

# ZigBee™ - The New Standard for Wireless Monitoring and Control

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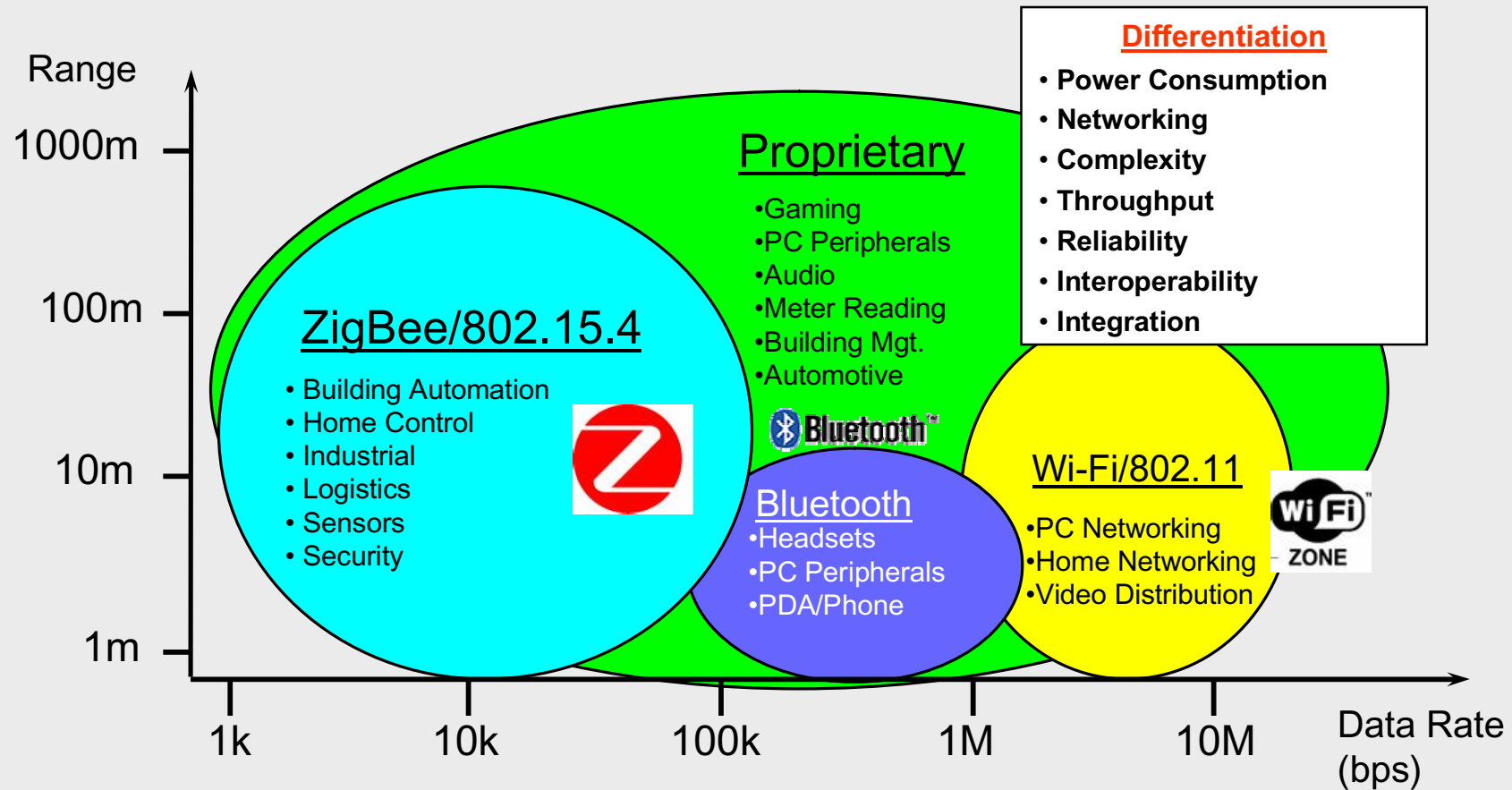
International workshop on: Technological  
advances for controlling indoor environment.  
November 25, 2005, Taastrup, Denmark



# Chipcon Overview

- ▶ **Established 1996; currently 112 employees**
- ▶ **Global technology company with HQ in Oslo**
- ▶ **Leading supplier of radios for short-range wireless communications**
  - ▶ High integration level, high performance, low power, RF-transceivers and transmitters, System-on-Chips (SoCs)
  - ▶ One-stop shop HW/SW solutions
- ▶ **Market and technology leader in Consumer Electronics**
- ▶ **Market and technology leader in ZigBee for Home and Building Automation**

# Short-range Wireless Communications



# Wireless Monitoring and Control Systems

- ▶ Large number of nodes → wireless solutions are required
- ▶ Low-complexity and low power protocol
- ▶ Low system cost

