

# Generic ZCL

by

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# Company Profile

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- Volansys Technology PVT. LTD.
- One stop solution enabler
- Offerings
  - Hardware Design & Development
  - Software Development
  - Quality Engineering (QA)
  - Embedded Design & Development
- IoT expert

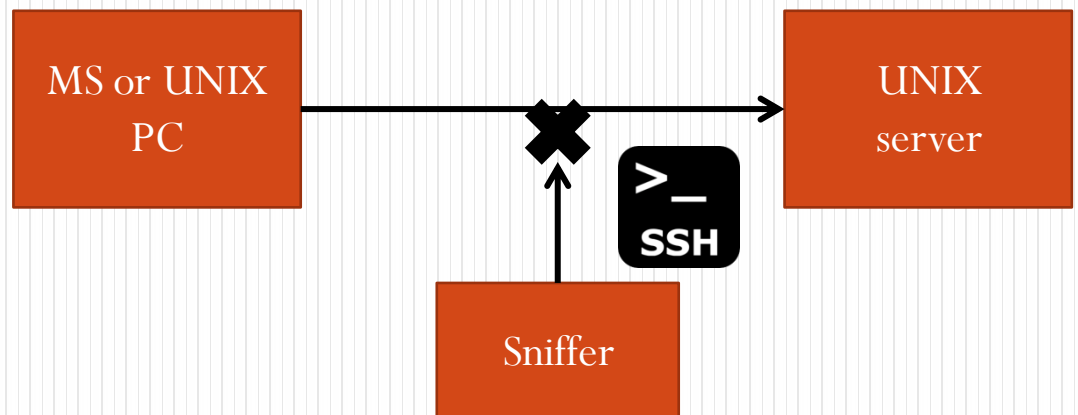
# Industry Training

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- 2 1/2 Month employee training
- Aim is to provide bridge between College and Industry
- Topic Includes
  - Linux Essential
  - Data structure
  - Advance C programming
- Helped lot in final project

# Linux Essential

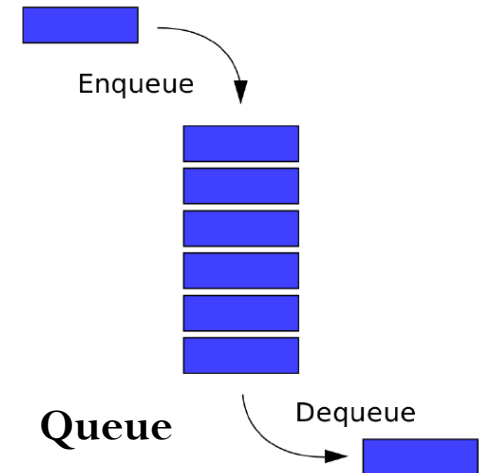
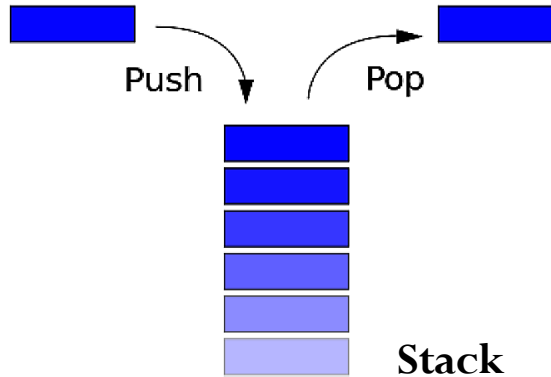
- Vim
- SSH, SAMBA, FTP
- OS programming - Semaphore, Mutex, Thread etc..
- System Calls & Socket programming
- GIT



# Data structure & Algorithms

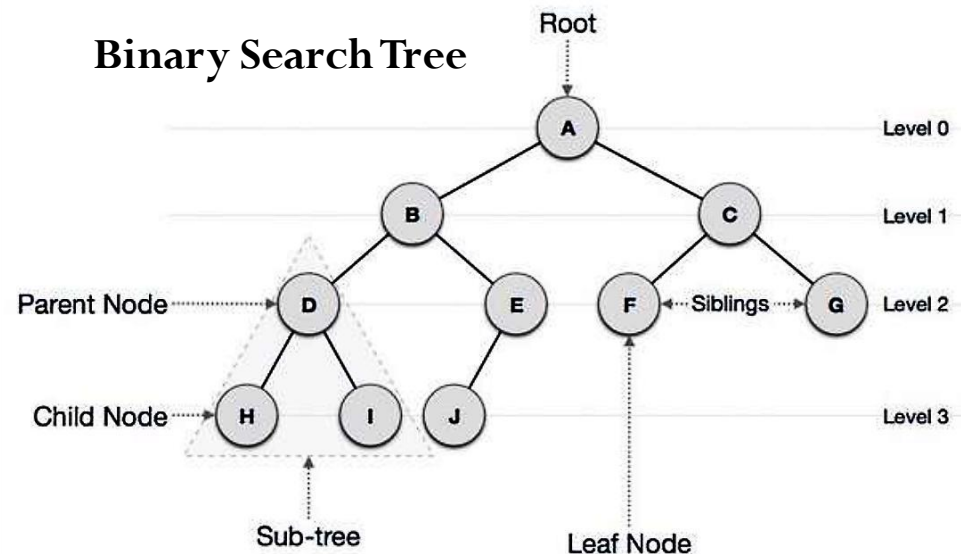
- Data structure

- Array
- Structure
- Link list



- Algorithms

- Stack vs. Queue
- Bubble sort
- Quick sort
- Binary Tree



# Advance C programming

- Valgrind
  - Memory management tool
  - Memory leak
  - Segmentation fault
- Mega Exercise – Railway Ticket Reservation System
- SRS – System Requirement Specification
- SDS – Software Design Specification
- Doxygen – A unique code documentation tool

# Project – Generic ZigBee Cluster Library

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Tries to solve compatibility issues with various IoT products by making a universal library which ideally supports all ZigBee platform.

