IOT Take Home Exam

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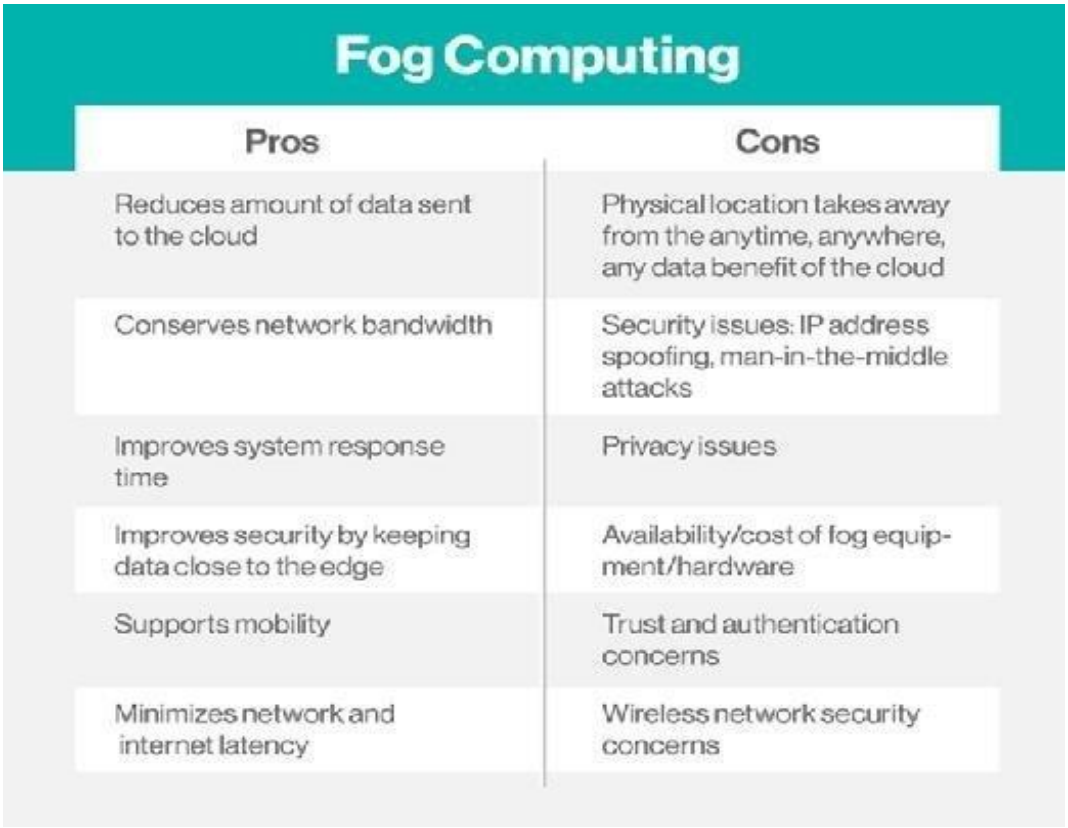
Paper 1, Fog Computing:

1. **What are the benefits of fog computing (Section 6 defines the Fog. However, you should digest it and write on your word)?**

   - The Main benefit of the fog computing is to solve the problems faced by cloud computing during IOT data processing.
   - Current cloud model cannot store huge amounts of data. Data needs to be filtered and pre-processed.
   - We use fog when there is a need to analyze data in a fraction of second, when there are huge number of devices, when the devices are separated by a large distance and when the IOT devices are exposed to the harsh environments condition.
   - Fog also provides better support and work capabilities in an improved network.
   - Fog is developed to overcome the challenges that are faced in cloud such as latency, band width, data security and operation reliability.
   - Fog nodes provides protection using the same controls, procedures, and better security policies.