# Wireless Monitoring and Control Systems

- ▶ **Sensor nodes have typically only limited amount of data to send**
- ▶ **Sensor nodes remain quiescent in long periods of time**

## What is ZigBee ?

- ▶ **“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 Promoters: BM, Chipcon, Ember, Freescale, Honeywell, Mitsubishi Electric, Motorola, Philips and Samsung**
- ▶ **More than 180 member companies**





**IEEE 802.15.4 and ZigBee**

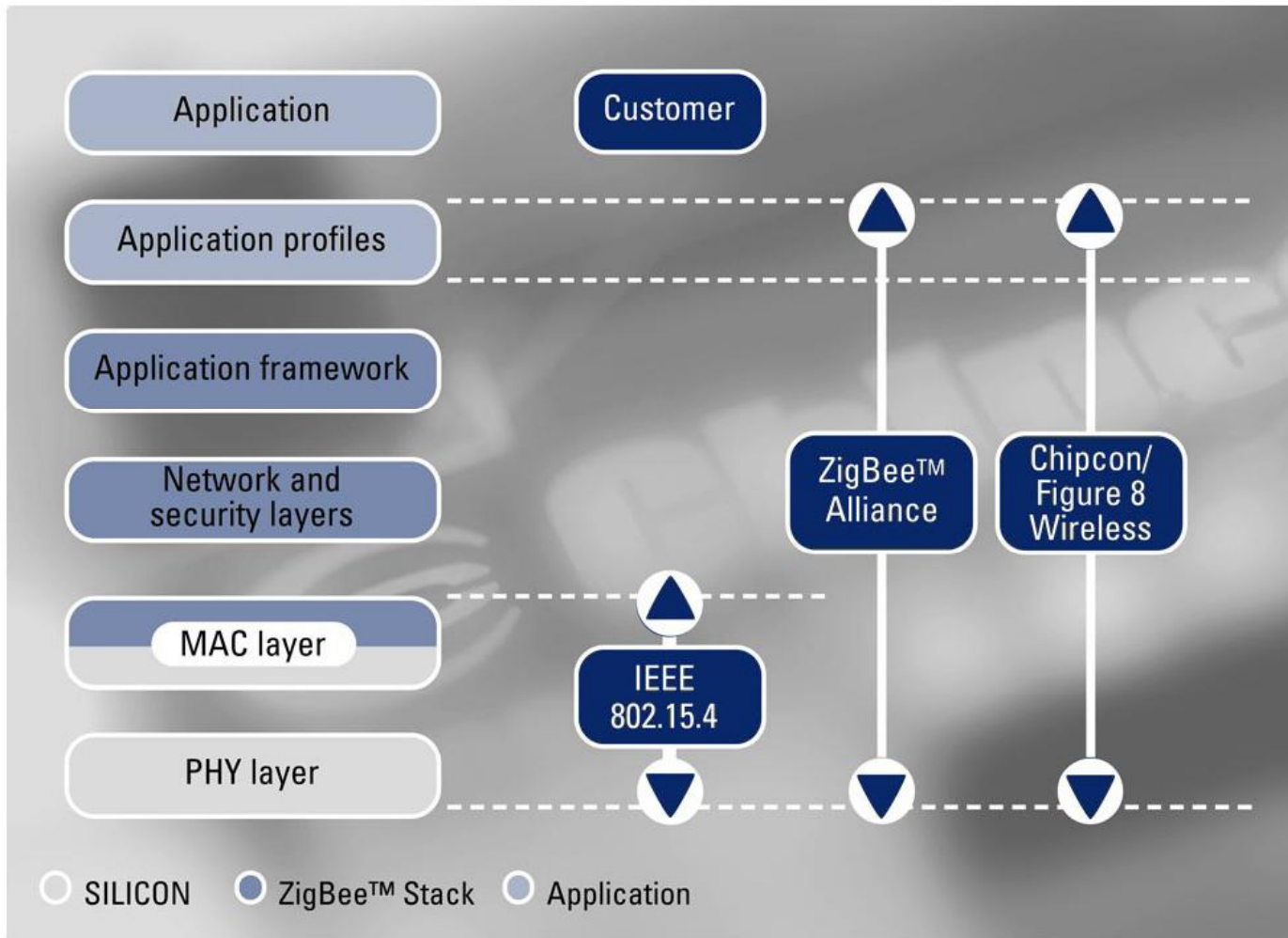
- ▷ ...In home and building automation
- ▷ ...In alarm and security systems
- ▷ ...In PC & peripherals
- ▷ ...In sensor networks
- ▷ ...In consumer electronics
- ▷ ...In personal health care

