IoT-Point MENU

Zigbee Tutorial

Introduction

This **zigbee tutorial** describes everything you would like to know about Zigbee protocol stack. Now-a-days zigbee is becoming very popular for low data rate wireless applications.

Zigbee devices are used in smart energy, medical and in home automation. In smart energy applications zigbee products are used to monitor and control use of energy and water, which helps consumers save energy and water and save money too.

In medical field it is used to connect unlimited number of health monitoring devices and many more.

In home automation it controls domestic lighting, such as switches, dimmers, occupancy sensors and load controllers.

It has two bands of operation 868/915MHz and 2450MHz. 868/915 band provides about 20-40Kb/s and 2450MHz band provides about 250 kb/s data rates. In addition to this uses zigbee end devices can go to sleep mode which saves battery consumption and it also takes care of security of the information owing to security layer.

Zigbee Network Overview:

zigbee coordinator
zigbee router
zigbee end device
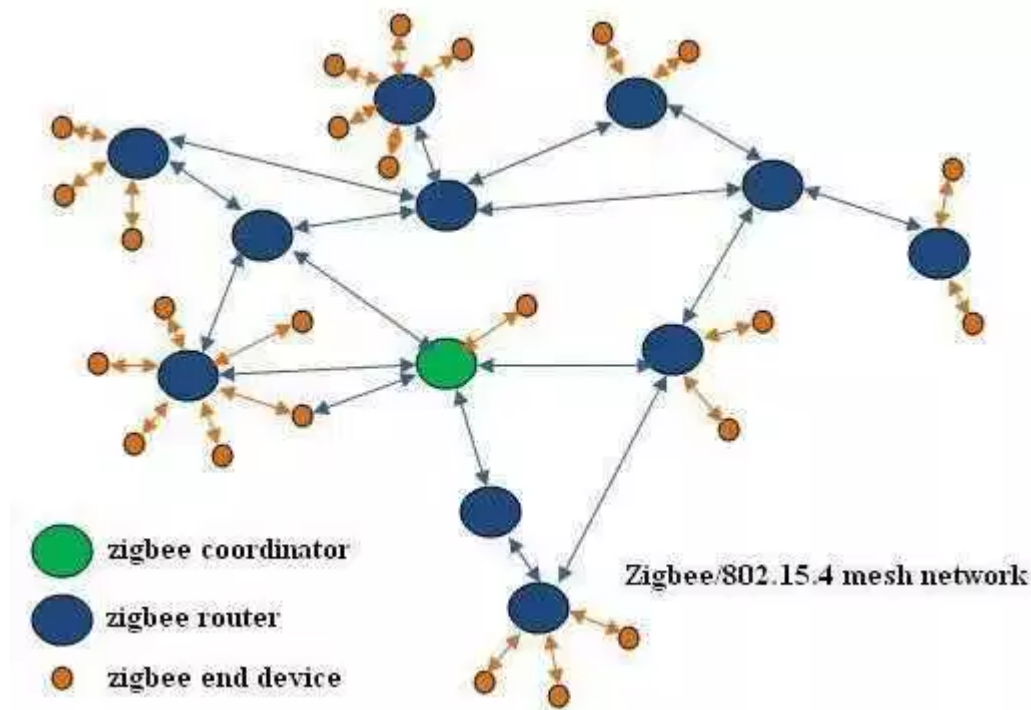
As mentioned in the network diagram, zigbee network is comprised of coordinator(C), router(R) and end devices (E). Zigbee supports mesh-routing. For detailed information on routing protocol employed in zigbee, one may refer Ad-hoc on-demand Distance Vector Routing protocol (AODV protocol), RFC 3561 (http://www.ietf.org/rfc/rfc3561.txt)

Coordinator:
– Always first coordinator need to be installed for establishing zigbee network service, it starts a new PAN (Personal Area Network), once started other zigbee components viz. router(R) and End devices(E) can join the network(PAN). – It is responsible for selecting the channel and PAN ID. – It can assist in routing the data through the mesh network and allows join request from R and E. – It is mains powered (AC) and support child devices. – It will not go to sleep mode.

