Notes for IoT - Internet of Things

Enablers of IoT:

- RFID
- Nanotechnology
- Sensors

Characteristics of IoT:

- Efficient, scalable, and associated architecture
- Unambiguous naming and addressing
- Abundance of sleeping nodes, mobile, and non-IP devices

Address Crunch:

- Increasing number of IoT devices can lead to an address crunch.

Gateway:

- The gateway has a unique network prefix for global identification.

- Direct communication to the Internet is achieved through tunneling.

Multi-Homing:

- Multi-homing enhances reliability by connecting a node/network to multiple networks.

IPv6 Notation:

- IPv6 notation uses hexadecimal values.

Sensors:

- Sensors detect and forward or process changes in ambient conditions or device/system states.
- Resolution of a sensor is the smallest change it can detect.
- Sensors are classified as Scalar and Vector/Multimedia based on data type.

Actuators:

- Examples of actuators include solenoid valves.
- Actuators require a control signal and a source of energy.
- Pneumatic rack and pinion actuators control water pipes.

IoT Gateway Functions:

- IoT gateways perform switching, routing, and protocol conversion.

MQTT (Message Queue Telemetry Transport):

- A message broker controls the publish-subscribe messaging pattern.
- Components of MQTT:
  - Publishers
  - Subscribers
  - Brokers
- SMQTT is an extension of MQTT with lightweight attribute-based encryption and four main stages.

CoAP (Constrained Application Protocol):

- Based on a Request-Response model between end-points.
- Two sub-layers:
  - Messaging
  - Request/Response

XMPP (Extensible Messaging and Presence Protocol):

- Used for real-time exchange of structured data.
- Utilizes the client-server architecture.

AMQP (Advanced Message Queuing Protocol):

- Message delivery guarantees include:
  - At-most-once: Each message is delivered once or never.
  - At-least-once: Each message is certain to be delivered but may do so multiple times.
  - Exactly-once: Messages will always certainly arrive and do so only once.
- Valid frame types: Open, Close, and End.
- The Bindings component manages message distribution rules.
- Exchange types:
  - Direct
  - Fan-out
  - Topic
  - Header

IEEE 802.15.4 (Wireless Personal Area Network - WPAN Standard):

- Standard for low data-rate WPAN.
- Networking topologies defined: Star and Mesh.
- Beacon-enabled networks involve periodic transmission of beacon messages.

Wired HART:

- Lacks a network layer.

HART Physical Layer:

- Derived from IEEE 802.15.4 protocol.
- Operates in the 2.4 GHz ISM band.

HART Super-Frames:

- Consist of grouped 10ms wide timeslots.

Channel Blacklisting:

- Identifies channels affected by interference and removes them from use.

Network Manager:

- Supervises each node in the network.
- Guides nodes on when and where to send packets.

NFC (Near Field Communication):

- Designed for use by devices in close proximity to each other.
- Passive NFC devices contain readable information but cannot read information themselves.
- Operates on the principle of magnetic induction.
- Three modes of operation:
  - Peer-to-peer
  - Read/Write
  - Card emulation

Bluetooth:

- Paging is the process of forming a connection between two Bluetooth devices.
- Four modes of operation.

Z-Wave:

- Uses RF for signaling and control.

Sensor Nodes:

- Must consume extremely low power.
- Must be adaptive to the environment.

Failed Nodes:

- Nodes unable to perform an operation, often due to power failure and environmental events.

Dumb Behavior of Sensor Nodes:

- Temporal in nature and dependent on environmental conditions.

Wireless Sensor Networks (WSN) Coverage:

- Coverage is defined as satisfying the area-of-interest.
- When transmission range >= 2 * sensing range, coverage implies connectivity.

Reporting in WSN:

- Two types: Event-driven and On-demand.

Objective of WSN Coverage:

- To use the minimum number of sensors and maximize the network lifetime.

Disadvantages of Stationary WSN:

- Node failure may result in network partition.
- Topology cannot change automatically.

Mobile Wireless Sensor Networks (MWSN):

- A mule collects data from sensor nodes and delivers it to the sink.

Participatory Sensing:

- Involves distributed sensing by humans.

- Goal is not just data collection but also enabling people to assess and share knowledge.

UAV (Unmanned Aerial Vehicle) Networks Features:

- Can form mesh or star networks.
- Support multi-tasking.
- Cover large areas.

UAV Network Constraints:

- Prone to frequent link breakages.
- Susceptible to malfunction.
- Very complex.

Multi-Star Configuration:

- UAVs form multiple star topologies, with one node from each group connecting to the ground station.

FANET:

- Full form is Flying Ad Hoc Network.

Low-End Sensor Nodes:

- Deployed with high density to increase network lifetime and survivability.
- Perform basic functions such as data aggregation, auto-configuration, and power saving.

M2M (Machine-to-Machine) Ecosystem Components:

- Device Providers
- Internet Service Providers (ISPs)
- Platform Providers
- Service Providers
- Service Users

M2M Device Platform:

- Enables access to objects connected to the Internet anytime, anywhere.

M2M Application Platform:

- Provides integrated services based on device-collected data sets.

