6LoWPAN Overview

Sure! Here's your **Introduction to IoT (Parts I, II, III)** content formatted in clear, structured **notes-style** just like the previous batch:

Introduction to IoT – Part I

Definition of IoT

- Involves connecting devices, machines, tools wirelessly to the internet.
- A network of physical objects embedded with technology to communicate and interact with internal states or external environments.

Scale of IoT

- Currently: 9+ billion connected devices.
- Projected: Over 20 billion in near future.

Key IoT Enablers

- Low-power embedded systems
- Cloud computing
- Big data
- Machine learning
- Networking
- RFID, nanotech, sensors, smart networks

Origin of the Term

- Popularized by **ITU Internet Report 2005**.
- Discussed extending M2M connectivity to everyday household devices.

machine to machine

Characteristics of IoT

- Efficient, scalable, and associated architecture
- Unique naming and addressing

- Abundant sleeping nodes
- Support for mobile and non-IP devices
- Intermittent connectivity

Intermittent connectivity refers to an Internet connection that continuously disconnects and reconnects, slows down, or becomes unstable at random intervals

IoT Market Applications

- **Business/Manufacturing**: Real-time analytics, robotics
- **Healthcare**: Portable monitors, e-records
- **Retail**: Inventory tracking, mobile purchasing
- **Security**: Biometric locks, remote sensors

Evolution of Connected Devices

- ATM (1974), WWW (1991)
- Smart meters, locks, vehicles, healthcare
- Smart Cities, Smart Dust

Modern IoT Applications

- Smart Parking
- Smart Grid
- Waste Management
- Forest Fire Detection
- Air Pollution Monitoring

Relationship with M2M, CPS, and WoT

- **M2M**: Communication between machines/devices, part of IoT.
- **CPS**: Cyber-Physical Systems—tight integration of computation with physical processes.
- **WoT**: Web-of-Things—uses web standards (e.g., REST APIs) to integrate IoT with the Web.

Introduction to IoT – Part II

Address Crunch in IoT

- Massive device growth (20–50 billion by 2018) leads to IP address shortage.
- Integration of legacy and new systems complicates address management.

IoT Network Topologies

- **IoT LAN**: Local comms, may not need internet access.
- **IoT WAN**: Connects LANs over geographic/organizational areas via the Internet.
- **IoT Node**: Connects with other nodes inside LAN.
- **IoT Gateway**: Router for LAN-to-WAN/Internet, forwards at IP layer.
- **IoT Proxy**: Active application-layer bridge between IoT nodes and external networks.

Addressing in IoT

- Use **local addresses** within gateway domains to conserve addresses.
- Gateways are assigned **unique network prefixes** by routers.

Impact of Mobility

- Changing WAN addresses doesn't affect LAN-level addresses when using **ULA (Unique Local Addressing)**.

Gateways vs. Proxies

- **Gateways**: Bridge between local devices and Internet.
- **Proxies**: Handle communication and processing for locally addressed nodes.

IPv4 vs IPv6

Feature	IPv4	IPv6
Address Length	32 bits	128 bits
Notation	Dotted Decimal	Hexadecimal
Allocation	DHCP	SLAAC / DHCPv6
Security	Optional IPSec	Mandatory IPSec
Header	Variable, Complex	Fixed, Simpler

IoT Deployment Challenges

- No global IPv6 transition plan.
- Interim solutions: NAT64, 6to4 Tunneling, Application-layer proxies.

Multi-homing

- Node/network connected to multiple networks to increase availability and reliability.

Introduction to IoT – Part III: Sensing & Actuation

Sensor

- Detects environmental/state changes and converts them into signals (input device).
- Part of a **transducer** when paired with an actuator.

Transducer

- Converts energy from one form to another.
- Includes both sensors and actuators.

Sensor Characteristics

- Sensitive to the desired property only
- Minimal influence on the measured property
- Resistant to interference

Sensor Resolution

- Smallest detectable change in measurement.
- High resolution → better precision (not necessarily accuracy).

