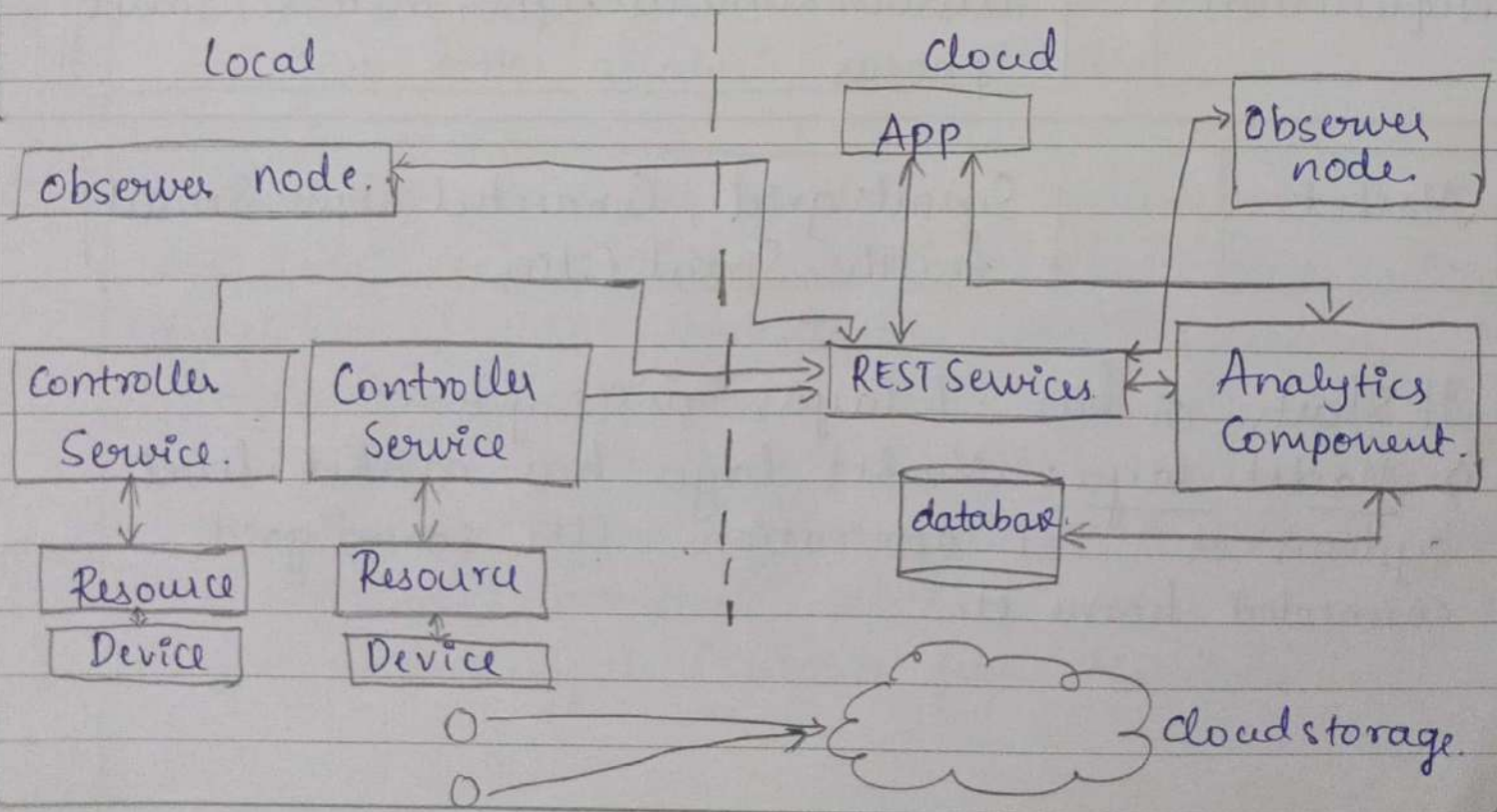
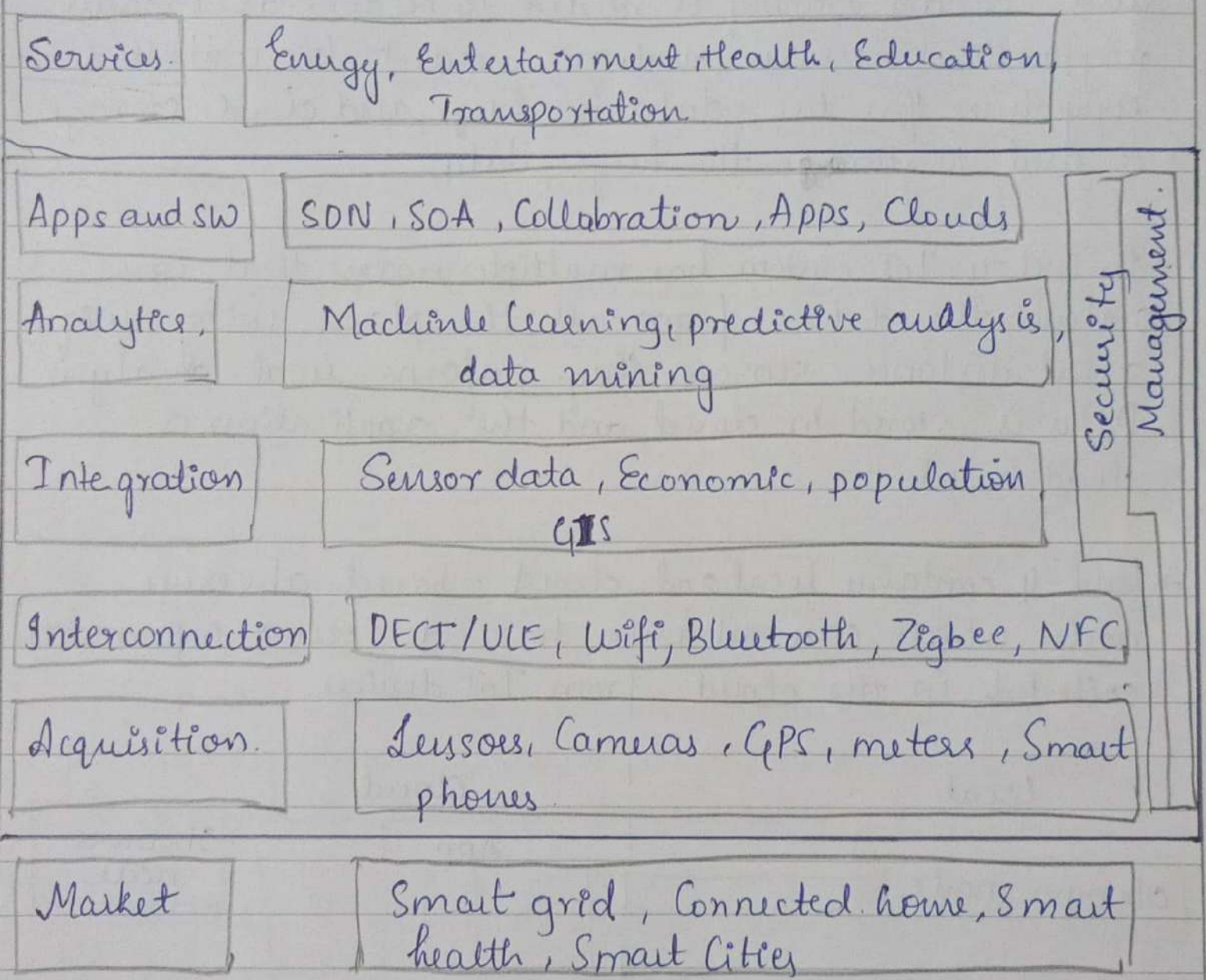
3b). Level-4 is suitable as cloud is involved and contact tracing is needed to be done at broader geographical area as pandemic needs to be controlled everywhere. Here the data is huge and cloud storage is used to store the huge data.

