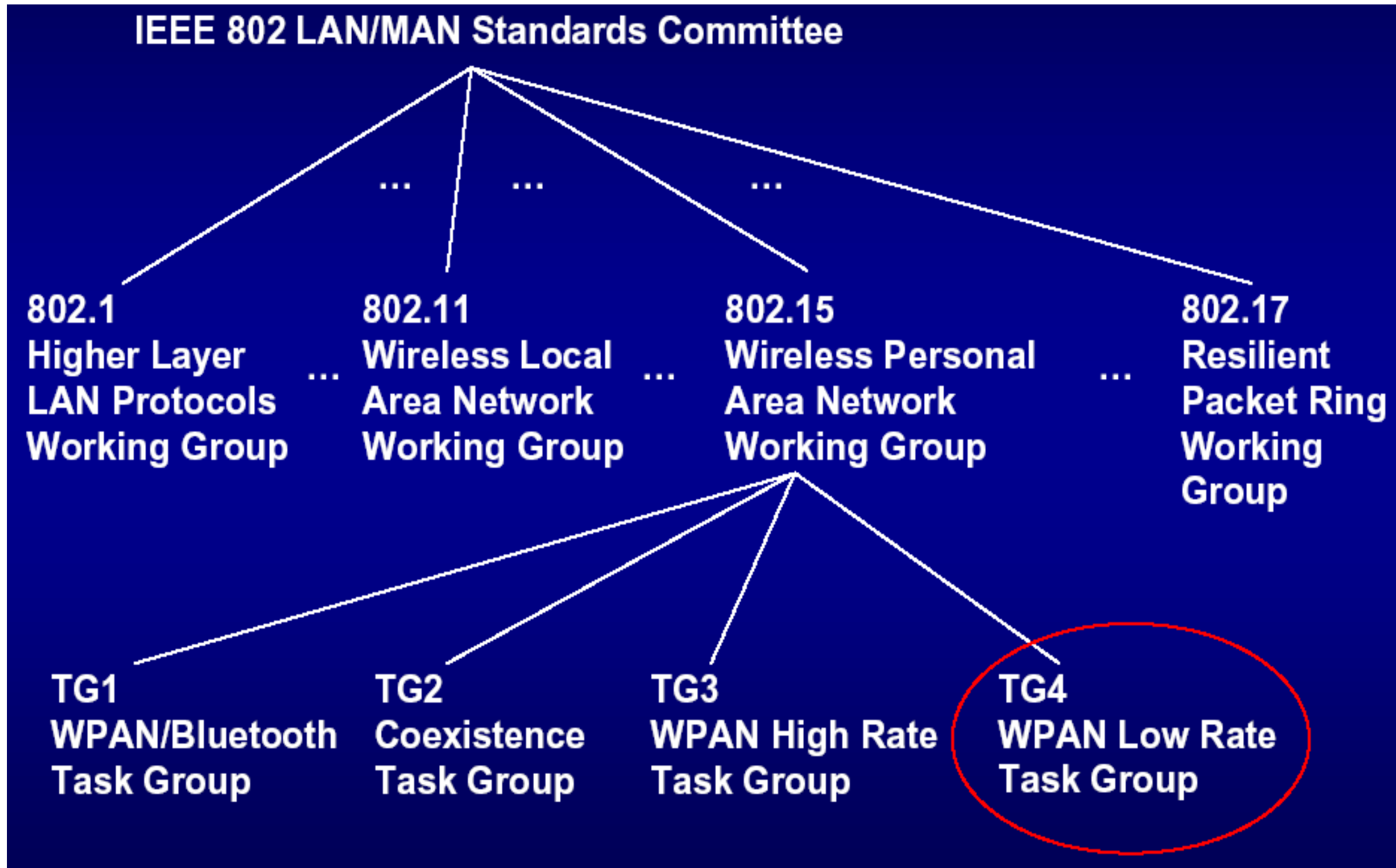


- Wireless communication between devices
 - Mobile phones, laptops, cameras, gaming controllers, computer peripherals, etc
- Short range sensor transmission
- Share multimedia - pictures, video, music
- A2DP - Advanced Audio Distribution Profile
 - Stream audio wirelessly





ZIGBEE 802.15.4





ZIGBEE NETWORK





ZIGBEE NETWORK

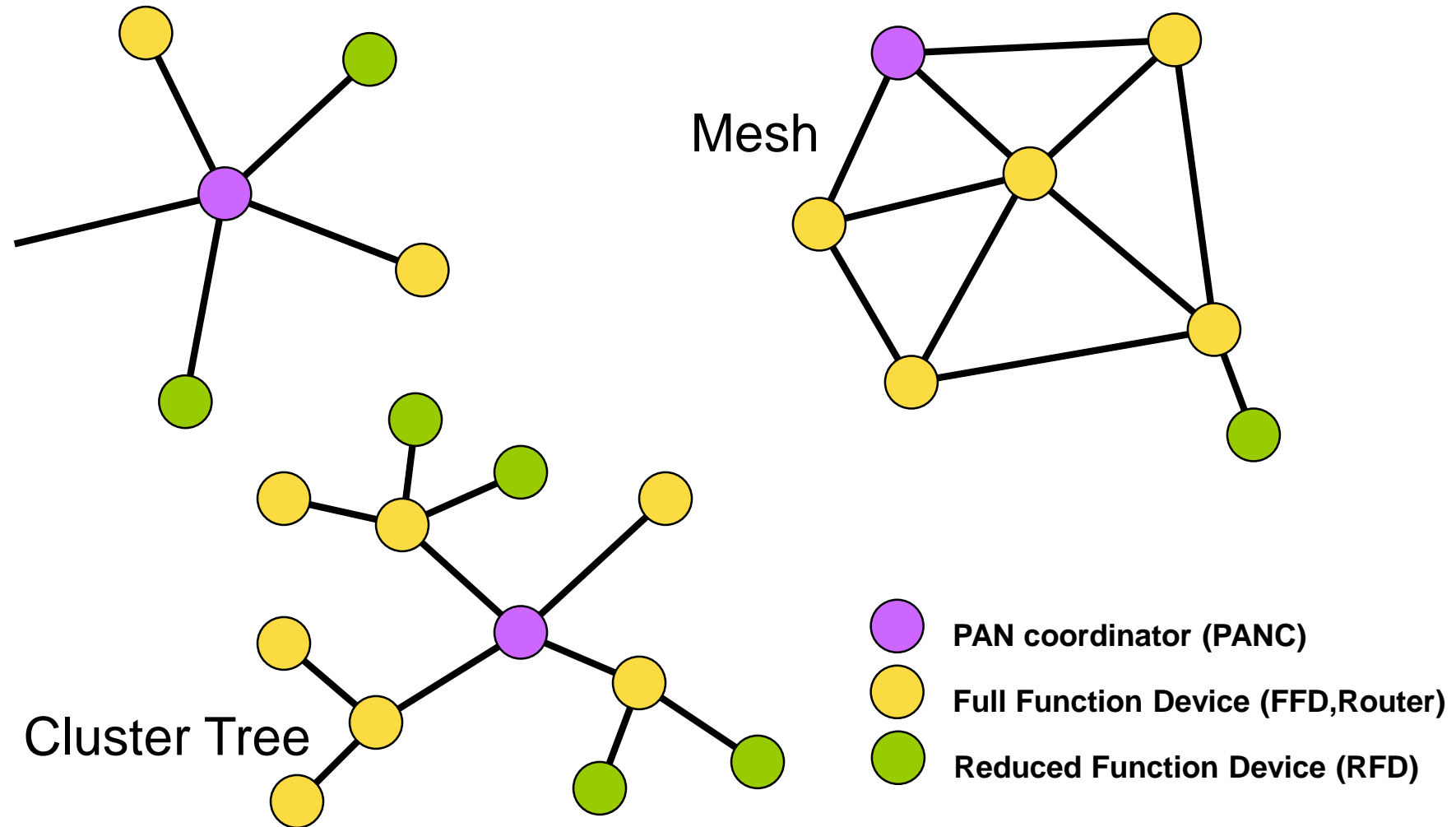


- IEEE 802.15.4 - Standard released in May 2003 for LR-WPAN
- Zigbee - set of high level communication protocols based upon the specification produced by 802.15.4
- The ZigBee Alliance is an association of companies working together to enable reliable, cost-effective, low-power, wirelessly networked, monitoring and control products based on an open global standard.





NETWORK TOPOLOGY MODELS





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



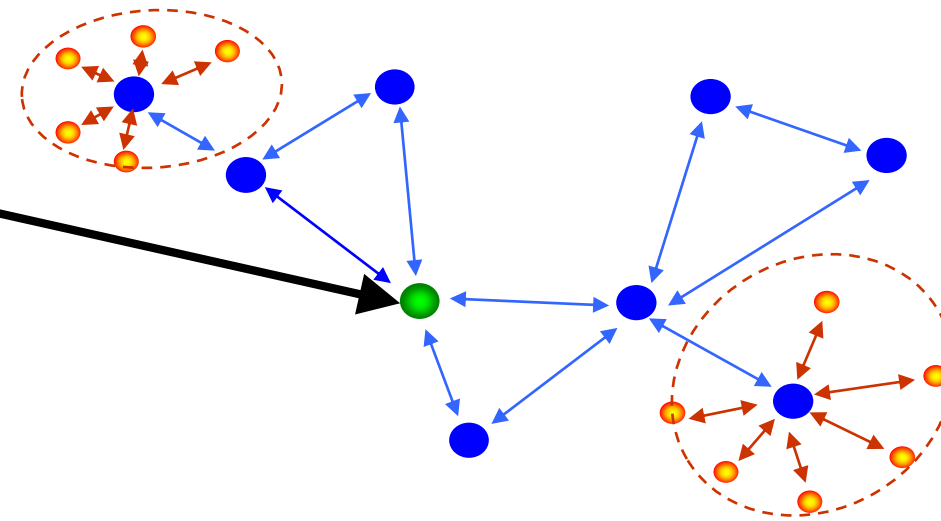
- PAN Coordinator

- “owns” the network

- Starts it
- Allows other devices to join it
- Provides binding and address-table services
- Saves messages until they can be delivered
- And more... could also have i/o capability