Sensor Classifications

- **By Output**:
  - Analog (continuous)
  - Digital (discrete)
- **By Data Type**:
  - Scalar (e.g., temperature)

- Vector/Multimedia (e.g., acceleration)

Examples of Sensor Types

Property	Sensor Type
Light	LDR, Photodiode
Temperature	Thermocouple, Thermistor
Force	Strain gauge
Position	Potentiometer, Encoders
Speed	Doppler-based sensors
Sound	Carbon Microphone
Chemical	Liquid/Gas Chemical Sensors

Sensorial Deviations (Errors)

- **FSR**: Full Scale Range
- **Sensitivity Error**, **Offset/Bias Error**, **Non-linearity**
- **Drift**, **Noise**, **Hysteresis**, **Quantization Error**
- **Dynamic Error / Aliasing**, **Cross-Sensitivity**

Actuator

- Converts energy into mechanical motion (output device).
- Receives control signals and performs physical actions.

Types of Actuators

- **Hydraulic**: Fluid-based (high force)
- **Pneumatic**: Air-based
- **Electric**: Motors, solenoids
- **Thermal/Magnetic**: Shape memory alloys
- **Mechanical**: Rotary to linear converters

Soft & Smart Actuators

- Designed for delicate operations.
- **SMPs (Shape Memory Polymers)**, **LAPs (Light Activated Polymers)** respond to stimuli like heat or light.

Basic IoT System Components

- **Device (Thing)**: Sensor/Actuator
- **Local Network**: Connectivity layer
- **Internet**: Communication backbone
- **Backend Services**: Data storage and processing
- **Applications**: User-facing interfaces

Functional Components

- Interaction and communication modules
- Data processing and analytics
- Web and application service integration
- User interfaces and dashboards

IoT Categories

- **Industrial IoT (IIoT)**: Large-scale, IP-network integrated.
- **Consumer IoT**: Home/retail use, often local networks (e.g., Bluetooth, Wi-Fi).

Associated Technologies

- Big Data, Cloud, Smart Grid, M2M, CPS, WoT

Challenges

- **Interfacing**
- **Interoperability**
- **Data Storage**
- **Security**
- **Scalability**
- **Energy Efficiency**

Sure! Here's a well-formatted and organized version of your notes for easier readability and quick reference:

Assignment 2

6LoWPAN (IPv6 over Low-Power Wireless Personal Area Networks)

- **Definition**: Enables small, low-power devices to communicate wirelessly using IPv6.
- **Purpose**: Facilitates IoT device integration with the Internet.
- **Standardization**: Defined by IETF (RFC 4919, RFC 5933).
- **IEEE 802.15.4 Support**: Supports 128-bit IPv6 addresses over IEEE 802.15.4 radios.
- **Header Compression**: Uses compression and translation to handle IPv6 headers efficiently.
- **Packet Handling**: IPv6 packets are compressed and adapted to IEEE 802.15.4 frame format.
- **Applications**: IoT, Smart Grid, M2M.
- **Addressing**:
  - 64-bit Extended (Globally Unique)
  - 16-bit Short (PAN-specific)
- **Multicast**: Handled as link-layer broadcast (802.15.4 doesn't support native multicast).
- **Packet Format Headers**:
  - *Dispatch Header*: Communication start and next header identification.
  - *Mesh Header*: For intra-PAN multi-hop routing.
  - *Fragmentation Header*: Supports large IPv6 packets.
- **Routing**:
  - *Mesh Routing*: Within PAN.
  - *Inter-domain Routing*: Between PAN and IPv6.
- **Protocols**:
  - *LOADng*: AODV-based; destination-only reply to RREQ.
  - *RPL*: Distance Vector for lossy networks, supports proactive/reactive behaviors.

RFID (Radio-Frequency Identification)

- **Definition**: Uses radio waves to read data stored on tags.
- **Components**:
  - RFID Tag (IC + Antenna)
  - RFID Reader
  - Antenna
- **Types of Tags**:
  - *Passive*: Powered by reader signal.
  - *Active*: Has its own power source.
- **Working Principle**: AIDC technology using radio waves.
- **Advantages**: No line-of-sight needed (unlike barcodes).
- **Applications**: Inventory, asset tracking, access control, supply chain, anti-counterfeit, etc.

MQTT (Message Queue Telemetry Transport)

- **Definition**: Lightweight, publish-subscribe messaging protocol over TCP/IP (ISO/IEC PRF 20922).
- **History**: Developed by IBM (1999), standardized by OASIS (2013).
- **Design Goal**: Efficient connectivity for low-resource devices and networks.
- **Architecture**: Event-driven (pub/sub), with a central *broker*.
- **Key Components**:
  - *Publishers* (e.g., sensors)
  - *Subscribers* (applications)
  - *Broker*: Routes messages by topic
- **Methods**: Connect, Disconnect, Subscribe, Unsubscribe, Publish.
- **Topics**: Hierarchical (e.g., `home/livingroom/temp`)

- `+`: single level wildcard
- `#`: multi-level wildcard

- **Applications**: Facebook Messenger, AWS IoT, Azure IoT, Adafruit IO.

