

Ubiquitous Networks

# 802.15: WPAN



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# 802.15

## IEEE 802.15

- ▶ **IEEE 802.15** is the 15<sup>th</sup> working group of the IEEE 802 and specializes in Wireless PAN (Personal Area Network) standards (PHY and MAC layer).

## 7 Task groups

- ▶ **IEEE 802.15.1 (Bluetooth)**
- ▶ IEEE 802.15.2 (Coexistence): WPAN coexistence with other wireless devices operating in unlicensed frequency bands such as WLAN
- ▶ **IEEE 802.15.3 (High Rate WPAN)**
- ▶ **IEEE 802.15.4 (Low Rate WPAN)**
- ▶ IEEE 802.15.5 (Mesh Networking): mesh networking with WPANs
  - ◆ Network initialization, addressing, multi-hop routing, multicast, etc. for 15.3/4
- ▶ IEEE 802.15.6 (BAN): body area network, short-range wireless standards
- ▶ IEEE 802.15.7 (VLC): visible light communication



# Body Area Network (802.15.6)

- ❏ **Wireless communication for wearable computing devices**
  - ▶ Communication between several small body sensor units (BSU) and a single body central unit (BCU) worn at the human body by using WPAN technologies
- ❏ **Applications**
  - ▶ Healthcare
    - ◆ Monitoring and logging vital parameters such as diabetes, asthma, and heart attacks
  - ▶ Sports, Military, and Security
- ❏ **Sensors**
  - ▶ Vital sign monitoring sensors, motion detectors
    - ◆ ECG, SpO2, blood pressure, EEG
- ❏ **Physical**
  - ▶ 40MHz channel allocated for 2.4GHz band for medical applications



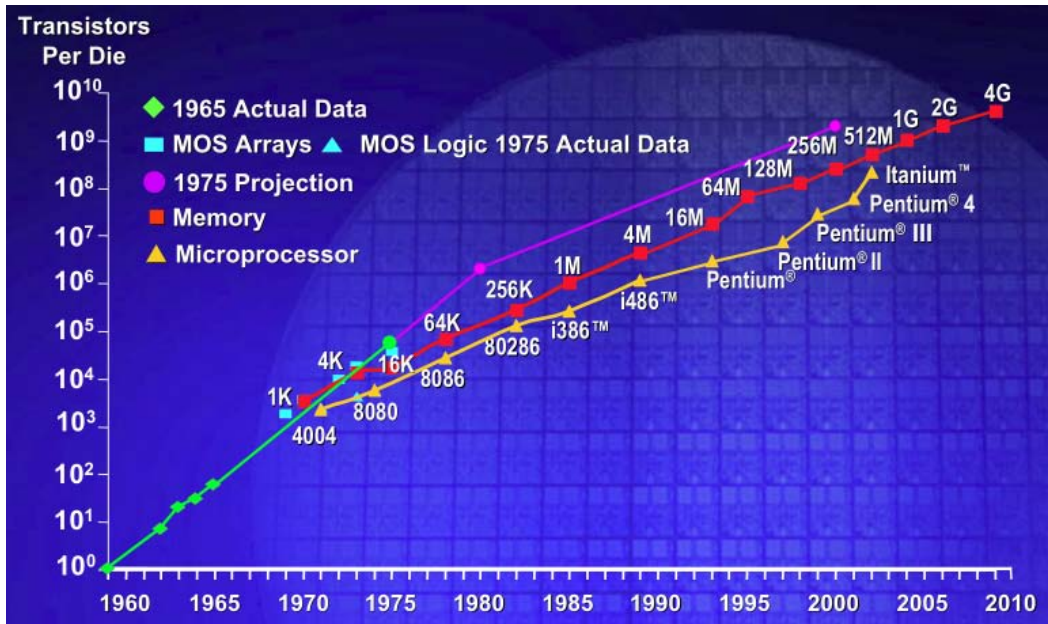
# New Generation of Computing Devices

## Moore's law

- ▶ # of transistors per chip doubles every 1~2 years

## Bell's law

- New computing class appears every 10 years
  - 1960's mainframe
  - 1970's minicomputer
  - 1980's workstation/PC
  - 1990's PC/mobile phones
  - 2000's PDA/mobile phones
  - 2010's smart phones
  - 2020's wearable sensors



