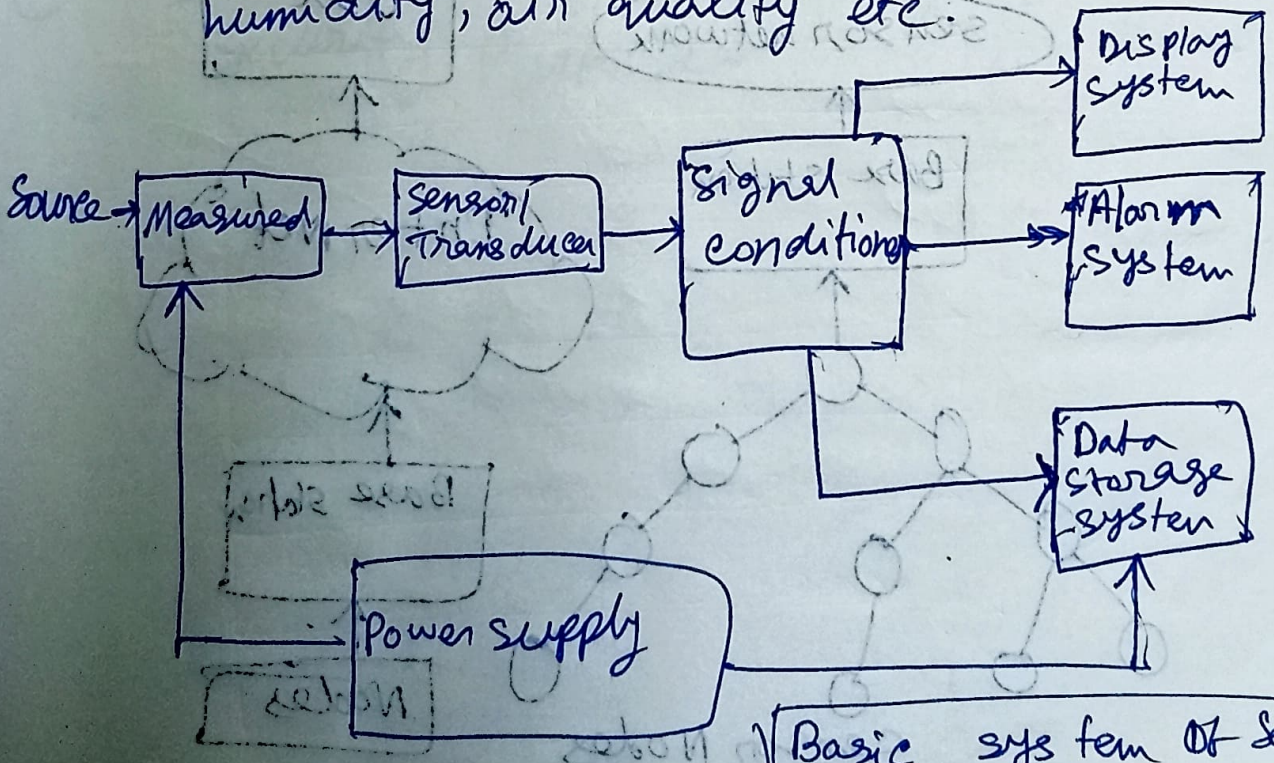
IOT Enabling Technologies

IOT is enable using many technologies such as -

(i) Wireless Sensor Networks (WSN)
(ii) Cloud Computing.
(iii) Big Data
(iv) Embedded System
(v) Internet.

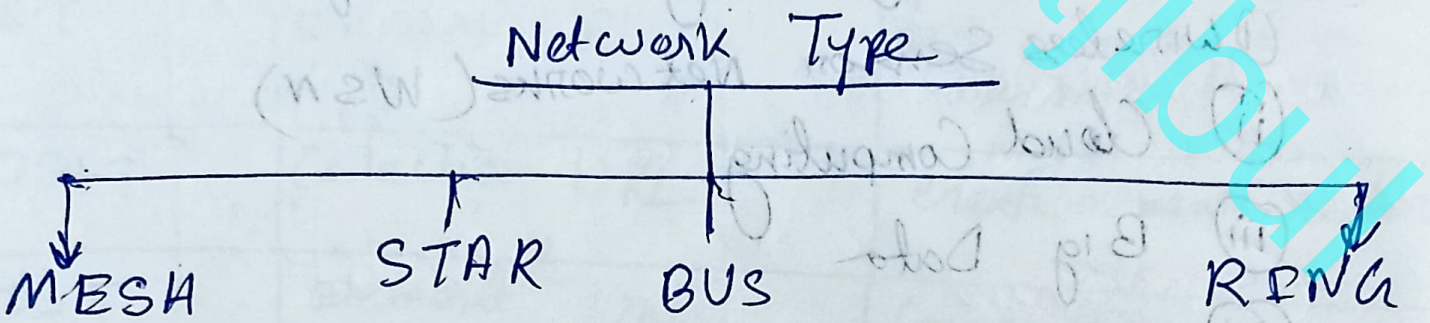
(i) Wireless Sensor Networks (WSN)

- Wireless Sensor Networks are a self-configured and infrastructure-less or ad-hoc type wireless network.
- They are used to monitor physical or environmental conditions such as temperature, pressure, humidity, air quality etc.



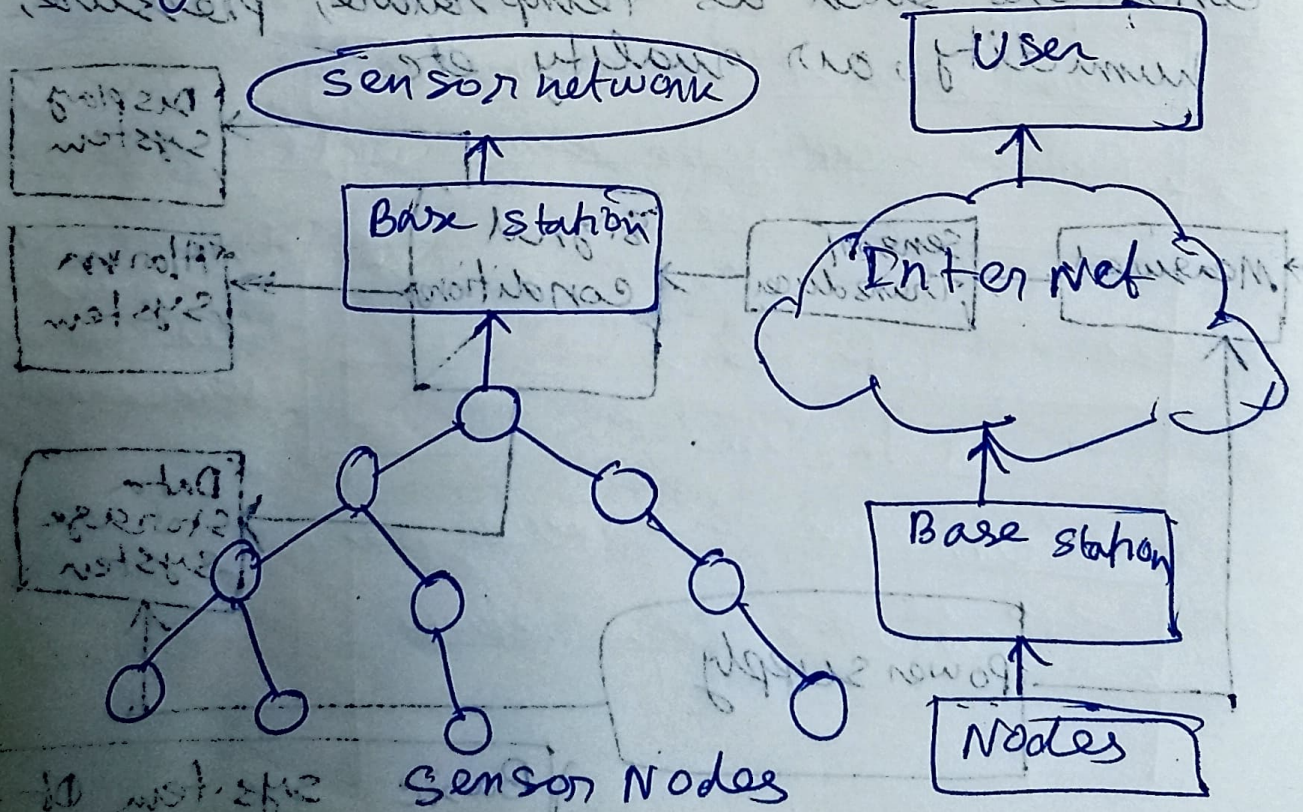
Basic system of Sensor

These sensors can be connected through various networks & topologies:-

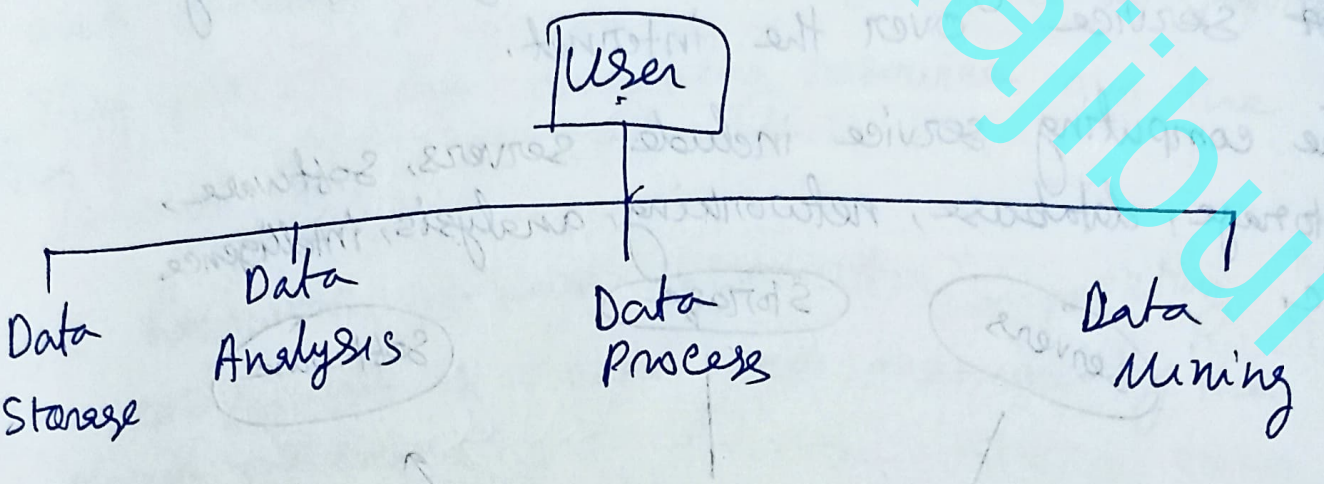


Sensor network

When different sensor nodes located in different locations to measures different variables, Then the final data transmitted to the Base station. Then from the base station the data send to the user by Internet.



After getting the data user can use the data according to his/her need.