IoT Characteristics:

- Heterogeneity with different devices using different protocols.

Semantic Conflict:

- Occurs when different IoT devices have different processing and business execution logic.

User Interoperability Issues:

- Should address all options to be resolved.

UMB-A:

- Responsible for converting physical devices into virtually abstracted ones.

Protocol Translation Unit (PTU):

- Acts as middleware between IoT devices with different native protocols.
- Enables communication by translating one device's language to the other.

Device's Cosign (A, B, C, D):

- 'D' refers to the definition of the object and is most appropriate for mapping to a configuration language.

Arduino UNO Board:

- Contains several components.
- Powered by ATMEGA series microcontrollers.

Arduino IDE:

- 'Verify' compiles the sketch and checks for correctness.

- 'Upload' uploads the sketch to the Arduino board.

Arduino Programming:

- Use 'analogRead()' for real numbers in analog format.
- Set pin 'g' to OUTPUT mode for writing digital values.

Sensor Libraries:

- Each type of sensor has specific libraries and functions that must be included with the Arduino sketch.

Servo Command:

- "ServoDemo.write(180)" best describes the command "Servo moves 180 degrees."

Arduino Sketch:

- The default function 'void setup()' is the point where the code starts.

Electro-Mechanical Switch:

- Described as a relay, which is an actuator.

Python Syntax:

- Python doesn't support strict rules for syntax and static variable declaration like C (True).

Python Data Types:

- Data types in Python include:
  - List
  - Tuple
  - Dictionary

Local Variables:

- Local variables are declared inside a function.

File Operations in Python:

- The `open()` function returns a file object for file operations.

Python Indentation:

- Python follows rigid indentation.

Displaying an Image in Python:

- To display an image in Python, you can use the method `image.show()`.

Python Networking Model:

- Python follows the client-server networking model.

'with' Statement in Python:

- "with" ensures the file is closed after the operation is completed, even when an exception occurs (False).

Raspberry Pi GPIO:

- Raspberry Pi GPIO acts as both digital output and digital input.

Raspberry Pi Camera Configuration:

- Raspberry Pi provides configuration options for cameras (Yes).
- The Python camera module `python-picamera` can be used to configure the camera.

Actuator:

- An actuator converts energy to motion.

Relay:

- A relay is a mechanical/electrochemical switch.

Sensors:

- Sensors can be analog or digital.

Raspberry Pi Devices:

- Raspberry Pi devices act like mini computers and can be configured for various purposes.

GPIO Pins on Raspberry Pi:

- General Purpose Input/Output is the complete form of GPIO pins on Raspberry Pi devices.

Python Syntax and Style:

- Python programs follow the same syntax and style regardless of their purpose.

Client-Server Communication:

- A client can communicate with a server if both the IP address and port numbers are known.

Data Processing Activities:

- Valid data processing activities include:
  - Data Splitting
  - Data Filtering
  - Data Plotting

Matplotlib:

- The `title(<name_of_title>)` function adds a title to a plot while using matplotlib.

Networking:

- Traditional networks are distributive, and all switches execute OSPF.
- SDN separates the physical and logical planes of the switch.
- OpenFlow by ONF is a popular protocol implementing SDN principles.
- SDN separates the data plane and control plane.
- East-Westbound APIs facilitate communication between SDN controllers and domains.
- Backup controllers are required to take over network control when the main controller fails.

Integration of SDN with IoT:

- SDN can be integrated with IoT to reap several benefits from both.

Cloud Computing:

- Traditional wireless mobile networks are expensive in terms of both capital expenditure (CAPEX) and operational expenditure (OPEX).
- Dynamic user mobility restricts the ease of rule placement for software-defined wireless mobile networks.

Mobi-Flow:

- Proposed for mobility-aware flow rule placement.

Trends in Computing:

- Major trends include Cloud, Utility, Grid, and Cluster computing.

Cloud Computing Features:

- Cloud computing uses virtualization and allows different users to share the same underlying physical infrastructure.
- "Hybrid Cloud" is a cloud deployment model, while "PaaS" is a cloud service model.
- Accessing Google Docs or Microsoft Word online is an example of the "SaaS" cloud service model.

Cloud Service Models:

- "Hybrid cloud" deployment model supports both public and private cloud features.
- Rapid elasticity is a key requirement for cloud computing paradigms.
- Start-up adopting cloud computing can use both PaaS and IaaS.

Data Security in Cloud Computing:

- Data security and client authentication issues exist in SaaS, PaaS, and IaaS.

- Network, host, and application-level securities are fundamental aspects of cloud infrastructure security.
- User authentication is a primary security issue.

Service Level Agreements (SLAs):

- SLAs are mutually agreed upon by the client and cloud service provider (CSP), providing views from both the customer and CSP.

CloudSim and OpenStack:

- CloudAnalyst is a simulation tool written on top of CloudSim modules.
- Horizon is the dashboard of OpenStack, providing a GUI to access components.
- Plasma is not a component of OpenStack, while Nova, Glance, Swift are.