Router:
– First router needs to join the network then it can allow other R & E to join the PAN. – It is mains powered (AC) and support child devices. – It will not go to sleep mode.

End Devices:
– It cannot allow other devices to join the PAN nor can it assist in routing the data through the network. – It is battery powered and do not support any child devices. – This may sleep hence battery consumption can be minimized to great extent. There are two topologies, star and mesh, as mentioned Zigbee supports mesh routing. PAN ID is used to communicate between zigbee devices, it is 16 bit number. Coordinator will have PAN ID set to zero always and all other devices will receive a 16 bit address when they join PAN. There are two main steps in completing Zigbee Network Installation. Forming the network by Coordinator and joining the network by Routers and End devices.

Forming the Zigbee Network

• Coordinator searches for suitable RF channel which is usable and not interfering with Wireless LAN frequencies in use. This is because WLAN also operates in the same 2.4GHz bands.This is done on all the 16 channels. It is also referred as energy scan.

• Coordinator starts the network by assigning a PAN ID to the network. Assignment is done in two ways. Manual (pre configured) and dynamic (obtained by checking other PAN IDs of networks already in the operation nearby so that PAN ID does not conflict with other networks). Here Coordinator also assigns network address to itself i.e. 0x0000.

• Now coordinator completes its configuration and is ready to accept network joining request queries from routers and end devices who wish to join the PAN.

In addition to above, Coordinator(C) sends broadcast beacon request frame on remaining quiet channel. This is also referred as beacon scan or PAN scan. By this Coordinator receives PAN ID of routers(R) and end devices(E) present nearby. It also comes to know whether R/E allow join or not.

Now R/E can join by sending association request to C. C will respond with association response.

Joining the Zigbee Network

• Let us examine how a router or end device joins zigbee network as part of zigbee tutorial. There are two ways to join a zigbee network viz. MAC association and network re-join.

• First one is implemented by device underlying MAC layer and second one is implemented by network layer, despite the name may also be used to join a network for the first time.

• MAC association can be performed between C and R/E or R and E or R and other R.

• Let us assume that Coordinator(C) has already established the PAN network. Hence next step for R or E is to find out whether C is allowing joining or not. So they do PAN scan or send beacon request frame.

• After they come to know that they can join the network, they will send association request frame and will join the network as soon as they receive the association response.

• As mentioned above whether or not C or R allow a new device to join depends on two main factors:
-Permit joining attribute
-Number of end device children it already has.
One of the applications of zigbee in home is that switch, speakers and lamp is controlled using zigbee technology.

Zigbee protocol

zigbee IP consists of various protocol layers viz. physical layer(PHY), mac layer, network layer and application layer. IEEE 802.15.4 standard defined zigbee PHY and MAC specifications. Zigbee alliance specifies network and application layers.

Zigbee Protocol stack

The following figure depicts **zigbee protocol** stack,which consists of four layers viz. PHY,MAC,network & security and application layer. The first two are covered in IEEE 802.15.4 WPAN standard and the later two are covered in documents published by zigbee alliance.
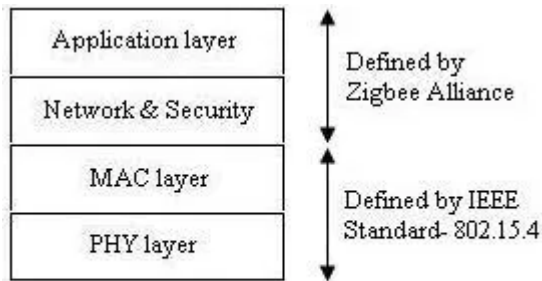
Zigbee Protocol Stack

Application Layer:

Pl. refer our article on Basics of OSI and TCPIP to understand application layer in general. There are two profiles at this layer. 1. Manufacturer specific application profile- Operate as closed systems and also ensured that they can coexist with other zigbee systems. 2. Public application profile- for this to work interoperability between various zigbee devices is a must. A single zigbee node supports up to 240 application objects called end points. An end point specifies specific application, for example, 0 dedicated to ZDO (Zigbee device object), provides control and management commands. 6 used for control of light. 8 used for manage heating and air conditioning.

