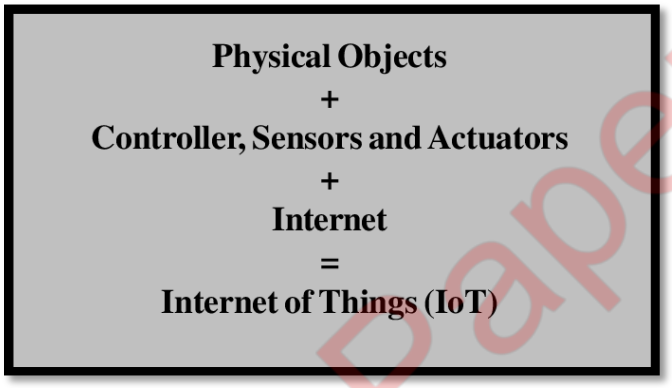
TYBSC IT

Internet of Things (IOT)

SEM5 (November-2018) Q.P.Code:57829

Q1 a) Define and explain the Internet of Things. (5)

Internet of Thing (IoT) is the object which is connected over the internet to send and receive instruction over the internet.



Equation of IoT

Example: Smart Umbrella, WhereDial, etc.

- The Thing is present, physically in the real world, in your home, your work, your car, or worn around your body.
- This means that it can receive inputs from your world and transform those into data which is sent onto the Internet for collection and processing.
- So your chair might collect information about how often you sit on it and for how long.
- The presence of the Thing also means that it can produce outputs into your world with what we call “actuators”.
- Some of these outputs could be triggered by data that has been collected and processed on the Internet.
- So your chair might vibrate to tell you that you have received email. • We could summarize these components in the following simple equation:
- Note that in all the cases we’ve looked at, the form of the object follows the function of the Thing:
- Your chair is designed to sit on, the sewing machine to sew at, and so on.
- The fact of also being connected to the Internet and having general-purpose computing capabilities doesn’t necessarily have an impact on the form of the object at all.

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Q2 b) "Any sufficiently advanced technology in indistinguishable from magic". Discuss. (5)

Arthur C. Clarke has claimed that "any sufficiently advanced technology is indistinguishable from magic," and given that the Internet of Things commonly bestows semi-hidden capabilities onto everyday objects, maybe the enchanted objects of magic and fairy tale are a good metaphor to help people grasp the possibilities.

- Some Internet of Things projects draw their inspiration directly from magic.
- For example, John McKerrell's WhereDial takes its lead from the clock in Harry Potter which tracked the location of the members of the Weasley family.
- The WhereDial, by comparison, has to rely on mere technology for its capabilities;
- however, with the GPS chipsets in smartphones and location check-in services like FourSquare, it isn't much of a leap to also own an ornament which updates to show when you are at work, or travelling, or at a restaurant.

The WhereDial

- The ambient orb is a "single-pixel display" that can show the status of a metric of its user's choosing—the price of a stock, the weather forecast etc.
- Ambient Devices then took the idea one step further and built an enchanted umbrella.
- It can read the weather forecast, and the handle glows gently if rain is expected, alerting you to the fact that you may need to pick it up as you head out of the house.
- Everyday sort of magic that makes tasks a bit easier and lives a little more fun.
- Using our understanding of magic and fairy tales to help make sense of these strange new gadgets.

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Q1 c) Explain Calm and Ambient Technology using example of Live Wire. (5)

- The IoT has its roots in the work done by Mark Weiser at Xerox PARC in the year 1990s.
- His work didn't assume that there would be network connectivity but was concerned with what happen when computing power becomes cheap enough that it can be embedded in to all manners of everyday objects.
- He coined the term ubiquitous computing or ubicomp. Ubicomp is ambient technology.
- Calm and Ambient technology means technology which acts in background, not something to which we actively pay attention i.e. Ambient noise in background recording.
- The term Calm technology means system that doesn't seek your attention.

Example: 1) **Live Wire**

- Live wire is one of the first IOT devices.
- Created by artist Natalie Jeremijenko.
- Live wire also known as Dangling String.
- It is a simple device: an electric motor connected to an eight-foot long piece of plastic string.
- The power for the motor is provided by the data transmissions on the Ethernet network to which it is connected, so it twitches whenever a packet of information is sent across the network.
- Under normal, light network load, the string twitches occasionally.
- If the network is overloaded, the string whirls madly.

Q1 d) What is manufactured normalcy field? Explain. (5)

- Technology blogger Venkatesh Rao came up with a good term to help explain how new technology becomes adopted.
- He posits (suggest something as a basic fact) that we don't see the present, the world that we live in now, as something that is changing.
- If we step back for a second, we do know that it has changed.
- Rao called this concept the manufactured normalcy (situation in which everythong is normal) field.
- For a technology to be adopted, it has to make its way inside the manufactured normalcy field. • As a result, the successful user-experience designer is the one who presents users with an experience which doesn't stretch the boundaries of their particular normalcy field too far, even if the underlying technology being employed is a huge leap ahead of the norm.
- For example, the mobile phone was first introduced as a phone that wasn't tethered to a particular location.

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- Now broadly the same technology is used to provide a portable Internet terminal, which can play movies, carry your entire music collection, and (every now and then) make phone calls.
- The way that portable Internet terminals made it into our manufactured normalcy field was through the phone metaphor.
- Introducing technology to people in terms of something they already understand is a tried and tested effect: computers started off as glorified typewriters; graphical user interfaces as desktops.