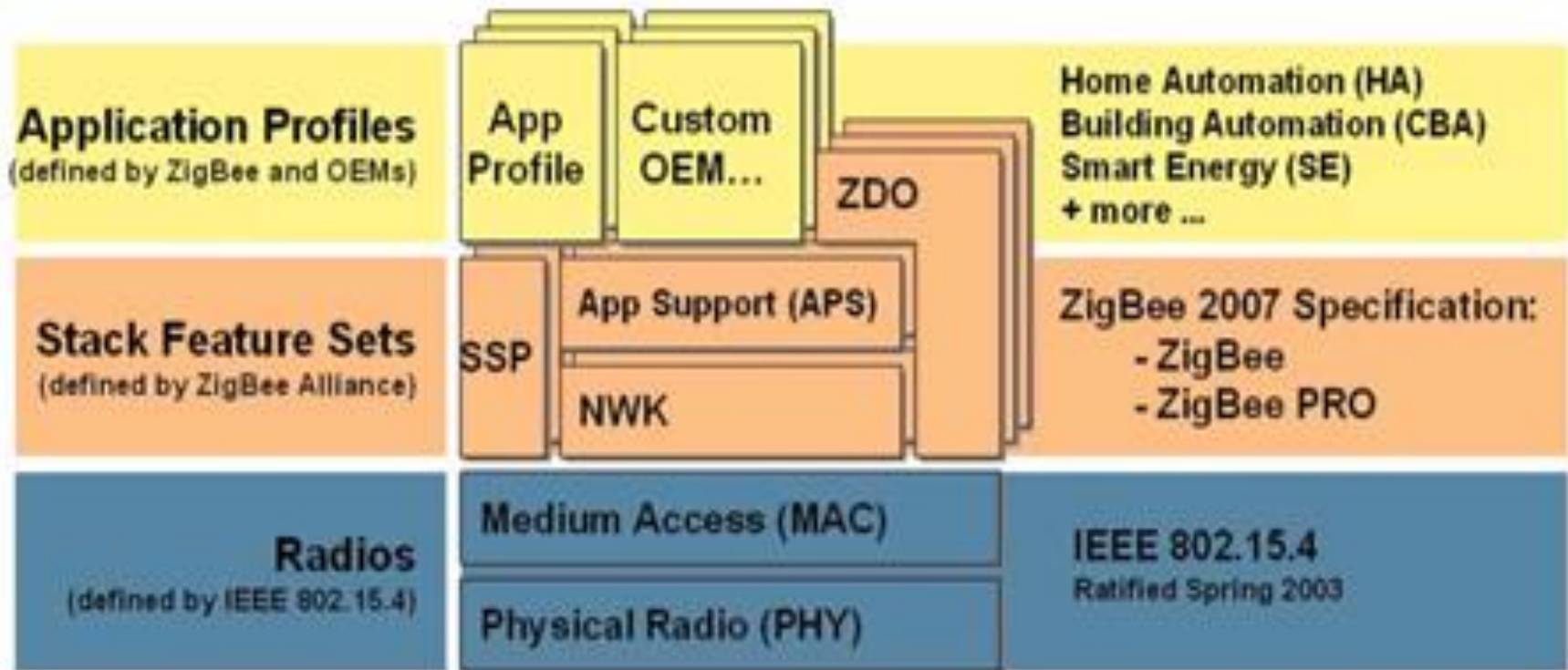


# What Is ZigBee ?

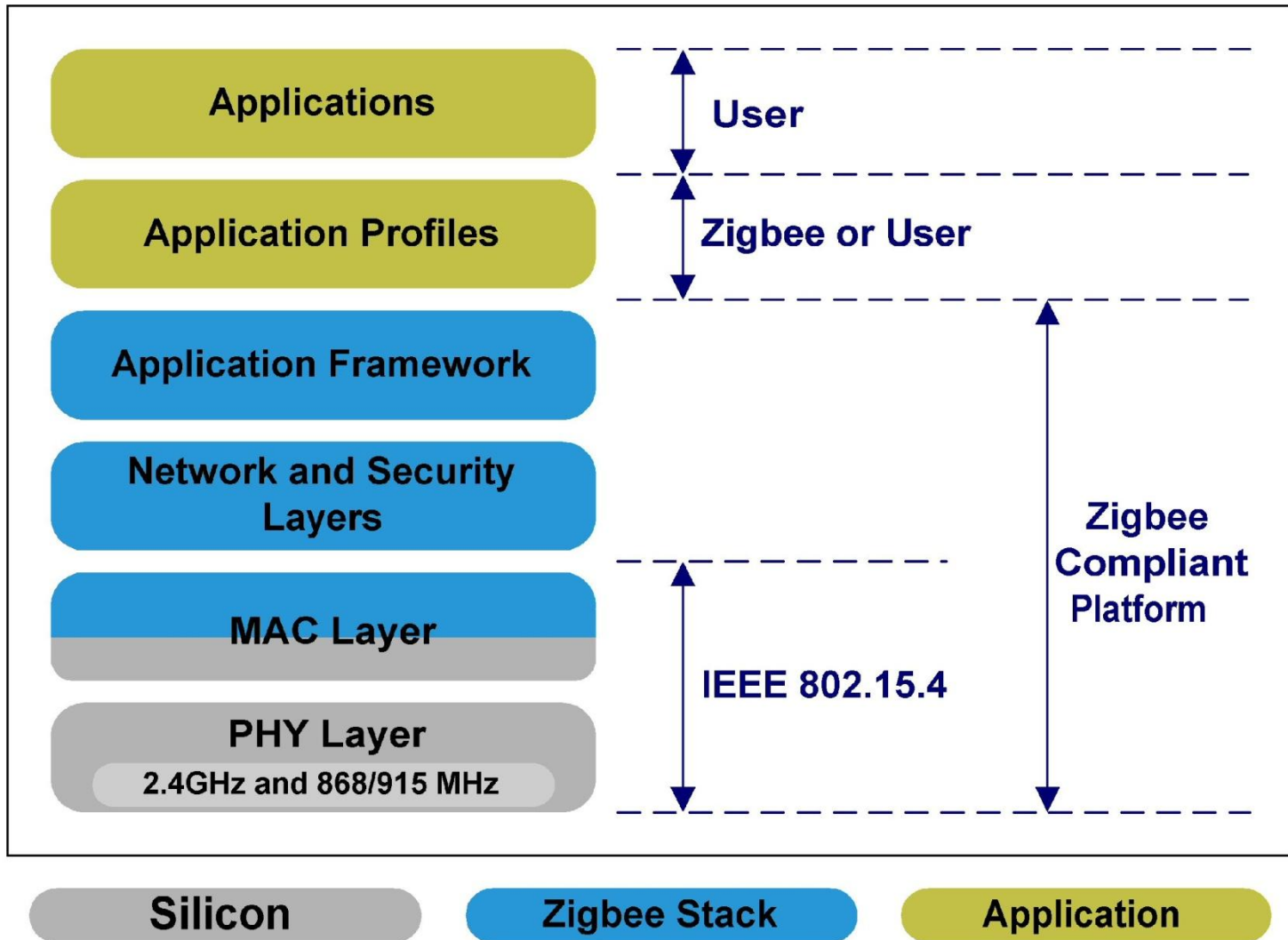
- Open global standard for wireless technology
- Developed and managed by ZigBee Alliance
- Operates on the IEEE 802.15.4 specification
- Used to create Personal Area Networks ( PAN )
- Advantage
  - Low data transfer rate
  - Energy efficiency
  - Secure networking
  - Operates on 2.4Ghz universal free band