SMQTT (Secure MQTT)

- **Definition**: MQTT with lightweight attribute-based encryption.
- **Key Advantage**: Broadcast encryption—one message for multiple recipients.
- **Phases**:
  - *Setup*: Key registration
  - *Encryption/Decryption*: With a master key
  - *Publish*: Broker handles encryption
- **Goal**: Enhance MQTT security.
- **Note**: Encryption standards are not yet fixed.

CoAP (Constrained Application Protocol)

- **Purpose**: Lightweight web protocol for constrained devices and networks.
- **Communication Model**: Request-response over **UDP**.
- **RESTful Design**: Supports HTTP-like methods (GET, PUT, POST, DELETE).
- **Structure**:
  - *Messaging Layer*: Handles reliability
  - *Request/Response Layer*: Handles communication
- **Messaging Types**:
  - *Confirmable (CON)*: Reliable
  - *Non-confirmable (NON)*: Unreliable
  - *Piggyback*: Response in ACK
  - *Separate*: Response sent later

- **Features**: Minimal overhead, discovery, simple caching, subscription mechanism.
- **Applications**: Smart energy, building automation, IoT.

XMPP (Extensible Messaging and Presence Protocol)

- **Type**: XML-based messaging protocol for real-time structured data exchange.
- **Standard**: Open and extensible.
- **Architecture**: Client-server; can be decentralized.
- **Key Features**:
  - Service discovery
  - Real-time messaging
  - Peer-to-peer capabilities
- **Technologies**:
  - *Jingle*: Multimedia signaling
  - *PubSub*: Event updates
  - *BOSH*: HTTP binding
- **Weaknesses**: No QoS, base64 encoding needed for binary, text-based overhead.
- **Use Cases**: VoIP, file sharing, gaming, smart grid, social networking.

AMQP (Advanced Message Queuing Protocol)

- **Definition**: Binary protocol for business message exchange (ISO/IEC 19464).
- **Purpose**: Secure, reliable, and interoperable messaging.
- **Core Components**:
  - *Exchange*: Routes messages
  - *Queue*: Message storage
  - *Bindings*: Routing rules
- **Exchange Types**: Direct, Fan-out, Topic, Header.

- **Message Delivery Guarantees**:
  - At-most-once
  - At-least-once
  - Exactly-once
- **Frame Types**: 9 control frames including Open, Attach, Transfer, Close, etc.
- **Applications**: Task delegation, offline communication, monitoring, distributed systems.

IEEE 802.15.4

- **Definition**: Standard for low-rate WPANs.
- **Layers**: PHY + MAC + (LLC & SSCS for upper layer interaction).
- **Frequency**: ISM band.
- **Modulation**:
  - *BPSK*: Low data rate
  - *O-QPSK*: High data rate
- **Channel Access**: CSMA/CA.
- **Power Efficiency**: Very low power, suitable for battery operation.
- **Range**: 10m–75m (up to 1000m LOS).
- **Topologies**: Star, Mesh.
- **Network Types**:
  - *Beacon-enabled*: Uses superframe and beacon sync
  - *Non-beacon-enabled*: Slotted CSMA/CA
- **Device Types**:
  - *FFD*: Full Function Device
  - *RFD*: Reduced Function Device
- **Frame Types**: Beacon, Data, MAC command, Acknowledgment.

Zigbee

- **Built On**: IEEE 802.15.4 (adds network and application layers).
- **Focus**: Mesh networking for WPANs.
- **Security**: Provides authentication and encryption.
- **Topologies**: Star, Tree, Mesh.
- **Device Roles**:
  - *ZigBee Coordinator (ZC)*: Forms and manages network
  - *ZigBee Router (ZR)*: Forwards data, runs applications
  - *ZigBee End Device (ZED)*: Minimal function, low power
- **Routing Protocol**: AODV-based for dynamic path discovery.
- **Applications**: Home automation, energy monitoring, lighting control, healthcare, telecom.

Let me know if you'd like this turned into a printable or presentation format!