Network Layer:

Ad-hoc on-demand Distance Vector Routing protocol (AODV) is used at network layer.

Security Layer:

If security is enabled C will start up using a 128 bit AES encryption key. Devices having same security key can communicate on PAN. How to obtain this key? 1. Pre-installation 2. Key is received over the air during joining.

MAC Layer

Each MAC frame consists of three fields MAC header, MAC payload and MFR (FCS).

Each MAC frame will contain Frame control field (16 bit), which carry frame type, addressing fields and other control flags.

This MAC control field contain frame type field, which is the main differentiating factor in identifying one MAC frame with the other. It is 3 bit in length.

The MAC frames are divided into following four major categories, which is used by zigbee devices to establish connection to the PAN by exchanging system information.
1. Beacon
2. Data
3. Acknowledgement
4. MAC command

Zigbee 3.0:

The standard zigbee 3.0 is variation to previous zigbee standards. The zigbee 3.0 specification enables interoperability among different application profiles. Due to this, zigbee 3.0 allows devices from different application areas to communicate and form single homogeneous network. For example, device#1 from zigbee light profile can coexist with device#2 from health care profile with same zigbee network.

Moreover zigbee 3.0 compliant devices support connectivity with IP networks such as LAN and WAN. Hence these devices can form IoT network. Hence products from different manufacturers can communicate together as single networking devices. Zigbee 3.0 is based on IEEE 802.15.4 standard specifications and support 2.4 GHz global frequency band. It uses zigbee PRO version.

Following are the features of zigbee 3.0 :
• Low Power: Zigbee 3.0 compliant devices support low power and low data rate. IoT devices require long life battery. Hence this standard is widely used in IoT (Internet of Things) network.
• Reliable and Robust: The zigbee 3.0 supports mesh topology and hence such network will avoid single point of failure and hence ensure reliable delivery of packets.
• Scalable: The devices can be added any time in zigbee 3.0 network.
• Secure: It supports AES-128 encryption type and hence it is secured network.
• Global Standard: The frequency band 2.4 GHz is used widely across the globe which is used in zigbee 3.0 based devices. Hence it is a global standard.
From the above points one can easily derive difference between zigbee 3.0 and other versions of zigbee standard.

Zigbee 3.0 Protocol Stack
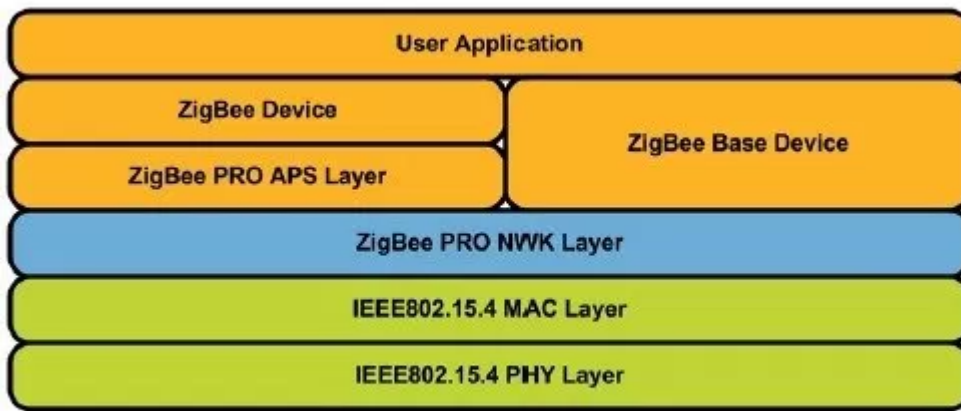
Zigbee 3.0 Protocol Stack

The figure-1 depicts **zigbee 3.0 protocol stack**. As shown it consists of PHY, MAC, network and application layers. The changes have been incorporated into application layer in zigbee 3.0 compare to previous zigbee versions. Network layer is sandwitched between upper layer i.e. application layer and PHY/MAC as defined in IEEE 802.15.4 standard.

