Task 3-

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1. **Explain different communication techniques in IoT with specifications and tell which oneis better for our project.**

We can boil down the wireless communication protocols into the following 6 standards:

- Satellite
- WiFi
- Radio Frequency (RF)
- RFID
- Bluetooth
- NFC

a)Satellite :

Satellite communications enable cell phone communication from a phone to the next antenna of about 10 to 15 miles. They are called GSM, GPRS, CDMA, GPRS, 2G / GSM, 3G, 4G / LTE, EDGE and others based on connectivity speed.
In Internet of Things language, this form of communication is mostly referred to as "M2M" (Machine-to-Machine) because it allows devices such as a phone to send and receive data through the cell network.

PROS:

- **Stable connection**
- **Universal compatibility**

CONS:

- **High monthly cost**
- **High power consumption**

b)WIFI:

WiFi is a wireless local area network (WLAN) that utilizes the IEEE 802.11 standard through 2.4GhZ UHF and 5GhZ ISM frequencies. WiFi provides Internet access to devices that are within the range (about 66 feet from access point).

Pros:

- **Universal smartphone compatibility**
- **Affordable**
- **Well protected and controlled**

Cons:

- Relatively high power usage
- Instability and inconsistency of WiFi

c) Radio Frequency:

Radio frequency communications are probably the easiest form of communications between devices. Protocols like ZigBee or ZWave use a low-power RF radio embedded or retrofitted into electronic devices and systems.

Z-Wave's range is approximately 100 ft (30 m). The radio frequency band used is specific to its country. For example, Europe has a 868.42 MHz SRD Band, a 900 MHz ISM or 908.42 MHz band (United States), a 916 MHz in Israel, 919.82 MHz in Hong Kong, 921.42 MHz in the regions of Australia/New Zealand) and 865.2 Mhz in India.

Pros:

- Low energy and simplicity for its technology is not dependent on the new functionality of phones

Cons:

- Radio frequency technology is not used by smartphones and without a central hub to connect the RF devices to the internet, the devices cannot be connected

d) RFID

Radio frequency identification (RFID) is the wireless use of electromagnetic fields to identify objects. Usually you would install an active reader, or reading tags that contain a stored information mostly authentication replies. Experts call that an Active Reader Passive Tag (ARPT) system. Short range RFID is about 10cm, but long range can go up to 200m. What many do not know is that Léon Theremin invented the RFID as an espionage tool for the Soviet Union in 1945.

Pros:

- Does not require power
- Established and widely used technology

Cons:

- Highly insecure
- Ongoing cost per card
- Tags need to be present as identifier and be handed over before
- Not compatible with smartphones

e) Bluetooth :

Bluetooth is a wireless technology standard for exchanging data over short distances (using short-wavelength UHF radio waves in the ISM band from 2.4 to 2.485 GHz). If you look at the frequencies it is actually the same as WiFi such that these two technologies seem very similar. However they have different uses.The 3 different styles of Bluetooth technology that are commonly talked about are:

- Bluetooth
- BLE (Bluetooth 4.0, Bluetooth Low Energy)
- iBeacon

Pros:

- Every smartphone has Bluetooth where the technology is continuously being upgraded and improved through new hardware
- Established and widely used technology

Cons:

- Hardware capabilities changes very fast and will need to be replaced
- Running on battery the lifetime of an iBeacon is between 1month to 2 years
- If people switch off Bluetooth, there are issues in usage.

f) Near Field Communication (NFC) :

Near-field communication uses electromagnetic induction between two loop antennas located within each other's near field, effectively forming an air-core transformer. It operates within the globally available and unlicensed radio frequency ISM band of 13.56 MHz on ISO/IEC 18000-3 air interface and at rates ranging from 106 kbit/s to 424 kbit/s. NFC involves an initiator and a target; the initiator actively generates an RF field that can power a passive target (an unpowered chip called a "tag"). This enables NFC targets to take very simple form factors such as tags, stickers, key fobs, or battery-less cards. NFC peer-to-peer communication is possible provided both devices are powered.

There are two modes:

- Passive communication mode: The initiator device provides a carrier field and the target device answers by modulating the existing field. In this mode, the target device may draw its operating power from the initiator-provided electromagnetic field, thus making the target device a transponder.
- Active communication mode: Both initiator and target device communicate by alternately generating their own fields. A device deactivates its RF field while it is waiting for data. In this mode, both devices typically have power supplies.

