

Z-Stack: a complete protocol stack conforming to ZigBee standard

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1

Agenda

- Z-Stack
- Texas Instrument (TI) developer kit
 - Hardware
 - Demonstration and Evaluation Board
 - Software
 - 3rd Party Software: IAR
- Z-Stack Application development
- Example: GenericApp
 - Download
 - Run

2

What is ZigBee?

- A high level communication protocol using small, low-power digital radios based on the IEEE 802.15.4 standard for wireless networks
- ZigBee is targeted at applications that require a
 - Low data rate
 - Long battery life
 - Secure networking

3

The ZigBee Alliance

- Organized as an independent, non profit corporation in 2002
 - Includes major names in Semiconductor, Software Developer, End Product Manufacturer and Service Provider Industries
- Open and global
- Activity includes
 - Specification creation
 - Certification
 - Market development and user education

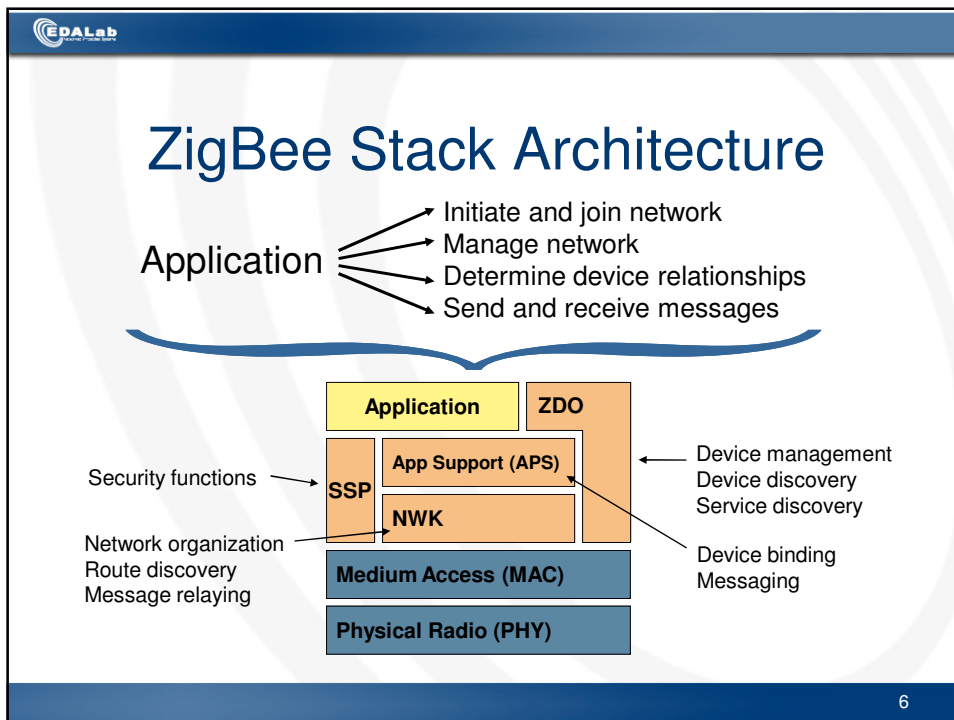
4

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The ZigBee Promoters

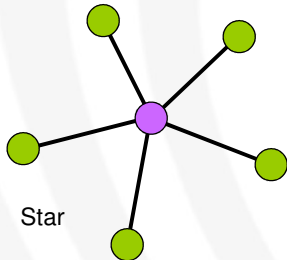
...plus over 225 member companies from around the world

5



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From 802.15.4 ...



Star

IEEE 802.15.4

● Full function device (FFD)

- Any topology
- PAN coordinator capable
- Talks to any other device
- Implements complete protocol set

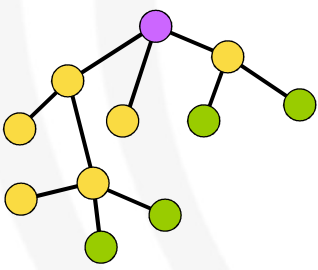
● Reduced function device (RFD)

- Limited to star topology or end-device in a peer-to-peer network.
- Cannot become a PAN coordinator
- Very simple implementation
- Reduced protocol set