# Why ZigBee?

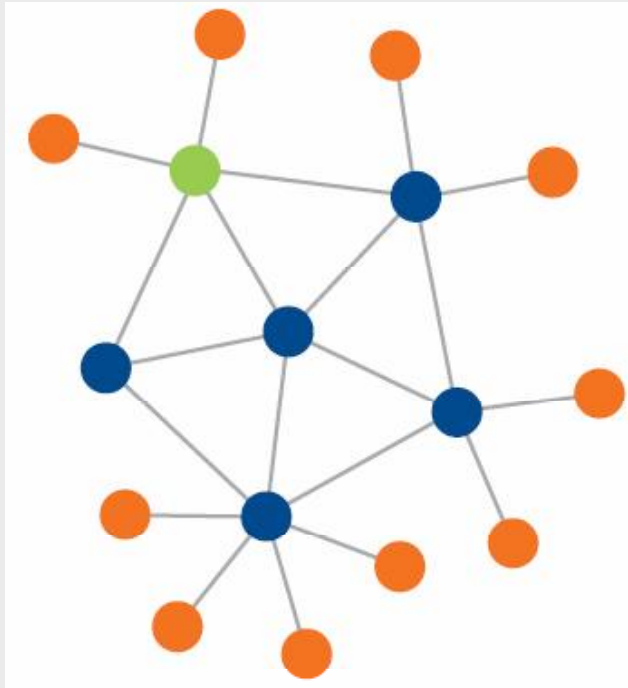
<b>Standard</b>	<b>ZigBee™ / IEEE 802.15.4</b>	<b>Wi-Fi™ / IEEE 802.11b</b>	<b>BlueTooth™ / IEEE 802.15.1</b>
<b>Application focus</b>	<b>Monitoring &amp; Control</b>	<b>Web, Email, Video</b>	<b>Ad hoc cable Replacement</b>
<b>Stack Size (kBytes)</b>	<b>&lt; 128</b>	<b>1000 +</b>	<b>250 +</b>
<b>Battery Life (days)</b>	<b>100 – 1000 +</b>	<b>0.5 - 5</b>	<b>1 - 7</b>
<b>Network Size (#nodes)</b>	<b>~Unlimited (65536)</b>	<b>Many</b>	<b>7</b>
<b>Bandwidth (kbps)</b>	<b>250</b>	<b>11 000</b>	<b>1000</b>
<b>Range (meters)</b>	<b>100 +</b>	<b>100</b>	<b>10 +</b>
<b>Target BOM costs</b>	<b>&lt; \$ 3</b>	<b>\$ 9</b>	<b>\$ 5</b>



# ZigBee Protocol Stack



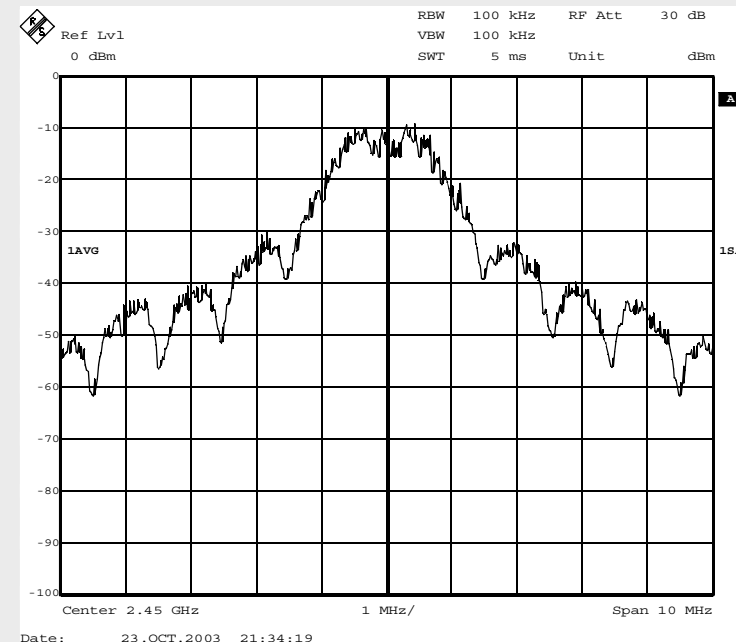
# IEEE 802.15.4 PHY and MAC



- ▶ **Standard for low data rate wireless Personal Area Networks (PANs)**
- ▶ **Focus on low power, low cost and robustness**
- ▶ **Defines the physical (PHY) and medium access control (MAC) communication layers**
- ▶ **250 kbps at 2.4 GHz, available world-wide**

# IEEE 802.15.4 PHY Layer (2.4 GHz)

- ▶ Operates in the 2.4 GHz frequency band
- ▶ Defines 16 channels, with 5 MHz spacing
- ▶ Uses Direct Sequence Spread Spectrum (DSSS)
- ▶ Robust against interferers
- ▶ Packets up to 127 bytes
- ▶ Raw bit rate of 250 kbps
- ▶ Bandwidth of ~3 MHz
- ▶ Focus on co-existence with Bluetooth™ / Wi-Fi™.  
Practical testing shows very good co-existence



