Internet of Things - Overview

- Objective: Understand the Internet of Things (IoT), its architecture, protocols, proposed solutions, enabling factors, weaknesses, and risks.
  目标：了解物联网（IoT）的架构、协议、提议的解决方案、启用因素、弱点和风险。

IoT Introduction:

- Definition: IoT is a paradigm involving the pervasive presence of objects with unique addressing schemes, capable of interacting to reach common goals.
  定义:物联网是涉及具有唯一寻址方案的对象无处不在存在的范式，能够相互作用以达到共同目标。
- Impact 影响：
  - Private Users: Domotics, assisted living, e-health, enhanced learning.
    私人用户：家庭自动化、辅助生活、电子健康、增强学习。
  - Business Users: Automation, industrial manufacturing, logistics, business/process management, intelligent transportation.
    商业用户：自动化、工业制造、物流、业务/流程管理、智能交通。
  - US National Intelligence Council: IoT listed as a disruptive civil technology.
    美国国家情报委员会：物联网被列为破坏性民用技术。
- Challenges: Interoperability, smartness, trust, privacy, security, resource efficiency, and scalability.
  挑战：互操作性、智能化、信任、隐私、安全、资源效率和可扩展性。
- Market Facts 市场事实：
  - Western Europe IoT market expected to grow from $507.7 billion (2013) to $2.1 trillion.
    西欧物联网市场预计从 2013 年的 5077 亿美元增长到 2020 年的 2.1 万亿美元。
  - Installed base to grow from 2.4 billion units (2013) to 8.3 billion units (2020).
    安装基数预计从 2013 年的 24 亿单位增长到 2020 年的 83 亿单位。
  - Security spending to account for 6% of total IoT spending by 2020.
    到 2020 年，安全支出将占物联网总支出的 6%。

IoT Perspectives:愿景

- Thing-Oriented Definition: World-wide network of uniquely addressable interconnected objects based on standard communication protocols.
  面向物的定义：基于标准通信协议的全球唯一可寻址互连对象网络。
  - Key Issues: Unique addressing, representation, and storage of exchanged information.
    关键问题：唯一地址、信息表示和交换信息的存储。
  - Origin: Term attributed to Auto-ID Labs.
    起源：术语归因于 Auto-ID 实验室。
- Internet-Oriented Definition: Connectivity for anything, as described by ITU and European Commission. 面向互联网的定义：ITU 和欧盟委员会描述的万物互联。
  - ITU Vision: Connectivity for anything.
    ITU 愿景：万物互联。
  - European Commission Vision: Things with identities and virtual personalities operating in smart spaces.
    欧盟委员会愿景：具有身份和虚拟个性，在智能空间中运行的物体。
- Semantic-Oriented Definition: Focuses on representing, storing, interconnecting, searching, and organizing information generated by IoT.
  面向语义的定义：专注于表示、存储、互联、搜索和组织物联网生成的信息。
  - Key Role of Semantic Technologies: Things description, reasoning over data, execution environments, and scalable infrastructure.
    语义技术的关键作用：事物描述、数据推理、执行环境和可扩展基础设施。

IoT Enabling Technologies:物联网的启用技术

- Core Technologies: Identification, sensing, and communication. 核心技术：识别、传感和通信。
- Sensor Networks 传感器网络：
  - Role: Bridging physical and digital worlds.
    角色：连接物理世界和数字世界。
  - Components: Sensing nodes, wireless multi-hop communication, reporting to special nodes.
    组件：传感节点、无线多跳通信、报告到特殊节点。
- SCADA Enhancements. SCADA 增强：
  - Current Issues: Single protocol limits new technologies, not easily connected to web-based applications, multiple custom connections needed for multiple applications. 当前问题：单一协议限制新技术，不易连接到基于网络的应用程序，多应用程序需要多个自定义连接。
- Network Topologies: Star, tree, mesh networks. 网络拓扑：星型、树型、网状网络。
  - Design Objectives: Energy efficiency, scalability, reliability, robustness, flexibility.
    设计目标：能效、可扩展性、可靠性、鲁棒性、灵活性。

IEEE 802.15.4 Standard:

- Framework: Defines physical and MAC layers for low-power, low-bit-rate communications in WPAN.
  框架：定义 WPAN 中低功耗、低比特率通信的物理层和 MAC 层。
  - Communication Range: 10 meters, transfer rate of 250 kbit/s.
    通信范围：10 米，传输速率为 250 kbit/s。
  - Features: Real-time suitability, CSMA/CA protocol, secure communications, power management.
    特性：实时适用性、CSMA/CA 协议、安全通信、功率管理。
  - Frequency Bands: 868.0-868.6 MHz (Europe), 902-928 MHz (North America), 2400-2483.5 MHz (worldwide).
    频段：868.0-868.6 MHz（欧洲）、902-928 MHz（北美）、2400-2483.5 MHz（全球）。