- A “Full-Function Device” – FFD

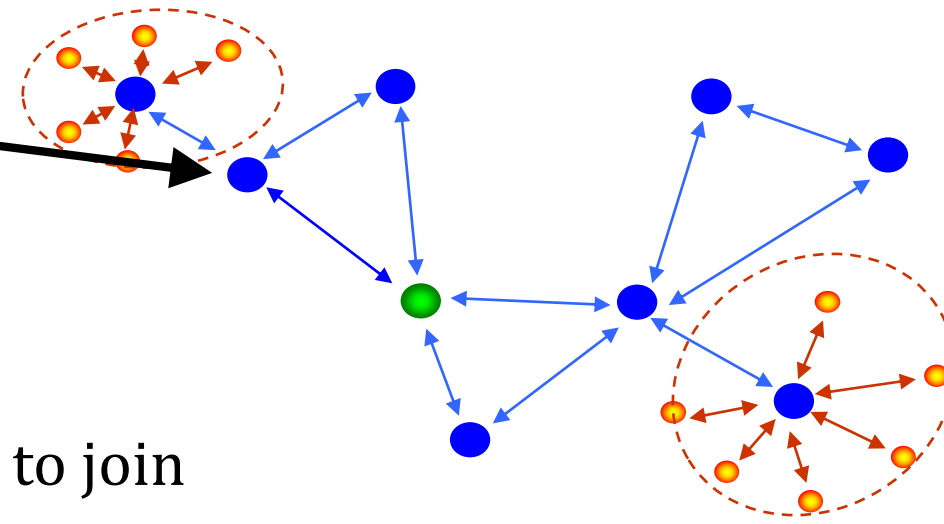
- Mains powered





NETWORK PIECES - ROUTER

- 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



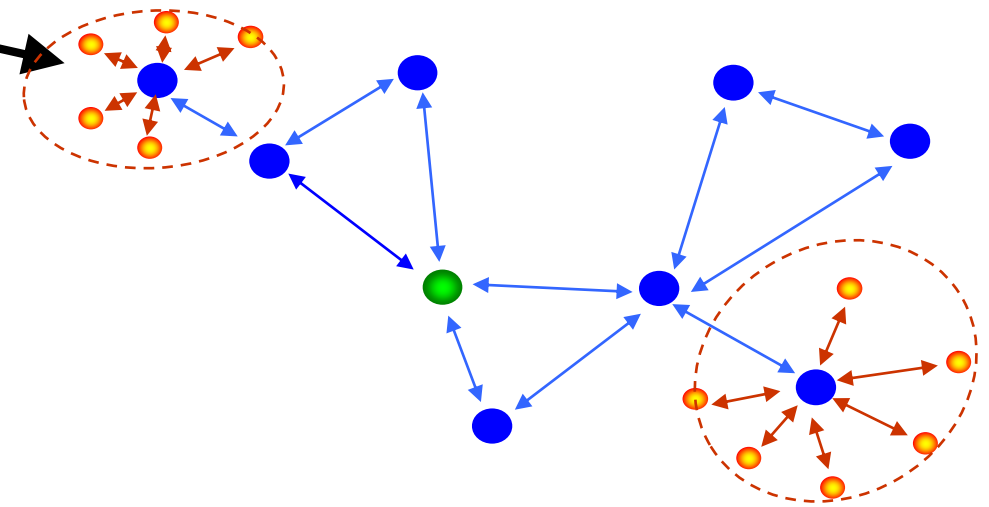


END DEVICE



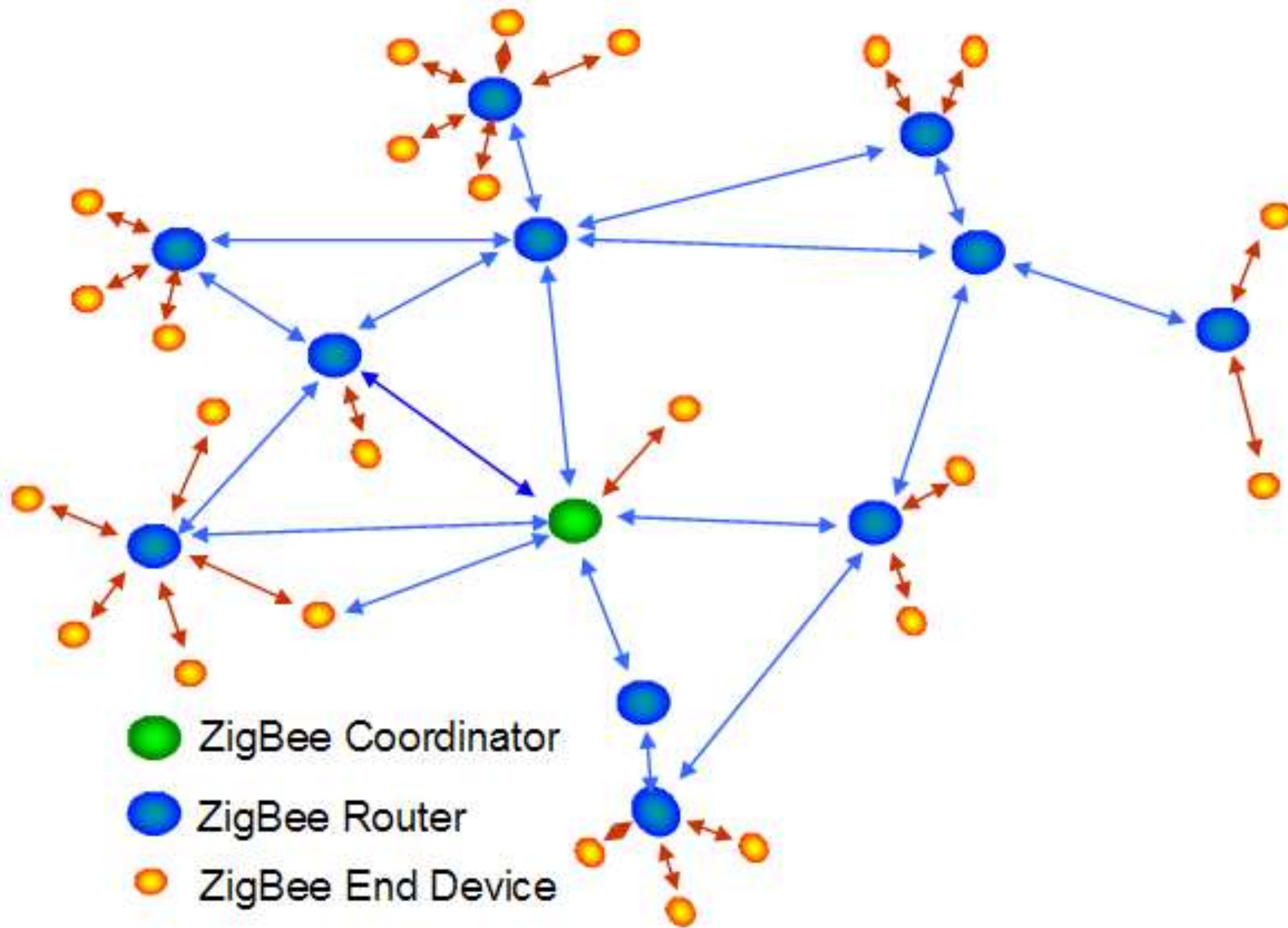
End Device

- 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





ZIGBEE IS MESH NETWORKING





TRAFFIC TYPES

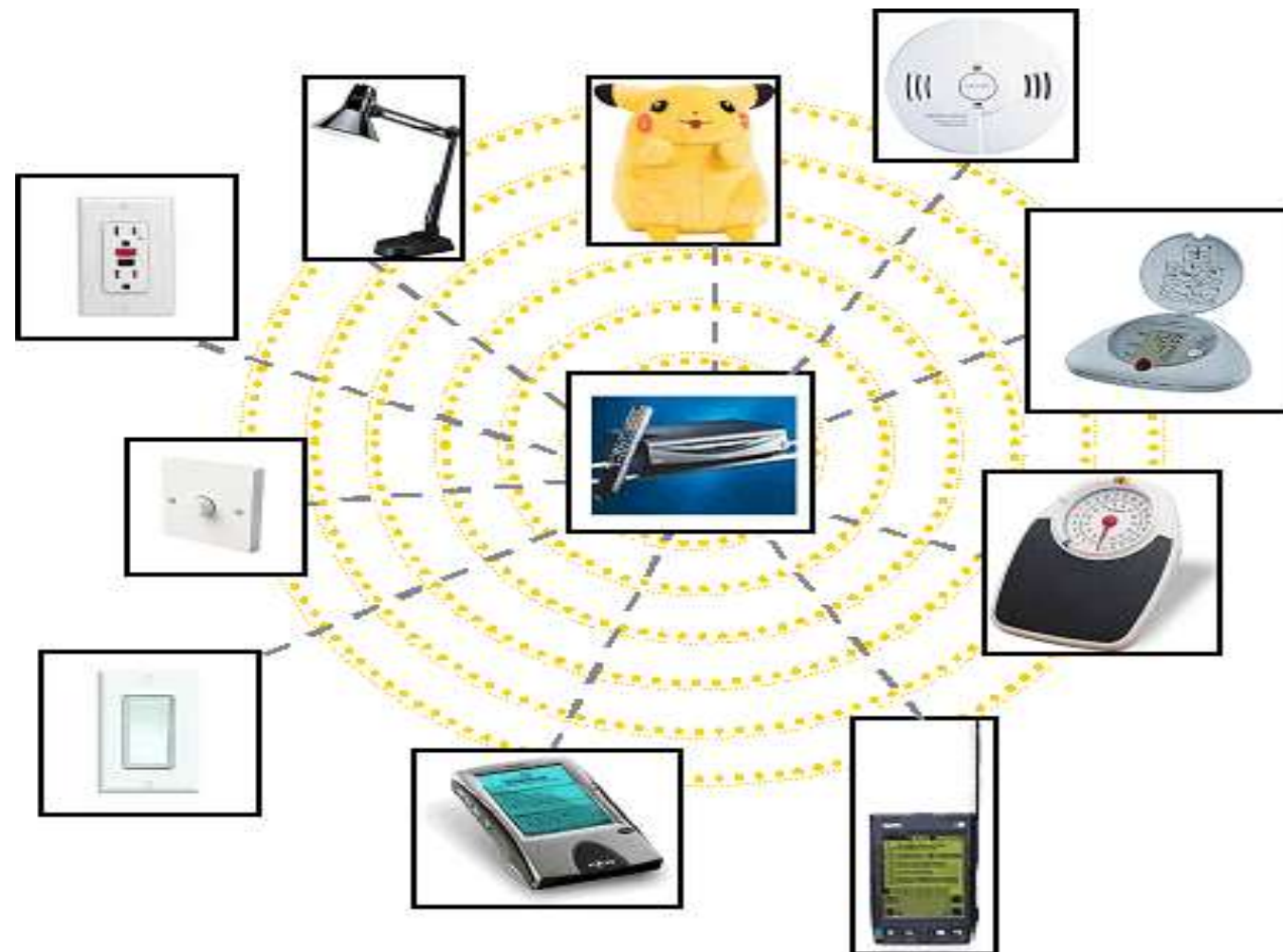
- Periodic data
 - Application defined rate (e.g. **sensing temperature**)
- Intermittent data
 - Application/external stimulus defined rate (e.g. **light switch**)
- Repetitive low latency data
 - Allocation of time slots (e.g. **mouse**)