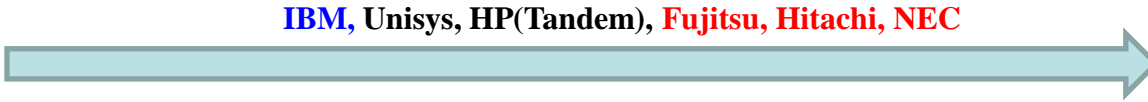
Source: Intel Corporation



# Computing Generations and Industry



IBM System/360



IBM zEnterprise



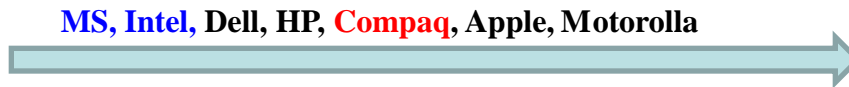
DEC PDP-11



SUN SparcStation 10



IBM PC AT



DELL PC



Palm Pilot



Apple iPhone

Apple, Google



Samsung Galaxy II



# 802.15

## IEEE 802.15.1

- ▶ **IEEE 802.15.1** is the WPAN standard based on the Bluetooth specifications. It includes a media access control and physical layer specification.
- ▶ **Bluetooth** is an open wireless technology standard for exchanging data over short distances (using short wavelength radio transmissions) from fixed and mobile devices, creating personal area networks (PANs) with high levels of security.
  - ◆ Created by telecoms vendor Ericsson in 1994, it was originally conceived as a wireless alternative to RS-232 data cables. It can connect several devices, overcoming problems of synchronization.

## IEEE 802.15.3

- ▶ MAC and PHY standard for high-rate (11 to 55 Mbit/s) WPANs.

## IEEE 802.15.4

- ▶ MAC and PHY standard for low data rate but very long battery life (months or even years) and very low complexity. The first edition of the 802.15.4 standard was released in May 2003.



# 802.15.4

## IEEE 802.15.4

- ▶ **IEEE 802.15.4-2006** is a standard which specifies the physical layer and media access control for low-rate wireless personal area networks (LR-WPANs).
- ▶ It is the basis for the ZigBee specification.
- ▶ Can be used with 6LoWPAN to build a Wireless Embedded Internet.

