**IoT Nodes**

**1. What capabilities does an IoT node need?**

* **Sensing/Actuating:** Measures environmental data (temperature, humidity, motion) or performs actions (turning devices on/off).
* **Processing:** Basic data computation (microcontrollers, SoCs).
* **Communication:** Network connectivity (Wi-Fi, Bluetooth, LoRa, NB-IoT, etc.).
* **Power Management:** Energy efficiency (battery, solar, energy harvesting).
* **Security:** Data protection (encryption, authentication).

**2. What hardware components does an IoT node need?**

* **Sensors/Actuators:** Collect data or interact with the environment.
* **Microcontroller (MCU):** Processes data (e.g., ESP32, Arduino, Raspberry Pi Pico).
* **Communication Module:** Wi-Fi, BLE, Zigbee, LoRa, or Cellular (4G/5G).
* **Power Source:** Battery, solar panel, or wired connection.
* **Memory:** Temporary data storage (RAM/Flash).

**3. Identify some commercially available IoT nodes.**

* **Raspberry Pi (Compute Module 4):** For complex IoT applications.
* **ESP32/ESP8266:** Low-cost, supports Wi-Fi/BLE.
* **Arduino MKR Series:** Supports LoRa, NB-IoT.
* **STM32 B-L4S5I-IOT01A:** Multi-protocol IoT development board.
* **Commercial IoT Devices:** Xiaomi Mi Temperature Sensor, Philips Hue Smart Lights.

**Communications**

**1. What do we need to consider in IoT communications?**

* **Range:** Short-range (Bluetooth) vs. long-range (LoRa, Cellular).
* **Power Consumption:** Battery-powered devices need low-power protocols (NB-IoT, Zigbee).
* **Bandwidth:** Small data (sensors) vs. large data (video streaming).
* **Latency:** Real-time applications (industrial IoT) require low latency.
* **Security:** Encryption to prevent cyberattacks.

**2. What IoT communication technologies exist?**

* **Short-range:**
  + **Wi-Fi** (ESP32 for high-speed data).
  + **Bluetooth/BLE** (wearables, beacons).
  + **Zigbee** (smart home devices like Philips Hue).
* **Long-range (LPWAN):**
  + **LoRa** (agriculture, smart cities).
  + **NB-IoT** (low-power, wide-area coverage).
  + **LTE-M** (4G/5G for mobile IoT).

**3. Identify IoT nodes with different communication technologies.**

* **LoRa:** **Dragino LoRa Node** (environmental monitoring).
* **NB-IoT:** **Quectel BC66** (smart city devices).
* **Zigbee:** **Xiaomi Aqara Sensors** (home automation).
* **Wi-Fi/BLE:** **ESP32 DevKit** (prototyping).

**Cloud Computing for IoT**

**1. How does Cloud computing support IoT?**

* **Data Storage & Processing:** Handles massive IoT data (Big Data).
* **Scalability:** Expands as more devices connect.
* **Real-time Analytics:** Processes live data (e.g., predictive maintenance).
* **AI/ML Integration:** Enables smart analytics (e.g., image recognition from IoT cameras).
* **Remote Management:** Controls devices via cloud platforms (AWS IoT Core, Azure IoT Hub).

**2. Key differences between public, private, and hybrid cloud**

|  |  |  |  |
| --- | --- | --- | --- |
| Cloud Type | Definition | Pros | Cons |
| Public | Shared cloud services (AWS, Azure, Google Cloud). | Low cost, easy scheduling. | Less customization, security concerns. |
| Private | Dedicated cloud for one organization (on-premise/hosted). | High security, customizable. | Expensive, requires maintenance. |
| Hybrid | Combines public + private clouds | Flexible, balanced cost/security | Complex integration |