→ In level-4 IoT system has multiple nodes that can capture the data from all the places using unique social distance sensors. They peform local analysis Data is stored in cloud and the application is cloud based.

→ Level-4 contains local and cloud-based observer nodes which can subscribe to and recieve information collected in the cloud from IoT devices.



3a) IoT Ecosystem.



It starts or has 7 layers in ecosystem:

1) Market layer: Market layer has market-level systems or IoT applications like smart grid, connected home etc.

2. Acquisition layer: It is the source of information origin Made of cameras, sensors to sense and gathu the data about surrounding physical environment. GPS (global positioning systems), metas, and smart phones etc. These are the IoT devices that collect data.

3) Interconnection: Hew protocols like wifi, bluetooth, Zegbee is used to transfes data that is collected at below layes to database / analyes component / cloud infrastructure.

4) Integration: Data collected from the acquistion is brought to storage componut via Interconnection layes. And hew it is integrated with othu useful information such as standaid datasets like population dataset, sensor data or economic data to give better analysis semantically.

5) Analytics: It is the analytical component. The integrated data set is thau analysed by eithu using machine learning techniques like regression, logistic regression or deep learning techniques to make predictions. Or statistically visualized to give a report. Datamining techniques like clustering, attribute selection can be done to get meaningful insights from the data.

6) Apps and SW: All this huge applications needs to be collaborated with others to give a better
→ Servica. Introduction of Servica-Oriented architecture (SOA) lead to web 2.0 servicas.
→ SDN (Software defined networking) is emerging as the new ray of hope in the field of networking.
→ Cloud services like SaaS, PaaS and IaaS has enhanced the features and richness of the IoT products.

7) Services: All these techniques in below layers are combined to give servics in field of energy, entertainment, health, education and transportation sectors.

2a) System.

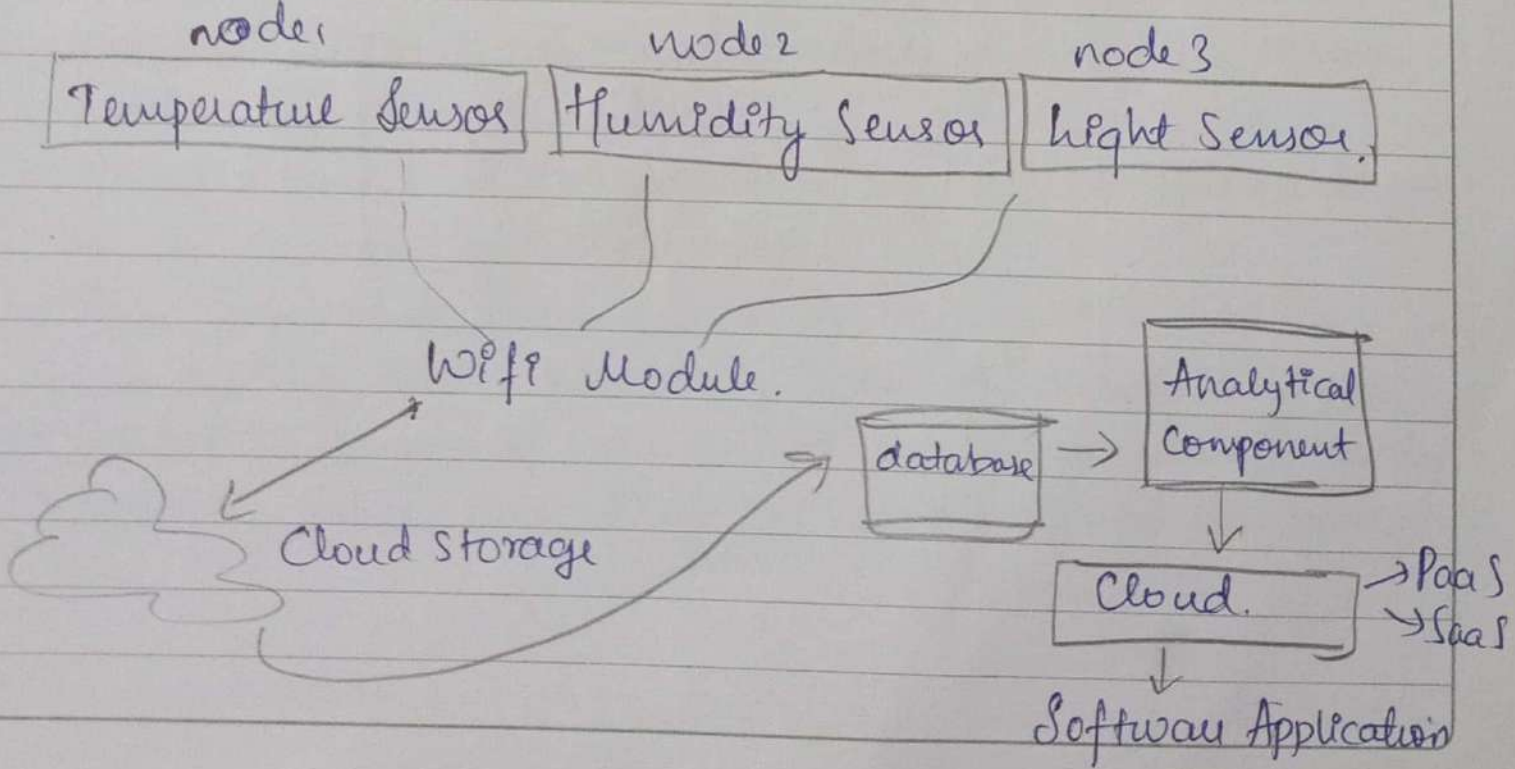
i) Raw sensors like: Temperature sensors, humidity sensors, light sensor are used to collect and gather the information at the acquistion layer level of the IoT ecosystem.