## ZigBee

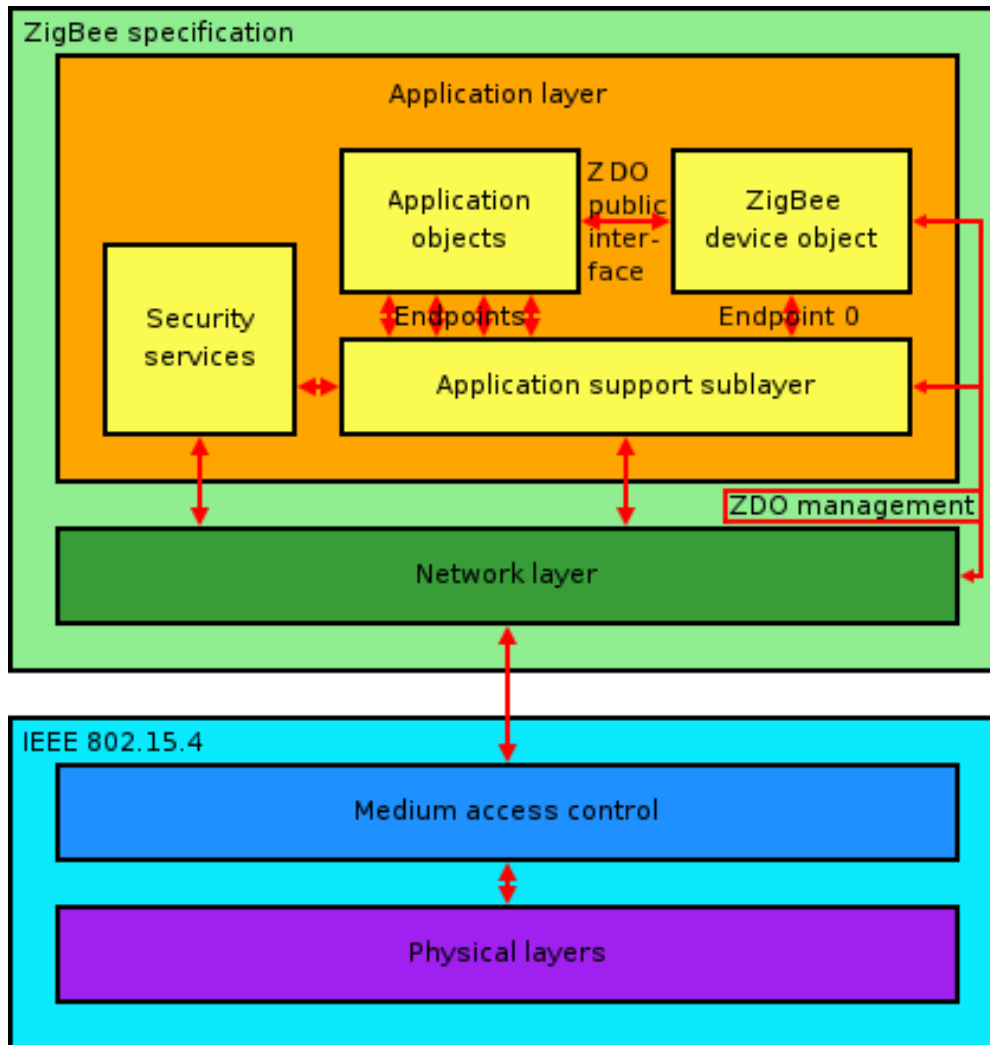
- ▶ A specification for a suite of high level communication protocols using small, low-power digital radios based on the IEEE 802.15.4-2003 standard.
- ▶ For wireless home area networks (WHANs), such as wireless light switches, electrical meters with in-home-displays, consumer electronics equipment.
- ▶ Simpler and less expensive than other WPANs, such as Bluetooth.

## 6LoWPAN

- ▶ **6lowpan** (IETF working group) is an acronym of *IPv6 over Low power WPAN*
- ▶ 6lowpan group has defined encapsulation and header compression mechanisms that allow IPv6 packets to be sent /received from over IEEE 802.15.4 networks.
- ▶ Applications: wireless embedded internet, smart grid



# Zigbee Protocol Stack



Source: [www.wikipedia.org](http://www.wikipedia.org)





# 802.15.4 PHY/MAC

## PHY layer

- ▶ Use unlicensed frequency bands
  - ◆ 868MHz (Europe) / 915 MHz (North America): 20~40 kbps up to 100~250kbps
  - ◆ 2.4GHz (World): 250kbps
- ▶ Modulation
  - ◆ DSSS (Direct Sequence Spread Spectrum)
  - ◆ Binary or offset quadrature *phase shift keying*, *amplitude shift keying*
  - ◆ Direct sequence UWB (<1GHz, 1~3GHz, 6~10GHz), CSS (Chirp Spread Spectrum, 2.4GHz)

## MAC layer

- ▶ MAC allows the transmission of MAC frames through the use of the physical channel. It manages access to the physical channel through network beaconing, controls frame validation, guarantees time slots and handles node associations.