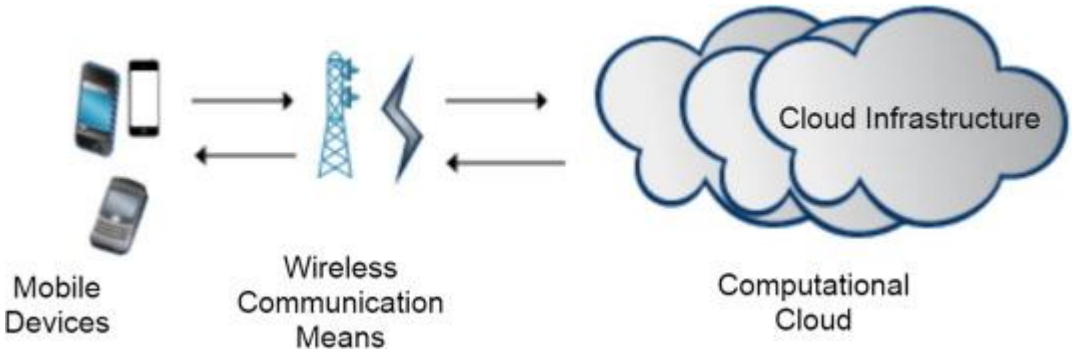
2. **What are the differences between Fog Computing and Mobile Cloud Computing?**

Fog Computing:

In Fog computing, Applications and processing's are focused in devices at the network edge rather than transfer to cloud for processing. So, processing is done at the smart device rather than the cloud.

Mobile Cloud Computing:

In Mobile computing, the mobile devices and cloud computing combine and create a new platform where the data processing and data storage are outside of mobile devices i.e. the processing and storage are done in the cloud.



3. **Explain how the fog does improve scalability issues?**

- According to the current statistics, by 2020, about 50 billion devices will be online
- Presently billions of devices produce huge-bytes of data every day.
- Device density is still increasing every day.
- Current cloud model is unable to process this amount of data.
- To address these issues, Data needs to be filtered.
- Reduce latency of data, i.e. latency can be reduced by analyzing the data close to the data source.
- Data security i.e., IOT data must be secured and protected from the intruders, they should be monitored 24*7.

4. **Explain how NFV and SDN are used to improve flexibility of fog?**

   - SDN has an enhanced cloud at the edge of the networks as a cornerstone for NFV.
   - NFV is the response of telco administrators to their absence of dexterity and consistent requirement for solid frameworks.
   - NFV attempts to give the capacity of powerfully conveying on-request organize administrations (e.g. a firewall, a switch or a WAN quickening agent, another LAN or a VPN) or client administrations (e.g. a database) where and when required.
   - SDN are one of the columns required for NFV, since some system administrations (e.g. making new "virtual" arranges over the physical framework) should be possible by programming as it were.
   - For example, some doors can be sent as virtual machines and their traffic can be firmly controlled because of SDN abilities in a nearby edge cloud.
   - Fog becomes an environment where applications and data are no longer required to stay in centralized database.
   - This improves the scalability and empowers users to retain control and ownership of their own data/apps.

5. **In addition to the traditional security issues, the Fog needs to deal with "Trust and Privacy" issues. Give a case example as well as suggest a potential solution (or the direction) on your own.**
   - Data ownership is an important step where fog, uses the network to run some applications instead of managing them on the centralized services.

     Examples:

     I have stored all my messages in the cloud that could leak all the private information if that is exposed. So, if the messages are encrypted on my device and the encrypted sensitive information is stored in the cloud that is how we keep the privacy.

     Pre-processing such encrypted data is tough, so we can use crypt-processors or applying special encryption functions makes overcome the issue.

     So here we replace all the centralized services with our enabled network.

<u>Paper 2, Indoor Positioning</u>:

1. **Explain why the wireless indoor positioning is challenging in comparison with the outdoor positioning technologies.**
   - Indoor Wireless positioning is a technology that allows users to accurately pinpoint the location of people or things inside a building using smartphones.
   - Using triangulation/trilateration to pinpoint a device in a building has enabled accurate navigation in indoor environments to be possible.
   - There are many different solutions and technologies on the market but mixing accuracy, cost, and implementation time means that the indoors solution is the best option.
   - Due to GPS' failure to work indoors, the need for a distinct Indoor Positioning system was born. That and the increasing complexity of buildings.