Spectrum measured from Chipcon CC2420

# IEEE 802.15.4 MAC Layer

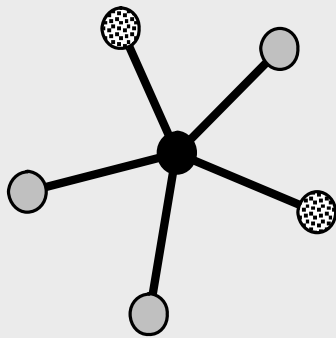
- ▶ CSMA-CA for collision avoidance
- ▶ Acknowledge and retransmission of data packets
- ▶ Node addressing
- ▶ Frame Check Sequence - FCS (CRC check)
- ▶ Transmitting optional beacons in the network
- ▶ Synchronizing to optional beacons
- ▶ Association / Disassociation on a network
- ▶ MAC layer security (based on AES-128 encryption)
- ▶ Gives the higher layer (e.g. The ZigBee network layer) a robust link for transmitting data ONE hop

## ZigBee Higher Layers

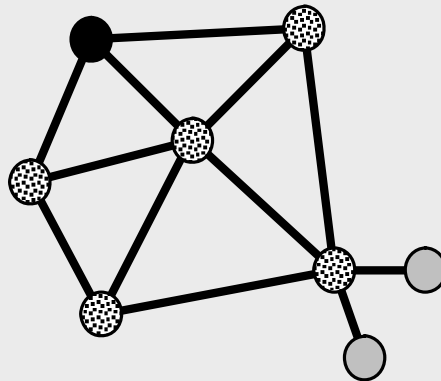
- ▶ Includes reliable and robust network layer
- ▶ Intelligent channel selection
- ▶ Extends communication range through multiple hops
  - ▶ “Self healing” in the event of errors
- ▶ Can use optional routing tables for optimising network traffic
- ▶ Includes application profiles for interoperability

# Types of networks

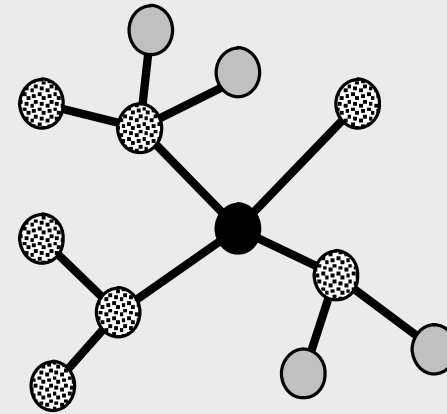
▶ ZigBee defines three network topologies:



Star



Mesh



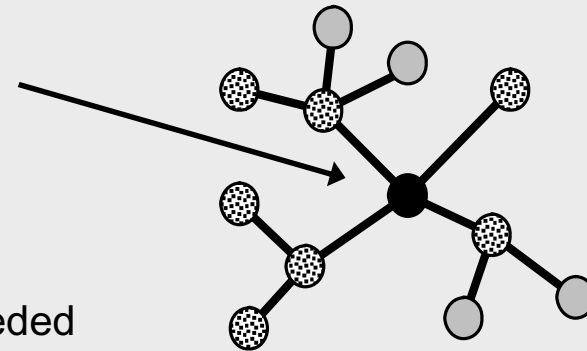
Tree

- PAN Coordinator - “Coordinator”
- Full Function Device - “Router”
- Reduced Function Device - “End Device”

# Network pieces – PAN Coordinator

## ▶ PAN Coordinator

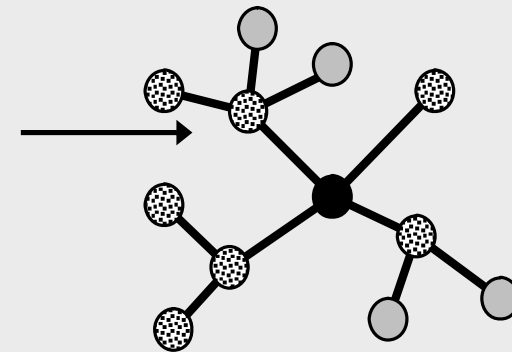
- ▶ “owns” the network
  - ◊ Starts a PAN
  - ◊ Allows other devices to join it
    - Saves messages for children as needed
  - ◊ Provides binding and address-table services
  - ◊ And more... could also have i/o capability
- ▶ A “full-function device” – FFD
- ▶ Mains powered



# Network pieces - Router

## ▶ Router

- ▶ Routes messages
- ▶ Does not own or start network
  - Scans to find a network to join
- ▶ Allows other devices to join it
  - Saves messages for children as needed
- ▶ A “full-function device” – FFD
- ▶ Mains powered depending on topology