7

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... to ZigBee



Cluster Tree

ZigBee Stack

IEEE 802.15.4

- 802.15.4 FFD → ZigBee Coordinator
- 802.15.4 FFD → ZigBee Router
- 802.15.4 RFD → ZigBee End Device

8

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ZigBee Node Types

- ZigBee Coordinator
 - One required for each ZB network
 - Initiates network formation and stores information about the network
- ZigBee Router
 - Participates in routing of messages
- ZigBee End Device
 - Enables very low cost solutions

9

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ZigBee Network Topologies

Star

Mesh

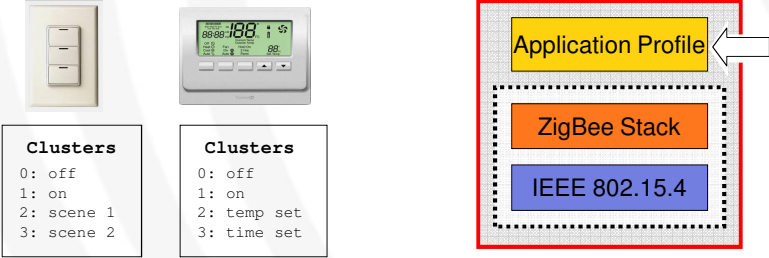
Cluster Tree


- ZigBee Coordinator
- ZigBee Router
- ZigBee End Device

10

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Application Profiles





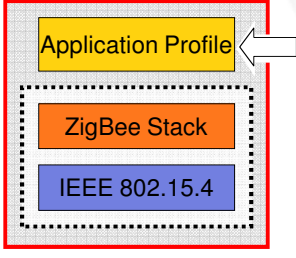
Clusters

```
0: off
1: on
2: scene 1
3: scene 2
```



Clusters

```
0: off
1: on
2: temp set
3: time set
```



- Application profiles define what messages are sent over the air for a given application
- Devices with the same application profiles interoperate end to end

11

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Why Do We Need Profiles?



- Need a common language for exchanging data
- Need a well defined set of processing actions
- Interoperability across different manufacturers
- Simplicity and reliability for end users
- Consumer flexibility for products

12

Home Automation Profile

- Management of lighting, heating and cooling system from anywhere in your home
- Automate control of multiple home systems to improve conservation, convenience and safety
- Embed intelligence to optimize consumption of natural resource
- Install, upgrade and network home control system without wires
- Easily install wireless sensors to monitor a wide variety of conditions
- Receive automatic notification upon detection of unusual events



13

Z-Stack (I)

- A complete protocol stack conforming to ZigBee Alliance standards
- Provided by Texas Instrument
- Microsoft Windows-based Free Software
- Includes all layers of ZigBee stack (IEEE 802.15.4 layer, ZigBee layer, O.S. layer)

14

Z-stack (II)

- HAL (Hardware abstraction layer)
- OSAL (Operating system abstraction layer)
- ZigBee Stack + IEEE 802.15.4 MAC
- User Application
- MT (Monitor Test) – Used to communicate with a PC-based test tool via the UART
- ZigBee 2006
 - Last version: ZStack-1.4.3 (CC2430/31)
- ZigBee 2007 (ZigBee and ZigBee PRO)
 - ZigBee PRO: routing, security, fragmentation, etc.
 - Last version: Z-Stack-2.2.0 (CC2530)

15

Working phases

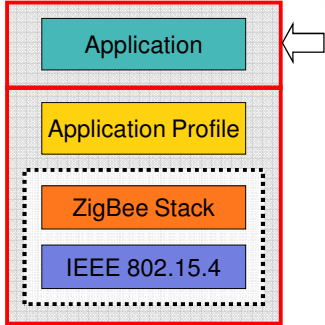
- **Network formation**: the Coordinator creates the network to which all other nodes will connect.
- **Join**: performed by non-coordinator nodes after powering on. The network topology is created (star, tree). Each node sends a message to the Coordinator or to a Router which registers the node as a child.
- **Binding**: creation of a logical link between two or more end systems for data exchange.
- **Data transmission**: data exchange between end devices or with the Coordinator.