Applications :-

(i) Home Automation :- Smart home

(ii) Water monitoring

(iii) Agriculture

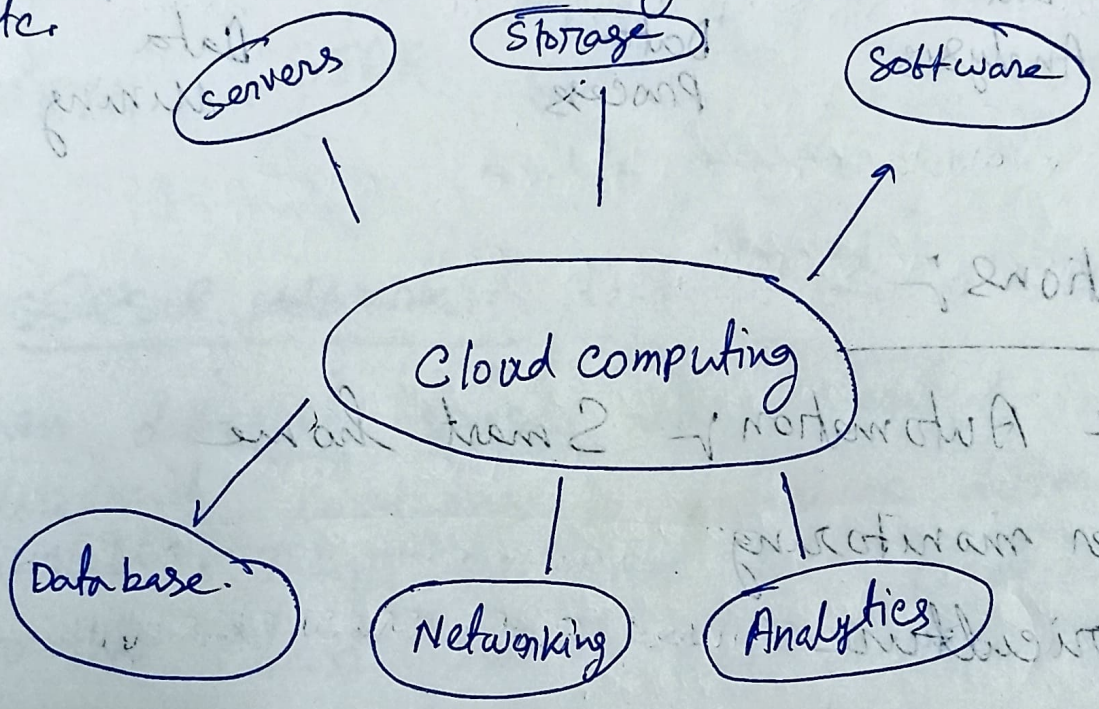
(iv) Biomedical Patinent Monitoring

(v) Surveillance and Monitoring For Security Purpose.

Cloud Computing

Cloud computing means providing computing service over the internet.

The computing service include servers, software, storage, database, networking, analysis, intelligence etc.



Cloud computing can be catogorised as

(i) Public cloud
(ii) Private cloud
(iii) Hybrid cloud

Public Cloud:- Public clouds are owned and operated by a third-party cloud providers. They provide the computing resource over the Internet.

All hardware software and other supporting infrastructure is owned and managed by the cloud provider.

We gain access of these services with our own unique account using a web browser.

Private Cloud:- A private cloud has cloud computing resources used exclusively by single business or organisation.

It is generally physically located on the company's on-site data center. Some companies also pay third-party service providers to host their private cloud.

The services and infrastructure are maintained on private network.

Hybrid Cloud:- Hybrid cloud combine public and private cloud.

They are bound ~~two~~ together by technology that allows data and applications to be shared between them.

It gives greater flexibility, more deployment options and helps in optimisation, security etc.

Types of cloud services

(i) Infrastructure as a service (IaaS)

(ii) Platform as a service (PaaS)

(iii) Software as a service (SaaS)

(i) Infrastructure as a Service (IaaS)

IaaS provides ~~Bd~~ IT infrastructure i.e, servers, storage, networks, operating system from a cloud provider on pay-as-you-go basis.

(ii) Platform as a service (PaaS)

PaaS provide an ondemand enviroment bor developing, testing, delivering and managing software applications.

(iii) Software as a Service (SaaS)

SaaS provides software applications over the Internet, on demand on a subeription basis.

Cloud service providers host an manage the software application and infrastructure.

User connect to the application over the internet, usualy with a web browser on their phone, table or PC.

Advantages of Cloud Computing

Cost: Cloud computing eliminates the cost of purchasing hardware and software, seeting up and running centers, keeping IT personnel for infrastructure management.

Speed:- Cloud computing services are provided as self service and on demand. Vast amount of computing resource can be provided in a few minutes with a ~~few~~ few mouse click.

Security:- Cloud service providers have rules, policies, regulations and controls that ~~strengthen~~ strengthen your security, protect the clients data, apps and infrastructure from potential threats;

Reliability:- Cloud computing has data backup, ~~dust~~ disaster recovery to ensure operational continuity. Data mirrored at multiple ~~redundant~~ redundant site on the cloud provider's network.

Scability:- It include the ability to scale elastically and flexibly. It means ~~incli~~ increasing or decreasing the amount of IT resources, more or less computing power, strong or bandwidth as per requirement.

Big Data

Data: Data is anything that represents information about a particular event or phenomenon.

It can be mechanical, optical, chemical, magnetic, electrical nature.

But it is convenient to have all data in electrical form for easier analysis and processing.

Big Data: Big Data refers to data which is of large size and is very complex.

It has three important characteristics

(i) Volume (ii) Velocity (iii) Variety.

Volume :- Big Data refers to data of enormous size. Size of data is an important factor in determining whether data falls in the category of big data or not.

Velocity:- Velocity refers to speed of generation and consumption of data. The rate at which data is generated, processed and analysed. It is the speed at which data flows in and out from different sources. The flow of data is massive and continuous.

Variety :- Variety refers to the different types of data. Big Data comes in different forms such as text, numbers, characters image, audio, video etc.

It can be structured, unstructured or semi-structured etc.

Ex: Weather monitoring system, Social media platforms, Stock exchange, search engine generate huge quantity of data per day of the order of terabyte.

These data are generated and consumed at a rapid rate and are hetrogeneous and complex in nature.

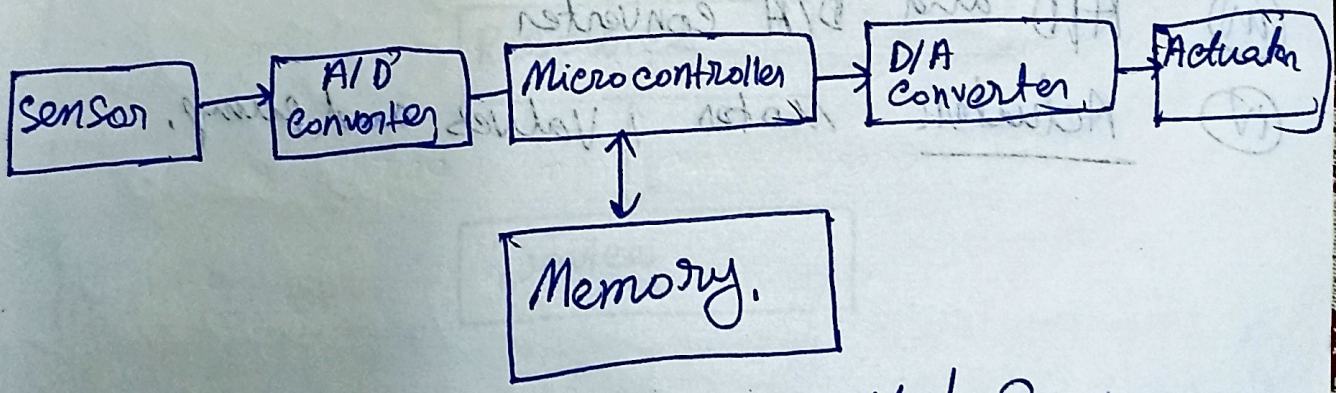
Embedded System:-

An embedded system is a combination of hardware and software elements which are designed for a specific perpose.

It can either be an independent system or a part of a large system

Basically, it is designed in the form of an integrated circuit to achive a single or multiple objectives.

Ex! Digital Watches, Smart phone, Microwave, Washing Machine etc.



Block Diagram of Embedded System

Sensors:- They are devices which measure various parameters (Physical, Chemical, mechenical, electrical, optical) and give out-put in electrical form.

A/D Converter:- A/D converter convarts output of sensors (which generally in analog form) into digital form so that it can be applied to microcontroller.

Ex:-

Automatic Lighting System

① Sensor :- Photodetector

② Micro controller

③ A/D & DA converter

④ Actuator :- Relay.

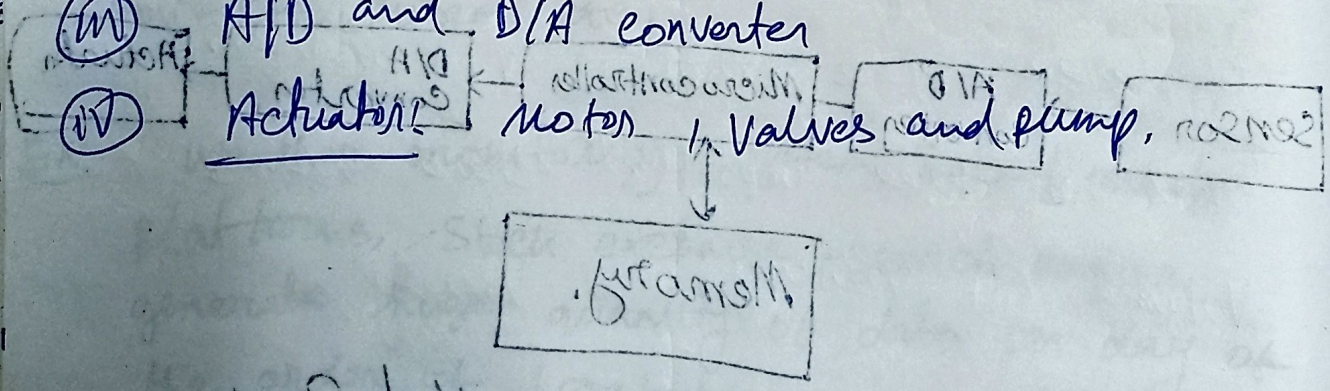
Automatic Irrigation System

① Sensor :- Hydrometer

② Microcontroller

③ A/D and D/A converter

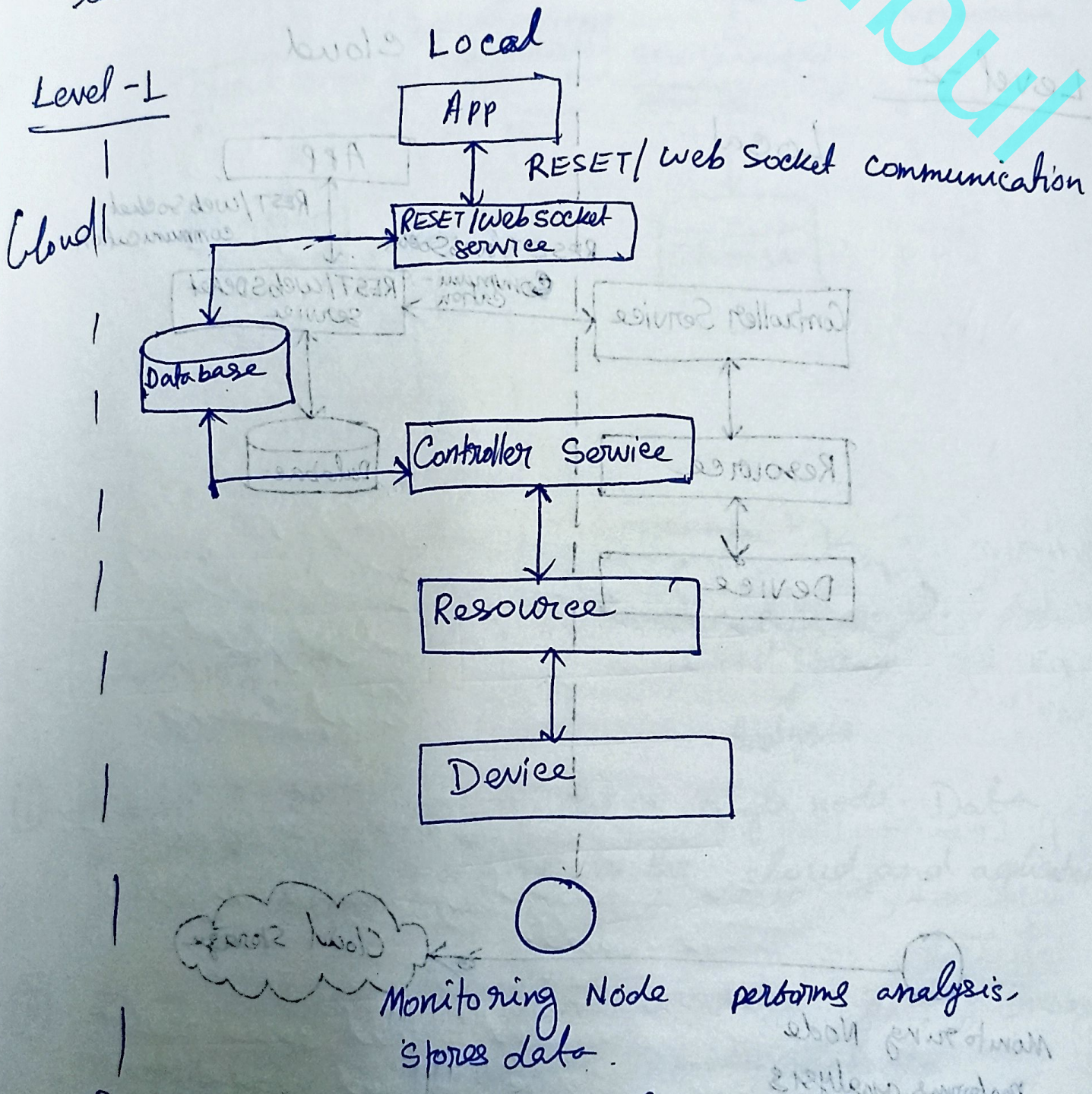
④ Actuator :- Motor / Valves and pump.