IoT Architecture:物联网架构：

- Infrastructure Overview: Central network server linking radio gateways to application routers.
  基础设施概述：将无线网关链接到应用路由器的中央网络服务器。
  - Functions and Characteristics: Secure bidirectional, low-data-rate connections.
    功能和特性：安全的双向、低数据速率连接。
- Cloud Deployment: Increasingly common for IoT applications due to cost and speed of deployment.
  云部署：由于成本和部署速度，物联网应用越来越常见。

Raspberry Pi and Node-RED:

- Raspberry Pi:
  - Small single-board computers. 小型单板计算机。
  - Supports various OS (Raspbian, Ubuntu, Windows 10 IoT Core). 支持多种操作系统。
  - Promotes Python and Scratch for programming. 推广 Python 和 Scratch 进行编程。
- Node-RED:
  - Tool for wiring hardware devices, APIs, and online services.
    用于连接硬件设备、API 和在线服务的工具。
  - Developed by IBM, browser-based editor, flow-based programming model.
    由 IBM 开发，基于浏览器的编辑器，基于流程的编程模型。
  - Key for typical IoT applications (event-driven).
    典型物联网应用的关键（事件驱动）。

Practical Application Example:实用应用示例：

- Objective: Create an application reporting the CPU temperature of the Raspberry Pi to the IoT platform.目标：创建报告树莓派 CPU 温度到物联网平台的应用程序。

- Steps:
    1. Setup and programming of IoT hardware. 设置和编程物联网硬件。
    2. Measure and manipulate physical computing (sensors and actuators).测量和操作物理计算。
    3. Connect the device to the Internet. 将设备连接到互联网。
    4. Mash-up with web-enabled devices. 与支持网络的设备混合。

Detailed Summary of IoT Training Sessions (1, 2, 3)

IoT Training Session #1

- Fundamentals: 基础：
    - Standards, networks, and protocols essential for IoT. 物联网必需的标准、网络和协议。
        - Standards: IEEE 802.15.4, LoRaWAN, Sigfox, LTE-M, NB-IoT.
        - Networks: WPAN, LPWAN, Cellular, Wi-Fi, Bluetooth.
        - Protocols: MQTT, CoAP, LWM2M.
    - B2C Market: Success stories in micromobility, smart home, and assistance for seniors.
      B2C 市场：微型交通、智能家居和老年人援助的成功案例。
    - Home Automation: Security (intelligent door locks), alarm systems, water breakers, and partnerships for smart home devices.
      家庭自动化：安全（智能门锁）、报警系统、水断路器和智能家居设备的合作伙伴关系。
- RF Standards:射频标准：
    - Technologies like Thread, CHIP (Matter), and convergence via gateways.
      Thread、CHIP（Matter）等技术以及通过网关的融合。
        - Thread: Low-power mesh networking protocol. 低功耗网状网络协议。
        - CHIP (Matter): Unified protocol for smart home devices.统一的智能家居设备协议。
        - Convergence via Gateways: Centralized control integrating various protocols.
          通过网关的融合：集成各种协议的集中控制。
    - Certification importance in IoT deployments. 物联网部署中的认证重要性。
        - Ensures Compliance: Adheres to regulatory standards. 确保合规：遵守监管标准。
        - Enhances Security: Validates security features. 增强安全性：验证安全功能。
        - Boosts Consumer Trust: Certification increases user confidence.
          提升消费者信任：认证增加用户信心。
- B2B Context:B2B 背景：
    - Ideal connected devices described by Rolls-Royce CTO.劳莱 CTO 描述的理想连接设备。
        - Characteristics: Reliable, secure, scalable, and interoperable.
          特点：可靠、安全、可扩展、可互操作。
    - IoT's role in business transformation, enhanced productivity, predictive maintenance, and improved logistics.物联网在业务转型、提高生产力、预测性维护和改善物流中的作用。
        - Business Transformation: IoT enables new business models and services.
          业务转型：物联网推动新的商业模式和服务。
        - Enhanced Productivity: Automation and real-time data increase efficiency.
          提高生产力：自动化和实时数据提高效率。
        - Predictive Maintenance: Reduces downtime and maintenance costs.
          预测性维护：减少停机时间和维护成本。
        - Improved Logistics: Real-time tracking and inventory management.
          改善物流：实时跟踪和库存管理。
- IoT Devices:物联网设备：
    - Components of IoT devices including RF, microcontrollers, sensors, and actuators.
      物联网设备的组件，包括射频、微控制器、传感器和执行器。
        - RF (Radio Frequency): Enables wireless communication. 射频：实现无线通信。