Pros:

- **Offers a low-speed connection with extremely simple setup**
- **Can be used to bootstrap more capable wireless connections**
- **NFC has a short range and supports encryption where it may be more suitable than earlier, less private RFID systems**

Cons:

- **Short range might not be feasible in many situations for it is currently only available on new Android Phones and at Apple Pay on new iPhones**

I think the most suitable form of communication for our device would be sigfox communication(which is explained later) as sigfox is not available in India I would choose for wifi or GSM

The air pollution monitoring device developed in the project is based on Arduino UNO. The Arduino board connects with ThingSpeak platform using ESP8266 Wi-Fi Module. So the device can be easily installed near any hotspot for its operation. The ThingSpeak is a popular IOT platform which is easy to use and program. The sensor used for monitoring the air pollution is MQ-135 gas sensor and other sensors. The sensor data is also displayed on a character LCD interfaced in the monitoring IOT device.
The sensing of data and sending it to the ThingSpeak server using Wi-Fi module is managed by the Arduino Sketch. The Arduino sketch is written, compiled and loaded to the Arduino board using Arduino IDE.

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2. What is a gateway? Explain its working.

An Internet of Things (IoT) gateway is a physical device or software program that serves as the connection point between the cloud and controllers, sensors and intelligent devices. All data moving to the cloud, or vice versa, goes through the gateway, which can be either a dedicated hardware appliance or software program. An IoT gateway may also be referred to as an intelligent gateway or a control tie

- **The gateways preprocess and analyze the data from the sensors hence it minimizes the volume of data that needs to be forwarded on to the cloud.**
- **These gateways provide additional security for the IoT network and the data it transports**

3. Understand and explain NB IoT?

First of all, it’s narrow-band IoT, and it’s a communication standard designed to let IoT devices operate via carrier networks, either within an existing GSM carrier wave, in an unused “guard band” between LTE channels, or independently.

NB-IoT is based on 3GPP standards and the standardization was already frozen on June,

2016. NB-IoT (Narrowband Internet of Things), is to use for high connection density devices for sending and receiving small amount of data. NB-IoT will mainly be used for indoor areas, where mobility is not required. Most of the NB-IoT devices will be powered with battery-backups, but with long life.

NB-IoT needs only 200kHz of bandwidth – hence the name – to support a huge number of endpoint devices, and it has very low power requirements, which opens it to use by small, uncomplicated IoT gadgets.

4. Understand and explain MQTT?

MQTT stands for **M**essage **Q**ueuing **T**elemetry **T**ransport. It is a lightweight publish and subscribe system where you can publish and receive messages as a client. MQTT is a simple messaging protocol, designed for constrained devices with low-bandwidth MQTT allows you to send commands to control outputs, read and publish data from sensor nodes

1)publish and subscribe:

Devices publish and subscribe to different topics based on which they receive messages and send messages

2)messgaes:

It is the info exchanged btw devices . It is either a command or a data

device 1 publishes on a toipc

devicde 2 is subscribed to tha same topic

hence device 2 recieves messages from device 1

3)topics:

a)interest for particular messages

b)specify where you want to publish

topic example: home/office/lamp

4)broker:

a)it gathers all the message

b)filters the message

c)sends it to all the subscribed clients commonly used broker :MOSQUITTO(r-pi)

5. Read about SigFox and explain steps to design a new device with sigfox. What inputs do you need to give at certification?

Sigfox is a French global network operator founded in 2009 that builds wireless networks to connect low-power objects such as electricity meters and smartwatches, which need to be continuously on and emitting small amounts of data.

a)**Low energy consumption**:

unique connectivity solution provides the lowest energy-consumption device-to-cloud. By simplifying communications, we enable unbeatable low energy consumption. Soon, there'll be no need for replacing or re-charging batteries since the devices will generate energy themselves.

b)low cost:

With its simple approach to connectivity, Sigfox provides extremely price-competitive connectivity subscriptions and even more importantly, enables extremely simple and cost-efficient silicon modules.

a) Sigfox is compatible with Bluetooth, GPS 2G/3G/4G and Wifi. By combining other connectivity solutions with Sigfox, business cases and user experience can be drastically improved.