- The Outdoor positioning of the object is easy compared to the indoor positioning of the object.
- The GPS works accurately and pinpoints the accurate location of the thing.
- The Real Time indoor systems should be used which includes heavy cost management and privacy of the building plan is exposed.
- These all factors contribute to the opinion that Outdoor positioning technology is better than indoor positioning.

2. **Explain physical location, symbolic location, absolute location, and relative location on your own word.**

   Physical location: Physical location is in the form of coordinates, which identify a point on a 2-D/3-D map. Coordinate systems used are degree/minutes/seconds (DMS), Universal Transverse Mercator (UTM) system.

   Symbolic location: It is expressed in the form of natural language processing. (e.g., floor kitchen, ground floor).

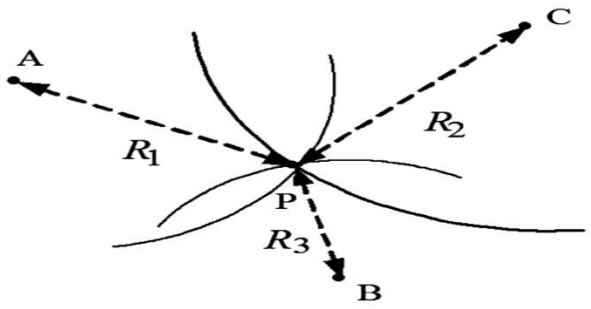
   Absolute location: It is defined as shared reference object for all the objects in the plane.

   Relative location: It depends on it frame of reference. Information is usually based on the proximity to known reference points or base stations.

3. **Explain "Triangulation". 1) Define lateration and angulation derivations; 2) identify which literation approaches are suitable for an indoor positioning; and 3) pros and cons of "Angulation" techniques.**

   Triangulation uses the geometric properties of triangles to estimate the target location. It has two derivations: lateration and angulation.

   Lateration: Lateration estimates the position of an object by measuring its distances from multiple reference points. So, it is also called range measurement techniques.



Angular Deviation: Angulation estimates the position of object by determining angle of incidence.

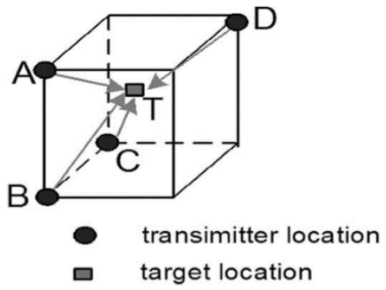


Fig. 4. Positioning based on signal phase.

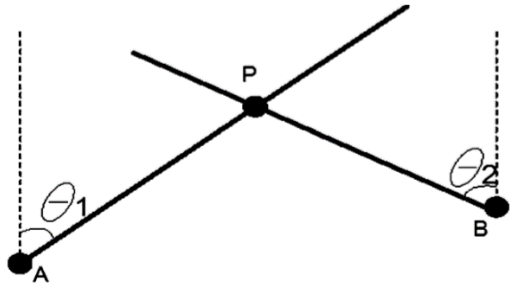


Fig. 5. Positioning based on AOA measurement.

pros	**cons**
The position can be determined by measuring 3 units for 3D and 2 measuring units for 2D positioning. Time synchronization between angles is not required.	It is relatively large, and it requires heavy and expensive hardware. As the mobile target moves farther from measuring units the location estimate degrades.

4. Among the performance metrics, explain differences between accuracy and precision.

Accuracy:
Accuracy is the average Euclidean distance between the estimated location and the true location. The higher the accuracy the better the system.

Precision:
It is a measure of the robustness of the positioning technique as it reveals the variation in its performance over the trails. It is also the distribution of distance error between the estimated location and the true location.