# ZigBee Architecture

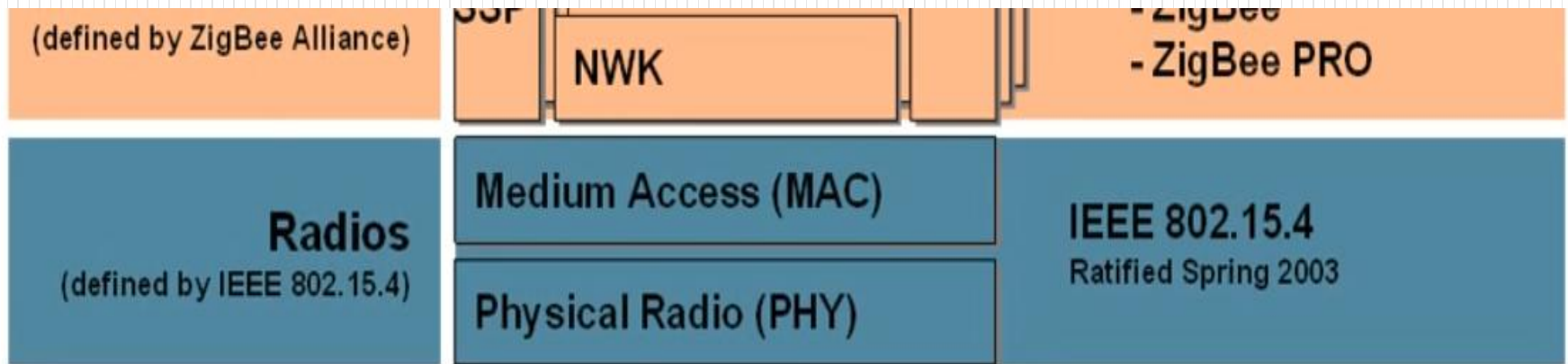


# ZigBee Architecture



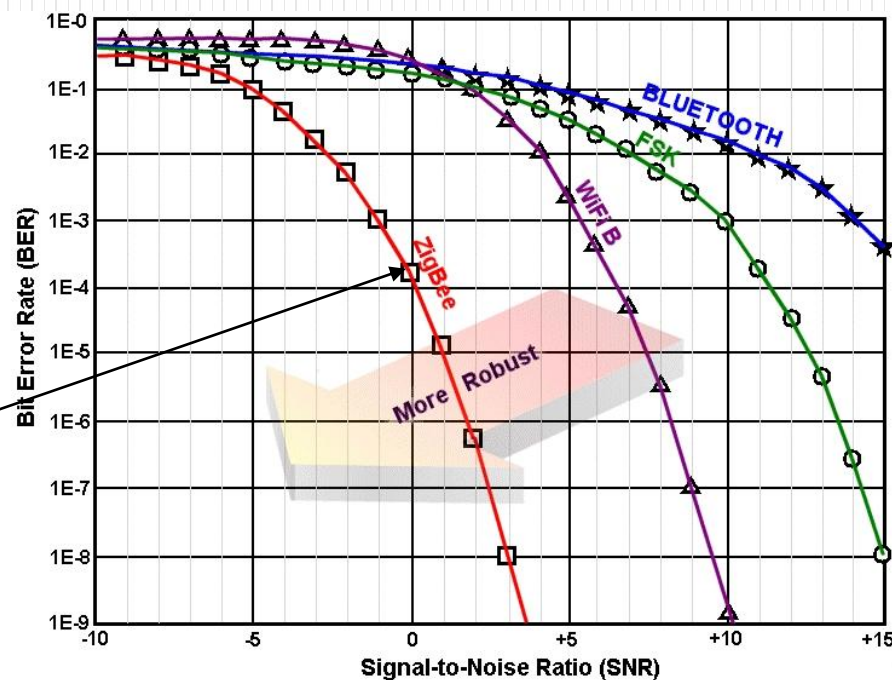
# MAC & PHY Layer in ZigBee

- IEEE 802.15.4 is a technical standard
- The physical layer performs modulation on outgoing signals and demodulation on incoming signals. It transmits information and receives information from a source.
- The MAC enables the transmission by CSMA/CA. Transmit beacon frames for synchronization.



# Basic Radio Characteristics

ZigBee technology relies upon IEEE 802.15.4, which has excellent performance in low SNR environments

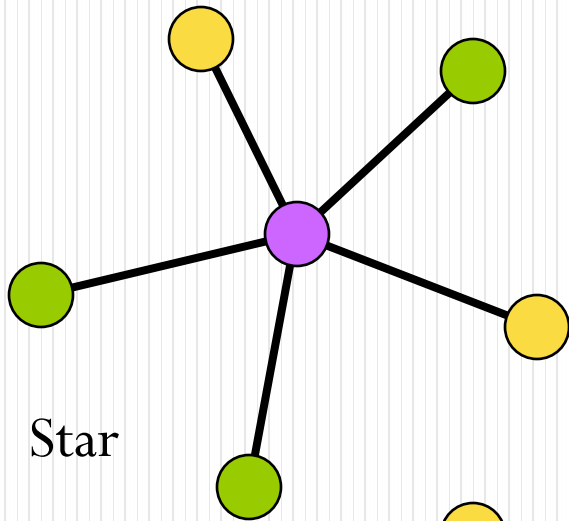


Frequency Band	License Required?	Geographic Region	Data Rate	Channel Number(s)
868.3 MHz	No	Europe	20kbps	0
902-928 MHz	No	Americas	40kbps	1-10
2405-2480 MHz	No	Worldwide	250kbps	11-26

# ZigBee Device Types

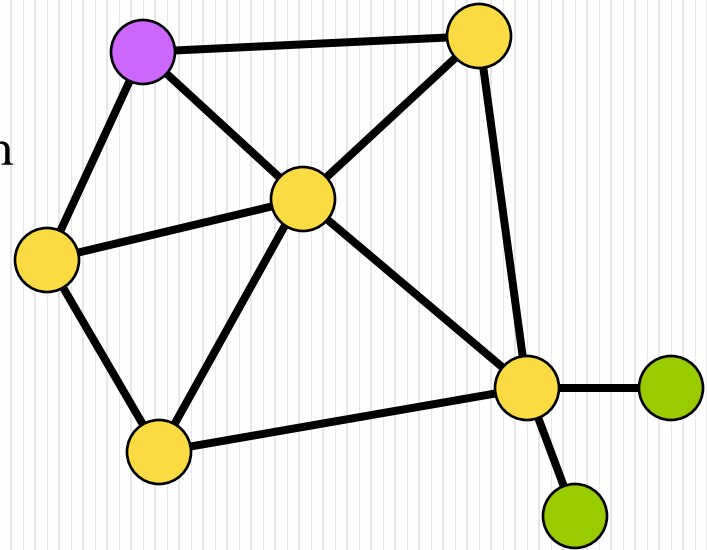
- • ZigBee Coordinator (ZC)
  - One required for each ZB network.
  - Initiates network formation.
  