Q1 e) Differentiate between Static IP address and Dynamic IP address. (5)

Sr.no	Static IP Address	Dynamic IP Address
1	It is provided by ISP (Internet Service Provider).	While it is provided by DHCP (Dynamic Host Configuration Protocol).
2	Static ip address does not change any time, it means if a static ip address is provided then it can't be changed or modified.	While dynamic ip address change any time.
3	Static ip address is less secure.	While in dynamic ip address, there is low amount of risk than static ip address's risk.
4	Static ip address is difficult to designate.	While dynamic ip address is easy to designate.
5	The device designed by static ip address can be trace.	But the device designed by dynamic ip address can't be trace.
6	Static ip address is more stable than dynamic ip address.	While dynamic ip address is less stable than static ip address.
7	The cost to maintain the static ip address is higher than dynamic ip address.	While the maintaining cost of dynamic ip address is less than static ip address.
8	It is used where computational data is less confidential.	While it is used where data is more confidential and needs more security.

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Q1 f) Define protocol. Explain the following application layer protocols: HTTP, HTTPS, SMTP, FTP. (5)

A protocol is a set of rules for communication between computers.

It determines what inputs are understood and what output is transmitted.

It also specifies how the message are sent and authenticated and how the message are sent and authenticated and how to handle errors caused by transmission.

1) HTTP

- The client requests a resource by sending a command to a URL, with some headers.
- Ex: try to get a simple document at http://book.roomofthings.com/hello.txt.
- The basic structure of the request would look like this:
- GET /hello.txt HTTP/1.1
- Host: book.roomofthings.com
- We specified the GET method because we're simply getting the page.
- We then tell the server which resource we want (/hello.txt) and what version of the protocol we're using.

2) HTTPS

- The request and response are created in a simple text format i.e. in plaintext.
- In case of Man in the Middle attack, someone eavesdropped your connection that person can easily read the conversation.
- The solution to this is send the request and response in an encrypted form, for this use a protocol service HTTPS.
- The HTTPS protocol is actually just a mix-up of plain old HTTP over the Secure Socket Layer (SSL) protocol.
- An HTTPS server listens to a different port (usually 443) and on connection sets up a secure, encrypted connection with the client).

3) SMTP

- SMTP stands for Simple Mail Transfer Protocol.
- It is an internet standard for e-mail Transmission. SMTP connections are secured with SSL (Secure Socket Layer).
- In SMTP, the messages are stored and then forwarded to the destination. SMTP uses a port number 25 of TCP.

4) FTP

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- FTP stands for File Transfer Protocol.
- It used to exchange files on the internet, to enable the data transfer FTP uses TCP/IP, FTP is most commonly used to upload and download files from the internet.
- It uses a reserved port no 21.

Q2 a) Discuss the tradeoffs between cost versus ease of prototyping. (5)

Familiarity with a platform may be attractive in terms of ease of prototyping.

It is also worth considering the relationship between the cost of a platform against the development effort that the platform demands.

This trade-off is not hard and fast, but it is beneficial if you can choose a prototyping platform in a performance/ capabilities.

You will be less likely to encounter any surprices over the cost, or even the wholesale viabilityof your project.

For example:

1) AVR

- AVR microcontroller is the simplest and the cheapest microcontroller chip.
- Which you can purchase from a component supplier for about Euro3.
- For many people, this platform would not be viable for initial prototype.

2) Arduino

- It cost around E20
- It would have exactly the same chip, but it would be laid on the board with labelled header to help you wired up component more easily.
- It has USB port where you could plug in computer.
- It has well supported IDE to make programming easier.

3) BeagleBone

- The cost of BeagleBone is around E30
- It runs on Linux and has enough processing power and RAM.
- To be able to run a high level language.

4) General Purpose mobile phones

- Smart phones might cost around E300
- They are very different beast; they have many of the same feature that make the internet (wireless or 3G).

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- Input capabilities (touchsceen, button, camera).
- Output capabilities (sound, screen display, vibration).

5) General Purpose Computer

- PC might be option for prototyping.
- PC cost from E100 to E1000.
- Have a host of internet connection and I/O possibilities.
- You can program them in whatever language you already know how to use.

Q2 b) what are the challenges when we move from prototype to mass production? Explain. (5)

1) There Will Be Multiple Iterations

- The prototype is literally the first version of the product. What many of us don't realize is how often the final version we use every day is very different from the initial prototype.

- The prototype may be modified to facilitate mass production. Alternatively, you may be told by manufacturers that the prototype can't be made at your desired price point. The design may also change because of customer feedback during beta testing.

- Recognize that there will be stops and starts and that you may end up with a very different product in mass production.

- Hardware production in particular is going to require extended trial and error. You may learn that you need to communicate your tolerances better or alter the range of specifications you'll accept from suppliers.

2) Understand the Financial Impact of Prototypes

- The prototype is a product development cost. Understand that the prototype isn't free and you may have to pay for several versions as you move from proof of concept to functional prototype.

- The prototype should be used to get hard information so you can update your financial projections. For example, the prototype allows you to better estimate production costs, as you'll end up with a detailed bill of materials that lets you estimate the cost of all parts, shipping, taxes and labor.

- Estimate costs based on the lowest production volume. Let manufacturers give you feedback on how you could reduce the cost of the final product.

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- This allows you to determine the cost of goods and how much you have to charge to earn a profit. If selling to customers, aim for a fifty to sixty percent margin. If selling to retail stores, you'll need a higher margin.

3) Prototypes Are Essential to Fundraising

- A prototype may be the key to getting investors onboard regardless of what you're making. In the case of hardware development, you may need millions to get a working prototype for consumer and regulatory testing.

- You could consider crowdfunding for raising capital, too. A prototyped, debugged design is often essential to setting up a kickstarter crowdfunding campaign.

- This is because crowdfunding sites are not pre-sales tools. The donors are only giving money toward projects they want to see come to life that have a good chance of doing so.

4) Plan for the Worst

- When scheduling, add 50 percent to your original estimate. This is especially true with hardware, since you're making and shipping physical hardware instead of sharing digital files.
- Assume contract manufacturers will take longer than expected. Know that issues with quality control and documentation will lead to delays.
- Monitor production certifications to take a while, and plan on needing to go through the process a few times to get approved.to make certain it is meeting your quality standards. Consider making extras, since there may be defective parts in your first batches.