        - Microcontrollers: Control device operations. 微控制器：控制设备操作。
        - Sensors: Collect environmental data.传感器：收集环境数据。
        - Actuators: Perform actions based on data.执行器：根据数据执行操作。
    - IoT value chain from connected devices to business applications.
      从连接设备到商业应用的物联网价值链。
        - Data Collection: Sensors gather data. 数据收集：传感器收集数据。
        - Data Transmission: RF modules send data to cloud. 传输：射频模块发送数据只云端
        - Data Processing: Cloud services analyze data. 数据处理：云服务分析数据。
        - Business Applications: Insights drive decision-making. 商业应用：洞察力驱动决策。
- Smart City Applications:智慧城市应用：
    - Use cases in street lighting, smart parking, motorway area management, and crane care.
      街道照明、智能停车、高速公路区域管理和起重机护理的用例。
    - Smart metering in utilities like gas, water, and electricity.
      公用事业（如燃气、水和电）的智能计量。
- IoT Networks:物联网网络：
    - Focus on LoRaWAN: Architecture, classes (A, B, C), adaptive data rate, geolocation, security, and provisioning.架构、类别、自适应数据速率、地理定位、安全性和配置。
        - Architecture: Central server and radio gateways. 架构：中央服务器和无线网关。
        - Classes: A (lowest power), B (synchronized 同步), C (continuous listening).
        - Adaptive Data Rate: Optimizes power and performance.
          自适应数据速率：优化功率和性能。
        - Geolocation: Tracks device location. 地理定位：跟踪设备位置。
        - Security: End-to-end encryption and secure provisioning.
          安全性：端到端加密和安全配置。
    - Comparison with Sigfox. 与 Sigfox 的比较。
        - LoRaWAN: Open standard, more flexible. 开放标准，更灵活。
        - Sigfox: Proprietary, simpler implementation.专有，实施更简单。
- 5G in IoT:物联网中的 5G：
    - Essentials of 5G including enhanced mobile broadband, ultra-reliable low-latency communications, and massive machine-type communications.
      5G 的基本要素：包括增强移动宽带、超可靠低延迟通信和大规模机器类通信。
    - Deployment options, frequency bands, virtualization, and slicing.
      部署选项、频段、虚拟化和切片。
        - Deployment Options: Standalone, non-standalone, hybrid.
          部署选项：独立、非独立、混合。
        - Frequency Bands: Sub-6 GHz and mmWave. 频段：Sub-6 GHz 和毫米波。
        - Virtualization: Network functions as software. 虚拟化：网络功能作为软件。
        - Slicing: Creates virtual networks for specific use cases.切片:为特定用例创建虚拟网络
- Security:安全性：
    - IoT vulnerabilities and best practices for securing IoT ecosystems.
      物联网漏洞和保护物联网生态系统的最佳实践。
        - Vulnerabilities: Weak passwords, outdated software, unencrypted data.
          漏洞：弱密码、过时软件、未加密数据。
        - Best Practices: Regular updates, strong authentication, encryption.
          最佳实践：定期更新、强认证、加密。
    - Notable IoT botnets and security threats along the value chain.
      值得注意的物联网僵尸网络和价值链中的安全威胁。

        - Botnets: Mirai, Mozi.僵尸网络：Mirai，Mozi。
        - Threats: DDoS attacks, data breaches. 威胁：DDoS 攻击、数据泄露。
    - End-to-end security, zero trust approach, and industry alliances for IoT security.
        - End-to-End Security: Protects data from device to cloud.
          端到端安全：保护从设备到云的数据。
        - Zero Trust: Assumes no device or user is trustworthy by default.
          零信任：假设默认情况下没有设备或用户是可信的。
        - Industry Alliances: Promote standards and best practices.
          行业联盟：推广标准和最佳实践。
- Use Cases:用例：
    - Selecting ideal connectivity types for various scenarios like transportation, supply chain, personal safety, and smart metering.
        - Transportation: LTE-M for vehicle tracking. 运输：LTE-M 用于车辆跟踪。
        - Supply Chain: LoRaWAN for inventory management.供应链：LoRaWAN 库存管理。
        - Personal Safety: BLE for wearable devices. 个人安全：BLE 用于可穿戴设备。
        - Smart Metering: NB-IoT for utility monitoring. 智能计量：NB-IoT 用于公用事业监控。