16

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Z-Stack Application Development

- Be event driven
 - Local (key stroke, sensor alarm)
 - Remote (remote message from another device)
 - Timers
- Follow a precise schema
- Interact with the ZigBee stack



The diagram illustrates the Z-Stack Application Development structure. It shows a stack of components: 'Application' (teal box), 'Application Profile' (yellow box), 'ZigBee Stack' (orange box), and 'IEEE 802.15.4' (blue box). The 'ZigBee Stack' and 'IEEE 802.15.4' components are enclosed in a dashed-line box. A red border encloses the 'Application' and 'Application Profile' components. An arrow points to the right from the 'Application' component.

17

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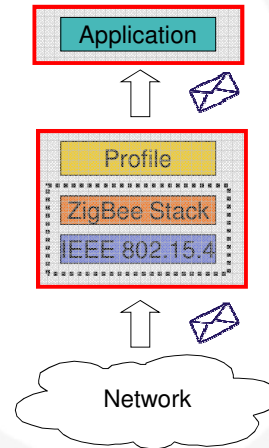
Z-Stack Application structure

- Each application must contain:
 - Init method
 - The application must provide information to the ZigBee stack
 - Node descriptor
 - Hardware specific information
 - Profile information
 - Event-loop method
 - The event loop method is invoked whenever an event is transmitted to the application
 - Mandatory (system events)
 - Application specific (timers)
- Applications can contain
 - Local functions
 - Callbacks
 - to process specific events

18

Event processing

- Events are received from the ZigBee stack
- Application events are then transmitted to application level
- The corresponding callback or function for each event is activated



19

Texas Instrument: Hardware (I)

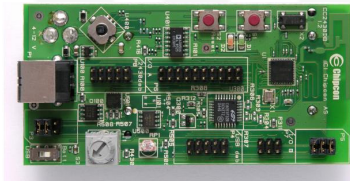


Chipcon SmartRF04EB Evaluation Boards

- Includes a USB and Serial interfaces
- Fitted with a CC2430EM
- LCD panel
- Can be powered from:
 - Batteries
 - Over the USB interface
 - The 9V DC connectors
- Includes a variety of sensors
 - Potentiometer
 - Pushbuttons and joystick
 - 2 LEDs
 - Audio filter and amplifier enabling transmission and reception of audio signals

20

Texas Instrument : Hardware (II)



CC2430DB Demonstration Boards

- Includes a USB interface
- Can be powered from:
 - Two AA batteries
 - Over the USB interface
 - The 9V DC connectors
- Includes a variety of sensors
 - Light sensor
 - 2-way accelerometer
 - Temperature sensor
 - Battery monitor
 - Potentiometer
 - Pushbutton and joystick

21

Texas Instrument : Hardware (III)



Chipcom SOC BB Battery Board

- Fitted with a CC2430EM
- Can be powered from:
 - Two AA batteries
- Includes a variety of sensors
 - Temperature sensor
 - Battery monitor
 - Pushbutton

22

IAR C-compiler

- IAR Embedded Workbench (EW8051) suite
- It supports project management, compiling, assembling, linking, downloading, and debugging for various 8051-based processors
 - Chipcon CC243x family

23

Example: “GenericApp”

Node 1



Node 2



- The GenericApp example provides a simple interface:
 - the ZigBee node finds an appropriate peer upon one button being pressed
 - It binds to that peer upon another button being pressed
 - It sends a packet containing “Hello World” every 5 seconds. Upon receiving a packet, it would display the contents on the LCD in the evaluation.

24

Project File for IAR

25

Application Type

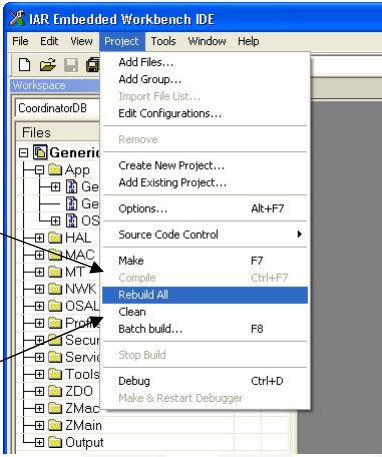
Coordinator
(Demonstration Board
Evaluation Board)

Router
(Demonstration Board
Evaluation Board)

End-Device
(Demonstration Board
Evaluation Board)