Q2 c) Discuss open source versus closed source hardware and software. State their advantages and disadvantages. (5)

Key Points	Open Source	Closed Source
Cost	Free	Cost vary with respect to complexity of software
Service	Poor	Good
Innovation	Innovation is more as the code could be changed	Innovation is less as the R&D is discussed only on discussion forums.
Usability	Less as it is not reviewed by experts	High
Security	Less as the software is not always developed in a controlled environment	High

1) Open Source

- **Advantages:**

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- Open source software is free to use.
- Open source is more secured as the code is accessible to everyone.
- It is not depend on the company and author that originally created it.

❖ **Disadvantages:**

- Open source is not being straight forward to use.
- Services and support are often fails to provide services.
- Many of latest hardware are incompatible on open source.

2) Closed source

❖ **Advantages:**

- It is more secure compare to open source.
- Services and support are also better than open source.
- Usability is the high selling point.

❖ **Disadvantages:**

- Less flexible.
- Customization available for specific user.
- Need to purchase and high cost.

Q2 d) Explain the following with respect to prototyping embedded devices: Processor Speed, RAM, Networking, USB, Power Consumption and Physical Size and Form Factor. (5)

1) Processor Speed

- The processor speed or clock speed of your processor tells you how fast it can process the individual instructions in the machine code.
- You might also make a comparison based on million of instruction per second (MIPS).
- Hardware floating-point process make more time to process.

2) RAM

- RAM provides the networking memory for the system.
- If you have more RAM, you may able to do more things or more flexible.
- Amount of RAM vary from project to project.

3) Networking

- Wired Ethernet is often the simplest for the user.
- It is generally plug and play and it is the cheapest.
- WIFI is the most widely deployed to provide connection.

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4) USB

- For more powerful computer, tethering to it via USB can be easy way to provide power and networking.
- So it is better that microcontrollers include support for USB, so no extra chip is not required.

5) Power Consumption

- Faster processors are often more power hungry than slower ones.
- Power consumption may be an issue for portable devices.
- More powerful processor may not be a disadvantage in a low-power embedded device.

6) Physical Size and Form Factor

- The limiting factor in the size of a chip is the amount of space required for the entire transistor and other component that make circuitry on the silicon.
- Number of IC's legs on a board is the form factor.

Q2 e) How is development done for Arduino? Explain. (5)

The Arduino is optimised for simplicity, and this is evident from the way it is packaged for use. Using a single USB cable, you can not only power the board but also push your code onto it, and (if needed) communicate with it

for example, for debugging or to use the computer to store data retrieved by the sensors connected to the Arduino.

1) Integrated Development Environment

- You usually develop against the Arduino using the integrated development environment (IDE) that the team supply at http://arduino.cc.
- Although this is a fully functional IDE, based on the one used for the Processing language (http://processing.org/), it is very simple to use.
- Most Arduino projects consist of a single file of code, so you can think of the IDE mostly as a simple file editor.
- The controls that you use the most are those to check the code (by compiling it) or to push code to the board.

2) Pushing Code

- Connecting to the board should be relatively straightforward via a USB cable.
- When your setup is correct, the process of pushing code is generally simple: first, the code is checked and compiled, with any compilation errors reported to you.

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- If the code compiles successfully, it gets transferred to the Arduino and stored in its flash memory. At this point, the Arduino reboots and starts running the new code.

3) Operating System

- The Arduino doesn't, by default, run an OS as such, only the bootloader, which simplifies the code-pushing process described previously.
- When you switch on the board, it simply runs the code that you have compiled until the board is switched off again (or the code crashes).
- It is, however, possible to upload an OS to the Arduino, usually a lightweight real-time operating system (RTOS) such as FreeRTOS/DuinOS.
- The main advantage of one of these operating systems is their built-in support for multitasking. However, for many purposes, you can achieve reasonable results with a simpler task-dispatching library.

4) Language

- The language usually used for Arduino is a slightly modified dialect of C++ derived from the Wiring platform.
- It includes some libraries used to read and write data from the I/O pins provided on the Arduino and to do some basic handling for "interrupts" (a way of doing multitasking, at a very low level).
- This variant of C++ tries to be forgiving about the ordering of code; for example, it allows you to call functions before they are defined.

5) Debugging

- Because C++ is a compiled language, a fair number of errors, such as bad syntax or failure to declare variables, are caught at compilation time.
- Because this happens on your computer, you have ample opportunity to get detailed and possibly helpful information from the compiler about what the problem is.

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Q2 f) Compare Raspberry Pi and Arduino. (5)

Specification	Arduino Uno	Raspberry Pi
	Arduino design for physical computing	Rpi wasn't design for physical computing
Price	$30	$36
Size	7.6*1.9*6.4	8.6*5.4*1.7
Memory	0.002 MB	512 MB
Clock Speed	16 MHz	700 MHz
OS	Boot loader	Linux OS
USB	One, Input only	Two, Peripherals OK
Flash	32 KB	SD Card (2 to 16G)
Multitasking	No	YES
Integrated Development Environment	Arduino	Scratch, IDLE, anything with Linux support
Input Voltage	7 to 12 V	5 V
Connection	54 GPIO pins	8 GPIO pins

Q3 a) Explain the non-digital methods of prototyping. (5)

Let's look at some of the more common non digital methods for protyping:

1. **Modelling clay:** The most well-known brands are Play-Doh and Plasticine, like Play-Doh, have a tendency to dry out and crack if left exposed to the air. Plasticine doesn't suffer from this problem, but as it remains malleable, it isn't ideal for prototypes which are going to be handled. Modelling clay is best used for short-term explorations.
2. **Epoxy putty:** You might have encountered this product as the brand Milliput; it is similar to modelling clay although usually available in fewer colours. You could mould it to the desired shape, and in about an hour, it sets solid.