IEEE 802.15.4

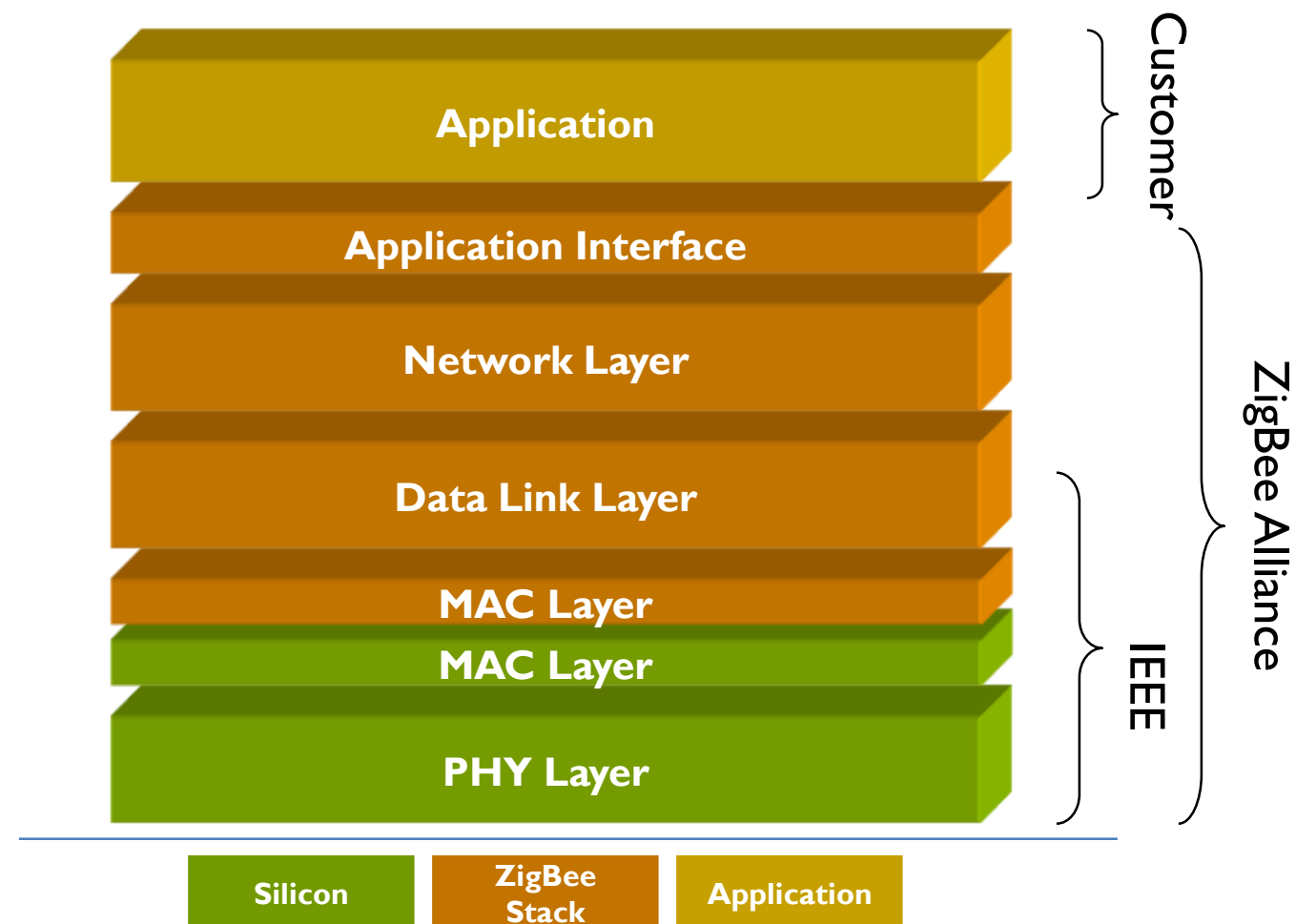


ZigBee™
Alliance



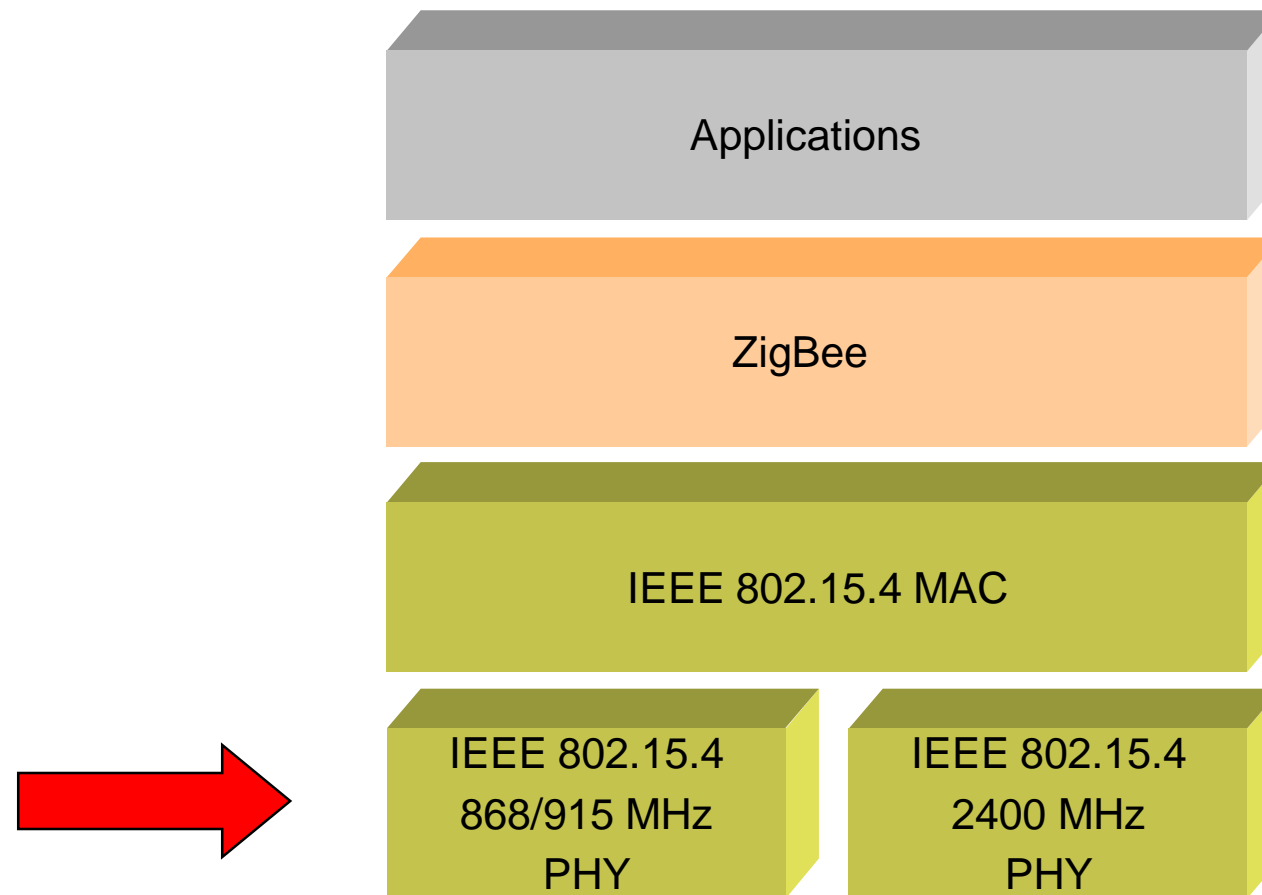


ZIGBEE ALLIANCE - IEEE - CUSTOMER RELATIONSHIP





802.15.4 ARCHITECTURE: PHYSICAL LAYER





PHYSICAL LAYER FUNCTIONALITIES:

- **Activation and deactivation of the radio transceiver**
- **Energy detection within the current channel**
- **Link quality indication for received packets**
- **Clear channel assessment for CSMA-CA**
- **Channel frequency selection**
- **Data transmission and reception**

ZIGBEE SPECIFIES TWO PHYSICAL MEDIA:

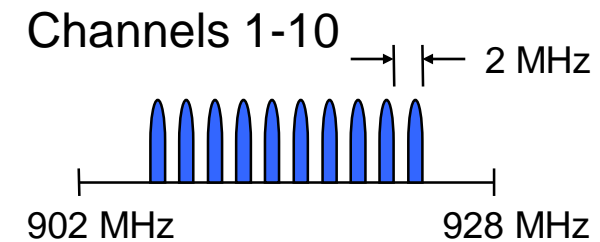
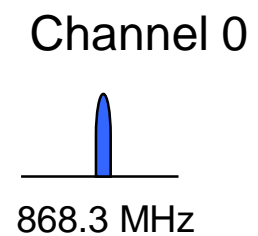
- **868 MHz/915 MHz direct sequence spread spectrum (DSSS) PHY (11 channels)**
 - **1 channel (20Kb/s) in European 868MHz band**
 - **10 channels (40Kb/s) in 915 (902-928)MHz ISM band**
- **2450 MHz direct sequence spread spectrum (DSSS) PHY (16 channels)**
 - **16 channels (250Kb/s) in 2.4GHz band**



