

Internet of Things (IoT)

Internet of Things (IoT) – Structured Study Notes

1. Definition & Core Idea

- **Internet of Things (IoT)** – Network of physical objects (“things”) embedded with sensors, actuators, software, and connectivity that enable them to collect and exchange data over the internet.
 - Goal: Turn everyday objects into *smart* devices that can sense, communicate, and act autonomously or with minimal human intervention.
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2. Key Components

Component	Function	Typical Technologies
Sensors & Actuators	Capture environmental data (temperature, motion, humidity, etc.) and perform actions (open valve, switch light).	MEMS sensors, LIDAR, cameras, piezoelectric actuators
Connectivity	Transmit data to/from devices and cloud/edge platforms.	Wi-Fi, Bluetooth LE, Zigbee, Thread, LoRaWAN, NB-IoT, 5G, Ethernet
Edge/Fog Computing	Process data locally to reduce latency, bandwidth, and privacy risks.	Microcontrollers (ESP32, STM32), Edge gateways, NVIDIA Jetson, AWS Greengrass
Cloud/Backend Services	Store, analyze, and orchestrate data; provide APIs and dashboards.	AWS IoT Core, Azure IoT Hub, Google Cloud IoT, IBM Watson IoT
Data Analytics & AI	Derive insights, detect anomalies, predict outcomes.	Time-series databases, Machine Learning models, Stream processing (Kafka, Flink)
User Interfaces	Allow humans to monitor and control IoT assets.	Mobile apps, web dashboards, voice assistants, AR/VR overlays

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Component	Function	Typical Technologies
Security & Management	Authentication, encryption, device provisioning, OTA updates.	TLS/DTLS, X.509 certificates, TPM, LwM2M, OMA SpecWorks, PKI

3. Architecture Layers

Application & Business Layer
- User dashboards, mobile apps, business logic, billing
Cloud & Data Services Layer
- Data ingestion, storage, analytics, AI, APIs
Edge/Fog Computing Layer
- Real-time processing, protocol translation, caching
Connectivity & Network Layer
- Wi-Fi, Cellular, LPWAN, Mesh, Ethernet
Device (Perception) Layer
- Sensors, actuators, microcontrollers, firmware

4. Communication Protocols (Commonly Used)

Protocol	Type	Typical Use Cases	Pros	Cons
MQTT	Publish/Subscribe	Low-bandwidth telemetry	Small footprint, QoS levels	No built-in security (needs TLS)
CoAP	Request/Response (REST-like)	Constrained devices	UDP-based, low overhead	Limited payload size
HTTP/HTTPS	Request/Response	Firmware updates, web integration	Widely supported	Higher overhead

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Protocol	Type	Typical Use Cases	Pros	Cons
AMQP	Message queue	Enterprise integration	Reliable delivery, routing	Heavier than MQTT
LWM2M	Device management	Remote provisioning, monitoring	Built-in security, OTA	More complex client implementation
BLE (GATT)	Short-range	Wearables, proximity sensors	Low power	Limited range
LoRaWAN	LPWAN	Rural/industrial monitoring	Long range, low power	Low data rate