Link to follow to deploy a device to sigfox: https://youtu.be/oQsnsuHu_-c

There are two ways to achieve Sigfox Ready Certification:

- Full approach: All Sigfox tests (RF & Protocol and Radiated Performance) are executed on the device.
- Modular approach: Only Radiated Performance tests are executed on the device. Evidences of compliance to RF & Protocol specifications are inherited from a Sigfox Verified modular design (module or ref design).

Sigfox certification step by step:

a. Plan testing: Plan your Sigfox certification, and request a quotation from a Sigfox accredited test house.

b. Prepare product for testing: Make sure your product is ready to start testing, *following the Be prepared certification documents according to your certification request.*

c. Ship candidate product to the Test House:

a1. The accredited Test House will execute tests according to the Sigfox Radiated Performance test specification and the Sigfox RF & Protocol test specifications.

b1. The accredited Test House will generate a report and will deliver it to you.

c1. Once you have received the test report, prepare the submission file on Build.

d. In the meantime, start your certification on Sigfox Build:

a1. Create a product and complete the product's information.

b1. Sign the Sigfox Master License Agreement. You only need to sign one per company.

c1. Once you have received the test house report, upload it on Build, along with all required documentation.

d1. Pay the certification fee on Build.

e. Submit the certification request on Sigfox Build:

a. The Sigfox Certification Authority will analyze the test results and documentation and will issue a product certificate.

6. What is the sleep mode of the device? How we can make it more energy efficient? Discuss both hardware and software

Sleep mode (or **suspend to RAM**) is a low power mode for electronic devices such as computers, televisions, and remote controlled devices. These modes save significantly on electrical consumption compared to leaving a device fully on and, upon resume, allow the user to avoid having to reissue instructions or to wait for a machine to reboot.

IoT sensors typically spend the vast majority of their time asleep, so idling the device for low sleep power is a must.

In general our sensors are going to sense the amount of matter in area after fixed intervals hence it is sufficient to keep the device switched on only during this duration of time. The time apart from the time which the device is on is called sleep time. This will help in reducing power consumption and also it will increase the lifetime of the device.

In more details, for example, an ESP8266 device has four different modes to “sleep” or save the battery:

- No sleep
- Modem sleep
- Light sleep
- Deep-sleep

  In this mode, everything is turned off except the RTC (Real Time Clock) , so that the ESP8266 can be turned on periodically. This is the most the most efficient mode. The deep-sleep mode can be used in scenarios where the device should send data at specific intervals. This is the example of an application that uses sensors. The application reads sensor data, sends the values and the goes into deep-sleep mode.

7. List down most energy efficient IoT devices with specifications.

1. Amazon Dash Buttons

   Amazon offers an assortment of buttons that will order additional supplies of commonly used household products directly from Amazon.com. There are buttons for toilet paper, goldfish crackers, soap, laundry detergent, trash bags, cleaners, Gatorade, soup, razors, beauty products, baby formula and much more.

2. Awair

A good option for people with asthma or allergies, Awair is an air-quality sensor that can send smartphone alerts and recommendations for improving your indoor air quality. It also has programs for improving sleep and productivity.

3. Nest

Nest is best-known for its Internet-connected thermostat, but it also makes smoke and carbon monoxide detectors and cameras. Its products also integrate with IoT home automation products from a variety of other vendors.

4. ATrack trackers

Focused on the transportation and logistics industries, ATrack offers GPS tracking for monitoring assets and vehicles. It supplies its technology to a variety of other manufacturers and tracking services.

5. AdhereTech

AdhereTech makes smart, wireless pill bottles that help insure that patients are taking their medication. They are currently being used for research studies, but their use will likely expand to the general population.

About device-

Answers to the following questions are not limited to 1 week. You will be adding answers to this till the launch of product 1. But try to answer in more details, at least 2 pages per question before the deadline.

8. What is industrial standardization of the device? What standardization we have to follow for our device? How to move from prototype to product? Find at least 5 vendors for converting prototype to product. Compare them and find the best one

The protocols have been divided into the following layers to provide some level of organization .