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3. **Sugru:** Sugru is a mouldable silicone rubber. It is good at sticking to most other substances and gives a soft-touch grippy surface, which makes it a great addition to the designer's toolkit.
4. **Toy construction sets:** You can use LEGO sets.
5. **Cardboard:** Cardboard is cheap and easy to shape with a craft knife or scissors, and available in all manner of colours and thicknesses.
6. **Foamcore or foamboard:** This sheet material is made up of a layer of foam sandwiched by two sheets of card. It's readily available at art supplies shops and comes in 3 mm or 5 mm thicknesses in a range of sizes.
7. **Extruded polystyrene:** This product is similar to the expanded polystyrene that is used for packaging but is much denser foam that is better suited to modelling purposes. It is often referred to as "blue foam", although it's the density rather than the colour which is important.

The combination of Moore's Law driving down the cost of computing and the expiration of the patents from the early developments in the 1980s has brought such technology within the reach of the economical and small business.

Q3 b) What are laser cutters? Explain the main features to consider while choosing a laser cutter. (5)

- Three-dimensional printers can produce more complicated parts, but the simpler design (for many shapes, breaking it into a sequence of two-dimensional planes is easier than designing in three dimensions), greater range of materials which can be cut, and faster speed make the laser cutter a versatile piece of kit.
- Laser cutters range from desktop models to industrial units which can take a full 8' by 4' sheet in one pass.
- Most of the laser cutter is given over to the bed; this is a flat area that holds the material to be cut.
- The bed contains a two-axis mechanism with mirrors and a lens to direct the laser beam to the correct location and focus it onto the material being cut.
- The computer controls the two-axis positioning mechanism and the power of the laser beam. This means that not only can the machine easily cut all manner of intricate patterns, but it can also lower the power of the laser so that it doesn't cut all the way through.
- At a sufficiently low power, this feature enables you to etch additional detail into the surface of the piece.

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- ❖ You can also etch things at different power levels to achieve different depths of etching, but whilst the levels will be visibly different, it isn't precise enough to choose a set fraction of a millimetre depth.

When choosing a laser cutter, you should consider two main features:

- ➢ **The size of the bed:** This is the place where the sheet of material sits while it's being cut, so a larger bed can cut larger items. You don't need to think just about the biggest item you might create; a larger bed allows you to buy material in bigger sheets (which is more ost effective), and if you move to small-scale production, it would let you cut multiple units in one pass.
- ➢ **The power of the laser:** More powerful lasers can cut through thicker material. For example, the laser cutter at our workplace has a 40W laser, which can cut up to 10mm-thick acrylic. Moving a few models up in the same range, to one with a 60W laser, would allow us to cut 25mm thick acrylic.

Q3 c) Explain the different methods used for 3D printing. (5)

- ❖ The 3D printer also known as additive method.
- ❖ The term additive manufacturing is used because all the various processes which can be used to produce the output start with nothing and add material to build up the resulting model.
- ❖ This is in contrast to subtractive manufacturing techniques such as laser cutting and CNC milling, where you start with more material and cut away the parts you don't need.
- ❖ Various processes are used for building up the physical model, which affect what materials that printer can use, among other things.
- ❖ However, all of them take a three-dimensional computer model as the input.
- ❖ The software slices the computer model into many layers, each a fraction of a millimetre thick, and the physical version is built up layer by layer.
- ❖ One of the great draws of 3D printing is how it can produce items which wouldn't be possible with traditional techniques.
- ❖ For example, because you can print interlocking rings without any joins, you are able to use the metal 3D printers to print entire sheets of chain-mail which come out of the printer already connected together.

Types of 3D printing.

1) Fused filament fabrication (FFF):

- ➢ Also known as fused deposition modeling (FDM), this is the type of 3D printer you're most likely to see at a maker event.
- ➢ It works by extruding a fine filament of material (usually plastic) from a heated nozzle.

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- The resulting models are quite robust, as they're made from standard plastic. However, the surface can have a visible ridging from the thickness of the filament.

2) Laser sintering:

- This process is sometimes called selective laser sintering (SLS), electron beam melting (EBM), or direct metal laser sintering (DMLS).
- It is used in more industrial machines but can print any material which comes in powdered form and which can be melted by a laser.

3) Powder bed:

- Like laser sintering, the powder-bed printers start with a raw material in a powder form, but rather than fusing it together with a laser, the binder is more like a glue which is dispensed by a print head similar to one in an inkjet printer.

4) Laminated object manufacturing (LOM):

- This is another method which can produce full-colour prints.
- LOM uses traditional paper printing as part of the process

5) Stereolithography and digital light processing:

- Stereolithography is possibly the oldest 3D printing technique and has a lot in common with digital light processing, which is enjoying a huge surge in popularity and experimentation at the time of this writing.
- Both approaches build their models from a vat of liquid polymer resin which is cured by exposure to ultraviolet light.

Q3 d) Discuss the different standards that must be considered while implementing APIs. (5)

Here are a few of the most common standards that you should consider:

1) Representational State Transfer (REST):

- Access a set of web URLs like http://timer.roomofthings.com/timers/ or http:://timer.roomofthings.com/timers/1234 using HTTP methods such as GET and POST, but also PUT and DELETE.
- The result is often XML or JSON but can often depend on the HTTP content-type negotiation mechanisms.

2) JSON-RPC:

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- Access a single web URL like http://timer. roomofthings.com/api/, passing a JSON string such as {‘method’:’update’, ‘params’: [{‘timer-id’:1234, ‘description’:’Writing API chapter for book’}], ‘id’:12}. The return value would also be in JSON, like {‘result’:’OK’, ‘error’:null, ‘id’:12}.

3) XML-RPC:

- This standard is just like JSON-RPC but uses XML instead of JSON.

