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ZigBee: Standard for Control and Sensor Networks

ITG FG 5.2.4 Workshop
„Ad hoc, Sensor and Mesh Networking:
New Opportunities for Wireless Communication"
München, 10.02.2005

Contents

- IEEE PAN Standards
- ZigBee Protocol stack
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  - MAC Layer
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IEEE PAN Standards

PAN: interconnection of information technology devices within the range of an individual person (typically within a range of 10 meters)

IEEE 802.15 working groups:

- 802.15.1 = Bluetooth
- 802.15.2 = Interoperability
- 802.15.3 = High data rate communication
- 802.15.4 = Low data rate communication (**ZigBee**)

ZigBee: from the zig-zag path of bees that for mesh networks between flowers

ZigBee: Technology Drivers

- Long battery life
- Ease of installation
- Reliable data transfer
- Short-range operation
- Extremely low-cost
- Simple and flexible protocol

ZigBee/ IEEE 802.15.4 developed by 

ZigBee Alliance Members

More than 90 members

ZigBee Alliance

Promoters

Honeywell

MITSUBISHI ELECTRIC

PHILIPS
Let's make things better.

invensys

SAMSUNG

MOTOROLA
intelligence everywhere

Participants

ABB

ADCON TELEMETRY

ANALOG DEVICES

ARDESTA
Leading the Small Tech Revolution.

ATMEL

BOSCH

Cambridge Consultants

Chipcon

CompXs

Danfoss

EATON

ember

ETS

figure 8 wireless

LEVITON

france telecom

Helicomm

INOVONICS WIRELESS CORPORATION

INTEGRATION ASSOCIATES

hp invent

intel

Micro Linear

NTS

OKI

OMRON

XEMICS

betronic
THE POWER OF INNOVATION

RF MICRO·DEVICES

Millennial Net
Wireless Data Links

ZMD

BlueChip communications

XANBOO

zensys

duolog

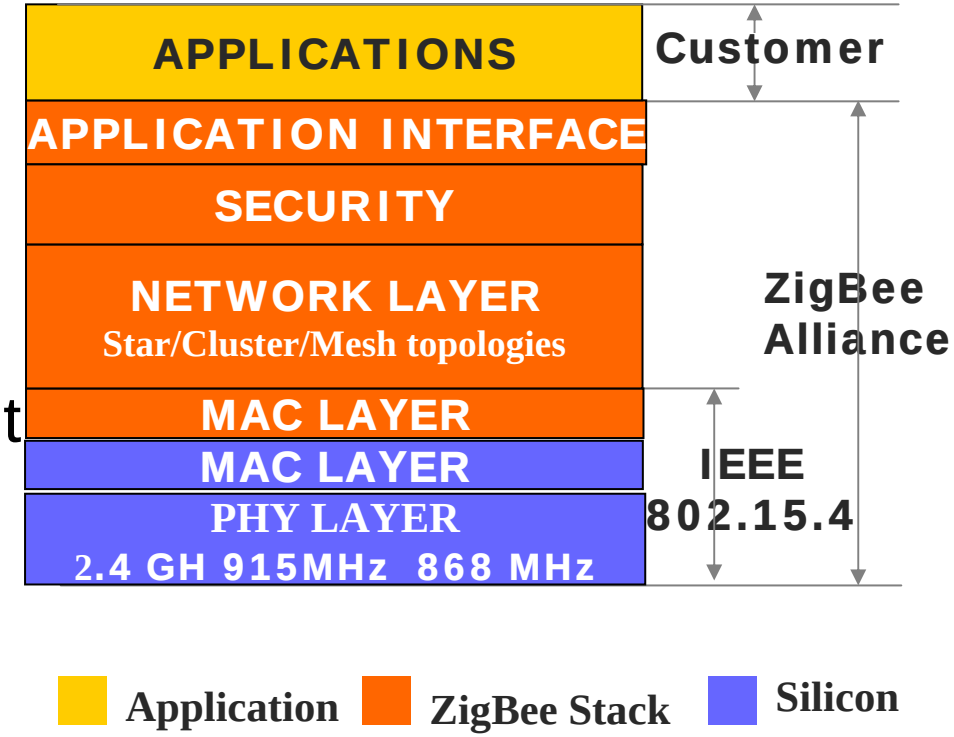
eaZix

Wireless Standards

Market Name **Standard**	Wi-Fi™ 802.11b	Bluetooth™ 802.15.1	ZigBee™ 802.15.4
Application Focus	Web, Email, Video	Cable Replacement	Monitoring & Control
System Resources	1MB+	250KB+	4KB - 32KB
Battery Life (days)	.5 - 5	1 - 7	100 - 1,000+
Network Size	32	7	255 / 65,000
Bandwidth (KB/s)	11,000+	720	20 - 250