IOT Levels and Templates.

There are total six levels of IOT. levels level 1 to level 6.

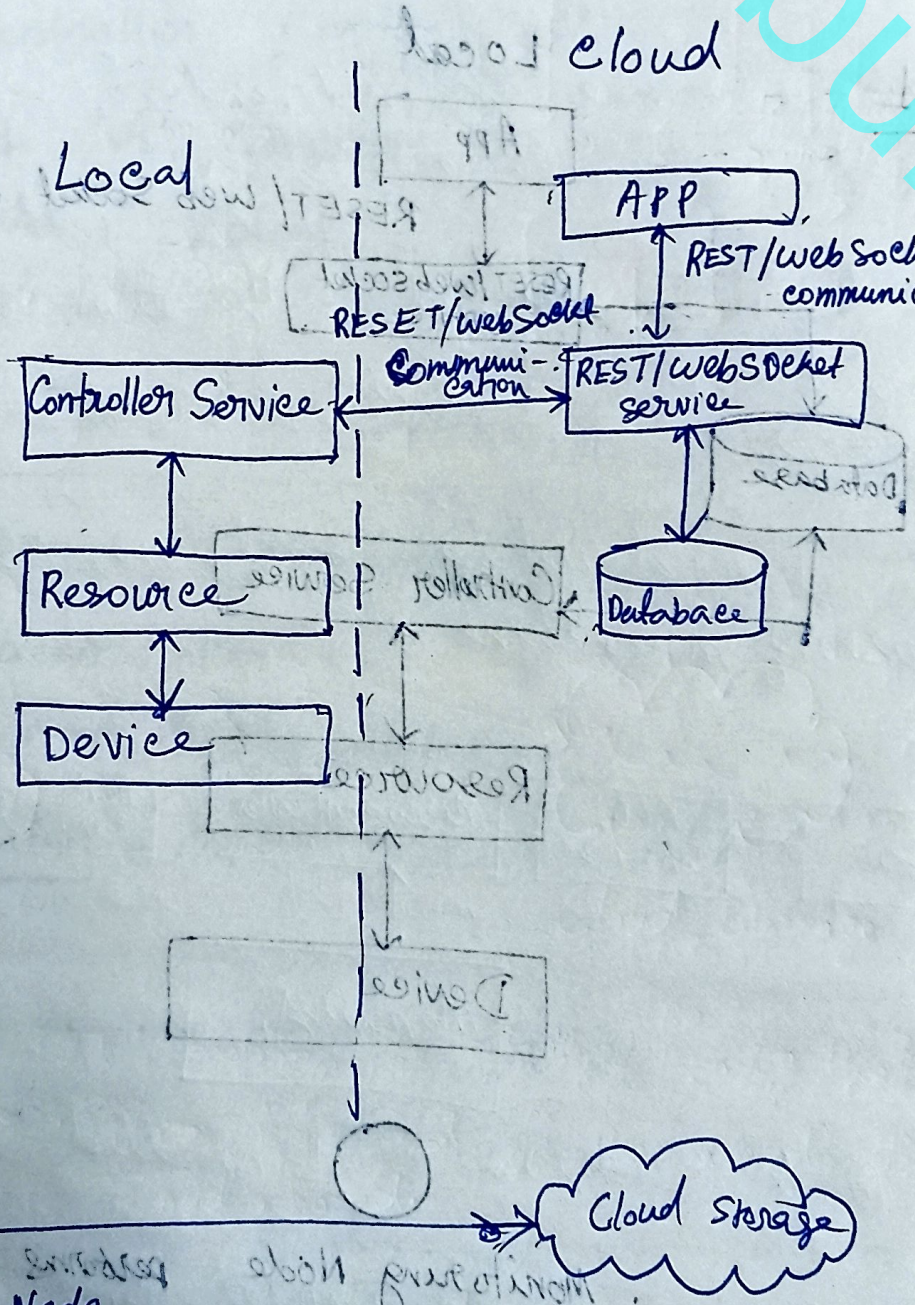
Level-1



A level-1 IOT system has a single node/ device that perform sensing and/or actuation, stores data, performs analysis and hosts the application.

(iv) It suitable for modeling low cost and low complexity solutions where the data involved is not big and the analysis requirements are not computationally intensive.

Level -2

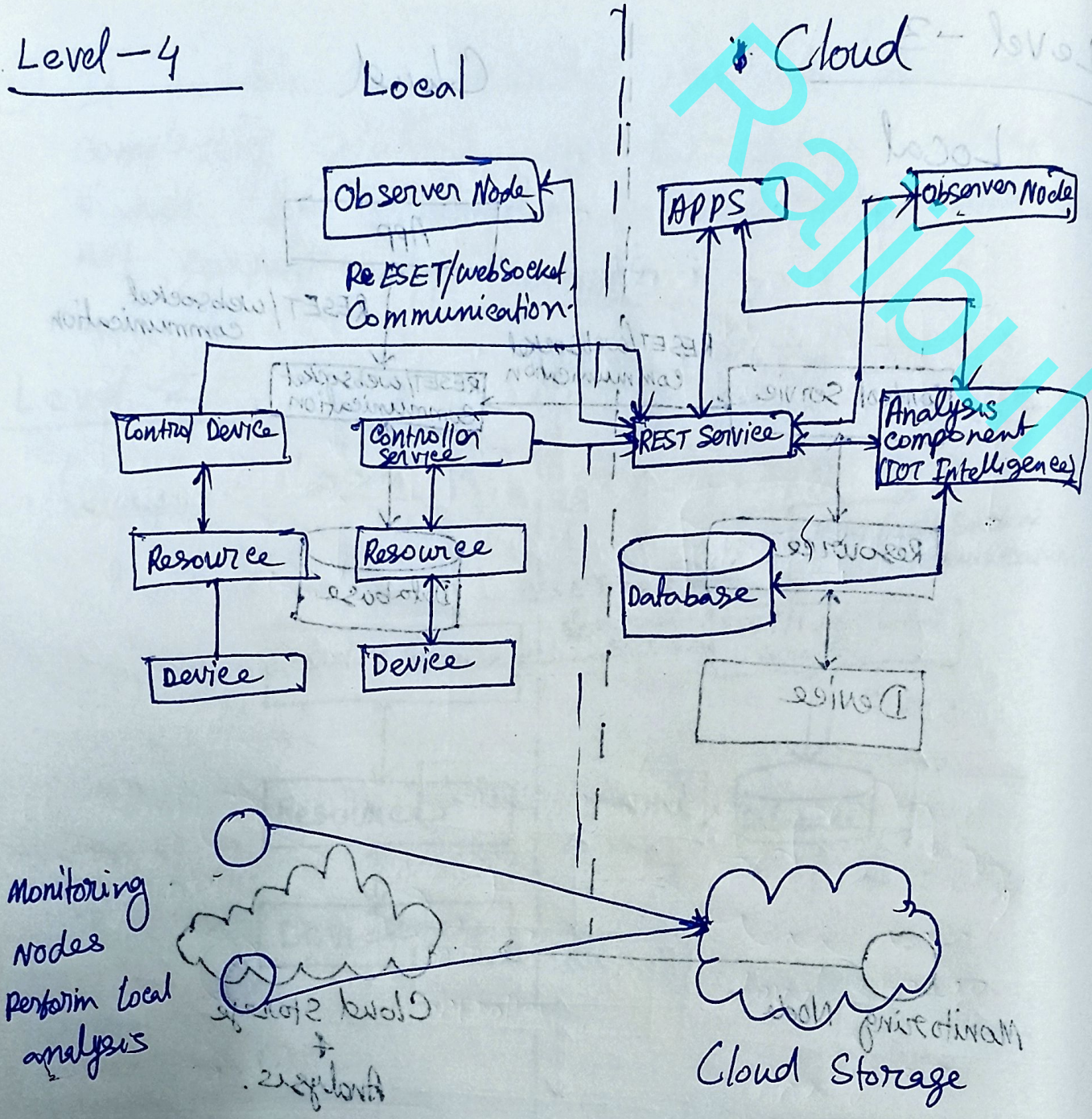


(i) At level-1 IOT system has a single node that performs sensing and/or actuation and local analysis

(ii) Data is stored in the cloud and application is usually cloud based.

(iii) It is suitable for solutions where the data involved is big.

Level-4

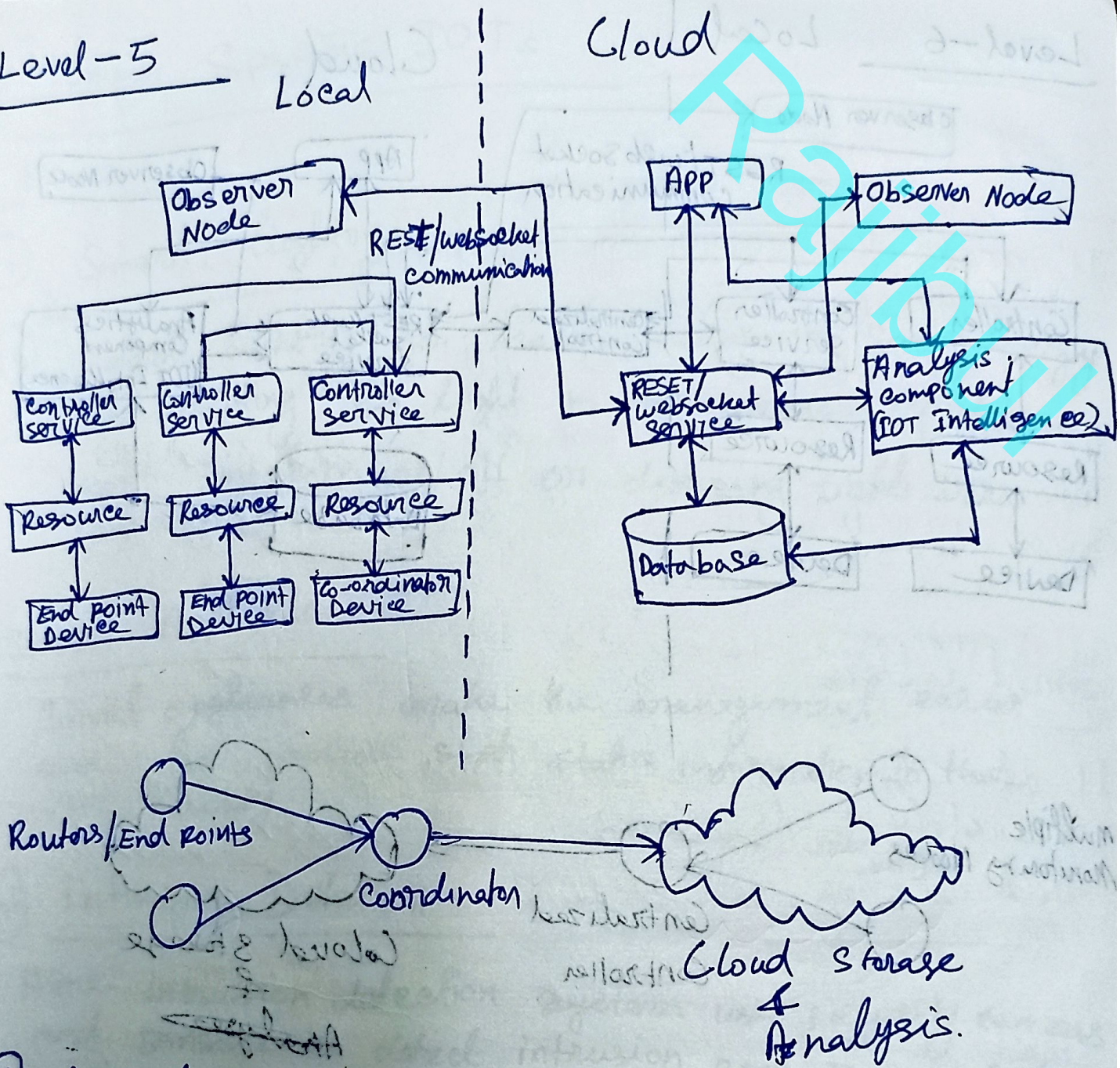


(i) A Level-4 IOT system has multiple nodes that perform local analysis. Data is stored in the cloud and application is cloud based.