4) Simple Object Access Protocol (SOAP):

- This standard uses XML for transport like XML-RPC but provides additional layers of functionality, which may be useful for very complicated systems.

Use a REST API because it is popular, well supported, and simple to interact with for a limited microcontroller. The design considerations we describe mostly apply for all the standards.

Q3 e) Explain POLLING and COMET. (5)

1) POLLING

Polling is not a hardware mechanism; it’s a protocol in which CPU steadily checks whether the device needs attention.

If you want the device or another client to respond immediately, how do you do that? You don’t know when the event you want to respond to will happen, so you can’t make the request to coincide with the data becoming available.

Consider these two cases:

- The WhereDial should start to turn to “Work” the moment that the user has checked into his office.
- The moment that the task timer starts, the client on the user’s computer should respond, offering the opportunity to type a description of the task.

2) COMET

Comet is an umbrella name for a set of technologies developed to get around the inefficiencies of polling. As with many technologies, many of them were developed before the “brand” of Comet was invented; however, having a name to express the ideas is useful to help discuss and exchange ideas and push the technology forward.

- Long Polling (Unidirectional) The first important development was “long polling”, which starts off with the client making a polling request as usual.

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- However, unlike a normal poll request, in which the server immediately responds with an answer, even if that answer is "nothing to report", the long poll waits until there is something to say.
- This means that the server must regularly send a keep-alive to the client to prevent the Internet of Things device or web page from concluding that the server has simply timed out.
- Long polling would be ideal for the case of WhereDial: the dial requests to know when the next change of a user's location will be.
- As soon as WhereDial receives the request, it moves the dial and issues a new long poll request. Of course, if the connection drops (for example, if the server stops sending keep-alive messages), the client can also make a new request.
- However, it isn't ideal for the task timer, with which you may want to send messages from the timer quickly, as well as receive them from the server.
- Although you can send a message, you have to establish a connection to do so. Hence, you can think of long polling as unidirectional.

Q3 f) Write a short note on Message Queuing Telemetry Transport Protocol.

- ❖ MQTT is one of the most commonly used protocols in IoT projects.
- ❖ It stands for Message Queuing Telemetry Transport.
- ❖ In addition, it is designed as a lightweight messaging protocol that uses publish/subscribe operations to exchange data between clients and the server.
- ❖ Furthermore, its small size, low power usage, minimized data packets and ease of implementation make the protocol ideal of the "machine-to-machine" or "Internet of Things" world.

MQTT server is called a broker and the clients are simply the connected devices.

- When a device (a client) wants to send data to the broker, we call this operation a "publish".
- When a device (a client) wants to receive data from the broker, we call this operation a "subscribe".

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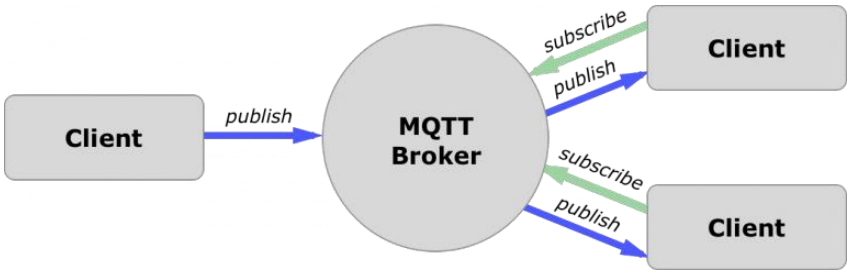

MQTT has unique features you can hardly find in other protocols, like:

- **It's a lightweight protocol:** So, it's easy to implement in software and fast in data transmission.
- **It's based on a messaging technique:** Of course, you know how fast your messenger/WhatsApp message delivery is. Likewise, the MQTT protocol.
- **Minimized data packets:** Hence, low network usage.
- **Low power usage:** As a result, it saves the connected device's battery.
- **It's real time:** That's is specifically what makes it perfect for IoT applications.

Q4 a) Discuss the limitations of memory in embedded devices. How is it managed? Explain. (5)

The rapid development of the Internet of Things has created a number of exciting new opportunities and challenges for designers.

Yet whether an IoT device is brand-new technology specifically designed to be connected, or an upgrade to an existing device to create more capability, there is one consideration that cannot be overlooked: The need for the device to have memory.

And while the number of memory options hasn't quite reached the number of IoT devices on the market, when you are trying to make a decision about what to include, it can certainly feel that way. From traditional RAM-based and Flash memory to more advanced, chip-based memory solutions, there are plenty of options to choose from.

Limitation of memory in embedded devices are:

1. **Cost:** Cost is a concern in any project; the more expensive the memory selection, the more expensive the final device.Depending on the market, you need to weigh the cost vs. performance options.
2. **Size:** Most IoT devices are small, and thus the embedded technology must also be small. The amount of space required for memory processing must also be kept to a minimum, as the more silicon wafer space required, the more costs go up.

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3. **Power Consumption:** Most IoT devices either run on small batteries or rely on energy harvesting for recharging. For this reason, it's important to consider the power consumption of the memory selection, and choose an option that uses the least amount of power and voltage, both in use and during standby.
4. **Startup time:** Users want excellent device performance, so memory needs to be sufficient to allow for a quick startup. Implementing a code-in-place option, which allows the device to execute code directly without needing to copy operating code from a separate EEPROM chip reduces the time required to boot up, as well as the cost of the chip since there is less need for RAM with substantial on-chip storage.

One of the major aspects in any computing device is memory, whenever the system runs out of memory OS is responsible to active special reserved memory known as virtual memory.

The memory management is simpler in a computer system, getting a warning message of low memory space, OS will active Virtual Memory. But on embedded environment with no screen and OS similar situation become difficult to handle.