- • ZigBee Router (ZR)
  - Participates in multi hop routing of messages.
  
- • ZigBee End Device (ZED)
  - Does not allow association or routing.
  - Enables very low cost solutions

# ZigBee Network Topologies

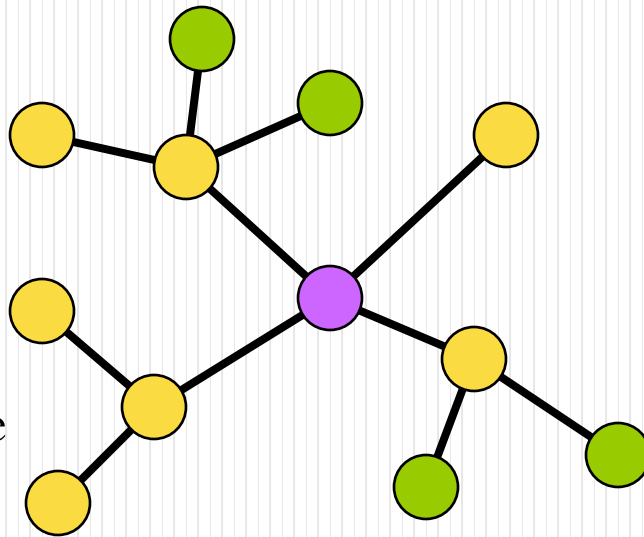




Star

Mesh



Cluster Tree



-  ZigBee Coordinator
-  ZigBee Router
-  ZigBee End Device

# NWK Layer

- Located between the MAC layer and APS.
- It provides the following functions:
  - Starting a network
  - Managing end devices joining or leaving a network
  - Route discovery
  - Neighbour discovery

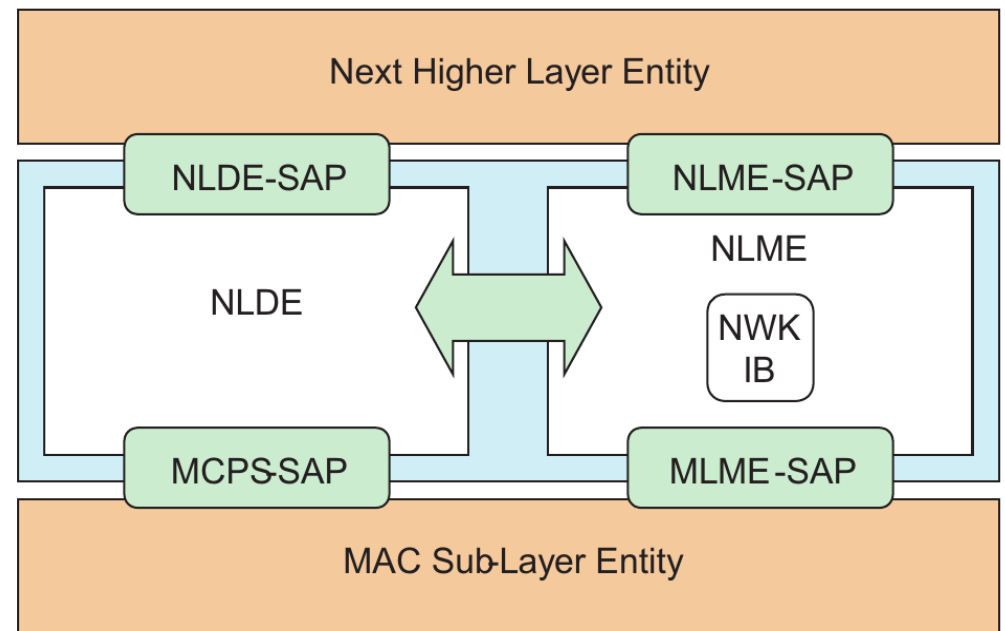


Fig : The NWK Layer Reference Model

# APS Layer

- In the application layer services are provided by two entities:
  - **The APS data entity (APSDE)** provide a data service to the network layer and both ZDO and application objects to enable the transport of application PDUs between two or more devices
  - **The APS management entity (APSME)** provide a management service to allow an application to interact with stack.
- **ZDO** : Endpoint address 0 on each node is reserved for a special application called the ZDO (ZigBee Device Objects).
  - This application has a number of roles, including defining the type of node (Coordinator, Router or End Device), initializing the node and participating in network creation.