(ii) Level-4 contains local and cloud based observer nodes which can subscribe to and receive information collected in the cloud from IOT device.

(iii) It suitable for solutions where multiple nodes are required.

Level-5



(i) A level-5 IOT system has multiple end nodes and one co-ordinator node.

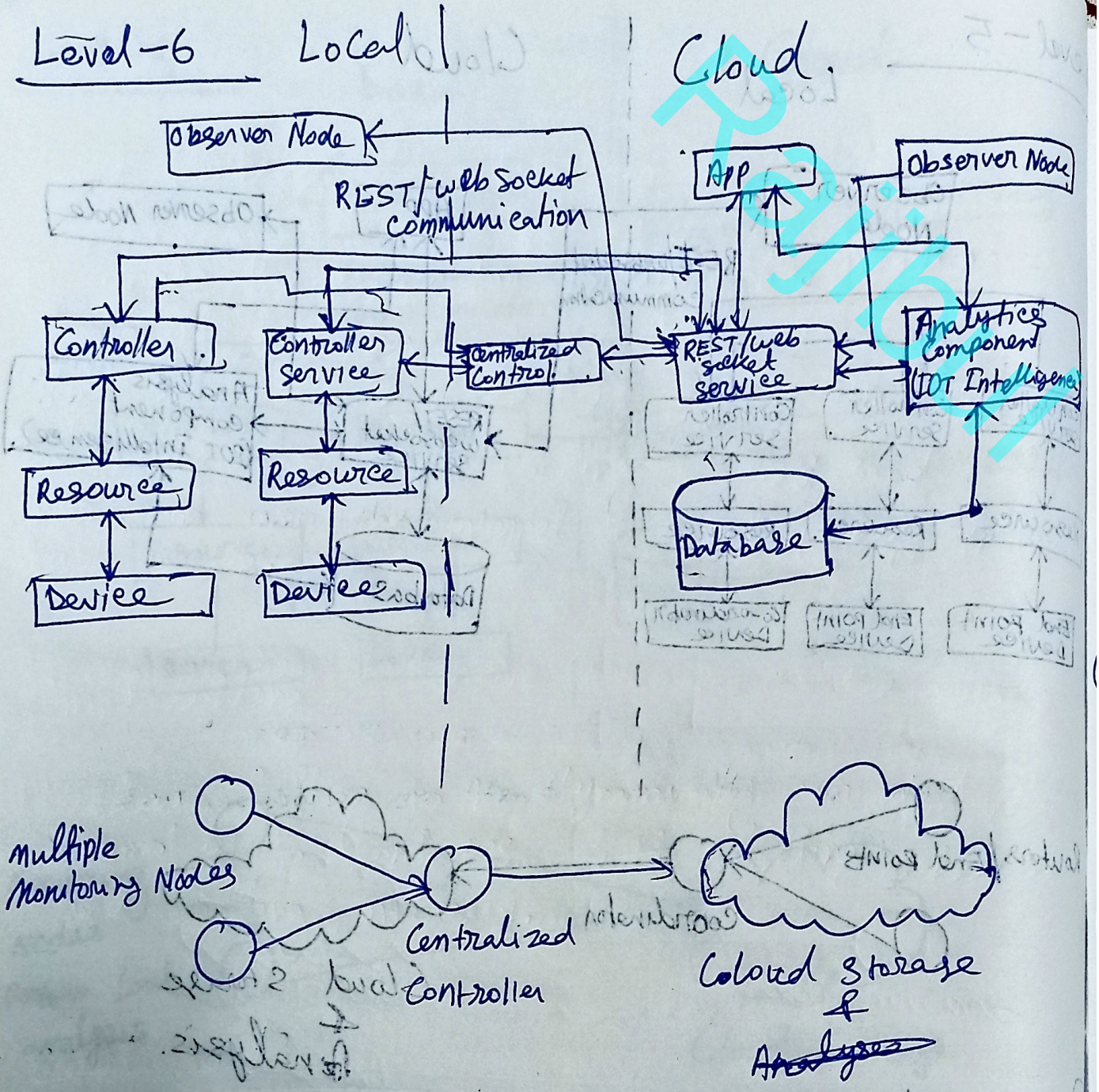
(ii) The end nodes perform sensing and/or actuation

(iii) Co-ordinator node collects data from the end nodes and sends to the cloud.

(iv) Data is stored, analyzed in the cloud and application is cloud based.

(v) It is suitable for solutions based on wireless sensor networks in which the data involved is big and the analysis requirements are computationally intensive.

Level-6



(i) A Level-6 IOT system has multiple independent end nodes that perform sensing and/or actuation and send data to the cloud.

(ii) Data is stored in the cloud and applications is cloud based.

(iii) The analytics component analyzes the data and stores the result in the cloud database.

(iv) The centralized controller is aware of the status of all the end nodes and send control commands to the nodes.

Domain Specific IOTs

Home

(i) Smart lighting.

(i) Smart lighting for home helps in saving energy by adapting the light to the ambient conditions and switching on/off or dimming lights when needed.

(ii) Smart Appliance

Smart appliances make the management easier and also provide ~~stat~~ status information to the user remotely.

(iii) Intrusion Detection:

Home intrusion detection system uses security cameras and sensors to detect intrusion and raise alarts. Alart can be form of SMS or an email sent to the owner.

(iv) Smoke/Gas detectors:

Smoke detectors are ~~an~~ installed in home and building to detect smoke that is typically an early sign of fire.

Cities

Smart Parking:-

It make the search for parking space easier and conveient for drives.
These are powered by IOT system that detect the number of empty parking slots and send the information over the internet to smart parking application back-ends.

Smart lighting:-

It allows lighting to be dynamically controled remotely to configure lighting schedules and lighting intensity.

Smart roads:-

Smart roads can provide information on driving conditions, travel time estimates and alarts in case poor driving conditions, traffic congestions and accidents.

Structural Condition monitoring

This system uses a network of sensors to monitor the vibration level in the structures such as bridge and building.

~~Smart~~

Surveillance:-

Surveillance of infrastructure & public transport and events in cities is requested to ensure safety and security.

Environment:

Weather monitoring System

weather monitoring System can collect data from a number of sensors attached (such as temprature, humidity, pressure etc) and send the data to cloud-based applications and ~~back~~ storage back-end.

Air polution Monitoring:-

IOT based air pollution monitoring system can monitor emission of harmful gases by ~~the~~ factories and automobiles using gaseous and meteorological sensors.

Noise poluti on:-

The system uses number of noise monitoring stations that are deployed at different places in a city.

The data on noise levels ~~from~~ from the stations are collected on servers on the cloud

Forest Fire detection

Early detection of fire can be help in minimizing the damage cause by forest fires. IOT based forest fire detection system use a number of ~~sensor~~ monitoring nodes ~~deploy~~ deployed at different locations in ~~the~~ a forest.

River Floods Detection

It can cause extensive damage to the natural and human resource and human life. IOT based river flood monitoring system use a number of sensor nodes in at monitor the water ~~lata~~ level and flow rate.

Energy

Smart Grid:

Smart grid is a data communications network integrated ~~which it~~ with the electrical grid that collects and analyzes data computed in near real time about power transmission, distribution and consumption.

Renuable Energy System:-

Due to the variability in output from renuable energy source integrating them into the grid can cause stability and reliability problem.

Prognastics

Energy system have a large number of critical components that must function correctly so in that the system perform their operation correctly.

IOT based prognostic real time health mangers System can predict performane of mechnas on energy system by analizing the extent of divition of a system from its normal operating profiles.

Retail:

① Inventory Management

Overstoking of products can result in additional storage expenses, understocking can lead to loss of revenew.

IOT system using Radio frequency Indentification (RFDI) tags can help in inventory management and maintaining the right inventory levels.

Smart Payments

Smart payment solutions such as contact less payments powered by ~~technologies~~ technologies such as Near field communication (NFC) and blue tooth.

Smart Vending Machines

Smart vending machines connected to the Internet allows remote monitoring of inventory levels, elastic pricing of products promotions and contact-less payment using NFC.

Logestics

Route Generation and Scheduling

Route generation and scheduling systems ~~can~~ can generate end to end routes using combination of route pattern and transportation modes and ~~feasible~~ schedules based on the availability of ~~vehicle~~ vehicles.

IOT based systems backed by the cloud can provide fast response to the route generation queries and can be scaled up to server a large transportation network.

Fleet Tracking

Vehicle fleet tracking systems use GPS technology to track the locations of the vehicles in real time.

Cloud based fleet tracking system can be scaled up to demand to handle large number of vehicle.

Alert can be generated in case of deviations in planned routes.

Shipment Monitoring:

IOT based shipment monitoring system use sensors such as temprature, pressure, humidity for instance to monitor the conditions inside the containers and send the data to the cloud, where it can be analyzed to detect food spoilage.

Agriculture

Smart Irrigation

Smart irrigation system use IOT devices with soil moisturing sensors to determine the amount of moisture in the soil and release the flow of water through the irrigation pipe only when the moisture level go below a predefined ~~there~~ threshold.

Green house control

The climatological conditions inside a green house can be monitored and controlled to provide the best condition for growth of plants. IOT systems play an important role in green house contol and help in improving production.

Industry

Machine Diagnosis and Prognosis

Machine prognosis - Predicting the performance of a machine by analyzing the data on the current operating conditions.

Machine Diagnosis - determining the cause of machines fault.

Sensor in the machine can monitoring the operating conditions such as temperature and vibration levels.

Indoor Air Quality monitoring

Monitoring indoor air quality in factories is important for ~~bett~~ health and safety of the workers.

IOT based gas monitoring system can help in monitoring the indoor air quality using various gas sensors.

Wireless sonson networks based IOT drives can identify the nazardous zones, so that corrective measures can be takes to ensure proper ventilation.

Health & Lifestyle

Health and bitness monitoring

Wearable IOT device that allows ~~non-invasive~~ non-invasive and continuous monitoring of physiological parameters can help in continuous health and bitness monitoring.

These wearable devices may can be in various forms such as belt & wrist band.

IOT & M2M

M2M Defination :-

Machine to machine (M2M) refers to networking of machine to machine (or drive) for purpose of remote monitoring and control and data exchange.

In M2M communication, objects can ~~talk to~~ communicate with eachother without human intervention.