Q4 b) What are the concerns regarding performance and battery life while writing code for embedded systems? (5)

- When it comes to writing code, performance and battery life tend to go hand in hand—what is good for one is usually good for the other.
- A device which is tethered to one place and powered by an AC adaptor plugged into the wall isn't as reliant on energy conservation.
- Similarly, if you're building something which doesn't have to react instantly— maybe an ambient notifier for a weather forecast, which doesn't have any ill effect if it updates a few seconds later—or if it doesn't have an interactive user interface which needs to respond promptly to the user's actions, maximising performance might not be of much concern.
- For items which run from a battery or which are powered by a solar cell, and those which need to react instantaneously when the user pushes a button, it makes sense to pay some attention to performance or power consumption.
- A lot of the biggest power-consumption gains come from the hardware design. In particular, if your device can turn off modules of the system when they're not in use or put the entire processor into a low-power sleep mode when the code is finished or waiting for something to happen, you have already made a quick win.
- One of the easiest ways to make your code more efficient is to move to an event-driven model rather than polling for changes. The reason for this is to allow your device to sit in a low power state for longer and leap into action when required, instead of having to regularly do busywork to check whether things have changed and it has real work to do.

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- On the hardware side, look to use processor features such as comparators or hardware interrupts to wake up the processor and invoke your processing code only when the relevant sensor conditions are met. If your code needs to pause for a given amount of time to allow some effect to occur before continuing, use calls which allow the processor to sleep rather than wait in a busy-loop.
- If you can reduce the amount of data that you're processing, that helps too. The service API that you're talking to might have options which reduce how much information it sends you.
- When you're downloading tweets from a certain account on Twitter, for example, you can ask for only tweets after a specified ID. The first time you call the API, you have to deal with all the tweets it sends, but on subsequent calls, you can ask just for tweets since the ID of the most recent one that you already processed.
- The shim service has all the processing power and storage available to a web server and so can do most of the heavy lifting. After this, it just sends the minimum amount of data across to be processed in your embedded system.

Q4 c) Write a short note on Libraries for embedded systems. (5)

When developing software for server or desktop machine, you are accustomed to having a huge array of possible libraries and framework to make your life easier.

To make software development easier we can make use of built in libraries given to us by the programming languages.

Here are few libraries that are available:

1. **lwIP:** LightWeight IP, is a full TCP/IP stack which runs in low-resource conditions. It requires only tens of kilobytes of RAM and around 40KB of ROM/flash.

2. **uIP:** It can run on systems with only a couple of kilobytes of RAM.

3. **uClibc:** It is similar version of the standard GNU C library (glibc) targeted at embedded Linux systems.

4. **Atomthreads:** It is a lightweight real-time scheduler for embedded systems, used for multitasking.

5. **BusyBox:** It is not really a library, it is only collection of a host of UNIX utilities into a single, small executable and a common and useful package to provide a simple shell environment and commands on your system.

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Q4 d) What is a business model? Who is the business for? Explain. (5)

Business model define as a "hypothesis about what customers want, how they want it, and how an enterprise can organize to best meet those needs, get paid for doing so, and make a profit".

This definition brings together a number of factors:

- A group of people (customers)
- The needs of those customers
- A thing that your business can do to meet those needs
- Organisational practices that help to achieve this goal—and to be able to carry on doing so, sustainably
- A success criterion, such as making a profit

The model is also useful if you want to get other people involved. This could be an employee or a business partner or an investor. In each of these cases, the other parties will want to know that the business has potential, has been thought out, and is likely to survive and perhaps even go places. With a new business startup, you have no track record of success to point to.

1. Make things, sell things: It is the simplest business model of Internet of Things. However, there are many small projects that choose option of selling their product in kit form which requires some additional assembly work. As these kind of kit products are aimed for specific customers and not of general people, the administrative burden reduces. Thus, limiting to the sell of specific product also limits the revenue generation.

2. Subscription: Now-a-days maximum number of things are available on subscription form. It helps in maintaining the rapidly growing demand of the customers efficiently. As the price in this model is fixed, the customers are known what services they are availing and how does that fit into their budget. Subscription helps in recurring sales, thus, it is easy to determine the revenue generation which in turn helps to maintain the resources and inventories and manage the growth of the business. For example, Netflix, HotStar, etc.

3. Customisation: Mass Production helped in development of business and generation revenue. But there are many premium customers who demand for customization of the product they buy. Thus, option for customization may also lead to the rise of new business models. When it comes to achieve both mass production and customisation, it becomes difficult as it is time consuming and more number of resources are utilised in completing the customer demand. Thus, it can be limited by allowing customization in a fixed boundary. For eg. Let us consider a company called makieMe that produces customised dolls. This company has its own website wherein, the customer and customize their doll by changing the wigs, scarves, dresses and make your doll unique. All these changes are done in a fixed boundary.

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Q4 e) Explain the following business models: Make Thing Sell Thing, Subscriptions, Customisation. (5)

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4. Be a Key Source: Not all the business would sell a product with mass production. There would be business who would specialize in manufacturing some of the parts of a device such as PCBs. Such companies would result to be a key source to those companies which require PCBs for making their products.

5. Provide Infrastructure: Sensor Networks Internet of Things provides many such systems where the system requires sensor data as input. This sensor data must be accurately calibrated and is very expensive to create. Such large but finite data is created by government agencies and organization. These organizations provide infrastructure to the companies that produce such system which requires sensor data.

6. Take a Percentage: In case, if the value of the gathered data is more than that of the physical device, then it might happen that you might sell the physical product for free. For example, the energy providing companies follows this strategy with the smart meters.

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Q4 f) Write a short note on venture capital. (5)

Every Start-up requires funding at some or other point of time.

Getting funding for a project from an external investor presents its own work and risks.

This funding process goes in 3 rounds, i.e. Friends, Family, and Fools (FFF) rounds, Angels round, and Venture Capital round.

Friends, Family, and Fools (FFF) Rounds:

- It is the most straight forward round, you try to get funds from family members or best friends and even local business pitch into it.
- This round totally depends on how strong your relationship is with the person you have approach for funding.

