**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)?

Fog computing is a scenario where a huge number of heterogeneous (wireless and sometimes autonomous) ubiquitous and decentralised devices communicate and potentially cooperate among them and with the network to perform storage and processing tasks without the intervention of third-parties.

Benefits: 1) In fog computing network and user device/sensor elements can behave as mini-clouds.

2) Applications and data are no longer required to stay in centralised data centres.

3) Scalability is improved and empowers users to retain control and ownership of their own data/apps.

4) Applications can securely run in devices at the edge with minimum interaction with central/coordinating elements, reducing unnecessary/ undesired uploads of data to central servers in corporate data centers.

1. What are the differences between Fog Computing and Mobile Cloud Computing (Table 1 compares cloud and fog features, but the question is about “mobile cloud computing”. You can search it via Wiki and compare it to the Fog.)?

1. In Fog Computing Nodes are located at end devices. In mobile cloud computing Nodes are located at Macro base station.

2. In fog computing internode communication is supported. It is partially supported at mobile cloud computing.

3. Fog computing uses Wifi, Bluetooth for access mechanism. Mobile Cloud Computing uses Mobile Networks for access mechanism.

1. Explain how the Fog does improve scalability issues.

Scalable issues can be resolved in fog by P2P Connections. This type of connection removes the need for central management point. User devices & sensor elements can behave as mini-clouds. As a result the fog becomes an environment where applications and data are no longer required to stay in centralized data centers. This improves scalability and users can retain control and ownership of their own data and apps.

1. Explain how NFV and SDN are used to improve flexibility of the Fog.

Network Function Virtualization connects the heterogeneous devices like Sensors, Routers, Mobiles etc in an homogeneous manner. It dynamically deploys the on-demand Network & User Services when needed.

Software Defined Networks helps in creating virtual networks on top of physical infrastructure.

Even though NFV and SDN has many advantages their capabilities do not reach end user devices or sensors yet. Billions of user handheld devices and trillions of sensors should have a similar automation process that can cope with the required scale.

1. 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.

“Trust and Privacy” are the key issues that user had to look after, as now a days we offer our private data to many apps and websites. Storing our private data such as (Date of Birth, Address, Mobile number, Email etc) in encrypted format is the best solution for tackling the trust and privacy issues. Applications must run on a network where the private data is stored in encrypted form and the data is managed without relying on centralized services.

**Paper 2, Indoor Positioning:**

1. Explain why the wireless indoor positioning is challenging in comparison with the outdoor positioning technologies.

When compared to outdoor positioning technology, indoor positioning technology is more complex. In Indoor Positioning, to achieve a solution of a problem with high accuracy and precision, cost to be spent is more. To achieve a solution a problem with low accuracy and precision, cost to be spent is less. Object detection and 3D modeling detection is complex in IP when compared to OP.

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

Physical location is expresses location 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 expresses a location in a natural-language way( in the office, in the second floor kitchen , etc.) .

Absolute location uses a shared reference grid for all located objects.

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

1. 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 estimates the target location by using geometric properties of a triangle. It has two derivations: lateration and angulation.

Lateration is also called range measurement techniques. Estimates the position of an object

by measuring its distances from multiple reference points. Angulation estimates the position of object by determining angle of incidence.

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

Accuracy : Accuracy defines the closeness of measured value to the actual value. Accuracy is high if the measured value is close to the actual value

Precision : Precision defines the closeness of measured value among themselves.

1. 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).

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| --- | --- |
| **WLAN** | **TOPAZ** |
| Accuracy 3-5 m | Accuracy 2 m |
| Scalability is good | Scalability is poor |
| Robustness is good | Robustness is poor |
| Cost is low | Cost is medium |
| Complexity is moderate | Complexity is High |
| Precision is 50% within 2.5m and 90% within 5.9m | Precision is 90% within 2 m |

**Paper 3, Opportunistic IoT:**

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

In Opportunistic Networking, the IOT Devices both static and mobile are connected through a network where the data is passed in order to communicate with each other even in the absence of a predefined end-to-end path between data sources and sinks. For example, In a smart city the static devices (Traffic sensors, Cameras, Weather Stations)

And mobile devices such as cars are connected with each other to allow data flow among them. Opportunistic routing paths help to connect disconnected networks of devices to the Internet world.

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

Extended Lifetime : It helps in increasing the lifetime of devices, by avoiding wastage of resources when they are in communication range with low probability where the chance of communicating among them is very low. Power Consumption is also improved.

Communication Time : After Neighbor discovery the knowledge about nodes arrival times and contact durations are known which helps to reduce the wastage of resources as a result Communication Time is reduced.

Communication Planning : Communication Planning can be improved having knowledge about mobility patterns.

1. 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 through the use of Global Positioning System (GPS) receivers or Network Time

Protocols (NTP).

       Example: In the ZebraNet 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: Nodes are synchronized at a particular time frame.

        Cons: For some applications GPS receivers are not applicable.

1. 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: Power consumption of devices are improved by using the devices like ZigBee instead of a higher power radio like Wi-Fi.

         Cons: Integration of devices like ZigBee and Bluetooth is difficult.

1. 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 devices’ 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.

  Example: Context Aware Resource Discovery (CARD)

Pros: Power consumption is improved across the devices.

Cons: The accuracy and precision is low