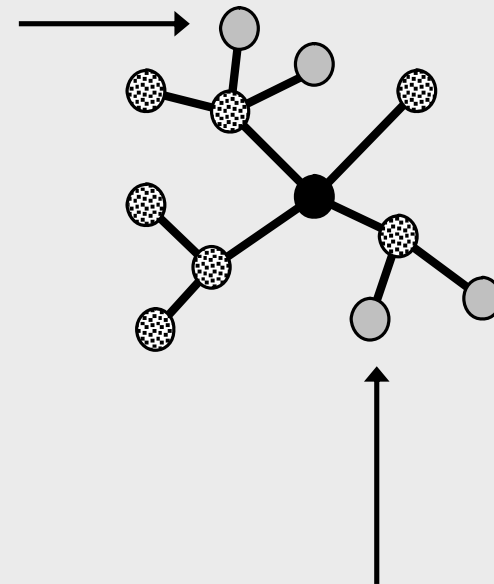




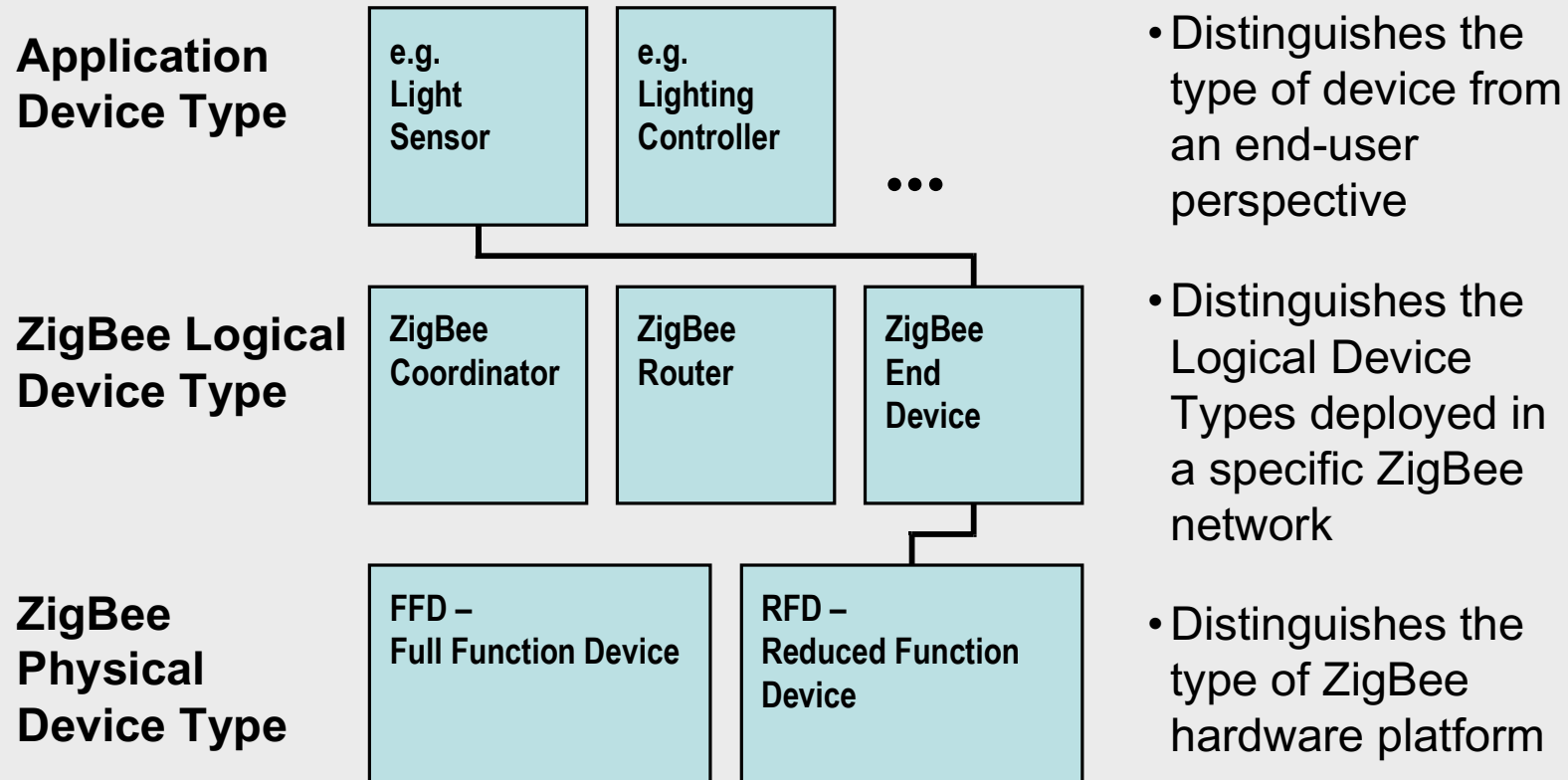
# Network pieces – End Device

## ▶ End Device

- ▶ Does not route messages
- ▶ Does not own or start network
  - Scans to find a network to join
- ▶ Does not allow other devices to join it
- ▶ Polls parent to get messages
- ▶ A “reduced-function device” – RFD