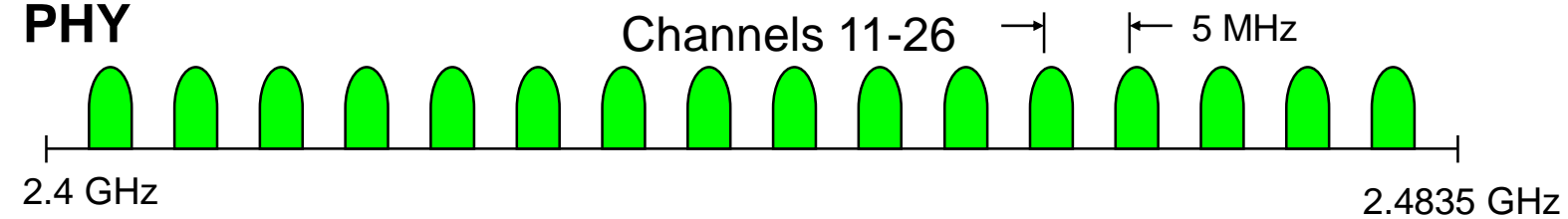
IEEE 802.15.4 PHYSICAL LAYER

- Operates in unlicensed ISM bands:

**868MHz/
915MHz
PHY**



**2.4 GHz
PHY**

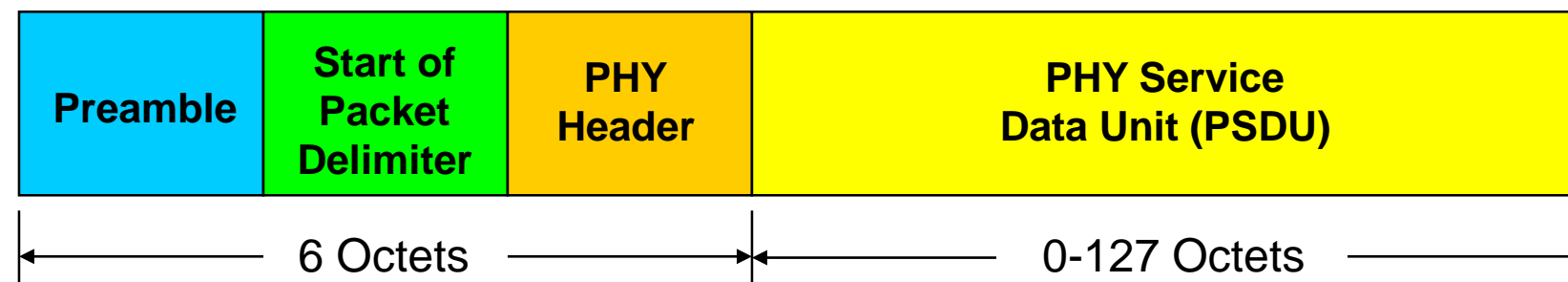




IEEE 802.15.4 PHY OVERVIEW PACKET STRUCTURE

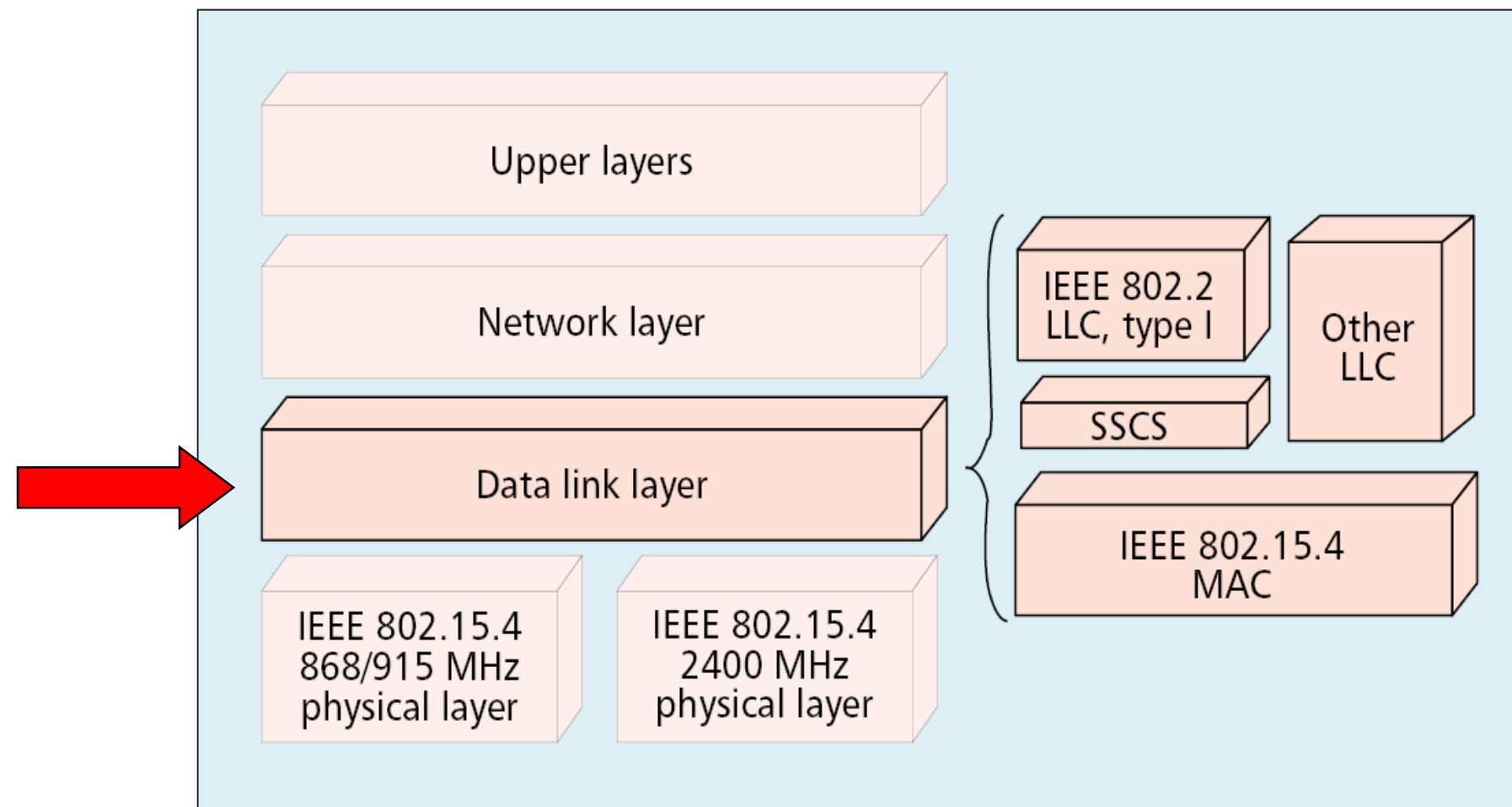
PHY Packet Fields

- Preamble (32 bits) – synchronization
- Start of Packet Delimiter (8 bits)
- PHY Header (8 bits) – PSDU length
- PSDU (0 to 1016 bits) – Data field





802.15.4 ARCHITECTURE: MAC LAYER





IEEE 802.15.4 MAC OVERVIEW DESIGN DRIVERS

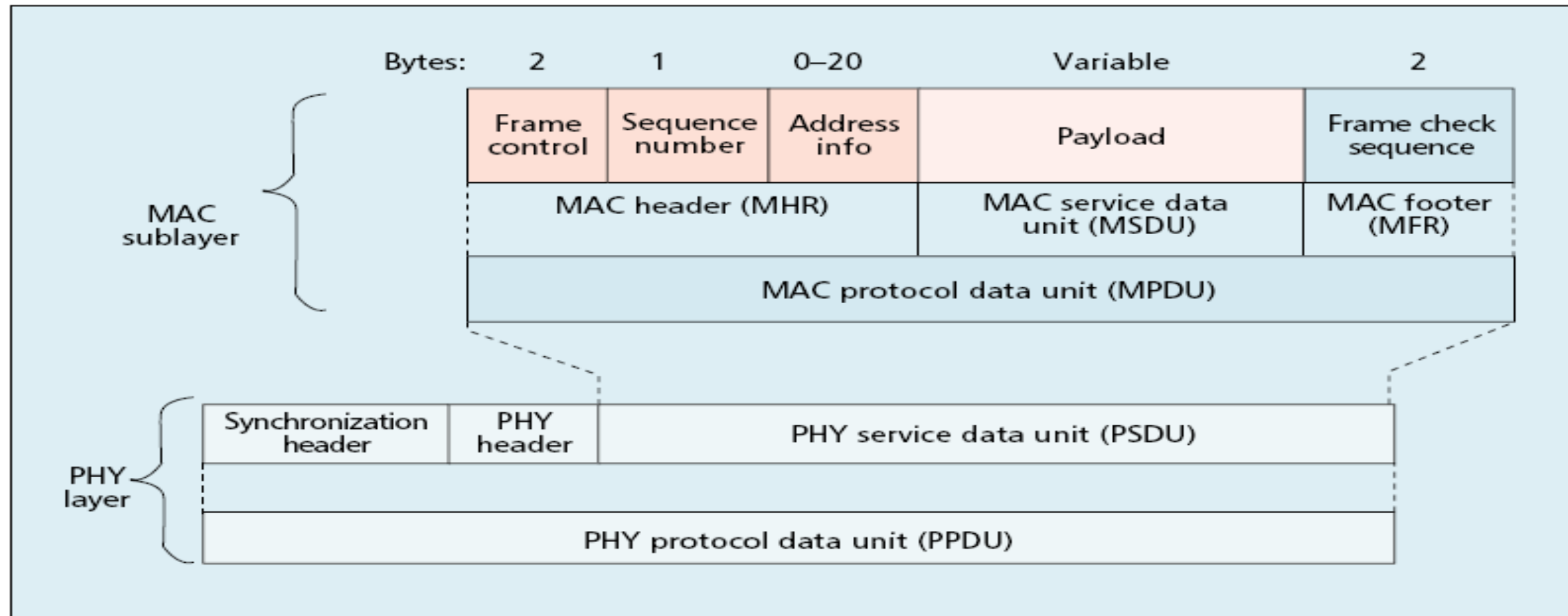
- Extremely low cost
- Ease of implementation
- Reliable data transfer
- Short range operation
- Very low power consumption

Simple but flexible protocol !



