**Makerere University**

**College of Computing and Information Sciences**

**School of Computing and Informatics technology**

**End of Semester I exam 2019/2020**

**PROGRAM:** MASTER OF SCIENCE IN DATA COMMUNICATIONS & software engineering

**COURSE NAME:** INTERNET OF THINGS

**YEAR OF STUDY:**  1

**COURSE CODE:** MCN 7110

**DATE:** 2ND December 2019

**TIME:** 4PM

**INSTRUCTIONS**

1. **ATTEMPT ANY FOUR QUESTIONS**
2. **ALL ROUGH WORK SHOULD BE IN YOUR ANSWERS BOOK**
3. **DO NOT OPEN THIS BOOKLET UNTIL YOU ARE TOLD TO DO SO**
4. **THE EXAMS RUNS FOR THREE HOURS**
5. **ATTEMPT EACH QUESTION BEGINNING ON A NEW PAGE**

**Question 1**

1. Explain the difference between Adaptation and adoption (3 Marks)

counterparts, simplifying the deployment model and operations.

**Ans**:Adaptation, Application Gateways must be implemented to ensure translation between IP and Non-IP while Adoption involves replacing all non-IP with their IP counterparts.

1. Evaluate the pros and cons of IP adoption versus adaptation (4 Marks)
2. While the Internet Protocol is key for a successful Internet of Things, constrained nodes and constrained networks mandate optimization at various layers and on multiple protocols of the IP architecture. What are some of these optimizations already available from the market or under development by the IETF? (6 Marks)

ANSWER **From 6LoWPAN to 6Lo, 6TiSCH, RPL**

1. Explain the key differences between TCP and UDP. What are the key challenges of using TCP with IoT/Constrained Networks? (6 Marks)

**Ans:**Reliability, retransmission of packets, amount of data transmitted, Nature of connection, Session requirement.

1. Because of the diverse types of IoT application protocols, there are various means for transporting these protocols across a network. What are the transport methods for the following IoT application protocols (6 Marks)?
   1. Supervisory control and data acquisition (SCADA)

**Ans:** Raw sockets and protocol translation

* 1. Generic web-based protocols: Generic protocols, such as Ethernet, Wi-Fi, and 4G/LTE

**Ans**: HTTP/HTTPs or web sockets

* 1. IoT application layer protocols

**Ans** MQTT and CoAP

**Question 2**

1. What is the key difference between IT and IoT? (1 Mark)

Key difference between IT and IoT is **Data**

1. As more OT systems become connected to IP networks, their capabilities increase, but so does their potential vulnerability, Traditional models of IT security are simply not designed for the new attack vectors introduced by highly dispersed IoT systems, For optimum security, what mechanisms should IoT systems be able to do to address this security challenge. (5 Marks)

1.Ensure that data shared by end point devices and backend applications is encrypted,

2. holistic-network-level approach to security,

3. comply with local data protection regulations so that data is protected and stored correctly,

4. identify and authenticate all entities involved in the IoT services,

5. rule based security policies to identify anomalies

1. What are the some of the unique challenges posed by IoT networks and how have these challenges driven new architectural models? (5 Marks)

1. Scalability,

2. Security,

3. Devices constrained by Power, Memory, CPU

4. Support for legacy,

5. Data that needs real time analysis,

6. Massive volume of Data Generated

1. In 2014 the IoTWF architectural committee published a seven-layer IoT architectural reference model. Each of the seven layers is broken down into specific functions, and security encompasses the entire model. Briefly describe the functionality of each of the layers (14 Marks)

7. **Collaboration** => Consumes and shares application information

6. **Application** =>Interprets data using a software application into a meaningful information

5. **Data Abstraction** => Reconciles multiple data formats and ensures semantics

4. **Data Accumulation** =>Captures and stores data so that it can be usable

3. **Edge** => Evaluate and Reformat Data for processing, Filter Data to reduce traffic, Assess Data for alerting and notification

2. **Connectivity**=>Reliable and timely transmission of data, switching and routing, ensures communications between layer 1 devices.

1. **Physical layer or thing** => they generate data from the environment



**Question 3**

1. What major challenges do constrained nodes and networks pose for IoT connectivity in the last mile. (6 Marks)

=> The implementation of technologies with low bandwidth,

=> Limited distance and bandwidth due to regulated transmit power,

=> and lack of or limited network services.

1. How might Internet Address (IPv6) affect the development and implementation of the Internet of Things? (3 Marks)

=> IPv6, the successor to the IPv4 protocol, will provide vast address space to enable the present and future growth of the internet.

=> IPv6 is usually seen as a key enabler technology for the internet of things, since it can easily accommodate the increasing number of smart sensors connecting to the internet.