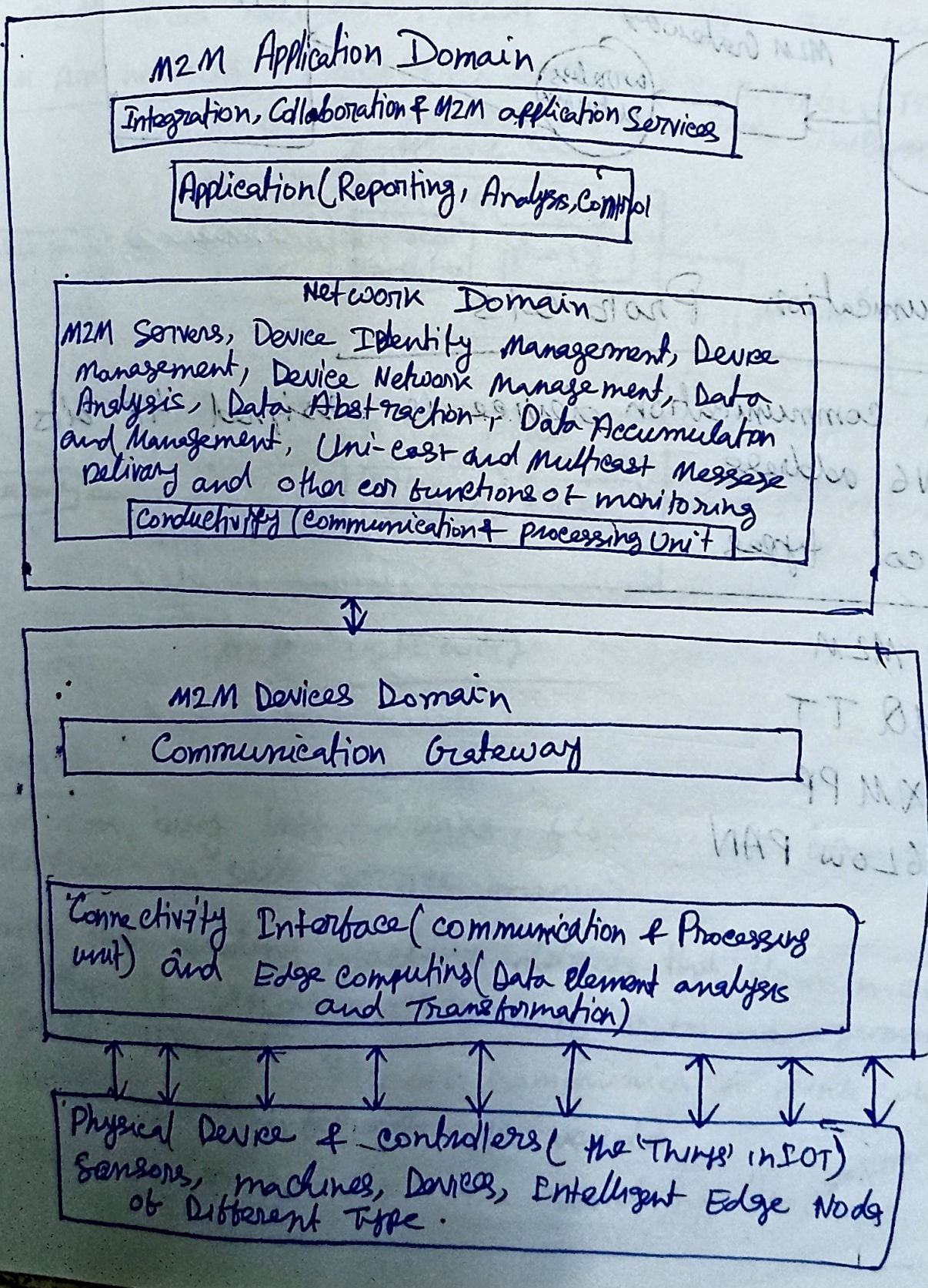
Machine to machine (M2M) refers to the process of communication of a physical or device at machine with others of the same type, mostly for monitoring but also for control purpose.

Each machine in an M2M system embeds a smart device. The device senses the data or status of the machine, and performs the communication and communication functions. A device ~~communication~~ communicates via wired or wireless system.

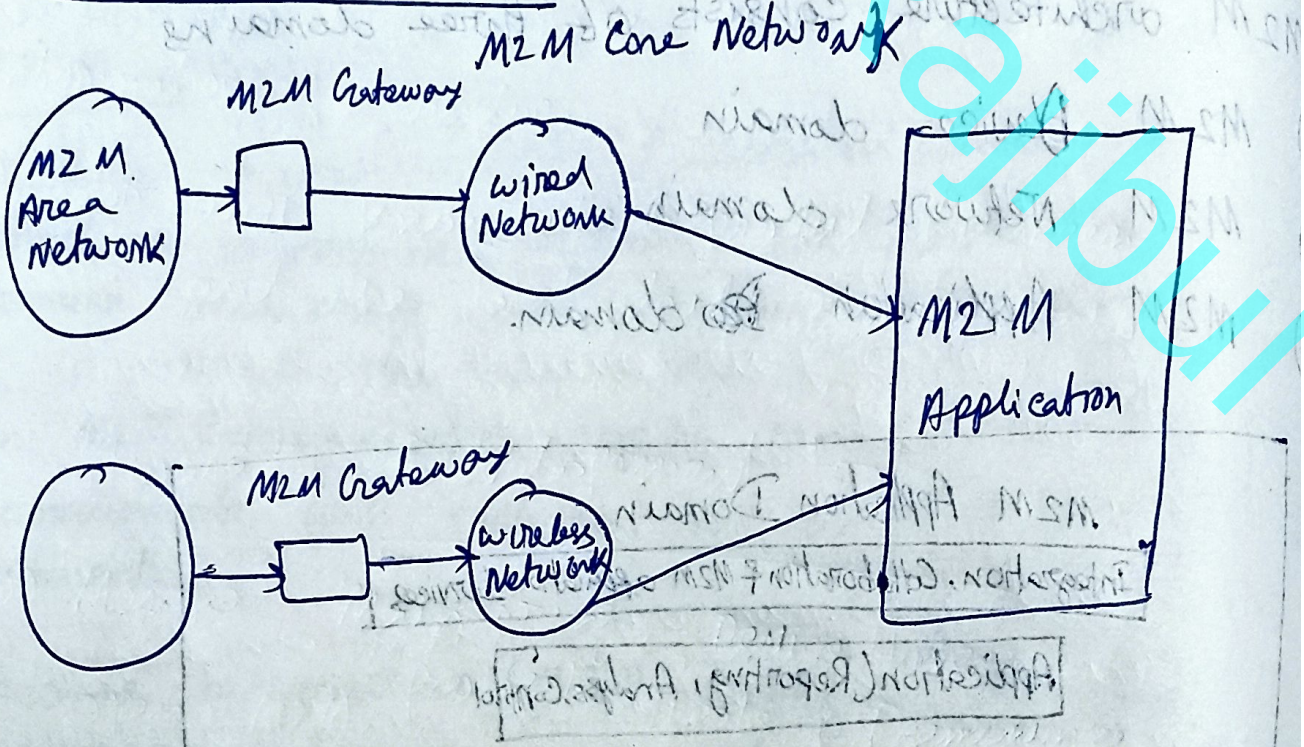
M2M System Architecture

M2M architecture consists of three domains

(i) M2M Device domain
(ii) M2M Network domain
(iii) M2M Application domain.



System Architecture



Communication Protocols

Each communication device is assigned 48 bits IPV6 address

Protocol types

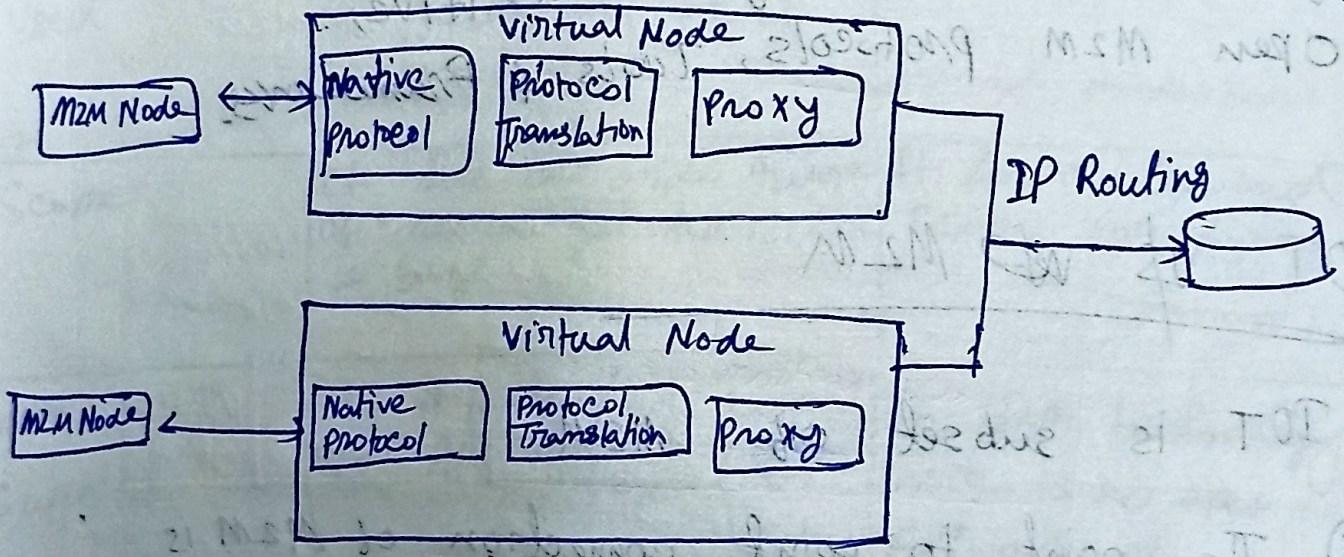
(i) LW M2M
(ii) MQTT
(iii) XMPP
(iv) 6Low PAN

M2M Gateway

Since non-IP based protocols are used within M2M area networks, the M2M nodes within one network communication with nodes in a external network.

To enable the communication between remote M2M area networks M2M gateways are used.

M2M Area networks: Bluetooth, ZingBee, 802.15.4, 6LowPAN, M-Bus, wireless M-Bus, UWB, ModBus, Z-Wave.



M2M Gateway

Example:-

One can buy soft drinks, flowers, etc, from vending machines in self service manner.

Once the vending machine detects the item in out-of-stock, it sends message to order management server through 3G/4G communication link which further send information to vendor.

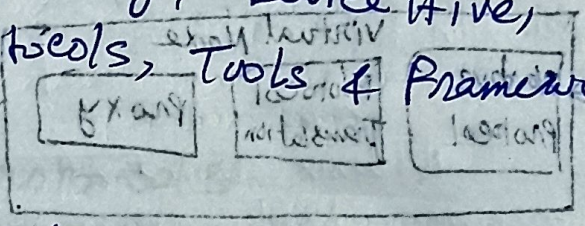
The vendor re-stock the vending machine

Vending machine stores daily sales data in Internal database and sends information to vendor.

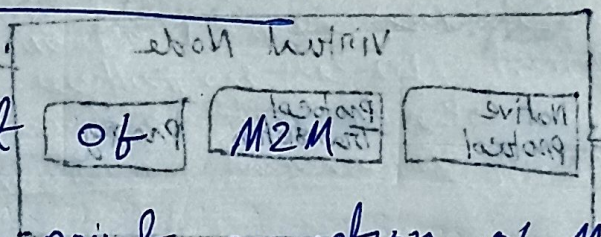
Vendor will know which product has been sold and the total daily revenue.

Software & Development Tools

(a) Mango, Mainspring, Device Hive, Open M2M protocols, Tools & Frameworks.



IOT Vs M2M



(i) IOT is subset of M2M

(ii) The point to point connection of M2M is main difference between M2M & IOT

(iii) Another key difference between IOT & M2M is scalability.