IEEE 802.15.4 MAC OVERVIEW

GENERAL FRAME STRUCTURE



4 Types of MAC Frames:

- Data Frame
- Beacon Frame
- Acknowledgment Frame
- MAC Command Frame

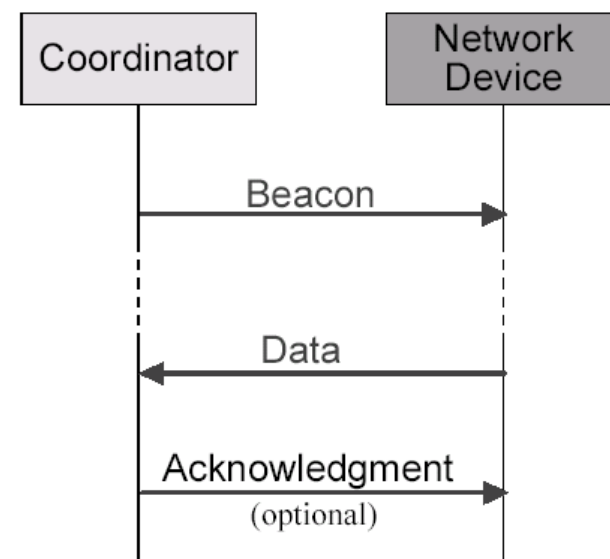


DATA TRANSFER MODEL

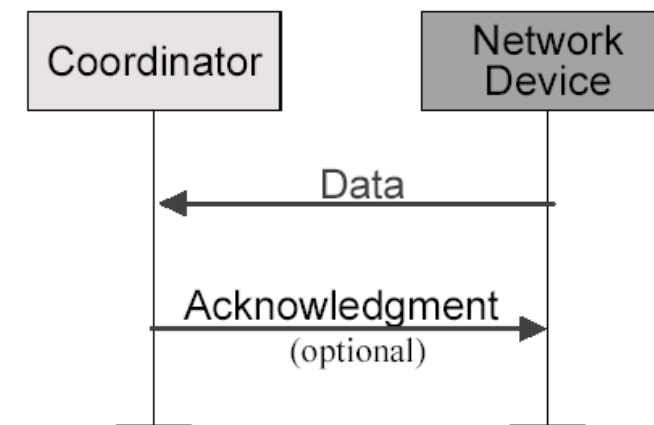


Data transferred from device to coordinator

- In a beacon-enabled network, device finds the beacon to synchronize to the super-frame structure. Then using slotted CSMA/CA to transmit its data.
- In a non beacon-enabled network, device simply transmits its data using un-slotted CSMA/CA



Communication to a coordinator
In a **beacon-enabled** network



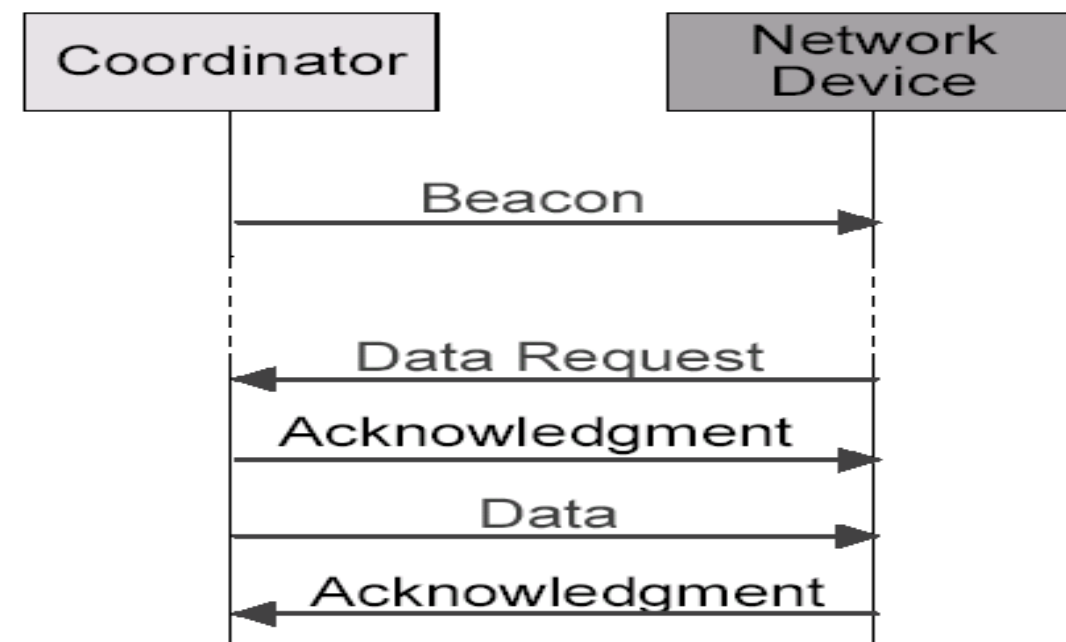
Communication to a coordinator
In a **non beacon-enabled** network



DATA TRANSFER MODEL



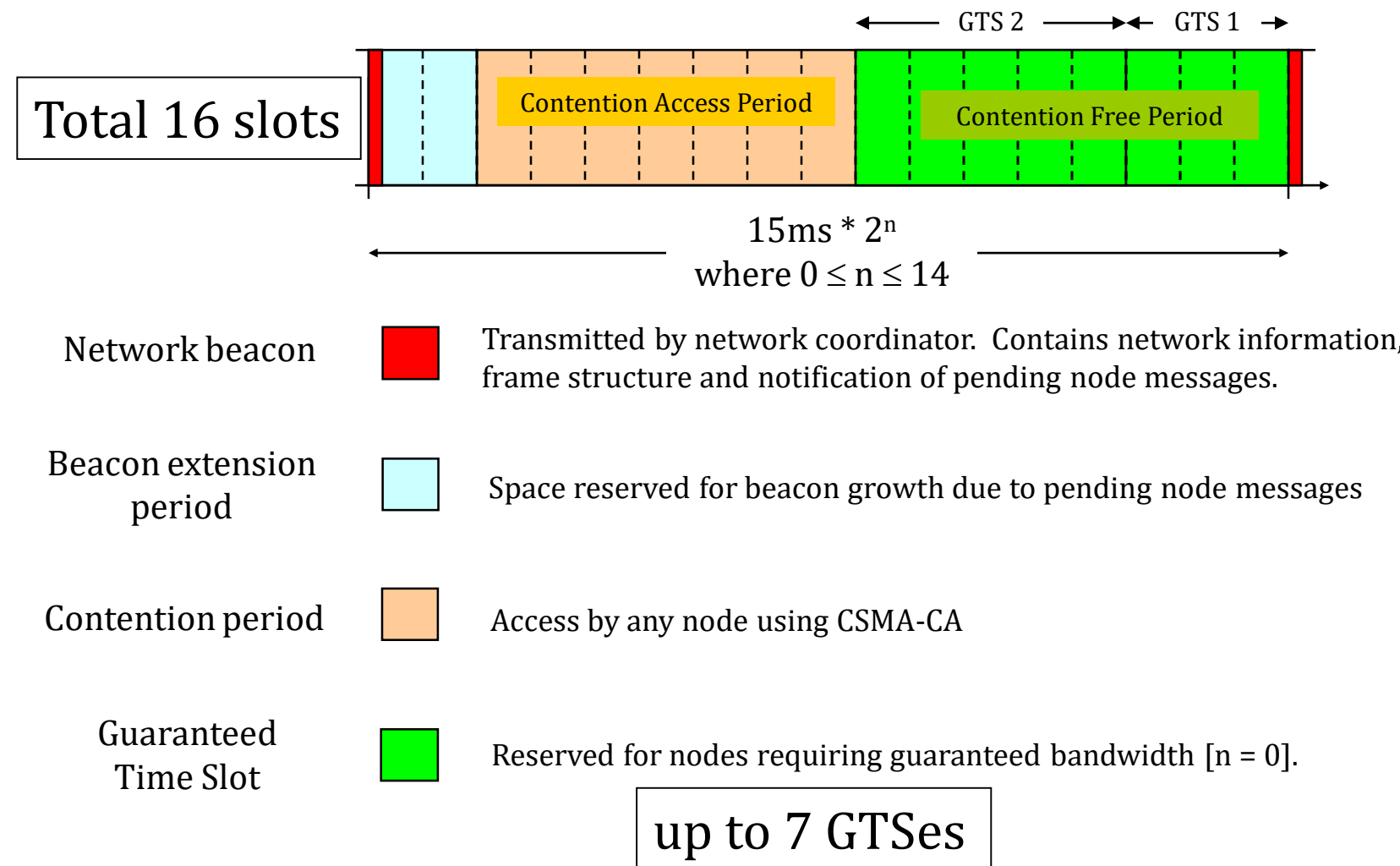
- Data transferred from coordinator to device
 - In a beacon-enabled network, the coordinator indicates in the beacon that “**data is pending.**”
 - Device periodically listens to the beacon and transmits a **MAC command request** using slotted CSMA/CA if necessary.