# ZigBee Cluster Library

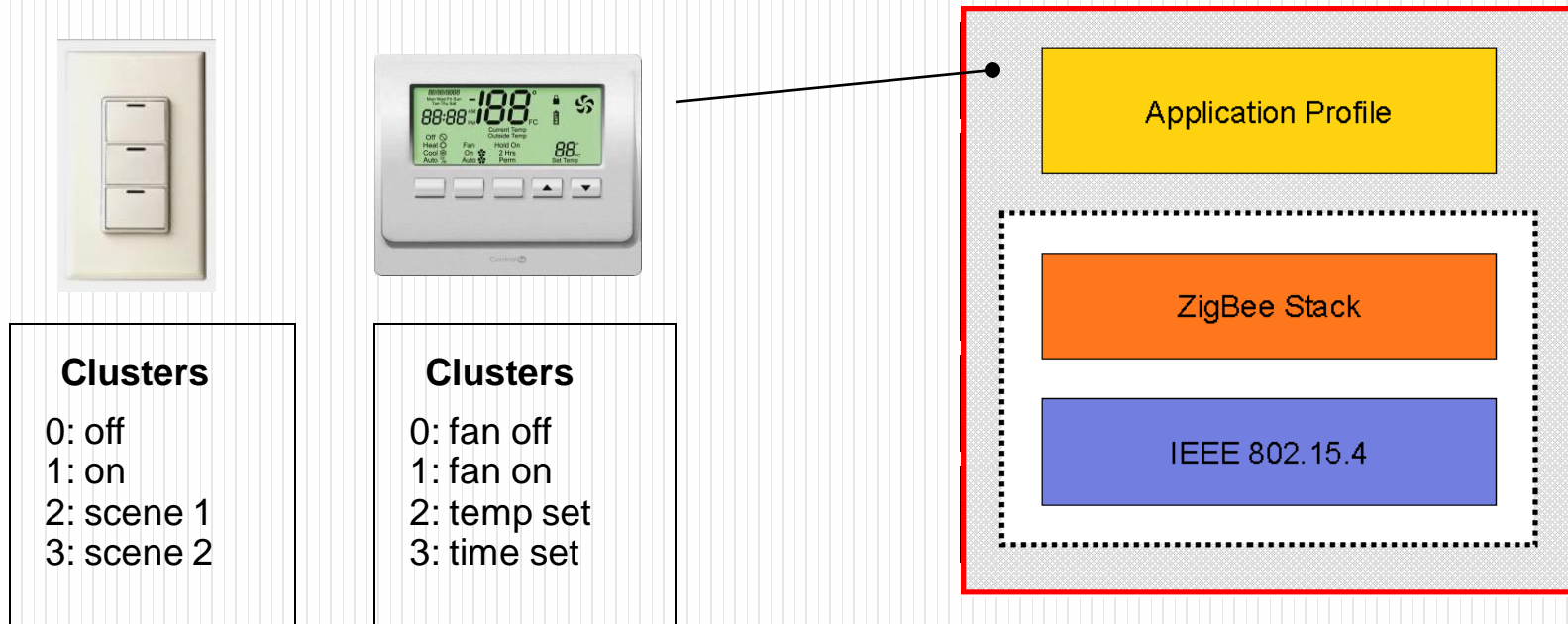
- The ZCL is a repository for cluster functionality.
- As a consequence, it will be a working library with regular updates as new functionality is added.
- The ZCL consists of the a set of elements that apply across the entire library (such as frame structures, attribute access commands and data types), and a number of sets of clusters.

# ZCL – Frame Formats

- The ZCL frame format is composed of a ZCL header and a ZCL payload.

Variable	8	8	0/16	Bits: 8
Frame payload	Command identifier	Transaction sequence number	Manufacturer code	Frame control
ZCL Payload	ZCL header			

# Application Layer



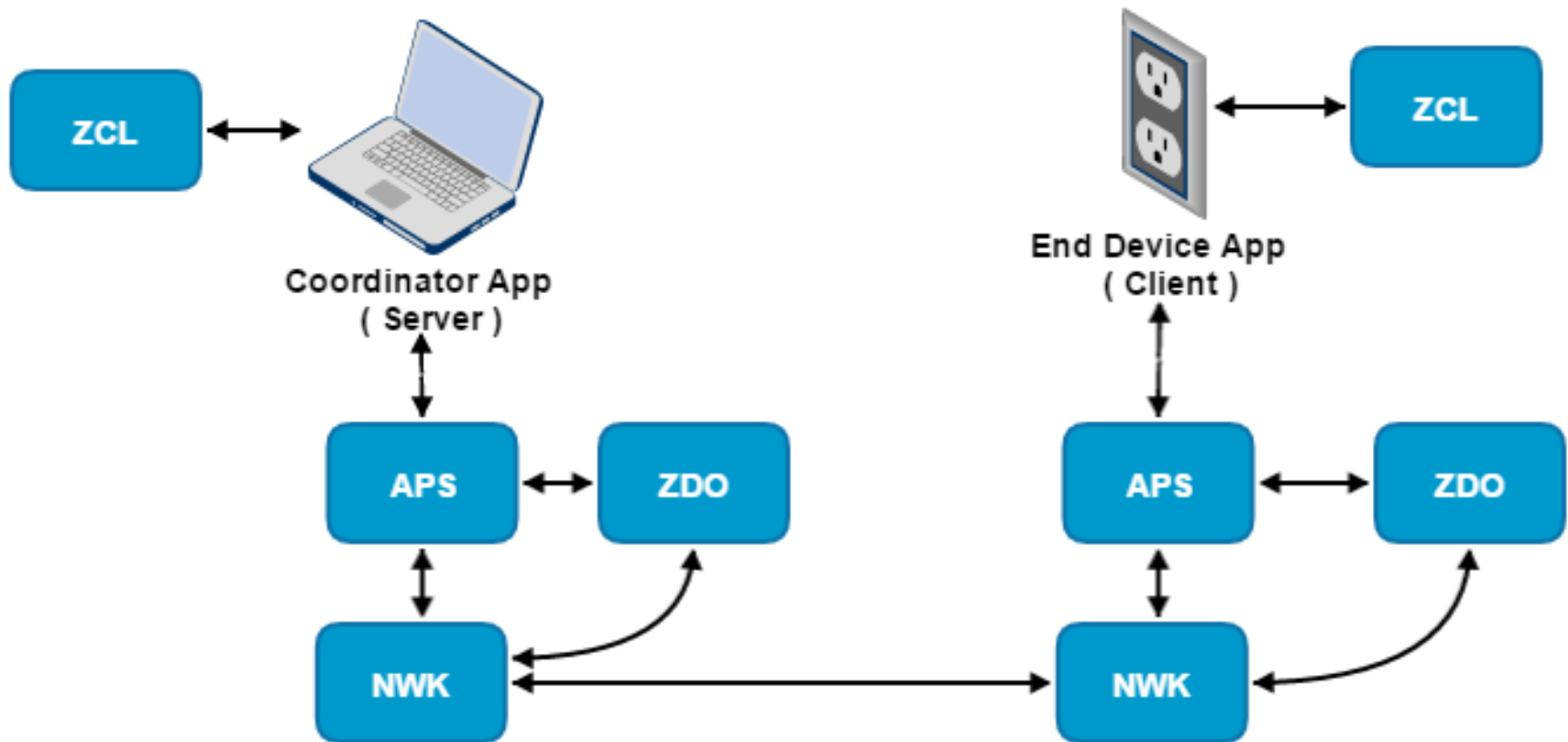
- Application profiles define what messages are sent over the air for a given application
- Devices with the same application profiles interoperate end to end
- ZigBee publishes a set of public profiles, but vendors may create manufacturer specific ones as well