Then for interconnection we can use a Wifi module to transmit the data from the sensors to the cloud Storage.

Then the data on the cloud can be integrated with geographical data or population data.

to get better insights and provide different services to users in the form of application.

In analytics using machine learning or deep learning techniques can be used as data can be integrated with other datasets like geographical location a PaaS service of cloud can be used to [illegible] and deploy the [illegible] application that makes suggestions to carry an umbrella if it might drizzle or sweater if it's going to snow in America. Or to catch a cup of coffee when it snows. This app can be deployed publically and given as SaaS to end users. Or data mining techniques can be applied to visualize the data and a statistical view can be presented to the users.



A level-6 IoT system is suitable for weather monetoring system.
The system consists of multiple nodes placed in different locations to collect data via different raw sensor. Each node is equipped with different types of sensors.
The end nodes send the data to the cloud on the computing cloud via Wife (Bluetooth/ BLE . the data is stored in the cloud database.

1. Mesh under - technique.

→ In mesh-under scheme, the network layer does not perform any IP routing inside a 6LoWPAN.

→ The adaption layer performs the mesh routing and forwards packets to the destination over multiple radio hops

→ In mesh-under scheme, routing and forwarding are performed at link layer based 802.15.4 frame or the 6LOWPAN header

→ To send a packet to a particular destination, the EUI 64 bit address or the 16 bit short address is used and sent it to a neighbor node to move the packet closer to the destination

→ Multiple link layer hops are used to complete a single IP hop soit is called mesh-under

→ 6LoWPAN employs the idea of the originator and the final address to describe the original source and the ultimate destination node of a single IP hop within a PAN respectively