Communication from a coordinator
In a **beacon-enabled** network

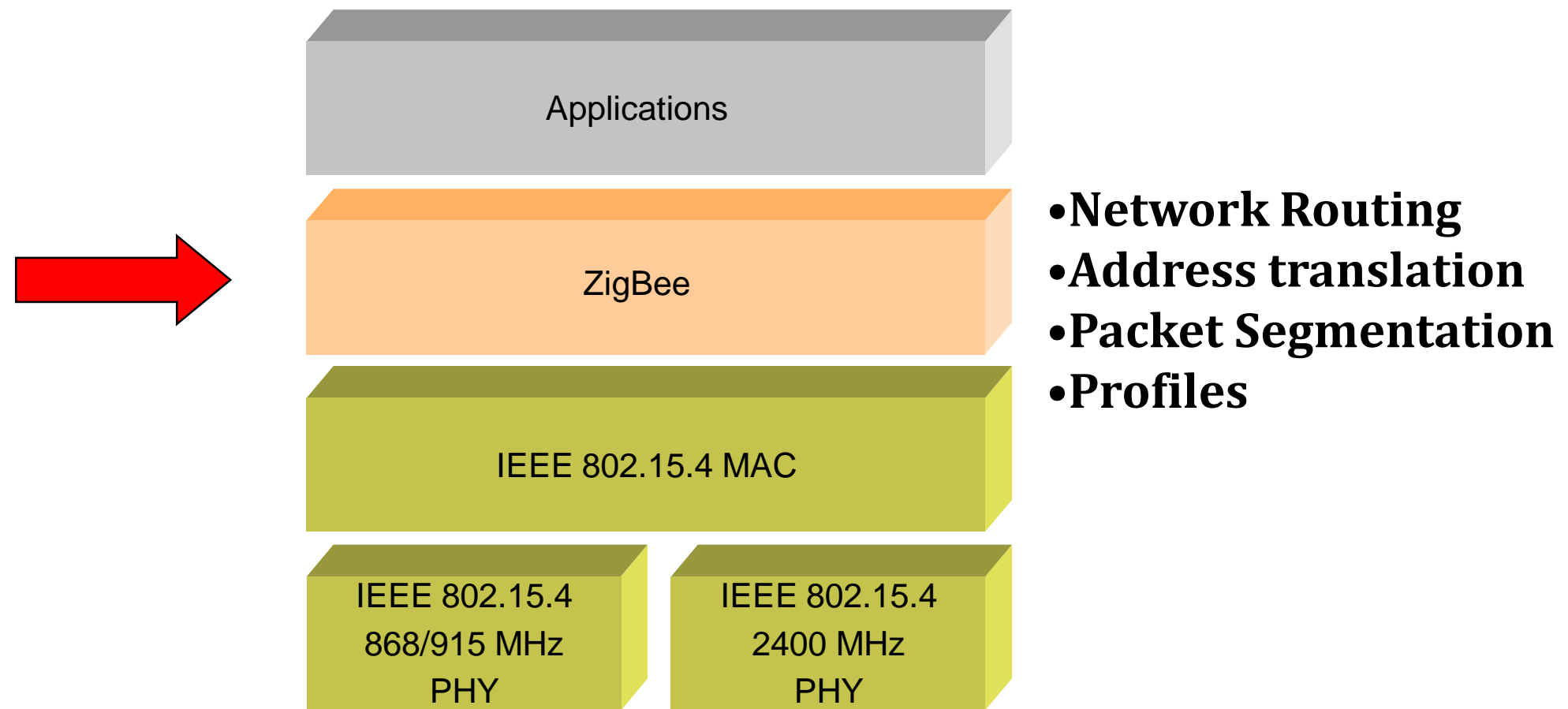


Superframe: CSMA-CA + TDMA



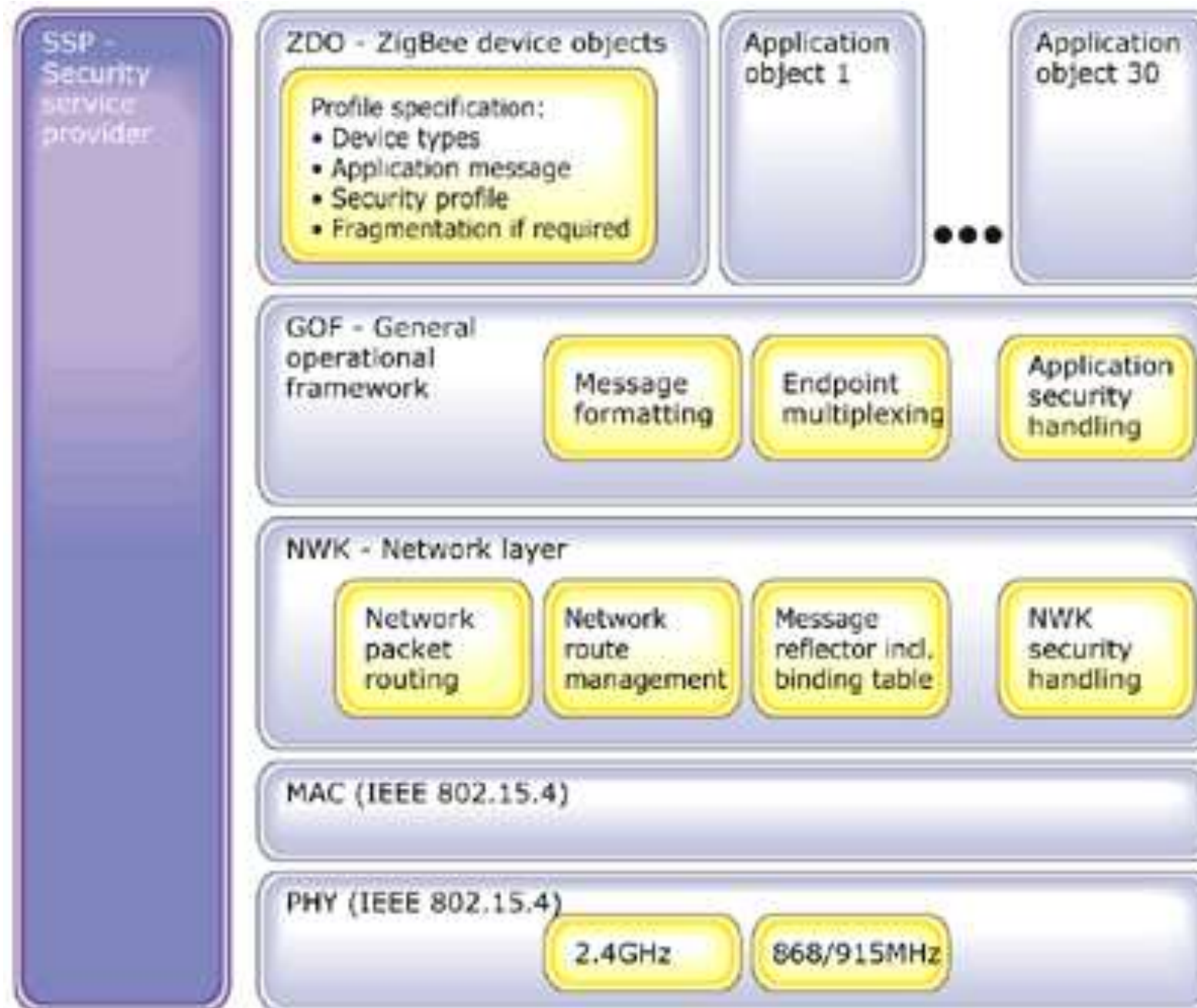


802.15.4 ARCHITECTURE





ZIGBEE STACK ARCHITECTURE :





COMPARISON WITH PEER TECHNOLOGIES!

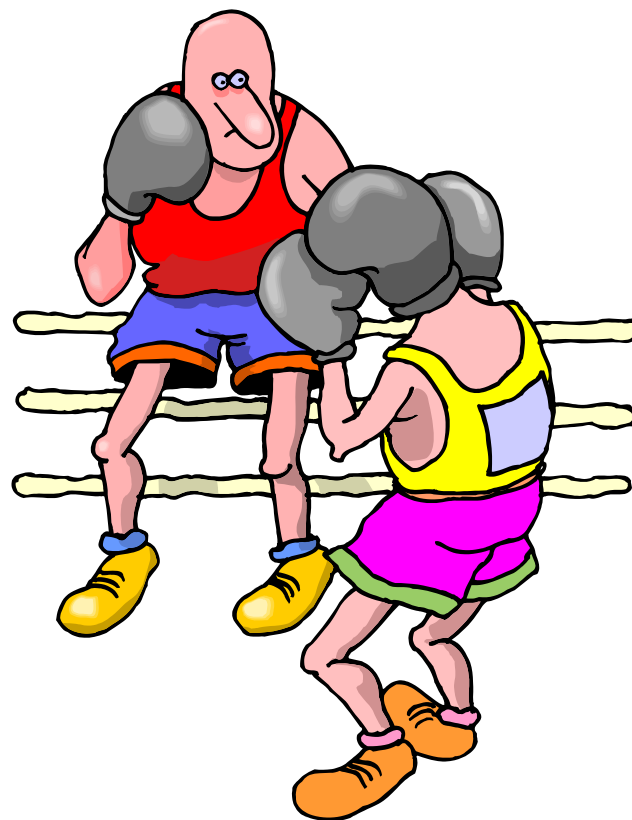
Feature(s)	IEEE 802.11b	Bluetooth	ZigBee
Power Profile	Hours	Days	Years
Complexity	Very Complex	Complex	Simple
Nodes/Master	32	7	64000
Latency	Enumeration upto 3 seconds	Enumeration upto 10 seconds	Enumeration 30ms
Range	100 m	10m	70m-300m
Extendability	Roaming possible	No	YES
Data Rate	11Mbps	1Mbps	250Kbps
Security	Authentication Service Set ID (SSID)	64 bit, 128 bit	128 bit AES and Application Layer user defined



ZIGBEE VS BLUETOOTH



Competition or Complementary?