# Implementation

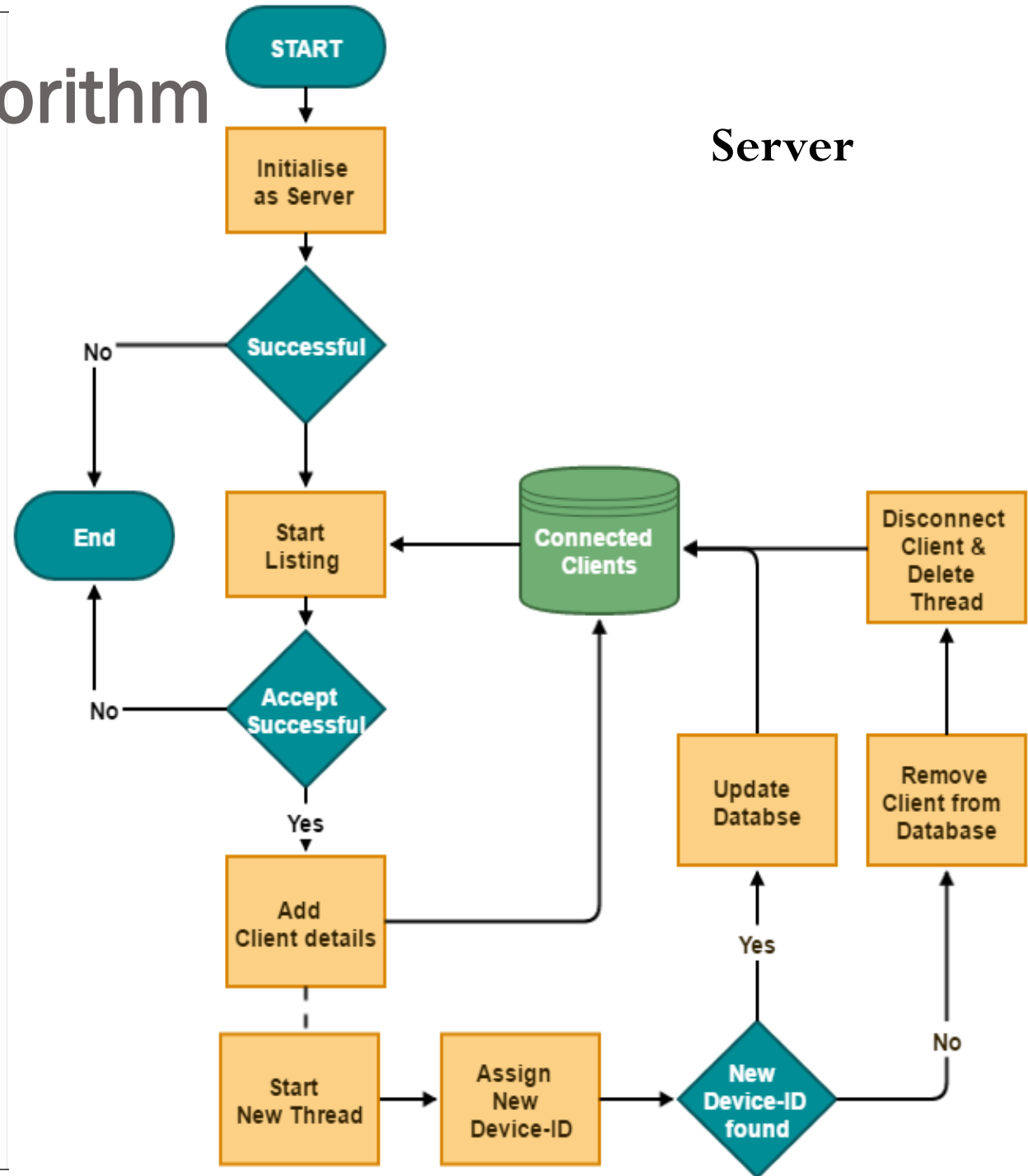
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- Simulation of ZigBee IoT device
- Star Topology used
- ZCL, ZDO and APS made as per ZigBee Specification
- Network layer is replaced by Socket Programming
- Terminal based End user application