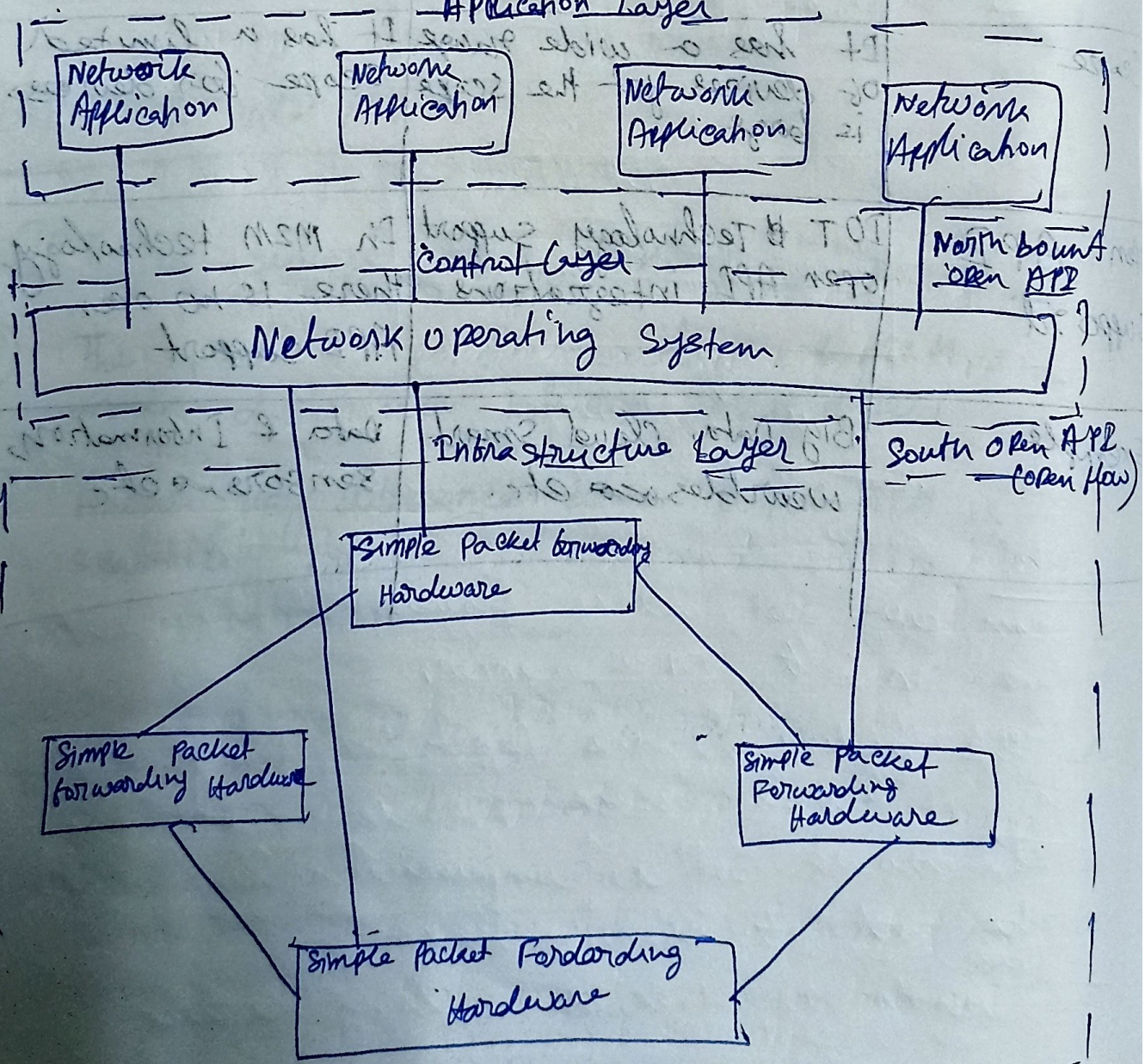
Features	IOT	M2M
Abbreviation	IOT stands for the Internet of things	M2M stands for Machine to Machine communication
Intelligence	Devices include object that are responsible for decision-making process	In M2M, there is a limited amount of intelligence observed
Connection type Used	The connection of IOT is through the network and using various type of communication	M2M uses a point to point connection
Scope	It has a wide range of devices yet the scope is large	It has a limited scope for devices.
open API support	IOT Technology support open API integrations	In M2M technology there is no open API support
Example	Big Data, Cloud Smart wearables etc.	Data & Information, sensors, etc

Software-Defined Networks (SDN)

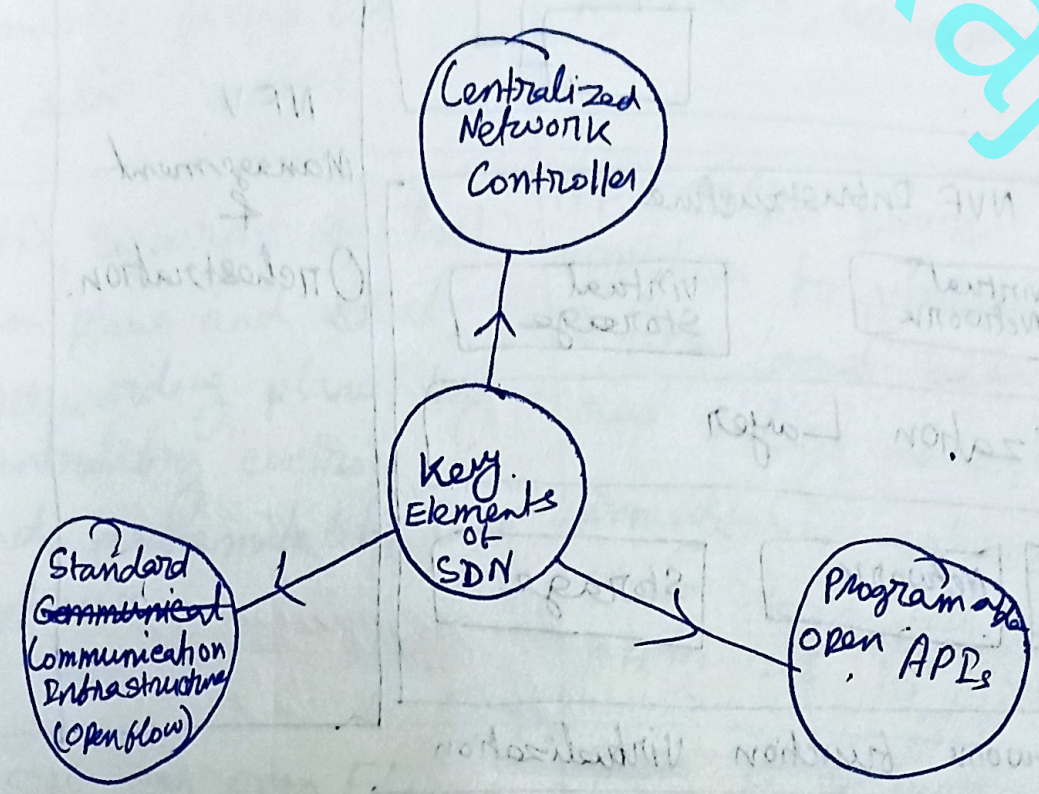
It is an architecture separate control plane from data plane and centralizes network control.

SND controllers maintain a unified view of the network & make configuration, management and provisioning simpler.

Underlying infrastructure in SND uses simple packet forwarding as opposed to specialized hardware in conventional network



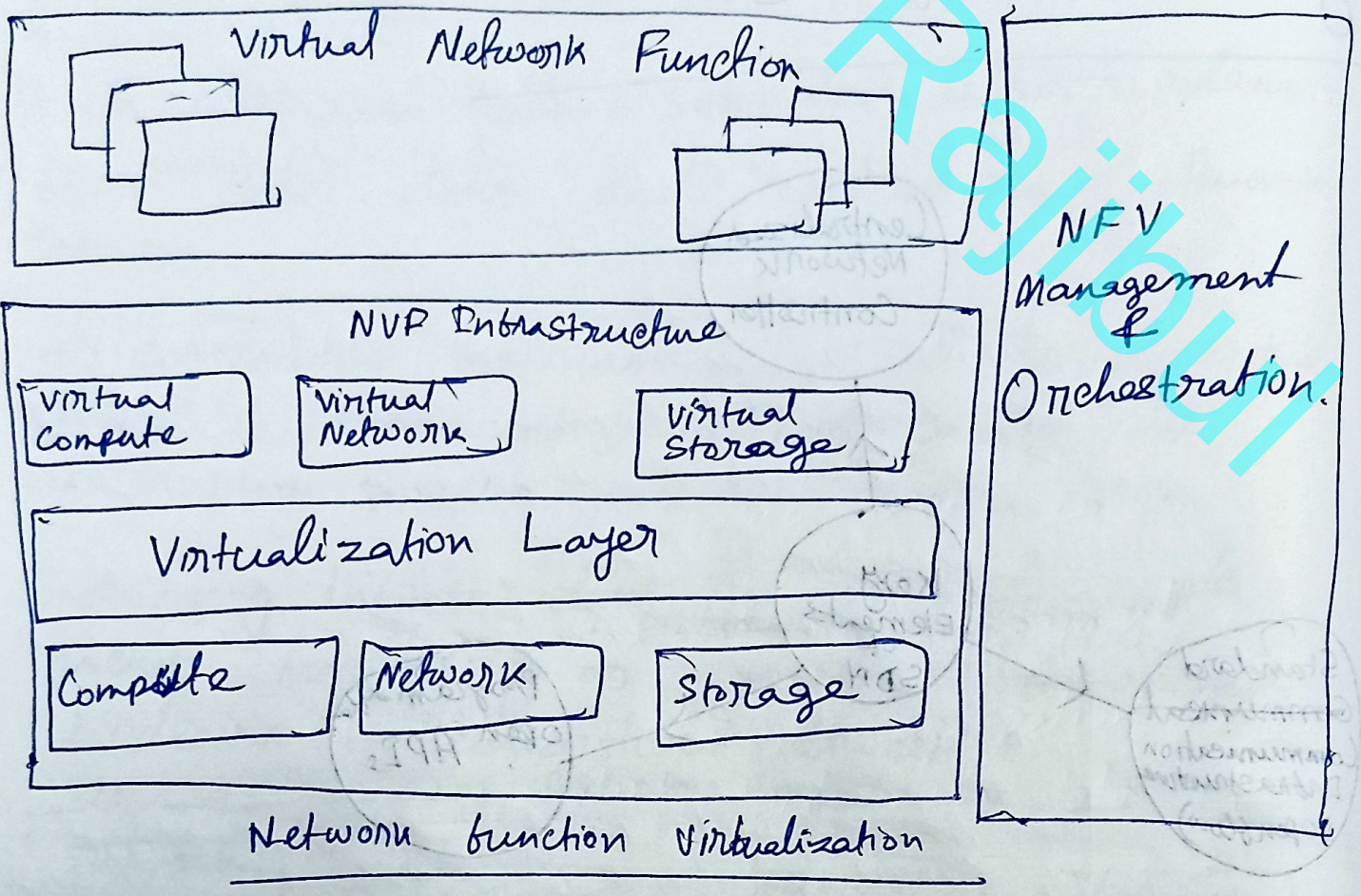
Key elements of SDN



Network function Virtualization (NFV)

It is the technology that controls virtualization to combine the heterogeneous network devices onto industry standard high volume servers switches and storage.

NVF is complementary to SND as NFV can provide infrastructure on which SND can run



Virtual Network function (VNF)

It is a software implementation of network function which is capable of running over NFV Infrastructure

NFV Infrastructure

It includes compute, network and storage resource that virtualization

NFV Management and Orchestration

It focuses on all virtual - specific - management tasks.

It covers life-cycle management of physical & / or software resources that support infrastructure virtualization and the life-cycle management of VNFs.

SND	NVF
SND architecture mainly focus on data centers	NVF targeted at service providers or operators
SND separate control plane and data forwarding plane by centralizing control and programability of network	NFV helps service provider or operators to virtulize functions like load balancing, auting and policy management by transforing network function from dedicated appliances to virtual servers
SND uses open Flow as a communication protocol	There is no protocol determined yet for NFV
SND supports open Networking Foundation	NFV is driven be ETSI NFV working group
Various support open Networking Foundation	NFV is driven by ETSI NFV working.
Various enterprises networking software and hardware vendors are initiative supports of SND	Telecom service providers or operators are prime initiative supports of NFV
Corporate IT act as a Business initiator for SND	service providers or operators act as a Business initiator for NFV
SND reduce cost of network because now there is no need of expensive switches or routers	NVF increase scalability and agility as well as time to time market as it dynamically allot hardware a level of capacity to network functions needed at a particular time.