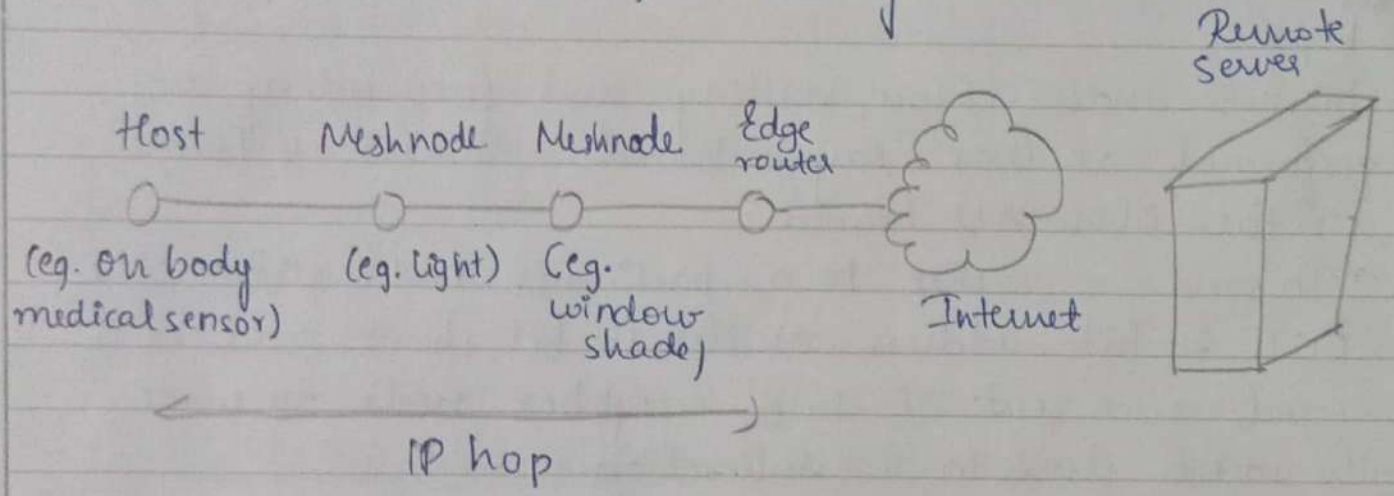
→ An IP packet is fragmented by the adaption layer to a number of fragments

→ These fragments are delivered to the next hop by mesh routing and eventually reach the destination.

→ Different fragments of an IP packet can go through different paths and they are gathered at the destination.

→ If all fragments are reached successfully, adaption layer of the destination node reassembles all fragments and creates an IP packet

→ In case of any fragment missing in the forwarding process the entire IP packet is retransmitted to the destination for recovery



Source	Intermediate node	Intermediate node	destination
5. Application layer	5 AL	5 AL	5. Application layer
4. Transport layer	4 TL	4 TL	4. Transport layer
3. Network layer	3 NL	3 NL	3. Network layer
2 Data link layer	2 DLL	2 DLL	2. Data link layer
1 Physical layer	1 PL	1 PL	1 Physical layer

AL - Application layer
TL - transport layer
NL - network layer
DLL - data link layer
PL - Physical layer

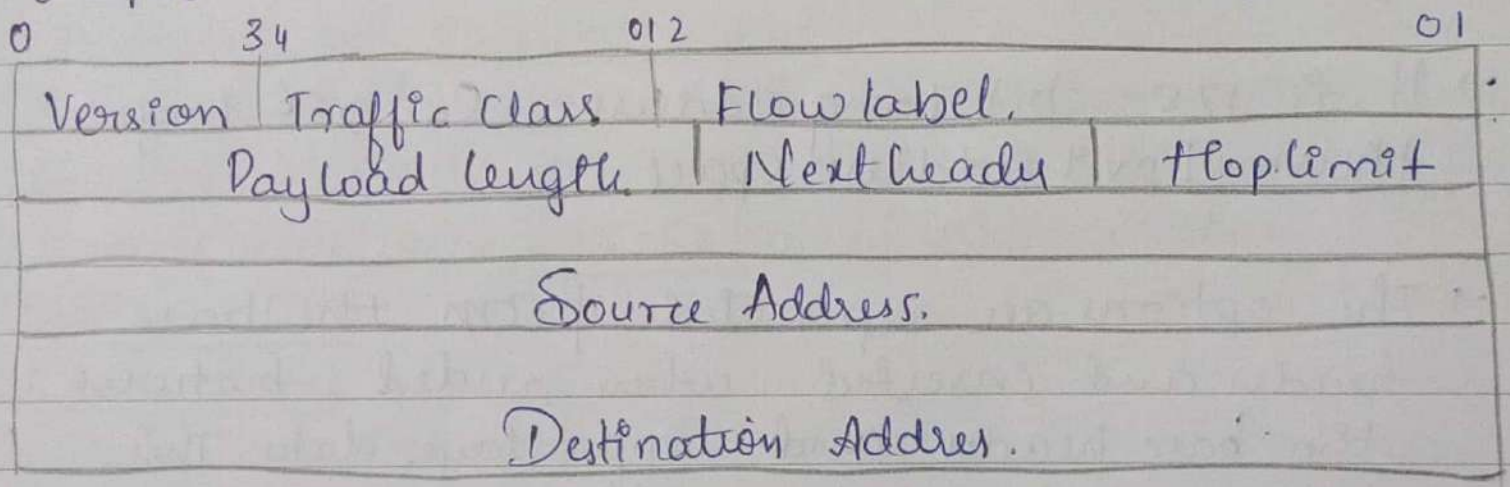
In intermediate it passes only through data link layer