# Data Flow Diagram

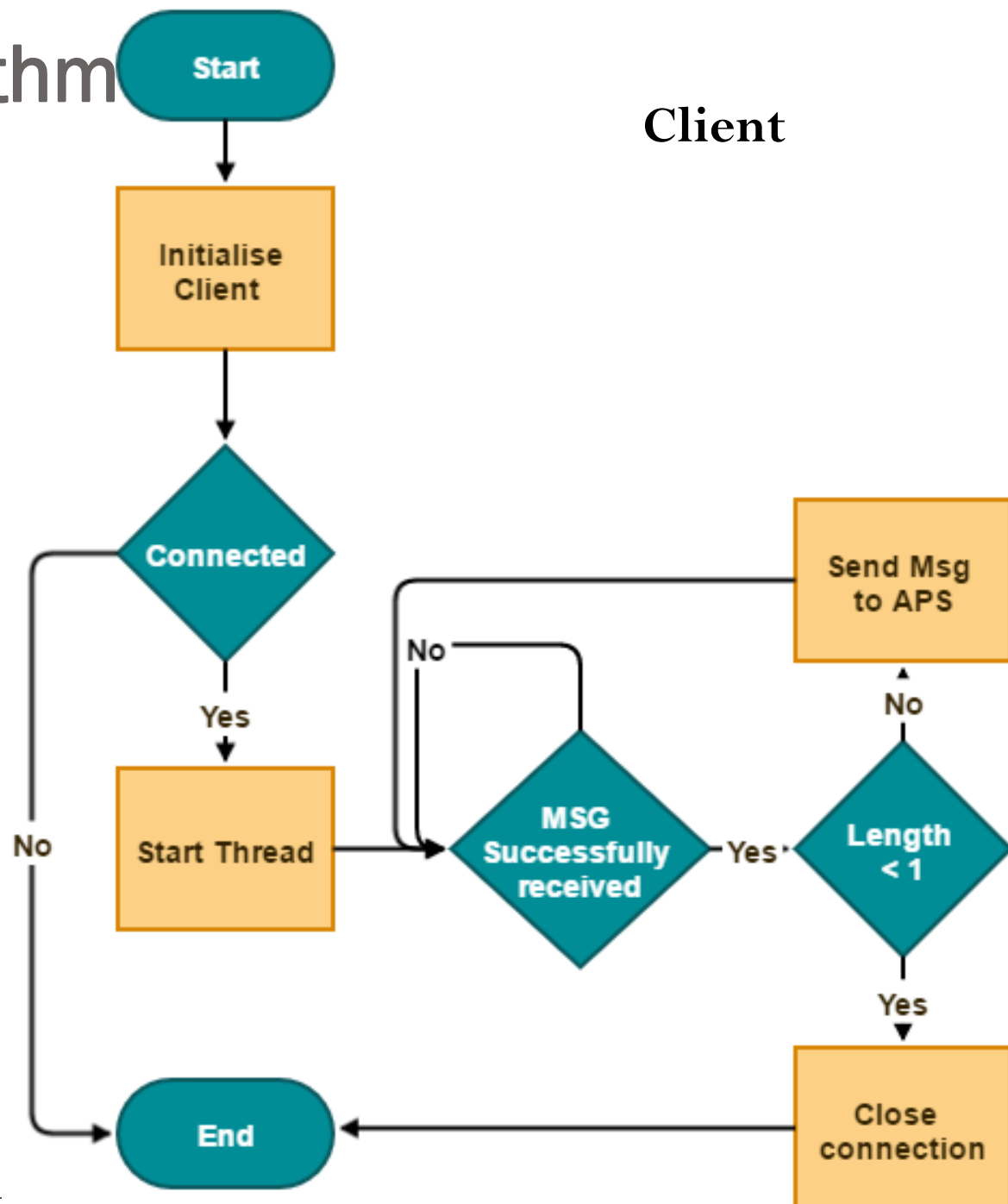


# NWK Layer Algorithm



# NWK Layer Algorithm

Client



```
rishabh@rishabh: ~/Integrated/server-coordinator
```

```
Enter port number : 8888
```

```
rishabh@rishabh: ~/Integrated/server-coordinator
```

```
Press D to get available device list
```

```
Press C to controll devices
```

```
Press E to exit
```

```
Please Enter your choice
```

```
D
```

## Output

**Starting Server**



```
rishabh@rishabh: ~/Integrated/server-coordinator
```

```
Press D to get available device list  
Press C to control devices  
Press E to exit  
Please Enter your choice  
█
```

```
rishabh@rishabh: ~/Integrated/client-enddevice
```

```
=====
```

```
gcc `pwd`/source/*.c -I`pwd`/include -lpthread -o client  
mv client `pwd`/bin
```

```
=====
```

```
Compilation Finished
```

```
=====
```

```
rishabh@rishabh:~/Integrated/client-enddevice$ ./bin/client  
Enter ip address : 127.0.0.1  
Enter port number : 8888█
```

## Output

### Starting Client

```
rishabh@rishabh: ~/Integrated/client-enddevice

enter y/Y to announce the device : y
ZD0 : Announcing this device
ZD0 : Handing over Announce packet to APS
APS : Data received
NWK : Dumping packet into the Network Layer
NWK : Packet received from coordinator
APS : Packet received from NWK
APS : Decoding received Frame
APS : Data sending to ZD0
ZD0 : Packet recieved from APS
ZD0 : Packet is for Simple discriptor request
ZD0 : Sending descriptor response
APS : Data received
NWK : Dumping packet into the Network Layer
Bulb is : Off
█

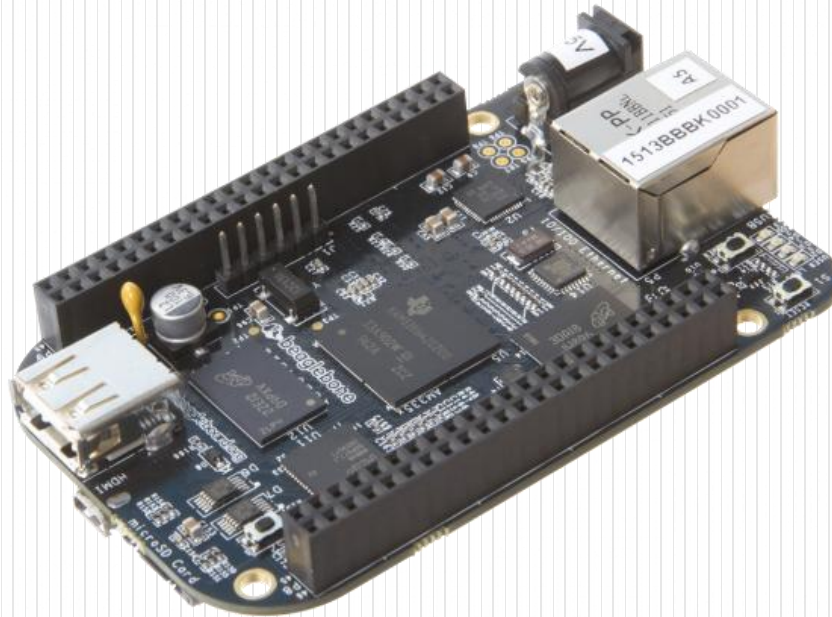
rishabh@rishabh: ~/Integrated/server-coordinator
No device bound till now
APS : Packet received from NWK
APS : Decoding received Frame
APS : Data sending to ZD0
ZD0 : Packet recieved from APS
ZD0 : Device Announce packet received
ZD0 : Sending Simple descriptor request
APS : Data received
NWK : Dumping packet into the Network Layer
APS : Packet received from NWK
APS : Decoding received Frame
APS : Data sending to ZD0
ZD0 : Packet recieved from APS
ZD0 : Device simple descriptor response packet received
```