Protocol Stack

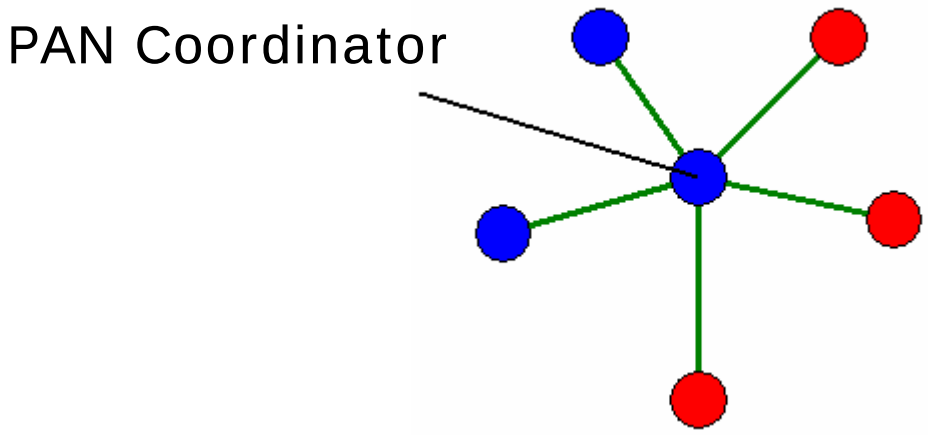
- IEEE 802.15.4
  - PHY and MAC layers
  - –PAN maintenance
- ZigBee
  - –Topology management
  - –Routing protocol
  - –Discover protocol
  - –Security management
  - –Includes 802.15.4 portion



Phy Layer

BAND	COVERAGE	DATA RATE	# OF CHANNEL(S)
2.4 GHz	ISM Worldwide	250 kbps	16
868 MHz	Europe	20 kbps	1
915 MHz	ISM Americas	40 kbps	10

Star Topology



Full Function Device

Reduced Function Device

Device Classification

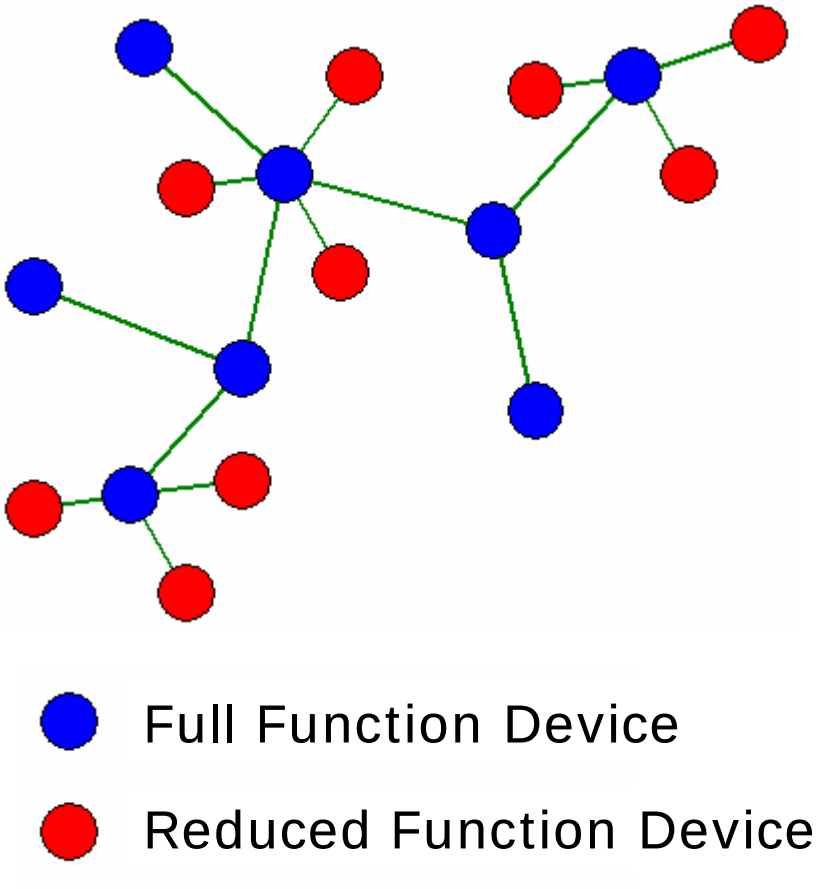
Full Function Device (FFD)