This is all possible things which is to be followed in order to standardize any generic product.:

1. **Infrastructure** (ex: 6LowPAN, IPv4/IPv6, RPL)
2. **Identification** (ex: EPC, uCode, IPv6, URIs)
3. **Comms / Transport** (ex: Wifi, Bluetooth, LPWAN)
4. **Discovery** (ex: Physical Web, mDNS, DNS-SD)
5. **Data Protocols** (ex: MQTT, CoAP, AMQP, Websocket, Node)
6. **Device Management** (ex: TR-069, OMA-DM)
7. **Semantic** (ex: JSON-LD, Web Thing Model)

8. **Multi-layer Frameworks** (ex: Alljoyn, IoTivity, Weave, Homekit)

The following steps can be followed to convert a prototype into production:

1. **Prepare A Request For Quote Package**

- Compile an appropriate, complete package for each vendor.
- Use revision control (dated files, revision numbers, etc.) that can be easily referenced.
- Send the entire package at one time. A barrage of emails to sort through is inconvenient for the recipient and increases the chance that things will be lost.
- Special operations/secondaries can be specified in the BOM. If further granularity is required, 2D control drawings can be generated.

2. **Construct A Realistic Timeline**

Final file delivery	
Moldability evaluation	1-2 weeks
Discussion & part modification	2-3 weeks
Final review & tool design approval	1 week
Tool construction & T1 samples	**5 weeks**
Part evaluation, testing, and file updates	2-4 weeks
Tool grooming and texturing	2-3 weeks
T2 samples delivered	1 week

3. **Finalize The Documentation Package**

After vendors are selected and the product design is finalized, the documentation process discussed in step one will need to be repeated at a more discrete level. f working with a CM, assembly drawings should be included, with all pertinent drawing views and instruction to enable a third party to assemble the product. Don’t forget to update and send your BOM with the final files in a complete package. It is critical that vendors have easy access to the most recent documentation to avoid mistakes, and it is wise to include revision numbers on individual file names that can be cross-referenced to the BOM.

4. **Manage The Design For Manufacturing (DFM) Process**

- Be clear and concise, and don’t forget there may be a language barrier. Label and date all files, as well as all comments.

- Pictures, arrows, & colours: The “1000 words” philosophy applies here, too, and simple sketches often can suffice, rather than investing time in an exploratory CAD change.
- Consolidate. If schedule permits, gather all the DFM feedback together to review instead of assessing it piecemeal. This is more efficient, and makes it easier to track responses. Provide 2D and 3D file updates in the same way (don’t forget to update your BOM with revisions).

5. Inspect, Evaluate, And Adjust

- Ask for inspection reports from vendors. For production parts, these should be available and provide direct measurement of critical dimensions identified on engineering drawings.
- Get all parts in-hand (preferably multiple sets). This includes electronics, fasteners, samples from each cavity in family tooling, custom cables, everything. Long lead time parts need to be sourced appropriately so they are all available.
- Assemble and test: Leverage sample parts and inspection reports to assess functionality.

Vendors possible:

1) PRG prototyping

2) enhance product development

3) T2 design and prototype

4) Inventionland factory(factory.inventionland.com)

5)ideareality .design

9. Where you want to place the device, like auto, bus or anything else. So that it can coverthe maximum area of the city with a minimum number of devices. Explain with SWOT analysis.

I would like to place my device on a bus. This is because I guess our first prototype will be tested here in Chennai only as our campus is here and its easy for us to do so.

As in Chennai unlike many other cities there is good amount of public transport available and large number of people travel by buses. Hence there is atleast one bus which travels in a route where want to measure our air quality

That would help us cover maximum area withy least possible devices.

STRENGTHS:

- Using buses will help us traverse major areas of the city with minimum number of devices
- The buses also do various turns along different directions hence will improve the amount of data that can be collected and improve the accuracy with which we predict the quality of air in an area
- Unlike autos or cars which may not be used daily the buses are assured to run everyday. This ensures that we get the information about the quality of air at peak hours and also during hours of less traffic
- This would help us indicate people with the help of our study that where there is more traffic and what route is best suited for patients etc..

WEAKNESS:

- If we find that there are not much fluctuations in air quality in a particular area and we wish to concentrate on an another area then it will be difficult to do so in buses
- Also getting permission from the concerned authorities to setup a device on a public transport is going to difficult.
- Largely the buses travel only along the main roads hence we will not be able to get the data regarding quality of air in places like schools or hospitals which are generally not situated on the main roads

OPPORTUINITIES:

- We are initially trying to find out only the air quality in several areas but we are not very sure of what are we going to do with them
- We can actually predict the traffic in that area with this data
- We can help out government or people building hospitals in an area that is polluted and is not very safe for patients
- We can also sell this data to various real estate people who can market their plots or flats using this data
- Also existing model of air quality measurement used by our government is immovable hence our model can   replace the existing models .