IOT System management - NETCONF - YANG

31.7.20

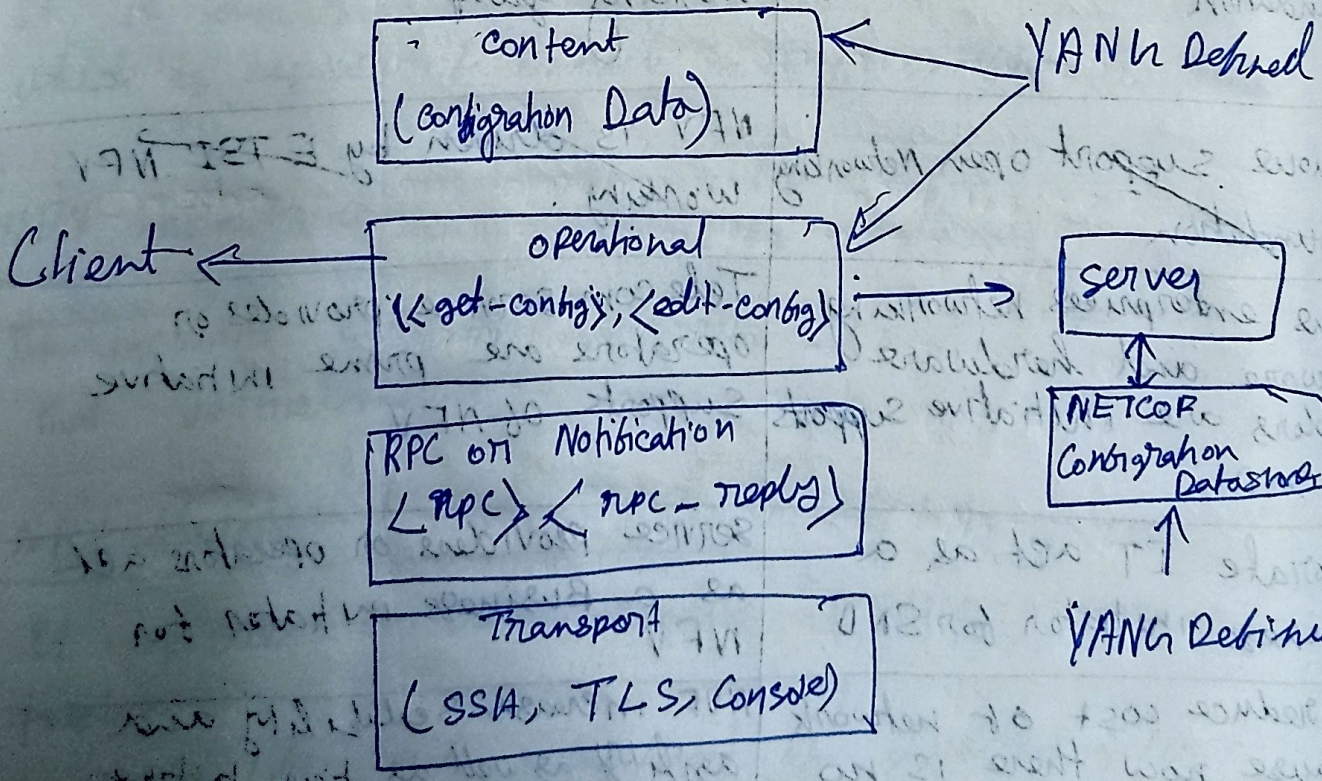
NETCONF

NETCONF :- Network configration Protocol.

It is a session-based network management protocol

It allows retrieving state or configration data and manipulating configration data on network devices

NETCONF Protocol Layer



It works on SSH (Secure Shell) Transport Layer protocol.

Transport layer provides end-to-end connectivity and ensure and reliable delivery messages.

NETCONF uses XML-encode procedure call (RPCs) for framing request and response messages.

The RPC layer provides mechanism for encoding of RPC calls and notifications.

NETCONF provides various operations to retrive and edit configration data from network devices.

The content Layer consists configration and state data which is XML encoded.

The ~~scar~~ Schema of the configration and state data is defined in a data modeling language called YANG

NETCONF provides a clear separation of the configration and state data.

The configration data resides withen a NETCONF configuration data store the server.

Operation	Description
Connect	Connects to a NETCONF server
get	Retrieve the running configration and state information
get-config	Retrieve all or a portion of a configration data store
edit-config	Loads all or part of a specified configration to the specified target configration
Copy-config	Create or replace an entire target configration data store with a complete source configration
delete config	Delete the contents of a configration data store
lock	Lock a configration data store for exclusive edit by a client
Unlock	Release a lock on a configration data store.
get-schema	This operation used to retrive a schema from the NETCONF server
commit	commit candidate configration as the device's new current configration
close-session	Gracefully terminate a NETCONF session
kill-session	Forcefully terminate a NETCONF session.

YANG

(i) YANG is a data modeling language used to model configration and state data manipulated by the NETCONF protocol.

(ii) YANG modules contain the defination of the configration data, State data, RPC calls that can be issued and the format of the notifications.

(iii) YANG module defines the data exchanged between the NETCONF client and server.

(iv) A module ~~comp~~ comprises of a number of leaf nodes which are organized into a hierachical tree structure.

(v) The 'leaf' nodes are specified using the 'leaf' or 'leaf-list' constructs.

(vi) Leaf nodes are organised using container or 'list' constructs.

(vii) A ~~YAUNG~~ YANG module can import defination from other modules.

(viii) ~~Constrai~~ constraints can be defined on the data nodes allowed values.

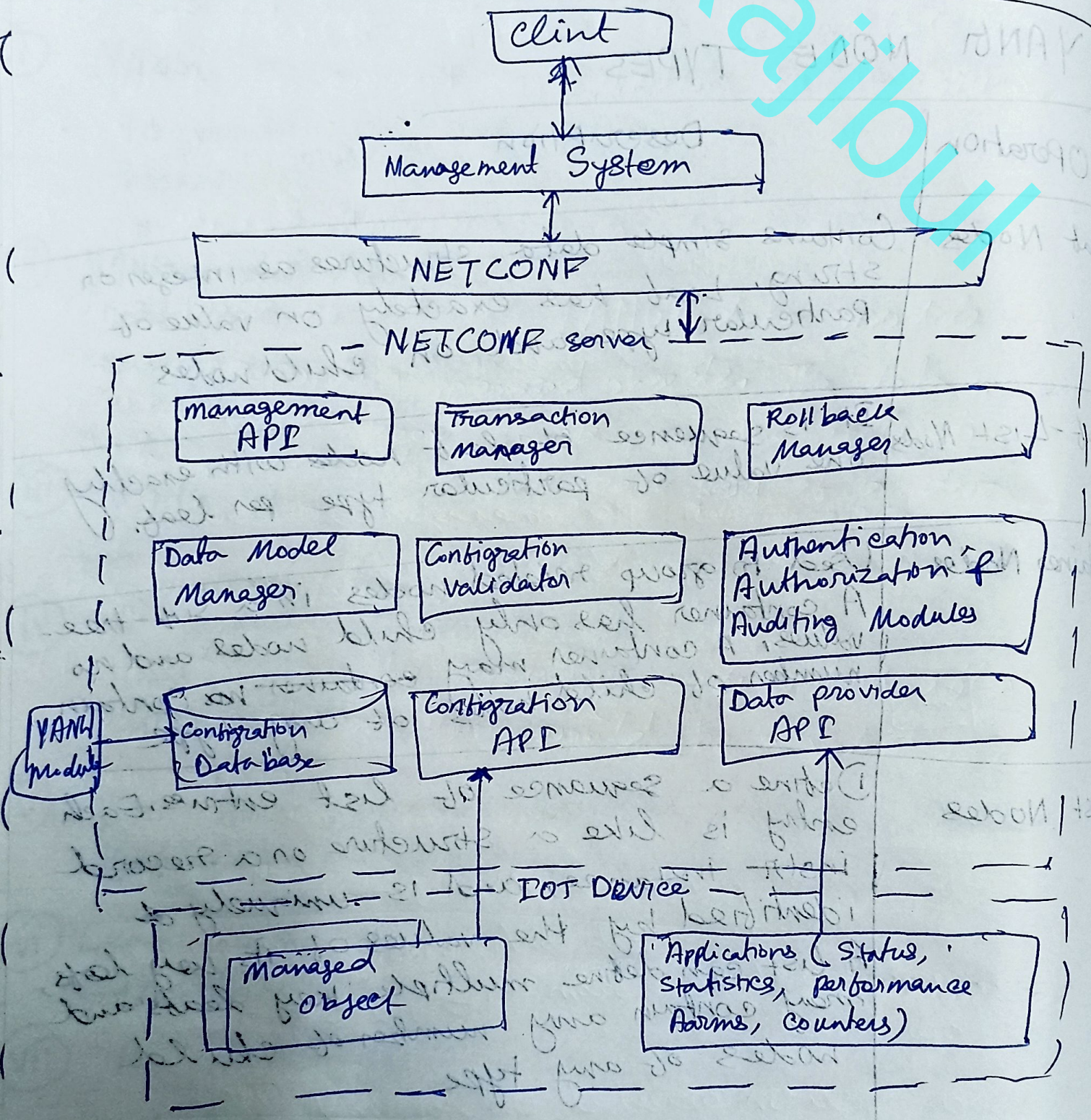
(ix) YANG can model both configuration data

and state using 'config' statement.

YANG NODE TYPES

Operation	Description
Leaf Nodes	Contains simple data structures as integer or string. Leaf has exactly on value of particular type and on child nodes
Leaf-List Nodes	It is sequence of leaf nodes with exactly one value of particular type per leaf.
Container Nodes	Used to group related nodes in a sub-tree. A container has only child nodes and no values. A container may ~~container~~ not contain number of child nodes of any type
List Nodes	Define a sequance of list entries. Each entry is like a structure on a record ~~instr~~ instance, and is uniquely identified by the values of its key leafs. A list can define multiple key leafs and may contain any number of child nodes of any type

IOT System management with NETCONF-YANG



Generic Architecture of NETCOMF - YANG

Management System:-

The operators uses a management system to sent NETCONF messages to configure the IOT device and receive state information and notifications from the device as NETCONF message.

Management API :-

It allows the applications to state NETCOMF sessions, read, and write configuration data, read state data, retrieve configurations and invoke RPCs, programmatically same way as an operator.

Transaction Management :-

It executes all the NETCONF transaction and ensure that ACID (Atomicity, consistency, Isolation, Durability) properties hold true of the transaction.

Atomicity :- Ensure the transaction is executed either completely on not at all.

Consistency :- Ensure that the transaction brings the device configuration from one valid state to another.

Isolation :- Ensures concurent execution of transaction result in same device if transaction executed seriably

Durability :- Ensure once a transaction is committed it will persist

Rollback Manager:

Responsible for generating all the ~~transact~~ transaction responsible to roll back a current configuration to its original state.

Data Model Manager

Keeps track of all the YANG data models and the corresponding managed objects. The data model manager also keep track of the application which provide data for each part of a data model.

Configuration Validator

It checks, if the resulting configuration after applying a transaction would be a valid configuration.

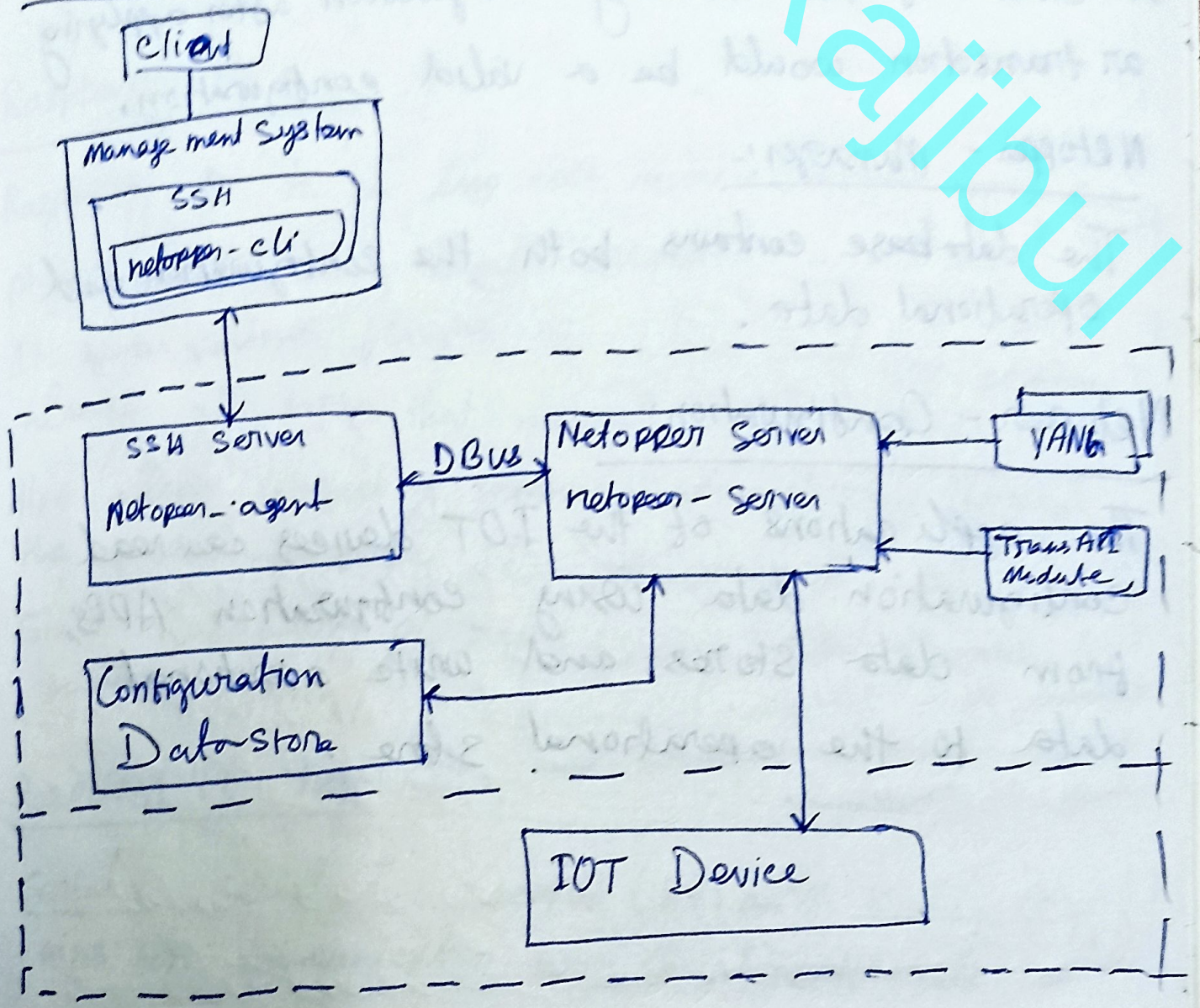
Configuration Database

The database contains about the configuration and operational data.