- Any topology
- Can talk to RFDs or other FFDs
- 3 modes of operation:
  - PAN coordinator
  - Coordinator
  - Device

Reduced Function Device (RFD)

- Limited to star topology
- Can only talk to an FFD (coordinator)
- Cannot be a coordinator
- Extremely simple
- With minimal resources and memory capacity

Combined Topology



IEEE 802.15.4: Networks without Beacon

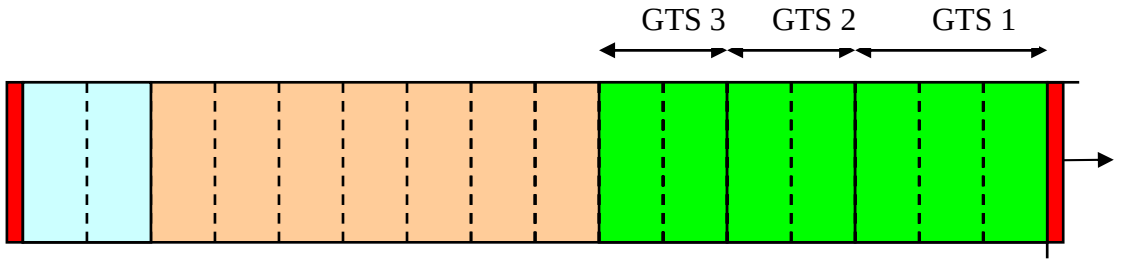
- Peer-to-peer communication
- Simple, traditional multiple access
- Unslotted or standard CSMA / CA is used

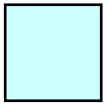
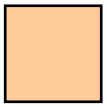
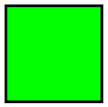
IEEE 802.15.4: Beacon-enabled network

- Network coordinator transmits beacons at predetermined intervals
- Scan function to search for beacon
- Client devices
  - wake up only when a beacon is broadcasted
  - listen for their address
  - and if not heard -> return to sleep
- Beacons keep all of the nodes synchronized
- For dedicated bandwidth and low latency

IEEE 802.15.4 MAC

Superframe: CSMA/CA + TDMA



Network beacon		Transmitted by network coordinator to synchronize the attached devices, to identify the PAN, to describe the structure of superframe.
Beacon extension period		Space reserved for beacon growth due to pending node messages
Contention period		Contention access period (CAP): Access by any node using CSMA-CA
Guaranteed Time Slot		Contention-free period (CFP): Reserved for nodes requiring guaranteed bandwidth.

Superframe may have active and inactive portion

ZigBee Network Layer

- Topology construction / maintenance
- Addressing scheme
- Routing (on demand protocols)
- Forming a network
- Joining and leaving a network
- Configuring a new device
- Synchronization within a network