Bluetooth is Best But ZigBee is Better

For :

- Ad-hoc networks between capable devices
- Handsfree audio
- Screen graphics, pictures...
- File transfer

If :

- The Network is static
- Lots of devices
- Infrequently used
- Small Data Packets





AIR INTERFACE



ZigBee

DSSS

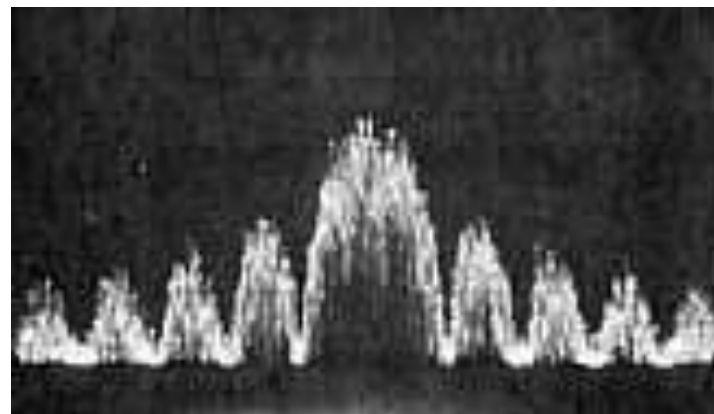
11 chips/ symbol

62.5 K symbols/s

4 Bits/ symbol

Peak Information Rate

~128 Kbit/second



Bluetooth

FHSS

1 M Symbol / second

Peak Information Rate

~720 Kbit/second





TIMING CONSIDERATIONS



ZigBee:

- New slave enumeration = 30ms typically
- Sleeping slave changing to active = 15ms typically
- Active slave channel access time = 15ms typically

Bluetooth:

- New slave enumeration = >3s
- Sleeping slave changing to active = 3s typically
- Active slave channel access time = 2ms typically

ZigBee protocol is optimized for timing critical applications



INITIAL ENUMERATION

ZigBee

Coordinator



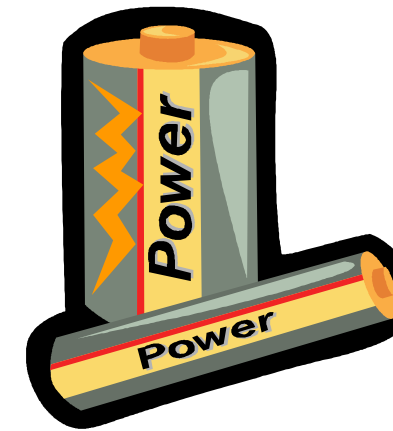
Bluetooth

Coordinator





POWER CONSIDERATIONS



ZigBee

- 2+ years from 'normal' batteries
- Designed to optimise slave power requirements

Bluetooth

- **Power model as a mobile phone (regular charging)**
- **Designed to maximise ad-hoc functionality**

Application example of a light switch with respect to latency and power consumption



SOME INTERESTING APPLICATIONS OF ZIGBEE



- Using the power of the mesh to automate a manual process
 - *Rental Car Return Automation**
- Long life battery powered sensing
 - *Wireless Termite Detection**

**From Software Technologies Group*



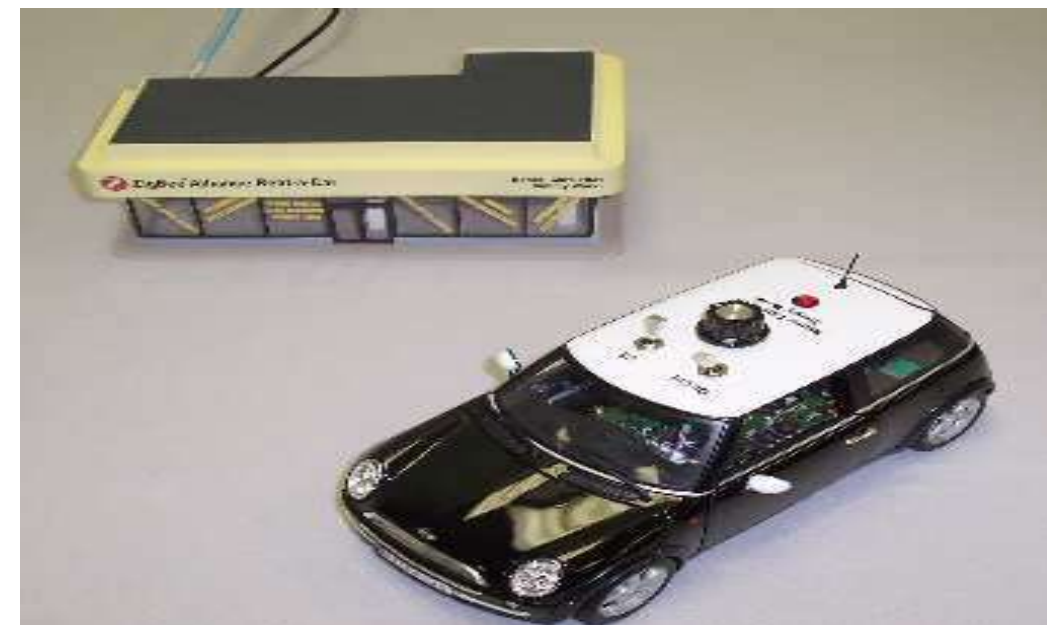
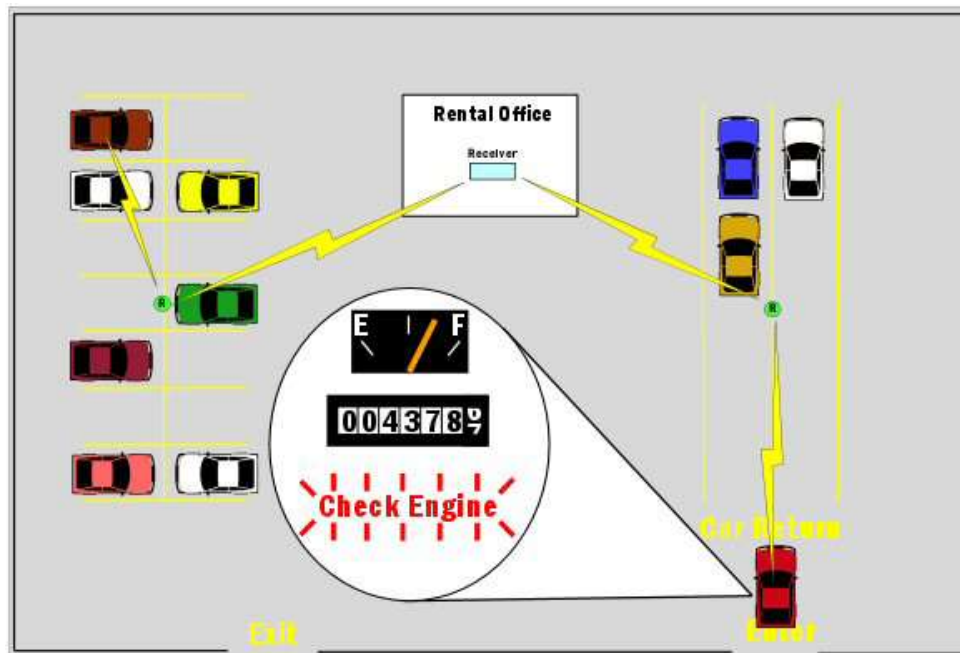
AUTOMATED RENTAL CAR RETURN*



Car Rental

File Settings

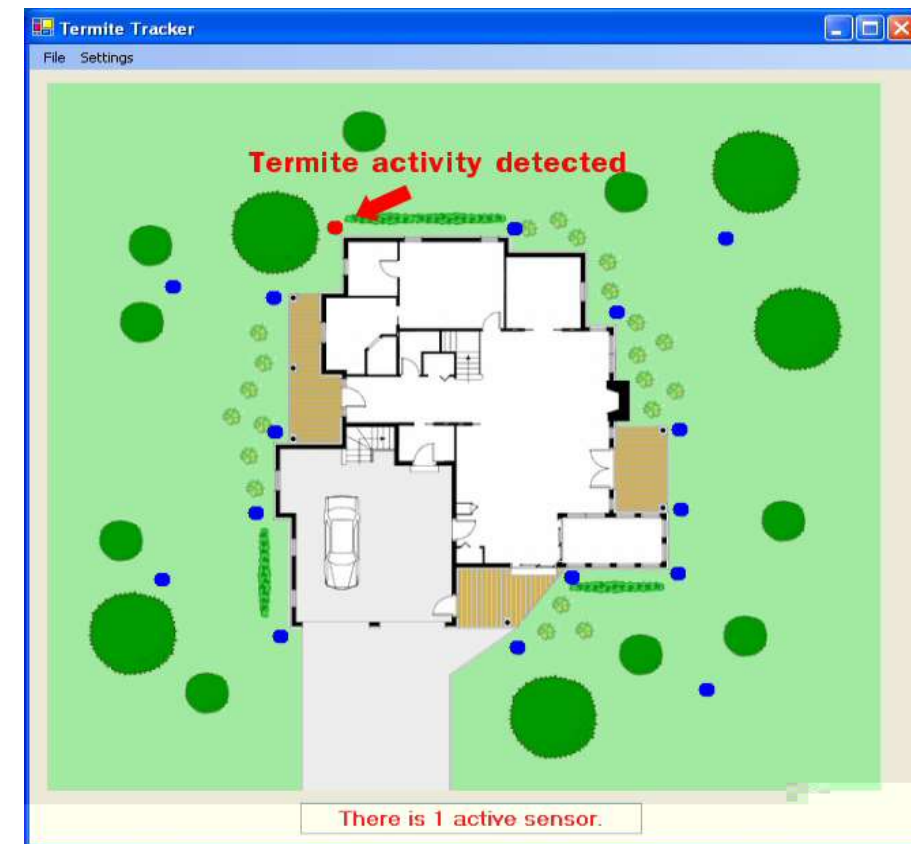
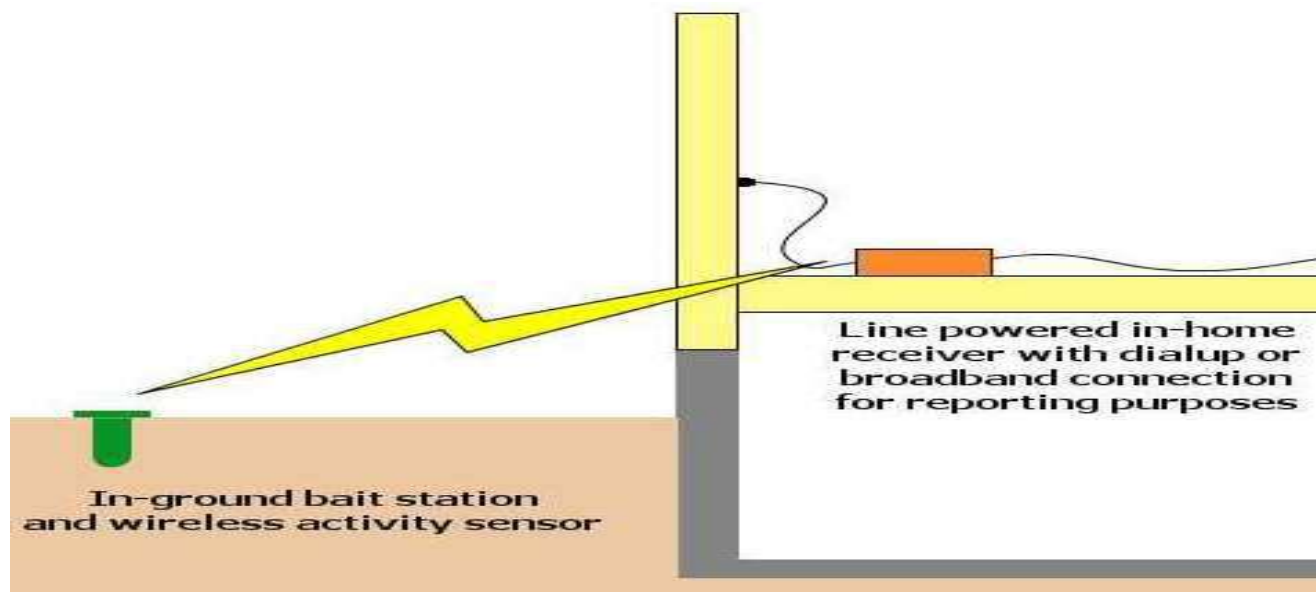
VIN	License	Description	Odometer	Fuel	Collision	Engine
WMWRC33412TC34910	MINI 723	2004 Mini Cooper, Black	57829	3/4	Check	Ok
WBAEH73455B191834	7Z 2715	2005 BMW 645Ci, Metallic Blue	87410	Empty	Ok	Check
WP0ZZZ99Z2S630474	SAB 1973	2003 Porsche 911, Silver	38579	1/2	Ok	Ok