Angels Round:

- This is the next round for raising funds.
- The angels here are the entrepreneurs who are willing to invest in the start-ups.
- These entrepreneurs invest in such start-ups because of their similar background and experience in this filed.

Ventures Capital Round

- Venture capital provides large amount of funds only if angels have already invested in your company and have gained profit out of it.
- Unlike angels, venture capital round would also demand to be board members and even a significant amount of equity.

Government Funding

- Governments typically want to promote industry and technological development in their country, and they may provide funds to help achieve particular aims.
- Although governments can and do set up their own venture capital funds or collaborate with existing funds in various ways, they generally manage the majority of their funds differently.
- For one thing, they also want to fund existing companies to do new research and innovation.

- **Outputs:**

- This metric may simply be a test that you are managing the money well or may be related to the goals that the body itself wishes to promote.

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- You might be required to write regular reports or pass certain defined milestones on schedule.
- If your funding is given in stages, the later payments may be conditional on successful delivery of previous outputs.

Crowd Funding:

- As the name suggests, it is getting funds from many people at a time.
- We can think of crowd funding as the long tail of funding projects.
- Getting many people to contribute to a project isn't exactly a new phenomenon.
- Over millennia many civic and religious monuments and constructions have been funded at least partly by the public.
- However, such projects have been mostly sponsored and given focus by some influential person or body.
- The main options for crowd funding are Kick-starter (www.kickstarter.com) and Indiegogo (www.indiegogo.com).

Q5 a) What are the different software options for designing PCB? Explain. (5)

1. It is always better to sell the idea as a complete product, many even provide on electronics and software for a particular application rather than a complete product, this approach is somewhat difficult to digest.
2. With so much improvement over 3d printing, it is always better that makers gives the complete ready product. This makes sense because it reduces the support overhead for the kit provider.
3. Only designing the circuit, identifying the electronics components and developing the software will not suffice, you need to also include designing a PCB, documenting the build process, and working out the costs.
4. So now working out what price to charge is to be given a thought So create BOM (Bill of Materials). Now depending on BOM take a decision on how much to charge the consumer. For this, look for similar product prices, check demand of the product and decide the cost.
5. The major issue while giving the kit for assembly to the consumer, will require you to give a support for the same and this is again an overhead.
6. These problems can all be resolved by moving on a step towards a consumer product and selling fully assembled PCBs, populated with all the components.

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Q5 b)Explain the steps for manufacturing PCBs. (5)

If you want only a couple of boards, or you would like to test a couple of boards (a very wise move) before ordering a few hundred or a few thousand, you may decide to make them in-house.

ETCHING BOARDS

- The most common PCB-making technique for home use is to etch the board.
- Some readily available kits provide all you need.
- The first step is to get the PCB design onto the board to be etched.
- This process generally involves printing out the design from your PCB design software onto a stencil.
- If you're using photo-resist board, it will be onto a stencil which masks off the relevant areas when you expose it to UV light.
- Your stencil then needs to be transferred to the board.
- For photo-resist board, you will expose it under a bright lamp for a few minutes.
- With the board suitably prepared, you can immerse it into the etching solution, where its acidic make-up eats away the exposed copper, leaving the tracks behind.
- After all the unnecessary copper has been etched away, and you've removed the board from the etching bath and cleaned off any remaining etchant, your board is almost ready for use.
- The last step is to drill the holes for any mounting points or through-hole components.

MILLING BOARDS

- In addition to using a CNC mill to drill the holes in your PCB, you can also use it to route out the copper from around the tracks themselves.
- To do this, you need to export the copper layers from your PCB software as Gerber files.
- These were first defined by Gerber Systems Corp., hence the name, and are now the industry standard format used to describe PCBs in manufacture.
- To translate your Gerber file into the G-code that your mill needs requires another piece of software.
- Some CNC mills come with that software already provided, or you can use a thirdparty program such as Line Grinder.
- The mill effectively cuts a path round the perimeter of each track to isolate it from the rest of the copper.
- As a result, PCBs which have been milled look a bit different from those which are etched because any large areas of copper that aren't connected to anything are left on the board.

THIRD-PARTY MANUFACTURING

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- If your design has more than two layers, if you want a more professional finish, or if you just don't want to go to the trouble of making the PCBs yourself, many companies can manufacture the boards for you.
- The price for getting the boards made varies based on the complexity and the size of the design but also varies quite a bit from company to company.
- If you need the boards quickly, a local firm is best.
- If you have more time you can give it outside country such as china, it might reduce cost.
- Either way, the Gerber files are what you need to provide to the manufacturer.
- Make sure you export all the relevant layers from your design, meaning each of the copper layers you're using, plus the solder mask, silkscreen and drill files.

Q5 c) What is the importance of Certification for IoT devices? Explain. (5)

Importance of Certificate for IoT devices are:-

- These regulations are there for good reason.
- They make the products you use day in, day out, safer for you to use; make sure that they work properly with complementary products from other suppliers; and ensure that one product doesn't emit lots of unwanted electromagnetic radiation and interfere with the correct operation of other devices nearby.
- The regulations that your device needs to pass vary depending on its exact functionality, target market (consumer, industrial, and so on), and the countries in which you expect to sell it.
- The best approach is to work with a local testing facility.
- They not only are able to perform the tests for you but also are able to advise on which sets of regulations your device falls under and how they vary from country to country.
- Such a testing facility subjects your device to lots of tests.
- Testers check over the materials specifications to ensure you're not using paint containing lead; zap it with an 8KV static shock of electricity to see how it copes; subject it to probing with a hot wire—heated to 500 degrees Celsius—to check that it doesn't go up in flames; and much more.
- Of particular interest is the electromagnetic compatibility, or EMC, testing.
- This tests both how susceptible your device is to interference from other electronic devices, power surges on the main's electricity supply, and so on, and how much electromagnetic interference your product itself emits.