Sensor Cloud:

- Sensor cloud incorporates various aspects beyond dumping sensor data over cloud platforms.
- Procurement, deployment, and maintenance are critical issues in traditional WSNs.
- Sensor cloud architecture places the sensor cloud infrastructure between the physical sensor layer and the application layer.
- SCSPs provide virtualized sensor services but may not own the physical sensors.

Sensor Virtualization and Cloud:

- One instance of a virtual sensor can be mapped with one, two, or more physical sensors.
- Sensor virtualization and cloud offer more flexibility and convenience than traditional sensor-based services.
- SCSPs provide the sensor virtualization layer between the application and physical sensor layers.

Caching in Sensor Cloud:

- Caching is important in sensor cloud to enhance performance and service delivery.

Sensor Data Pricing:

- In a single-owner scenario, all data traversing through the sensors is charged at a uniform price. In a multi-owner setup, different owners may charge different rates.

Fog Computing:

- Fog computing complements cloud-based technologies rather than replacing them.
- Processing "very time-sensitive data" is done at the nearest fog node.

Fog Computing Architectural Framework:

- Network, Accelerator, Compute, and Storage fall under the Node View in the Fog Computing Architectural framework.

Data Fusion Stages:

- Decision level
- Feature level
- Pixel level
- Signal level

Challenges of Data Fusion:

- Imperfection
- Conflicts
- Ambiguity

Data Fusion Theory:

- Belief function is one of the theories used in evidence-based mathematical methods of data fusion.

DLNA:

- Stands for Digital Living Network Alliance.

Smart Parking Functional Layers:

- Information collection
- System Deployment
- Service Dissemination

IEEE802.15.4 and Zigbee:

- IEEE802.15.4 defines the Physical and MAC layers.
- Zigbee defines the Network and Application layers.

X-10:

- Allows remote control of compliant transmitters.
- Has low speed and data rate.
- Adopted by GE.

V2X (Vehicle-to-Everything):

- Enables vehicles to wirelessly share a diverse range of information.

VANETs (Vehicular Ad-Hoc Networks):

- Based on DSRC and WAVE.
- Have guaranteed low-latency in mobile environments.

INN (Intelligent Network Node):

- A knob is a type of switch used in INN.

Body-Brain Architecture:

- The brain is responsible for central coordination in the Body-Brain architecture.

DSRC:

- Stands for Dedicated Short Range Communication.

VANET Domains:

- Ad-hoc is a domain of VANET.

Disadvantages of V2X Communication:

- Include tracking of movement, violation of privacy, loss of data control, and more.

Smart Grid:

- Also known as Electricity with a brain, Energy internet, and Electronet.
- A modernized grid enabling bidirectional energy flow.
- Provides efficient transmission of electricity, lower electricity rates, and improved security.

Components of Smart Grid:

- Smart meters
- Gateways
- DAUs (Data Acquisition Units)
- MDMSs (Meter Data Management Systems)

Plug-In Electric Vehicles (PEVs):

- Can be used as an energy source during on-peak hours.

Dynamic System Attacks:

- Types include Replay Attacks, Dynamic Data Injection Attacks, and Covert Attacks.

Gateways:

- Connect closely located smart meters.
- Communicate mostly on WiFi.
- Facilitate two-way communication.

MDMS (Meter Data Management System):

- Serves as a centralized coordinator for smart grid communication.

Communication Protocols:

- C-Bus, DECT, EnOcean, and Universal Powerline Bus.

Industrial Internet of Things (IIoT):

- A network of physical objects, systems, platforms, and applications.
- Based on the wrap and re-use approach.

Fourth Industrial Revolution:

- Involves mass production, internet evolution, and automation.

IIoT Safety Challenges:

- Worker health and safety
- Environmental production
- Optimized operations

Traditional Electrical Grid:

- Monitoring and restoration are done manually.

Hadoop:

- Used for distributed processing of large datasets across large clusters of computers.

Data Analysis:

- Qualitative and quantitative are the two types of data analysis.

Principles of Qualitative Analysis:

- The three principles of qualitative analysis are: Notice things, think about things, and collect things.

Types of ANOVA (Analysis of Variance):

- Include one-way analysis, two-way analysis, and K-way analysis.

Data Dispersions:

- Range, average absolute deviation, and variation are types of data dispersions.

Quantitative Analysis:

- Involves analyzing numerical data.

Statistical Model:

- A mathematical equation formulated in the form of relationships between variables.

Types of Statistical Models:

- Include complete and incomplete.

Contingency Table:

- Also known as cross-tabulation and cross table.

IoT Healthcare:

- Non-invasive monitoring, cloud-based analytics, and wireless transmission are types of IoT healthcare.

Components of IoT:

- Sensing layer, aggregated layer, processing layer, and cloud platform.

Advantages of Activity Monitoring:

- Long-term monitoring is one of the advantages of activity monitoring.

Deep Learning:

- Can be applied to sensor data, images, and videos for data analysis.

In-Place Activity Monitoring:

- Data analysis is on-device and power-intensive for in-place activity monitoring.

Handheld Activity Device Data:

- Processing with artificial intelligence can be used for detecting sudden falls of a person.