**FROM SOFTWARE TECHNOLOGIES GROUP*



TERMITE DETECTION*



**From Software Technologies Group*



802.15.4/ZIGBEE PRODUCTS



Control4 Home Automation System
<http://www.control4.com/products/components/complete.htm>



Eaton Home HeartBeat monitoring system
www.homeheartbeat.com



Chip Sets

- Ember, <http://www.ember.com/index.html>
- ChipCon, <http://www.chipcon.com>
- Freescale, <http://www.freescale.com>



Software, Development Kits

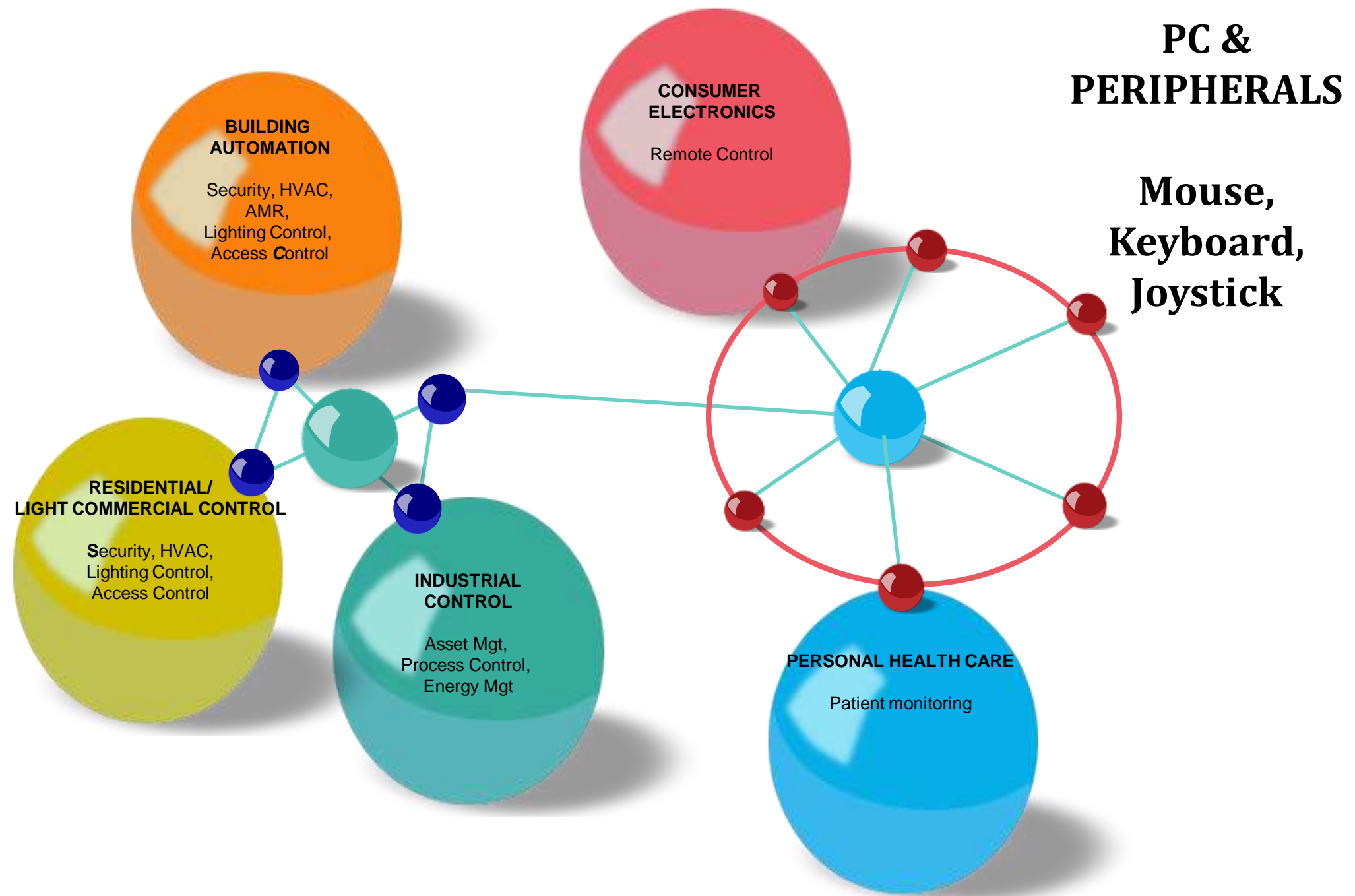
- AirBee, <http://www.airbeewireless.com/products.php>
- Software Technologies Group, <http://www.stg.com/wireless/>



Crossbow Technology - Wireless Sensor Networks
www.xbow.com



ZIGBEE WIRELESS MARKETS AND APPLICATIONS



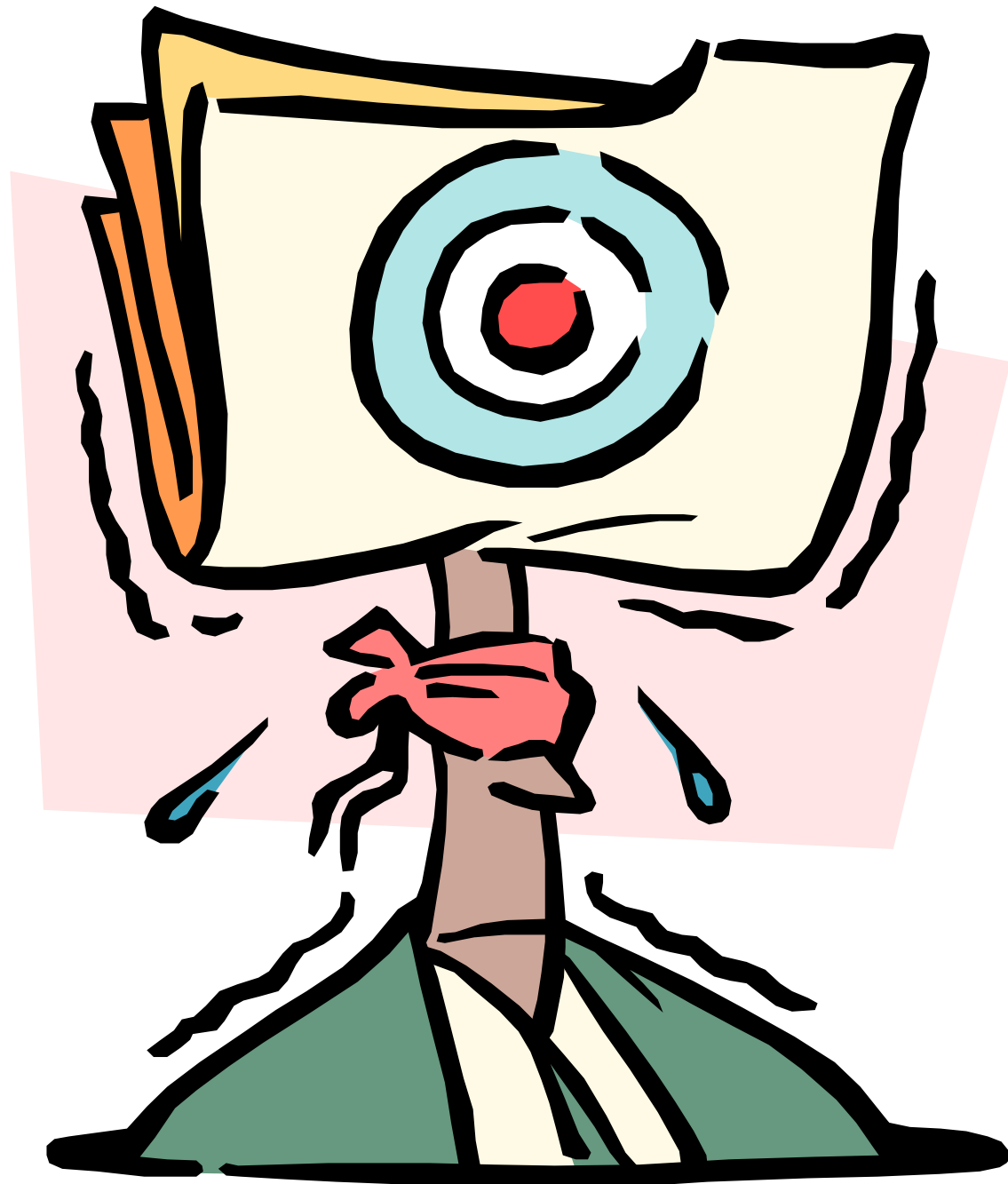


SUMMARY:

- 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. (Due to its architecture)



Any Questions /
Thank you



Shoot!