# ZigBee Device Type Model



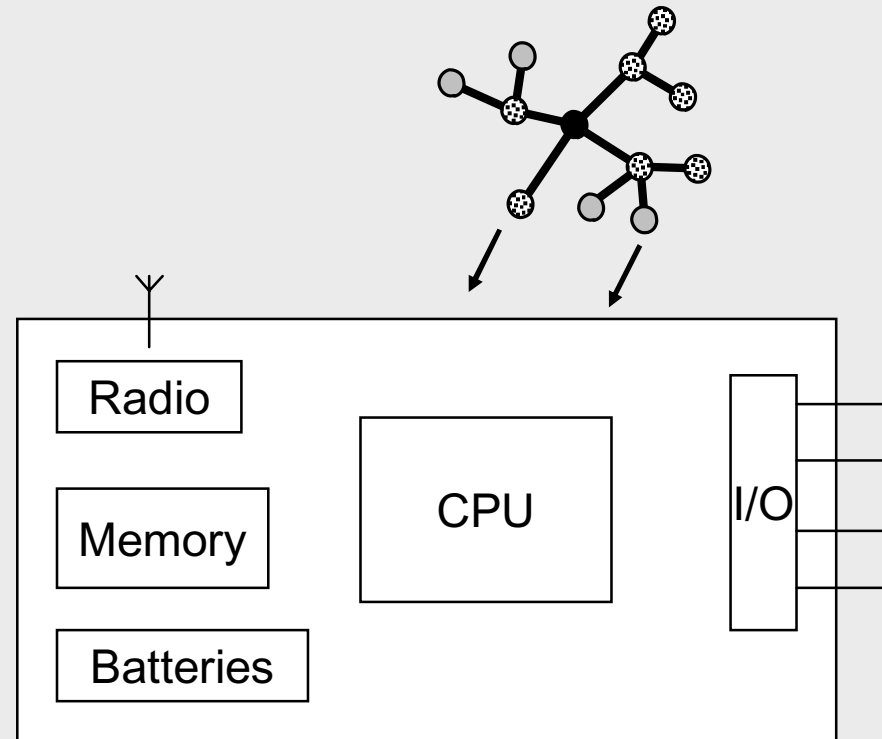
- ZigBee products are a combination of Application, ZigBee Logical, and ZigBee Physical device types
- Profiles may define specific requirements for this combination, but can also leave this up to manufacturers

# Inside a typical node

## ▶ Software:

- ▶ RTOS
- ▶ Radio MAC driver
- ▶ Protocol stack
  - ◊ Defines Coordinator, Router or End Device
- ▶ I/O functions
- ▶ Application code

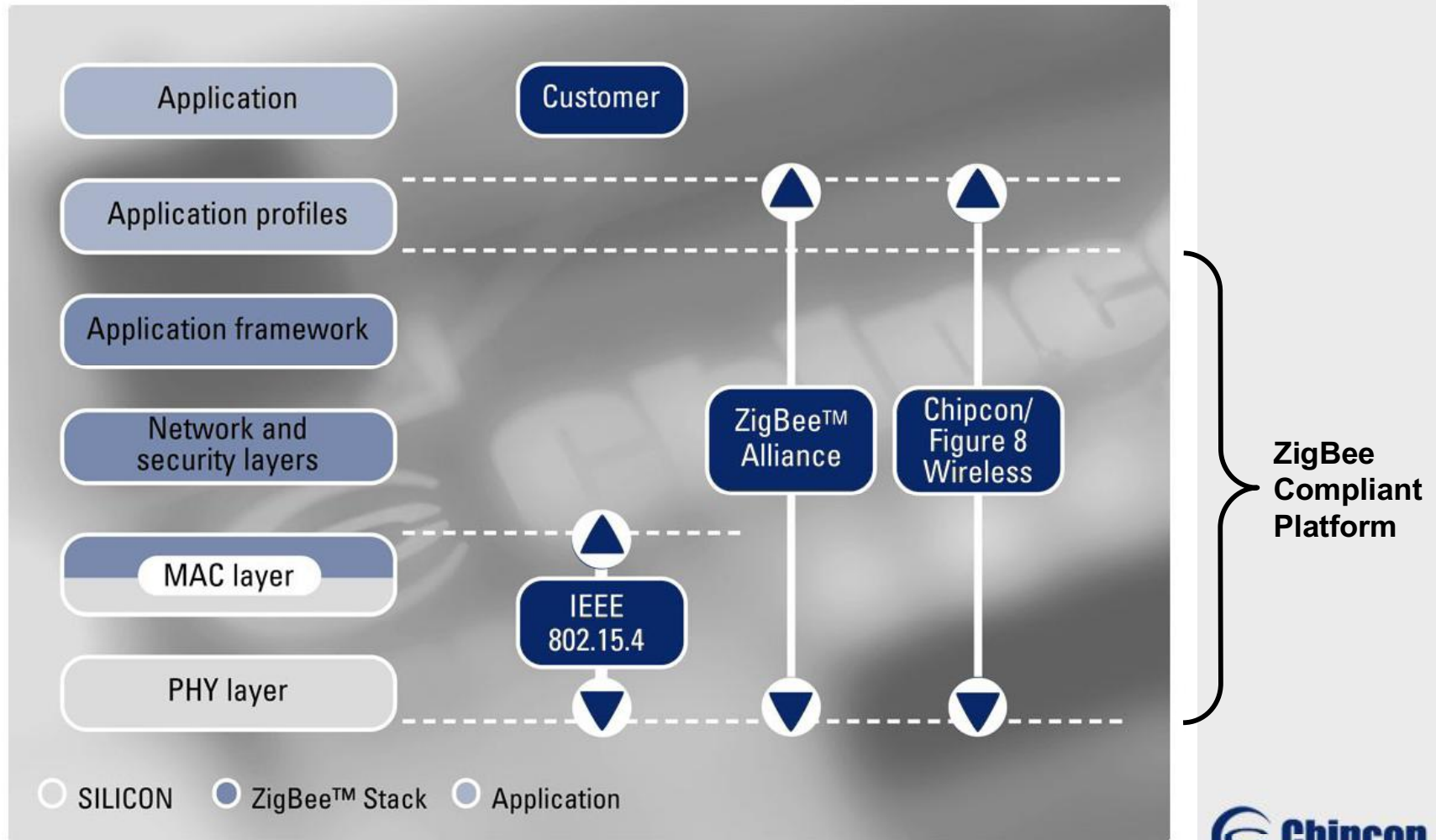
## ▶ User interface ?