2b. 2.

Ipv6 over Ipv4

→ Large address space. It is the address space is huge.
→ Better header format than Ipv4.
→ New options are available
→ Support for resource allocation.
→ Support for more security
→ Support for mobility.

o Ipv6 Header.



→ Ipv6 header length is 40 and Ipv4 is 20 bytes
→ IPv6 provides interoperability and mobility capabilities. which are already ~~end~~ widely embedded in network devices.
→ Direct addressing is possible due to vast address space. so the need of address translation is effectively reduced.
→ Allowance for extension: Ipv6 is designed to allow the extension of the protocol if required by new technologies or application.

→ Support for resource allocation In Ipv6, the type of service field has been removed, but a mechanism. (called flow label) has been added to enable the source to request special handling of the packet. This mechanism can be used to support traffic such as realtime audio and video.

→ Support for more security: The encryption and decryption and authentication options in Ipv6 provide confidentiality and integrity of the packet.

→ It is 128-bit long address. So 2^{96} huge than Ipv4 address space.

→ The options are separated from the base header and inserted, when needed, between the base header and upper-layer data. This simplifies and speeds up the routing process because most of the options do not need to be checked by router

(a)

→ Low Power Wide Area (LPWA) networks represent a novel communication paradigm, which all complement traditional cellular and short range wireless technologies in addressing diverse ~~dep~~ requirements of IoT applications
→ It has battery life of 20 years
→ LPWA networks are unique because they make different tradeoffs than the traditional technologies such as Zigbee, Bluetooth, Z-wave, Wi-fi, LTE etc.
→ It operates at 20m Watt power.
→ It achieves a long range with low power consumption and low cost. It works on ALOHA and uses star topology.
→ It covers wide area 15-50 km of urban indoor

Techniques Used:

1. Long Range

a. Use of sub frequencies of 1GHz band (More robut & Reliable communication)
b Modulation Techniques (Slows down modulation to put more energy)

2. Ultra low Power Operation

a. Topology (from mesh to Star)
b. duty cycling (allows radios to turn off transceiver)
→ It is a key requirement to tap into huge business opportunity provided by battery powered IoT and machine to machine devices.

→ A battery lifetime of 10 years or more with or coin cell batte is desirable to bring maintainence cost down

→ It uses star topology for the ultra low power operation

→ for duty cycling only during transmission of data transmitter is turned on

3 It has light weight Medium Access Control (MAC) (Simple random - acuss ALOHA) and off loading complexity from end devices

3. Low Cost

1) Reduction in hardware complexity compared to the cellular and short range wireless technology. LPWAN transceiver needs to process less complex waveform It enables them to re[illegible] transceiver footprints, peak data rates and memory sizes. Thus minimizing the hardware complexity that in turn reduces cost A single LWPAN can connect 1000's of devices distributed across the geographical area.

2) Minimum infrastructure

3) Using license free or own license band

4> Scalability