THREATS:

- As we plan to use the device on a public bus the safety of the device is at risk
- The device is going to placed on a public transport and we will be solely responsible if anything happens to the device.
- The fact of predicting data with only buses which travel along the main roads with heavy traffic may overshoot the current situation and at times our predictions may be wrong.
- Also the fact that we can largely use this method of measurement only in a place like Chennai where the buses are predominantly used also makes it difficult for us to adjust on how to measure data in other cities which are not like chennai

10. What features you want in the device? Explain all possible technical and non-technical stuff.

- I would like to first measure my data by attaching my device to several buses which move around the city in different directions simultaneously.
- My model for transferring data from the sensor will include the following :
    - I. Sensors required for different gases to be measured which is compatible with Raspberry Pi
    - II. A raspberry pi board
    - III. A 5.1V micro usb to power the raspberry pi 3
    - IV. A wifi hotspot provider which provide wifi for the device to add data into the cloud

Features

- Responsive to a wide scope of target gases
- Cost efficient
- Durable

METHOD2:

- Instead of a wifi module we can also try gsm type of communication
- In this we will have a arduino shield connected to the sensors
- The shield will also be connected to the gsm module

- The gsm module is then programmed to store location and data whenever the sensor wakes up from sleep
- The gsm module alone requires 12V battery to power it

The basic features of this device will be:

1) movable:

Unlike other devices largely used in the market we are not developing a device which is attached to a fixed support

2) measuring many gases:

The sensors are chosen in a such a way that we can measure the quantities of most of the gases and other pollutants that are present in the atmosphere.

3) optimal power requirement (other than sensor):

As our module uses only a raspberry pi port other than the sensor and a wifi providing module we don’t need to provide the device with heavy batteries.

4) minimal sleep time:

The device is working on a r-pi board and an esp hence unlike a gsm module or anything else we need not provide the device with high time intervals between successive measurements.

5) easy and secured storage of data:

As we are using thingsspeak or any other platform similar to that we are ensured to hold the data carefully and also only can be accessed by people who are provided with the Activation key by us.

6) easy rechargeable:

The wifi provider can be charged every eight to ten hours by using a battery and does not require a battery on its own(unless its not able hold the charge for so many hours)

7) quality of sensors:

The sensors should be of good sensitivity. This will help us with accurate measurements.

Also it is noted that sensors with continuous exposure to high level ofpollutants will reduce its sensitivity

8) Major gases to be measured:

a) MQ-2 Gas Sensor Module Smoke Methane Butane

b) MQ-7 Carbon Monoxide CO Gas Sensor Detection Module

c) MQ-135 Air Quality Sensor Hazardous Gas Detection Module

similar to this various other gases can also be maesured

11. Explain the final working of the product. How it will send data, about sleep mode, energy analysis, data size, protocols to follow for communication, basic PCB design and other stuff.

The node red two MQTT clients. One of this will be us who will subscribe to the get information via a MQTT broker(MOSQUITTO may be used). The broker is not public but is password protected .We can receive data from the sensor through this broker. Raspberry pi board is connected to the sensors which makes the sensors publishing information as publishing client. Also we can switch on and off the sensors using the same client of node red. Via node red we can add the information gathered into thingsspeak or any other cloud.

- This requires batteries to power the sensors and the r-pi board
- We need to triangle the location in r-pi to get the actual location from which the data is procured
- The location is determined as follws:
  - I. Setup raspberry pi to run on moving vehicles
  - II. Connect a 3G/4G usb dongle directly which acts as location provider
  - III. Get location from cell tower/IP address

- The node red will contain number of mqtt input nodes depending on the number of sensor data we are planning to collect
- The sensors are connected to the esp8266
- The esp is then connected to the r-pi board (so nodered input).
- There will be mqtt output node which will be controlling the esp's output
- This will be connected to a switch which will be on only when we need to measure. During other times it is sleeping.
- The input mqtt nodes maybe connected to a chart or a meter to show the different

readings. The input named as the gas/particulate matter which the sensor is measuring.

- The output node is then connected to a thingsspeak node which then starts collecting data including the time.

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