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- Electromagnetic interference is the “electrical noise” generated by the changing electrical currents in circuitry.
- When generated intentionally, it can be very useful: radio and television broadcasts use the phenomenon to transmit a signal across great distances, as do mobile phone networks and any other radio communication systems such as WiFi and ZigBee.
- The problem arises when a circuit emits a sufficiently strong signal unintentionally which disrupts the desired radio frequencies.
- In addition to the test report, you need to gather together PCB layouts, assembly certificates, the certificates for any precertified modules that you have used, and datasheets for critical components.
- This information is all held in a safe place by the manufacturer (that is, you) in case the authorities need to inspect it.
- The location of the technical file is mentioned on the declaration of conformity, which is where you publicly declare to which directives in the regulations your device conforms.
- In Europe, you must also register for the Waste Electrical and Electronic Equipment Directive (WEEE Directive).
- It doesn’t cover any of the technical aspects of products but is aimed instead at reducing the amount of electronic waste that goes to landfill.
- Each country in the EU has set up a scheme for producers and retailers of electronic and electrical products to encourage more recycling of said items and to contribute towards the cost of doing so.

Q5 d) Explain privacy with respect to Internet of Things. (5)

The Internet, as a massive open publishing platform, has been a disruptive force as regards the concept of privacy.

Everything you write might be visible to anyone online: from minutiae about what you ate for breakfast to blog posts about your work, from articles about your hobbies to Facebook posts about your parties with friends.

There is a value in making such data public: the story told on the Internet becomes your persona and defines you in respect of your friends, family, peers, and potential employers.

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A common argument is “if you’ve got nothing to hide, then you’ve got nothing to fear.” There is some element of truth in this, but it omits certain important details, some of which may not apply to you, but apply to someone:

- You may not want your data being visible to an abusive ex-spouse.
- You might be at risk of assassination by criminal, terrorist, or state organizations.
- You might belong to a group which is targeted by your state (religion, sexuality, political party, journalists).

More prosaically, you change and your persona changes. Yet your past misdemeanours (drunken photos, political statements) may be used against you in the future.

Even innocuous photos can leak data. With GPS coordinates (produced by many cameras and most smartphones) embedded into the picture’s EXIF metadata, an analysis of your Flickr/Twitpic/Instagram feed can easily let an attacker infer where your house, your work, or even your children’s school is.

Even if you stripped out the data, photo-processing technology enables searching of similar photos, which may include these coordinates or other clues.

Similar issues exist with sports-tracking data, whether produced by an actual Thing, such as Nike+ or a GPS watch, or a pseudo-Thing, like the RunKeeper app on your smartphone.

This data is incredibly useful to keep track of your progress, and sharing your running maps, speed, heartbeat, and the like with friends may be motivating.

But again, it may be trivial for an attacker to infer where your house is (probably near where you start and finish your run) and get information about the times of day that you are likely to be out of the house.

Q5 e) Discuss the five critical requirements for sensor commons project.(5)

Five critical requirements for a sensor commons project. It must;

1) Gain trust:

- Trust is largely about the way that an activist project handles itself beyond the seemingly neutral measurements; understanding local issues, being sensitive about the ways that the sensor network itself affects the environment (for example, local WiFi bandwidth usage), engaging the public with accessible and readable information about the project, and dealing with the local authorities to get access to the systems the project wants to measure.

2) Become dispersible:

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- Becoming dispersible means spreading the sensors throughout the community. Getting mass adoption will be easier if the proposed sensors are inexpensive (both the physical sensor itself and the ongoing costs of keeping it powered and connected to the network) and if the community already trusts the project.
- If the sensors are complicated to set up or require massive lengths of cabling, they will get much less take-up! The Xively air-quality project led to the creation of the "air-quality egg", a simple, inexpensive sensor with precisely these features.

3) Be highly visible:

- Being visible involves explaining why the project's sensors are occupying a public space. We've already discussed the ethics of hidden sensors.
- Being honest and visible about the sensor will help to engender trust in the project and also advertise and explain the project further.
- This may reduce the probability of vandalism too. Advertising not just the sensors but the data (both online and in real life) and the ways that data has helped shape behaviour will also generate a positive feedback loop.

4) Be entirely open:

- Being open is perhaps what distinguishes the sensor commons from a government project the most. Government data sets are often entirely closed, but the data that is released from them will be given a lot of attention because of the rigour and precision that (we expect) their sensor projects will have.

5) Be upgradable:

- Finally, the project should be designed to be upgradable, to enable the network to remain useful as the needs change or hardware gets to the end of its working life.
- This requirement interplays with the dispersibility and openness of the project, and the up-front thought to managing the project long term will feed back into the trust in the project.

Q5 f) Write a short note on cautious optimism. (5)

Be generally optimistic, but not wildly optimistic. Believe that the future will be mostly good. See opportunities, weigh them up in a positive light, and then take the best route to a good future rather than just selecting the route to the safest future.

A feeling of general confidence regarding a situation and/or its outcome coupled with a readiness for possible difficulties or failure. I've prepared for this exam for weeks, so I have a cautious optimism that it will turn out well. It's best to exercise cautious optimism when starting any new business.

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It is true that any technological advance adopted by corporations, governments etc. we always aim that technology can be used socially, responsibly, efficiently to mitigate and manage the given set of operations.

Assuming that Internet of Things can be fun, but being aware of the ethical issues around it, and facing them responsibly, will help make it more sustainable and efficient.

When designing the Internet of Things, or perhaps when designing anything, you have to remember two contrasting points:

- **Everyone is not you.** Though you might not personally care about privacy or flood levels caused by global warming, they may be critical concerns for other people in different situations.
- **You are not special.** If something matters to you, then perhaps it matters to other people too.

This tension underscores the difficulty of trying to figure out overriding concerns about any complex area, such as the Internet of Things!

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