5. **Explain WLAN (IEEE 802.11) based systems and compare them with the TOPAZ approach. Identify pros and cons of them from the aspects of performance parameters (accuracy, precision, complexity, scalability, robustness, and cost).**

Parameters	WLAN	TOPAZ
Accuracy	3-5m	2m
Scalability	Good	Poor
Robustness	Good	Poor
Cost	Low	Medium
Complexity	Moderate	High
Precision	Is 50% within 2.5m and 90% within 5.9m	Is 90% within 2m

<u>Paper 3, Opportunistic IoT</u>:

1. **Explain an Opportunistic Networking paradigm (in IoT) on your own word.**

- Opportunistic Networking Paradigm is a scenario where IOT devices are statistically deployed or moving.
- IOT Devices show different mobility patterns and an IOT device can be mounted on public, transportation or robotized systems or humans.
- It also acts as an enabler for communication where in the past the data is communicated in the static devices over the network but now we have mobile devices where we have opportunity for communication and reach any device.
- Opportunistic Networking assumes that each device acts as a gateway/forwarding device and hop-by-hop relay messages between sources and destinations.
- It also provides Delay/Disruption tolerant networking where the message is delivered from source to destination when the communication takes place over the disconnected static and mobile ad-hoc networks.

2. **Explain the benefits of an Opportunistic Networking in IoT on your own word.**

Extended Lifetime:
It means that the energy in an IOT device can be saved when the nodes of the neighboring nodes can be easily connected and the interaction with its direct neighbor. Thus, this saves energy and have good lifetime.

Communication Time:

The contact duration and the nodes arrival time saves the time and the interaction happens very fast when the nodes find the proper destination node.

Communication Planning:

Communication Planning can be improved having knowledge about mobility patterns. By assessing the behavior of the nodes such as the mobility patterns of the node can be predicted such as the contact duration and pre-forwarded node and where the node is being visited so that it plans the communication.

3. Among the taxonomy of neighbor discovery for Opportunistic Networking in IoT, explain the "Mobility agnostic & Time synchronized" approaches (definition, examples, pros, and cons).

- Mobility agnostic approach can be applied to both the static and mobile devices.
- In this approach the mobility patterns are not assumed for performing Neighbor Discovery.
- Time synchronized technique uses a common time reference, shared between all devices and ultimately used with the aim of reaching a common communication scheduling for the neighbor discovery process.
- Time references are commonly available using Global Positioning System (GPS) receivers or Network Time Protocols (NTP).

  Example:
- In the Zebra Net experiment sensors are used in the wild life to track the mobility of zebras.
- Power consumption and availability of GPS receivers are the problems in these devices.
- To overcome power consumption issue GPS time reference-based calibration is used for node synchronization.

Pros	**cons**
Nodes are synchronized at a particular time frame.	For some applications GPS receivers are not applicable.

4. Among the taxonomy of neighbor discovery for Opportunistic Networking in IoT, explain the "Mobility agnostic &Indirect request" approaches (definition, examples, pros, and cons).

- In Indirect Request based approach the nodes using customized or secondary radios are present in IoT devices.
- The IoT are communicated using a secondary radio of a neighboring device.
- Mobility agnostic approach can be applied to both the static and mobile devices.
- In this approach the mobility patterns are not assumed for performing Neighbor Discovery.

pros	**cons**
Power consumption of devices are improved by using the devices like ZigBee instead of a higher power radio like Wi-Fi.	Integration of devices like ZigBee and Bluetooth is difficult

5. Among the taxonomy of neighbor discovery for Opportunistic Networking in IoT, explain the "Mobility aware & Temporal Knowledge" approaches (definition, examples, pros, and cons).

- In Mobility aware approach uses contextual information (frequency of arrivals or the arrival times, or from spatial features, such as knowledge of position and movement or colocation.)
- To infer device availability over time, therefore organizing the schedule of the resources in an efficient fashion.
- Temporal knowledge approach uses the IOT devices mobility based on the temporal features by adapting the schedule for saving resources.
- Neighbor Discovery is implemented using the contact patterns of node movements.
- Temporal Knowledge is classified into arrival times-based approach and rate of encounters between devices.

Pros	Cons
Power consumption is improved across the devices.	The accuracy and precision are low.