# Typical ZigBee Platform Requirements

- ▶ **For battery operated nodes: Need low active power consumption of RF-transceiver and MCU**
- ▶ **Must also have MCU sleep modes with ultra-low power consumption**
  - ▶ In many applications the standby power is the dominant portion of the total power consumption
  - ▶ Wake up on interrupts
  - ▶ Wake-up on time-out event of real-time-clock
- ▶ **Equally important with very fast transition times from sleep modes to active**

# ZigBee Compliant Platform

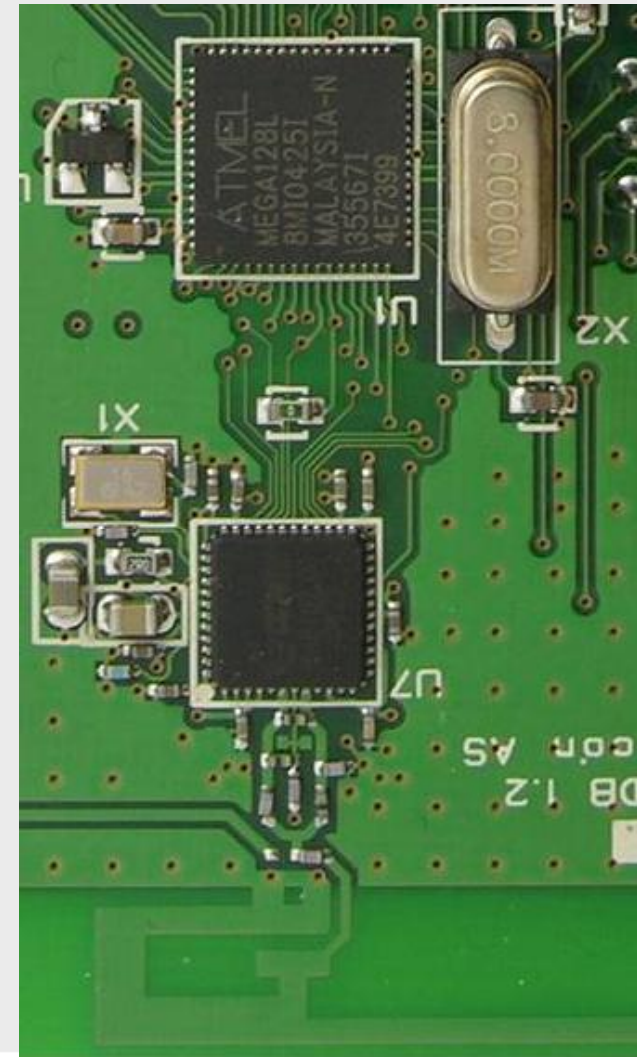


# ZigBee System Development

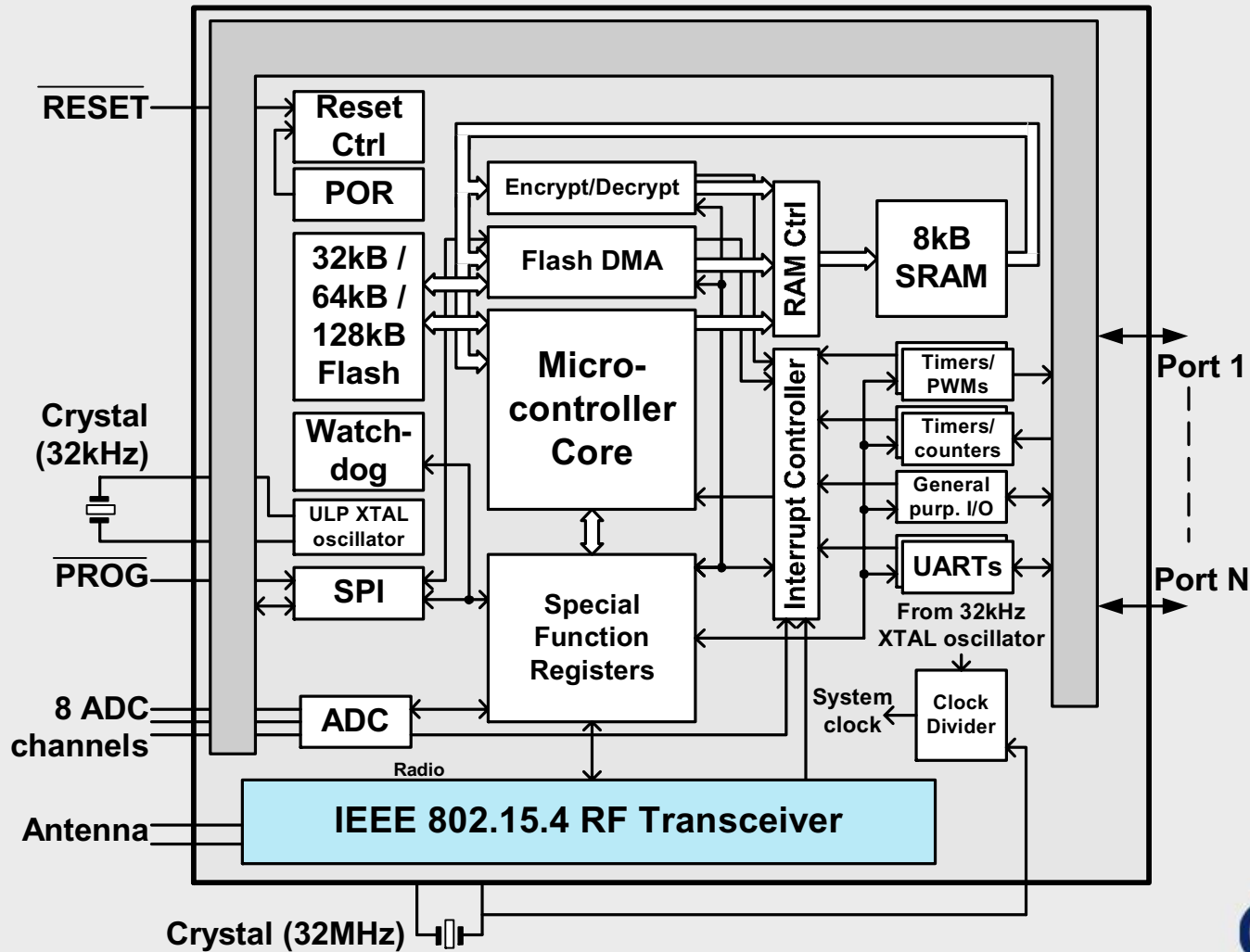
- ▶ ***The benefits with using a ZigBee Compliant Platform:***
  - ▶ Prequalified according to ZigBee requirements
  - ▶ Reduces development and certification costs
  - ▶ Shortens time-to-market
- ▶ **Note: The end-product must go through a ZigBee certification and interoperability program to claim that it is "*ZigBee Certified*"**
- ▶ **Note: Regulatory approvals come in addition (e.g. FCC/ARIB/ETSI)**

# ZigBee Compliant Platform Example

- ▶ **Embedded Software:**
  - ▶ ZigBee software stack (Z-Stack from Figure 8 Wireless / Chipcon)
  - ▶ IEEE 802.15.4 MAC functions
- ▶ **Hardware, i.e. PCB reference design, including:**
  - ▶ IEEE 802.15.4 RF-transceiver (CC2420)
  - ▶ Microcontroller
  - ▶ Antenna solution/connection



# CC2430 - System-on-Chip for ZigBee Systems





## Summary

- ▶ **ZigBee provides intelligence and wireless network capabilities into everyday devices**



**CHIPCON HELPS THE WORLD  
CONNECTING SMARTER**