Configuration API:-

The applications on the DUT devices can read configuration data using configuration APIs from data stores and write operational data to the operational data ~~stores~~ store.

IOT Device Management Using NETOPEER



Netopeer-Server: It is a NETCONF protocol server that runs on the managed device

Netopeer-Agent:

Keeps track of all the YANG data models and the corresponding managed objects. The data model manager also keeps track of application which provide data for each part of data model.

Netopeer - Cli

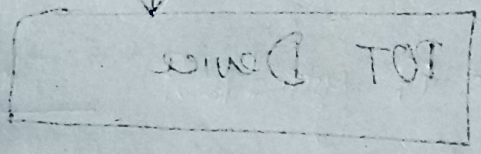
It check, if the resulting configuration after applying an transaction would be a valid configuration.

Netopper - Manager:-

The database contains both the configuration and operational data.

Netopeer - Configuration

The applications of the IOT devices can read configuration data from data stores and write operational data to the operational store.



Ans:-

Raspberry Pi board

Raspberry pi board has various components labeled—

Processor & RAM:- Raspberry pi is bas on an RAM processor. Some of the raspberry pi has 700 MHZ low power ARM 1176JZ-F processor and 512 MB SDRAM.

USB Ports:- Raspberry Pi comes with two 2.0 ports. The USB ports on Raspberry Pi can provide a current upto 100 mA. For connecting devices that draw current more than 100 mA, an external USB powered hub is required.

Ethernet Port:- Raspberry Pi comes with a standard RJ45 Ethernet port. You can connect an Ethernet cable or a USB wifi adapter to provide Internet connectivity.

HDMI output:- The HDMI port on Raspberry Pi comes with a composite video output with an RCA jack that supports both PAL & NTSC video output. The RCA jack can be used to connect old television that have an RCA input only. It provided both video & Audio Output.

Composite Video output

Raspberry Pi comes with a composite video output with an RCA jack that support both PAL & NTSC video output. The RCA jack can be used to ~~connect~~ connect old

Raspberry pi comes with a composite video output with an RCA jack that supports both PLA & NTSC video output. The RCA jack can be used to connect old television have an RCA input only.

Audio output: Raspberry Pi has a 3.5 mm audio output jack.

GPIO pins: General purpose I/O pins.

There are 4 types of pins on Raspberry Pi -

(i) True GPIO pin
(ii) I2C interface pin
(iii) SPI interface pin
(iv) Serial Rx & Tx pins.

Display Serial Interface (DSI): The DSI interface can be used to connect an LCD panel to raspberry pi.

Camera Serial Interface (CSI) :-

The CSI interface can be used to connect a camera module to Raspberry Pi.

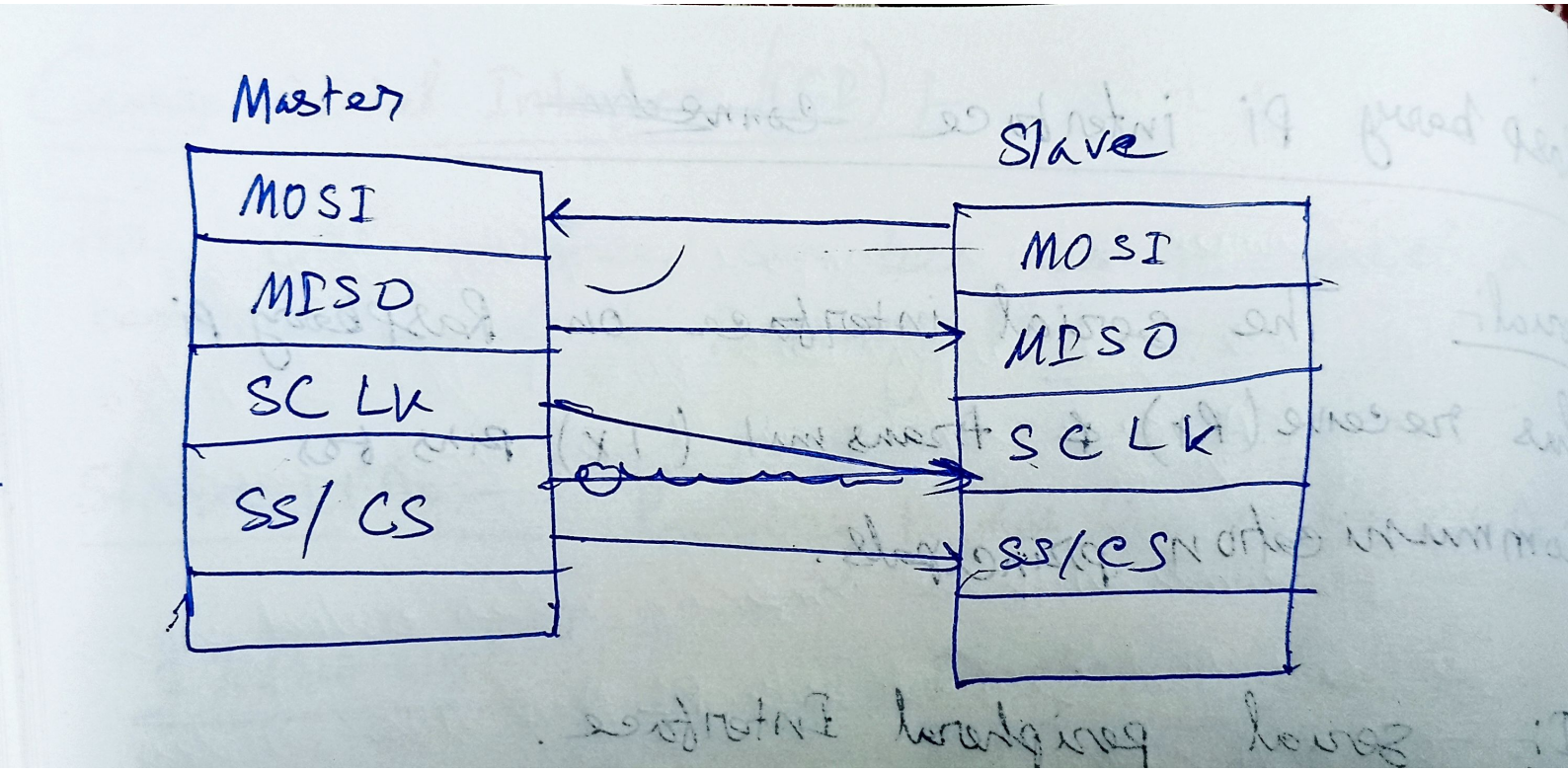
Status LEDs :- Raspberry Pi has five status LEDs.

status LED	Function
ACT	SD card access
PWR	3.3 V power is present
FDX	Full duplex LAN connected
LNK	Link/ Network activity
100	100 Mbit LAN connected.

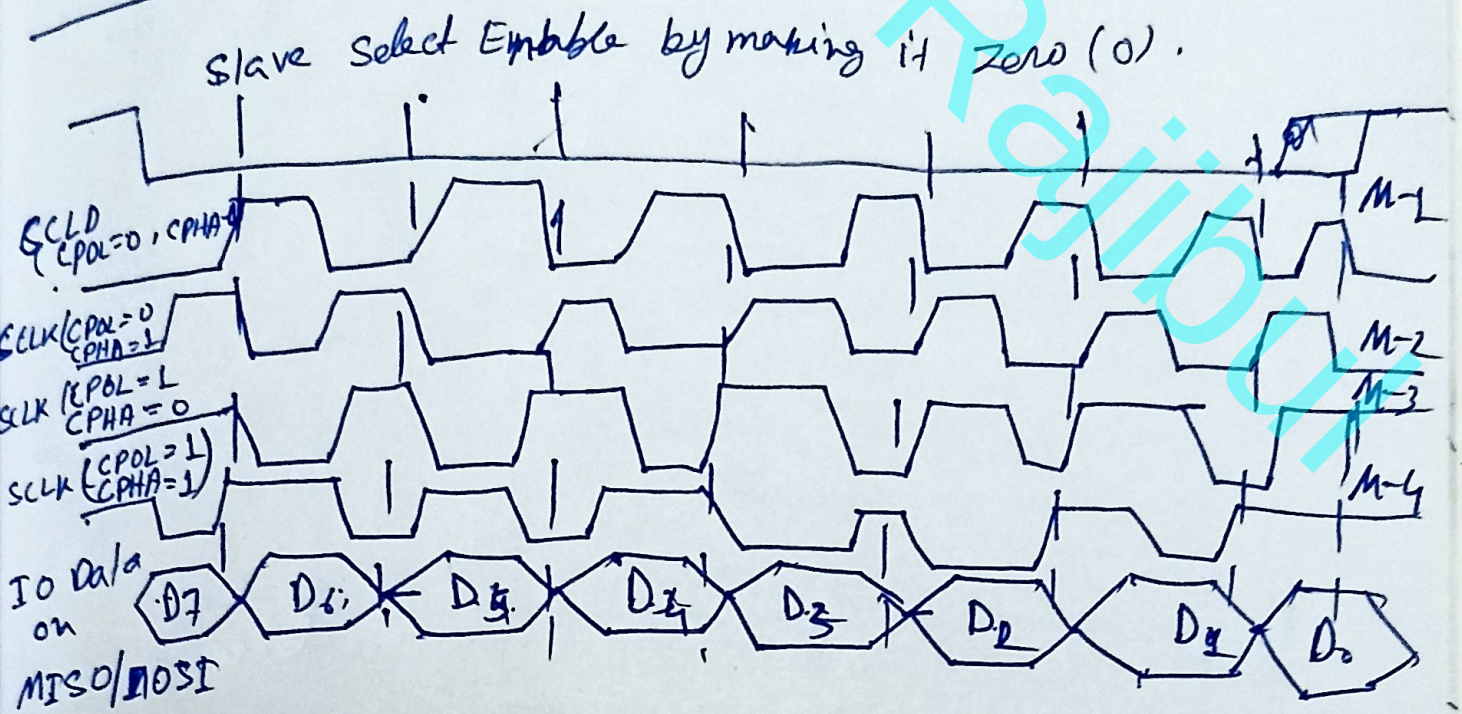
SD - Card Slot :-

Raspberry Pi does not have a built in operating system and storage, because of that SD-Card slot is given.

Power Input :- Raspberry Pi has a micro-USB connector for power input.



Modes of SPI



Advantage of SPI Protocol

(i) No start & Stop bits required.

(ii) SPI is full duplex protocol

(iii) Singl Signal are unidirectional allowing easy isolation

Disadvantage.

(i) Four wire required

(ii) only one master

(iii) Multiple SS required for multiple Slave

(iv) No protocol for error detection.