# 802.15.4 Node Type

## ▣ Node type

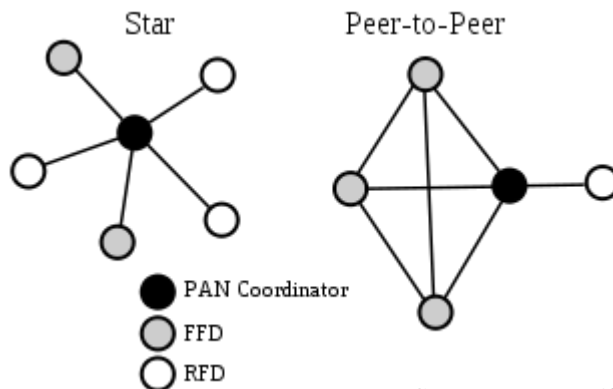
- ▶ **Full-function device (FFD)** serve as the coordinator of a personal area network just as it may function as a common node. It implements a general model of communication which allows it to talk to any other device: it may also relay messages, in which case it is dubbed a coordinator (PAN coordinator )
- ▶ **Reduced-function devices (RFD)** extremely simple devices with very modest resource and communication requirements; due to this, they can only communicate with FFD's and can never act as coordinators.



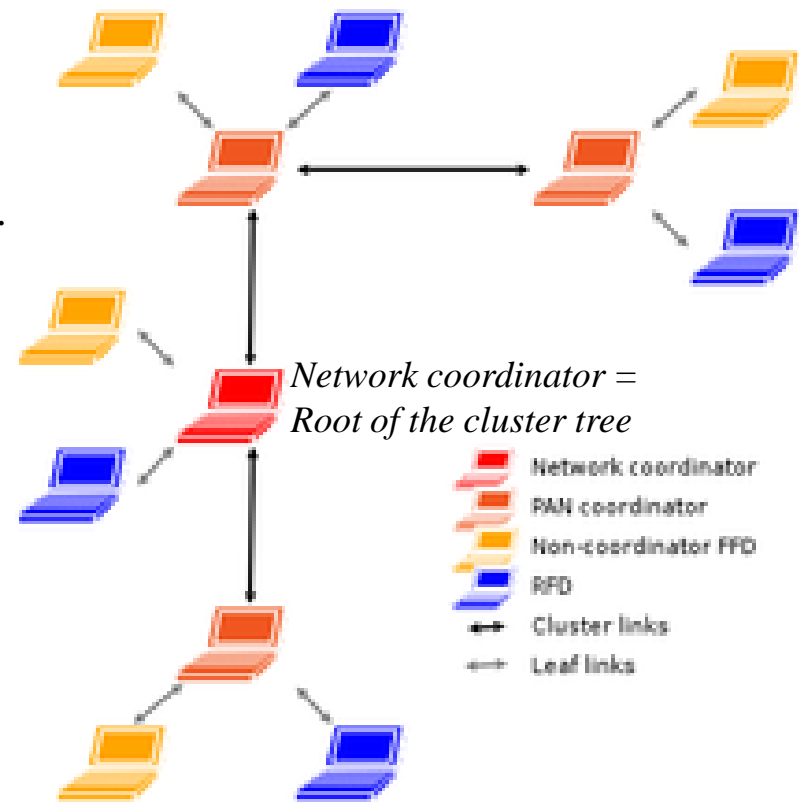
# 802.15.4 Topology

## Topology

- ▶ Either peer-to-peer or star networks
  - ◆ P2P: ad-hoc multi-hop network
    - ✦ Cluster Tree
    - ✦ Mesh network
  - ◆ Star network
    - ✦ A FFD declare itself its coordinator. After that, other devices can join.
- ▶ Every network needs at least one FFD to work as the coordinator of the network.



Source: [www.wikipedia.org](http://www.wikipedia.org)





# 802.15.4 MAC

## Frames

- ▶ Frames are the basic unit of data transport, of which there are four fundamental types (data, acknowledgment, beacon and MAC command frames)

## Superframe

- ▶ Each superframe consists of 16 equally sized slots and is bounded by network beacons, which are periodically broadcast by a designated coordinator device.
- ▶ During the *contention access period*, the *slotted* mode of the CSMA-CA algorithm is used, while transmissions in the *contention free period* take place according to pre-assigned guaranteed timeslots. Up to 7 slots can be allocated by a coordinator upon device's request