=> Unless explicitly dealt with, IPv6 may result into all internal nodes becoming directly reachable from public internet

1. Explain the role of the following new metrics and how they are used for routing by IPv6 Routing Protocol for Low Power and Lossy Networks (RPL) (12 Marks)
2. **Hop Count**=> Tracks the number of nodes traversed in a node, a path with low hop count is chosen over the one with high
3. **Latency**=>This is variance caused due to dependence on power conservation, paths with lower latency are preferred
4. **Link Quality Level**=>Measures the reliability of the link layer by taking into account the errors that might be generated by packets
5. **Node State and Attribute=>**Identifies nodes that act as traffic aggregators
6. **Node Energy=>** Avoids nodes with low power, so a battery powered node that is running out of energy so the life of that node and the network are preserved
7. **Throughput=>**  Provides amount of throughput for a node link, priority is given to nodes with high throughput.
8. Challenges still exist for IP in IoT solutions. Therefore, optimizations are needed at various layers of the IP stack to handle the restrictions that are present in IoT networks. Discuss the optimizations necessary for IP. (4 Marks)

- From IPv6 LoWPAN to 6Lo(Header compression, Fragmentation, Mesh Addressing

- 6TiSCH Standardizing IPv6 over a Time Slotted Channel hoping

- RPL IPv6 Routing Protocol for Low Power and Lossy Networks

**Question 4**

1. There are myriad different sensors available to measure virtually everything in the physical world, discuss ways how these sensors can grouped and/or clustered into different categories (5 Marks)

- Active or Passive,

- Invasive or Non-Invasive,

- Contact and non-contact,

- Absolute or Relative,

- Area of Application,

- what sensors measure

1. While Sensor networks can theoretically be connected in a wired or wireless fashion, what are some advantages and disadvantages that a wireless-based solution offers? (5 marks)

- Flexible Deployment

- Simplicity in scalability

- Lower Costs

- Longer term maintenance

- Equipped to handle changing topologies

- Effortless introduction of a new sensor

1. While smart objects often collect too much data, in most cases, the processing location is outside the smart object or the cloud. Does this model have any advantage? The model is also known to have some limitations, new requirements appear, and those requirements tend to bring the need for data analysis closer to the IoT system, what are these requirements? (5 Marks)**IoT Data Management and Compute Stack Chapter 2**

One advantage of this model is simplicity

**Limitations of this model**

- New requirements appear

- Large Data Volume

- Variety of Objects connecting to the network

- The need for more efficiency increase

**New requirements**

**-** Minimizing latency

- Conserving Network Bandwidth

- Increasing Local Efficiency

1. Explain the differences between edge, fog and cloud computing? when architecting an IoT network, what factors should you consider when deciding on where data should be analysed? (5 Marks)

**Edge,** All the data that is received by the node is instantly transferred from the device. It helps the device get faster results by processing data simultaneously

**The Fog**, receives the data and filters it, the important data is transferred to cloud for storage, less important data is discarded or deleted or kept for more analysis.

**Cloud Computing,** This provides means of storing and accessing of data programs hosted by a remote server on the internet.

Factors to consider where data should be analyzed

- **Sensitivity of Data**

The most sensitive data are processed on the edge or the fog closest to the things generating the data

- **Data that can wait for a minute**

Data that can wait for a second or minute for an action is processed along the aggregation node for analysis and action

- **Timeliness of data**

Data that is less time sensitive is sent to the cloud for historical analysis and big data analysis as well as long term storage.

1. Among the access technologies available for connecting IoT devices, three main topology schemes are dominant: star, mesh, and peer-to-peer, explain these topologies. Explain which topology is suitable for each of the following Long Range, Short Range and Medium Range technologies? (5 Marks)

**For Long and Short range technologies ,** a star topology is prevalent as seen with cellular, LWPA and Bluetooth Networks. A star topology utilizes a single bus or controller to allow communications between endpoints.

**For Medium range topologies,** a star, mesh or peer-to-peer topologies can be used. Peer-to-peer allows nodes to communicate with each other as long as they are in a range to each other forexample the Deployment of Wi-Fi

**Question 5**

1. Give one major difference between a sensor and an actuator (2 marks)

- A **sensor** senses and measures a physical quantity, converts that measurement typically into a digital representation or electric signal that is sent to a device transforms it into useful data that can be consumed by an intelligent device or a human

- An **actuator** refers to a device that receives an electric signal, and then triggers a physical effect usually some type of force or motion.

1. Explain three physical properties of sensor nodes that make them suitable to be deployed in remote locations (6 marks)

- They are small in size

- Their form factor

- Their decreasing cost

1. Explain two factors you would consider when choosing a sensor radio technology (4 marks)
2. Explain the following sensor network deployment technologies, giving example applications and reasons for choosing the deployment method (6 marks)
   1. Random
   2. Pre-determined
3. Explain why the following conditions must be met in wireless sensor networks (4 Marks)
   1. Algorithms should be localized in the sensor nodes
   2. The networks should be self-configuring
4. The Northern part of the country was recently hit by an earthquake, which destroyed the entire communication infrastructure. Despite the challenge, government is looking for means to communicate so as to rescue people who were affected in the shortest time possible. Giving reasons and using wireless sensor network skills, please advise government on how it can solve the communication problem as soon as possible. (3 marks)