# Output

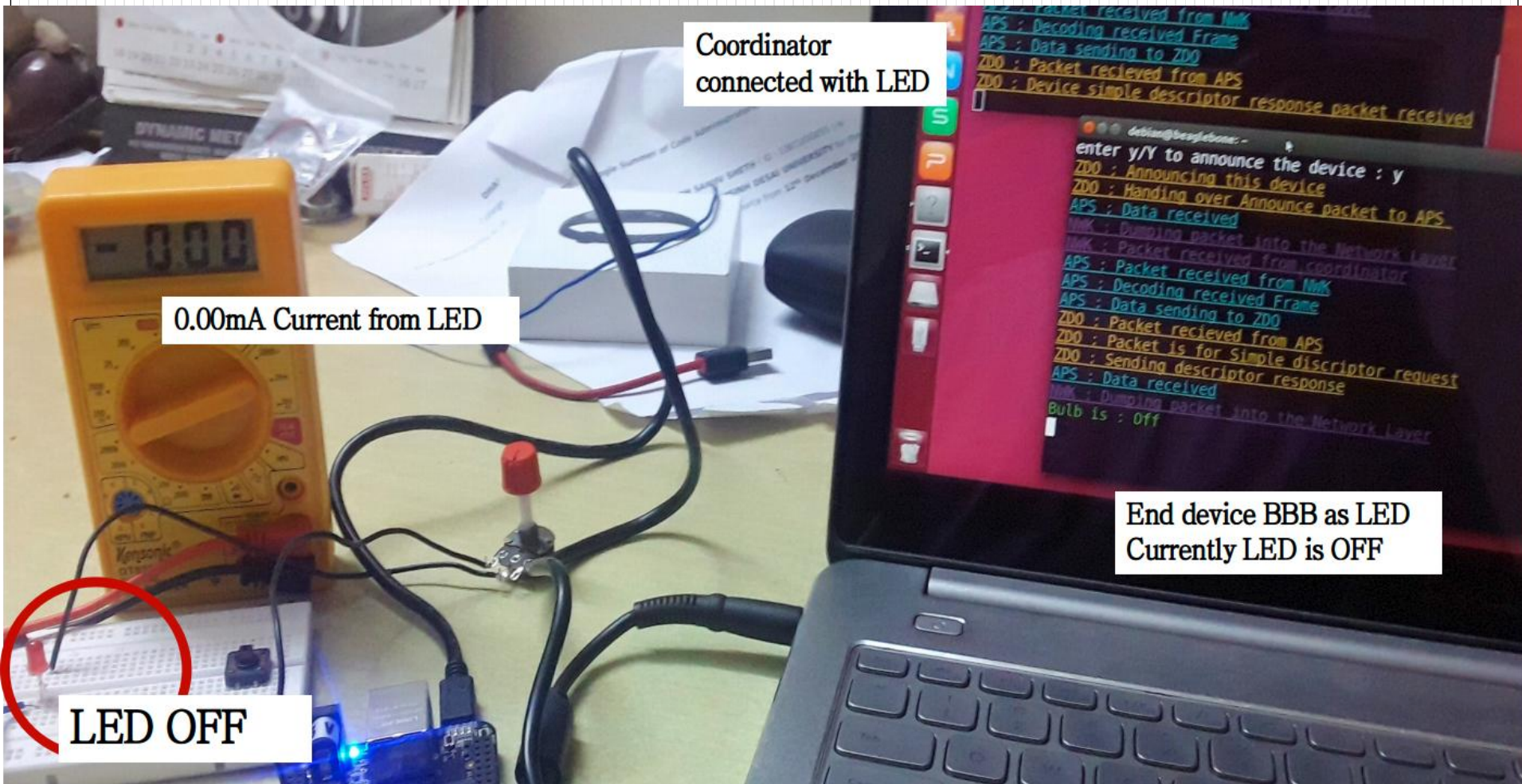
## Communication Between Server and Client

# Hardware Interface

- **BeagleBone Black** embedded board
  - 1Ghz ARM cortex A8 processor
  - USB , Ethernet, HDMI port
  - 64 GPIO
  - Debian Linux

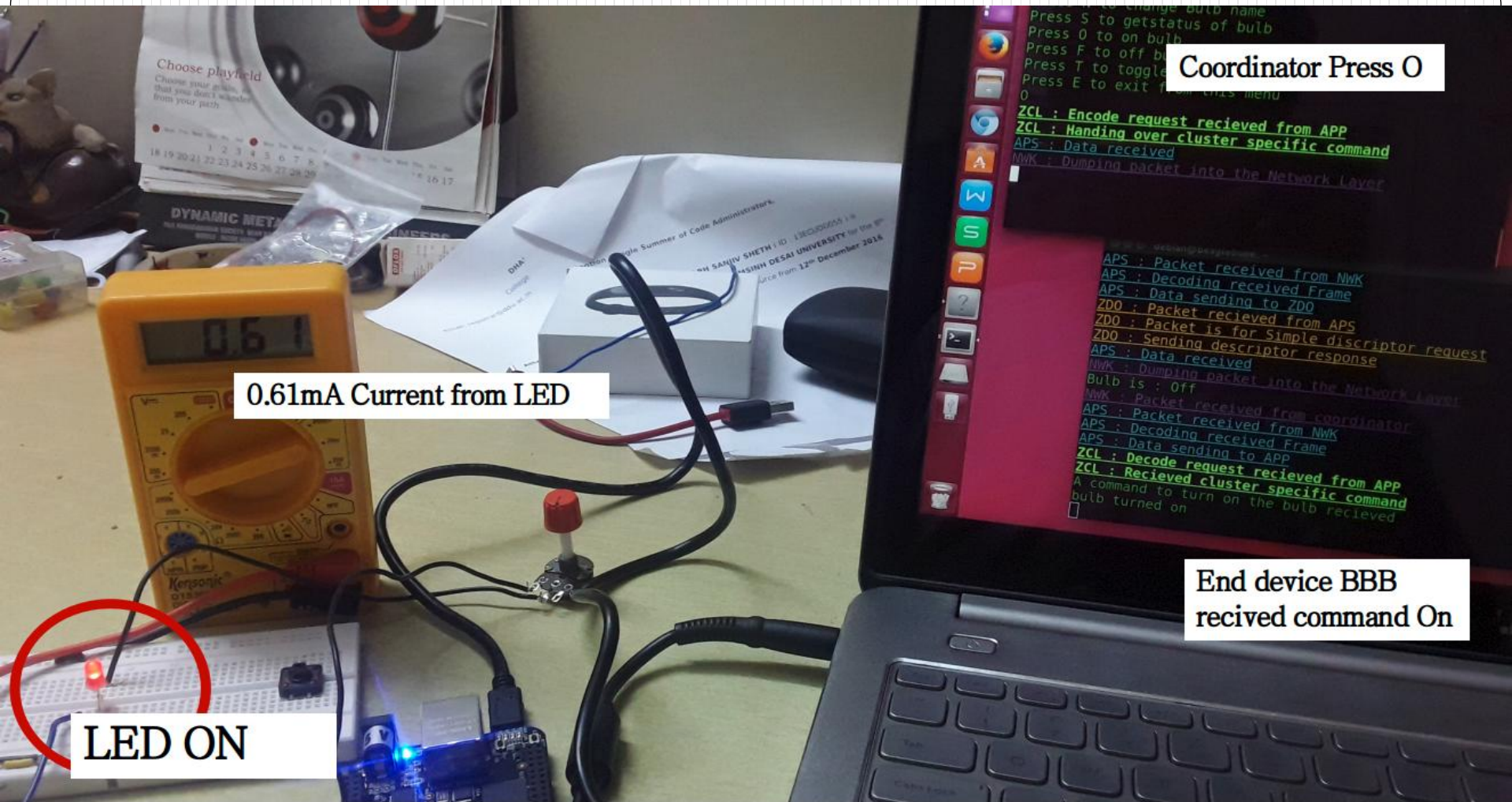






## Output

Client - BBB connected to Server LED is Off



0.61mA Current from LED

LED ON

Coordinator Press 0

End device BBB  
recieved command On

## Output

Client - BBB connected to Server & LED is On

# Conclusion

- ZigBee is one of the best choice available in market for IoT.
- ZigBee has good documentation for each layer but it clearly not define relation between two layers
- Part of ZCL and other layer in ZigBee specification implemented successfully
- Because time and resources are major constrain project is still in simulation so it needs to be test on real ZigBee device

Thank You

THE END