26

Build/Clean Application

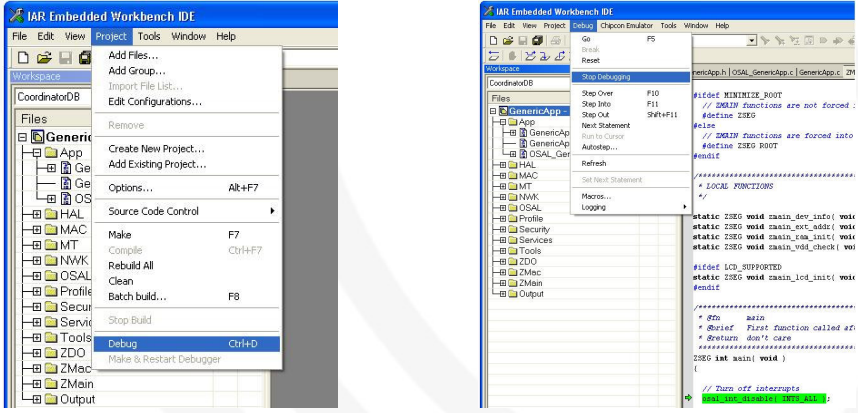


Executable file generation:

- a51 (HEX file: text file)
- s51 file (binary file with debug information)

27

Download Application (I)



```

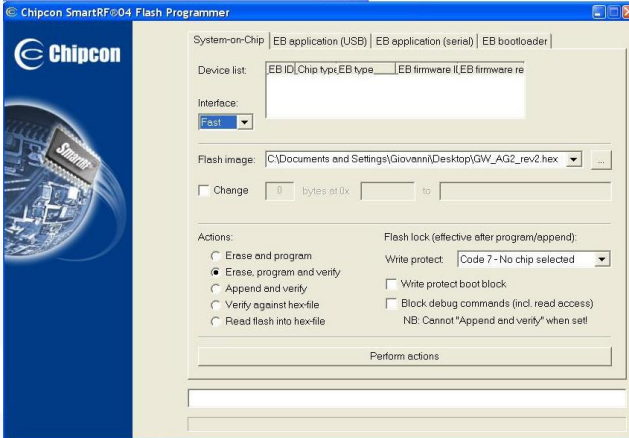
// Turn off assertions
// IAR_ASSERT(0);
    
```

28

Download Application (II)

Chipcom Flash Programmer

- Device select
- Read/Write IEEE Address
- Download application on the Flash



29

GenericApp (I)

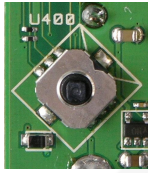
1. Build and Download GenericApp
 - Node1
 - Uses EndDeviceEB configuration
 - Receive packets
 - Node2
 - Uses CoordinatorDB configuration
 - Send packets

30

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GenericApp II

2. Start Node1 (Coordinator)
 - Red led light on
 - Network formation
3. Start Node2 (End Device)
 - Led orange light on
 - Join Network
4. SW4 Key Press on the Node1
 - Auto Find: start match description request
 - Led green light on



31

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GenericApp (III)


5. Node2 sends "Hello world" packets to the Node1 every 5 seconds
 - View results on the LCD
 - View results on the Z-Tool provided by Texas Instrument
 - By using serial port

32

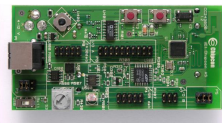
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Example: “SimpleApp”

**Node 1
Collector**



**Node 2
Temperature sensor**



←

- The SimpleApp example allows:
 - the ZigBee node finds an appropriate peer upon one button being pressed
 - It binds to that peer upon another button being pressed
 - It sends a packet containing “Temperature” data. Upon receiving a packet, it would display the contents sending it to the serial interface.

33

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SimpleApp (I)

1. Build and Download SimpleApp
 - Node1
 - Uses SimpleControllerEB configuration
 - Receive packets containing temperature data
 - Node2
 - Uses SimpleSensorDB configuration
 - Send temperature data

34

SimpleApp II

2. Start Node1 (SimpleCollector) and Node2 (End Device)
 - Allow Bind mode by pressing SW1 Key on Node1
 - Turn on LED1 on Node1
3. On the Node 1 (SimpleCollector device), any received sensor data are written to the serial port