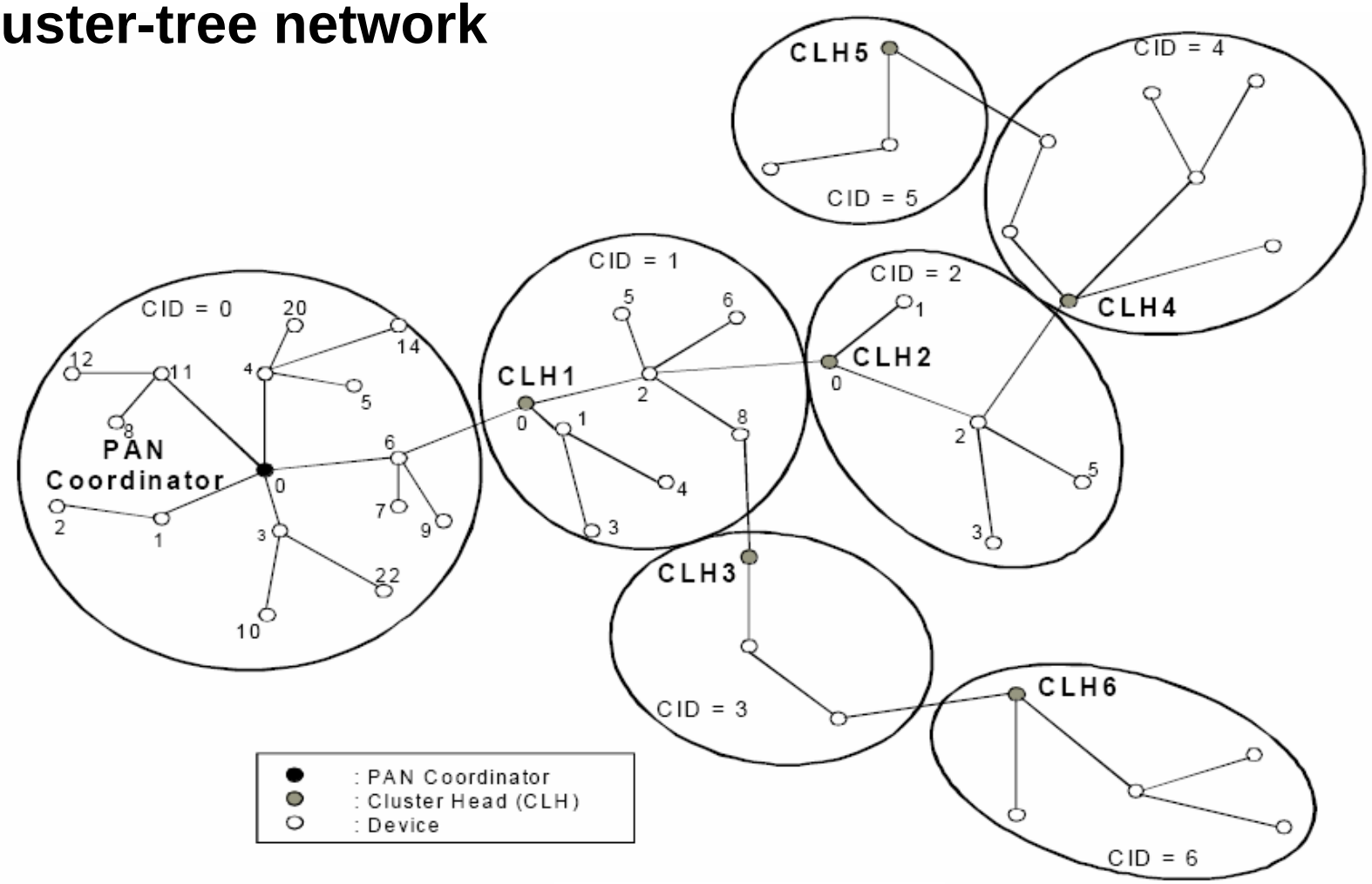
ZigBee Routing

AODV (Ad-hoc On-demand Distance Vector)

- Primary Objectives
  - Provide unicast and multicast capability
  - Minimize broadcast of control packets
- Characteristics
  - On-demand route discovery

ZigBee Network Layer

Cluster-tree network



Source: Motorola

ZigBee Network Layer

Cluster-tree (Motorola propose)

- **PAN coordinator forms the first cluster by establishing itself as the cluster head (CH) with**
  - **Cluster ID (CID) of zero**
  - **An unused PAN identifier**
  - **Broadcasting frames to neighboring nodes**
- **A candidate device**
  - **May request to join the network at the CH**
    - **Begin transmitting periodic beacons for other candidate devices**
- **PAN coordinator**
  - **may then instruct a device to become the CH of a new cluster adjacent to the first one**

Cooperation with ZMD

Setup and Evaluation of Networks based on the IEEE 802.15.4 Standard

- network based on a ZMD44101 transceiver and a 8051 microcontroller platform

- MAC-, network- and sample application code in C/C++ for the 8051 platform

- simulation of ZigBee stack

ZMD44101

Operating Reference Data	
Temperature Range	-40 to 85°C
Supply Voltage, V_{DD}	2.4 V
Typical Supply Current (TX active)	<20 mA
Typical Supply Current (RX active)	<19 mA
Typical Supply Current (power-down)	<4 µA
Frequency Range	868 to 928 MHz

Source: www.zmd.de

Development Kit(DK) for ZMD44101

DK consists of:
- two wireless transceivers
- quick-start hardware
- compiled MAC libraries supporting non-beacon mode services
- evaluation GUI

DK allows:
- measurements: packet error rate, channel characteristics, range, and spectral performance
- direct access to over one hundred internal registers
- simple peer-to-peer and star network demonstrations

Source: www.zmd.de

Summary

- ZigBee has a perspective
- Based on protocol features implemented in 802.15.4
- low battery-operated, low data rate devices
- home automation - the biggest market for ZigBee
- still needs to pass through technology critics