The zigbee 3.0 protocol stack incorporates zigbee base device layer which provides consistant behaviour for commissioning new nodes in the network.
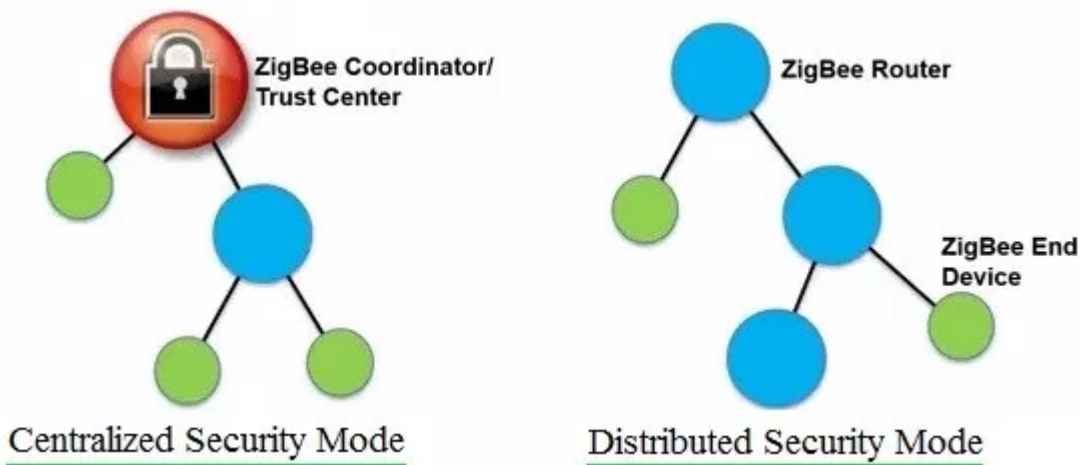
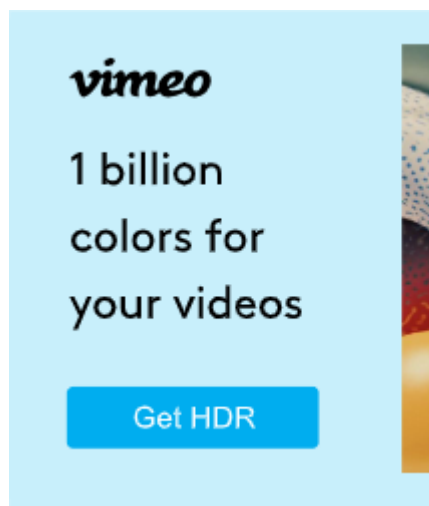The security layer is also enhanced and here there are two security modes supported.
Centralized: This mode is managed by central co-ordinator. This co-ordinator forms the network as well as takes care of key assignment to the new joining nodes.
Distributed: This mode does not have any central co-ordinator. The zigbee router itself manages network establishment and key assignment to peer router in the network.
The figure-3 depicts zigbee network security modes.

• Zigbee 3.0 support large number of nodes about 250.
• It also supports dynamic nature of the network.
• It supports rejoining of orphaned nodes with the new parent node in the event of loss of parent.
• Zigbee 3.0 provides backward compatibility with other zigbee application profiles such as zigbee light link 1.0 profile, zigbee home automation 1.2 profile etc.

[Powered by WordPress.com](#).