IoT Training Session #2

- Asset Tracking:资产追踪：
    - Technologies for indoor and outdoor tracking including UWB, RFID, BLE, and LPWAN.
      室内和室外跟踪技术，包括 UWB、RFID、BLE 和 LPWAN。
        - UWB: High precision indoor positioning. 高精度室内定位。
        - RFID: Inventory and asset management. 库存和资产管理。
        - BLE: Proximity-based tracking. 基于接近的跟踪。
        - LPWAN: Long-range, low-power tracking. 长距离、低功耗跟踪。
    - Cost and energy savings considerations. 成本和节能考虑。
        - Cost: Economical solutions for large-scale deployment.
          成本：大规模部署的经济解决方案。
        - Energy Savings: Low power consumption for extended battery life.
          节能：低功耗以延长电池寿命。
- LoRaWAN and Sigfox Comparison: LoRaWAN 和 Sigfox 的比较：
    - LoRaWAN: Flexible architecture, geolocation, adaptive data rate, strong security.
      灵活的架构，地理定位，自适应数据速率，强大的安全性。
    - Sigfox: Simple architecture, limited geolocation, fixed data rate, basic security.
    - 简单的架构，有限的地理定位，固定的数据速率，基本的安全性。
- LTE-M and NB-IoT Essentials: LTE-M 和 NB-IoT 的基本要素：
    - Cellular IoT advancements for machine-to-machine communication.
        - LTE-M: Supports higher bandwidth, mobility, and voice.支持更高带宽、移动性和语音
        - NB-IoT: Optimized for low power, deep indoor coverage.
          优化用于低功耗、深度室内覆盖。
    - Benefits like deep-indoor coverage, energy savings, and advanced modulation technologies.
      深度室内覆盖、节能和先进调制技术等优点。
        - Deep Indoor Coverage: Improved signal penetration.深度室内覆盖:提高信号穿透力。
        - Energy Savings: Extended battery life.节能：延长电池寿命。
        - Advanced Modulation: Enhanced data transmission.先进调制：增强数据传输。
- Protocols: 协议：
    - MQTT: Publish-subscribe protocol for one-to-many communication. Lightweight, efficient, ideal for IoT. 用于一对多通信的发布-订阅协议。轻量级、高效，适合物联网。

- CoAP: Client-server protocol for constrained environments. Designed for low-power, low-bandwidth devices. 用于受限环境的客户端-服务器协议。为低功耗、低带宽设备设计。
- LWM2M: Application layer protocol for IoT device management. Simplifies device management and monitoring.用于物联网设备管理的应用层协议。简化设备管理和监控。

- Embedded Hardware: 嵌入式硬件：
  - Anatomy of IoT embedded hardware, including sensors and actuators. 物联网嵌入式硬件的结构，包括传感器和执行器。
  - Design considerations for protection, explosion-proof marking (ATEX), and enclosure design. 保护、防爆标记（ATEX）和外壳设计的设计考虑。
- Sensors and Actuators: 传感器和执行器：
  - Types of sensors (temperature, humidity, pressure, proximity, level, acceleration, gas & particles, light). 传感器类型（温度、湿度、压力、接近、液位、加速度、气体和颗粒、光）
  - Actuators (relays, control valves, motors, vibration motors). 执行器（继电器、控制阀、马达、振动马达）。
- AI and IoT: 人工智能和物联网：
  - Integration of AI with IoT (AIoT).人工智能与物联网的集成（AIoT）。
    - Integration: Combines the data collection and connectivity of IoT with the decision-making capabilities of AI.集成：将物联网的数据收集和连接功能与人工智能的决策能力相结合。
    - Benefits: Enhances automation, predictive maintenance, real-time analytics, and smart decision-making.好处：增强自动化、预测性维护、实时分析和智能决策。
  - Machine learning types (supervised, unsupervised, reinforcement learning).机器学习类型。
    - Supervised Learning: Uses labeled data to train models for tasks like classification and regression. 监督学习：使用标记数据训练模型，用于分类和回归等任务。
    - Unsupervised Learning: Analyzes unlabeled data to find hidden patterns or intrinsic structures, such as clustering. 无监督学习：分析未标记的数据以发现隐藏的模式或内在结构，如聚类。
    - Reinforcement Learning: Trains models based on rewards and punishments from interacting with an environment, often used in robotics and gaming. 强化学习：根据与环境交互的奖励和惩罚训练模型，通常用于机器人和游戏。
  - Neural networks and their applications. 神经网络及其应用。
    - Neural Networks: Composed of interconnected nodes (neurons), mimicking the human brain's structure. 神经网络：由互连节点（神经元）组成，模仿人类大脑的结构。
    - Applications: Image and speech recognition, natural language processing, autonomous driving, and predictive analytics. 应用：图像和语音识别、自然语言处理、自动驾驶和预测分析。
- Distributed Ledgers and Blockchain: 分布式账本和区块链：
  - Blockchain Technology: A decentralized ledger that records transactions across multiple computers securely.区块链技术：一种去中心化账本，安全地记录跨多个计算机的交易。
    - Applications in IoT: Ensures secure and tamper-proof data transactions, enhances trust between devices, and improves data integrity. 在物联网中的应用：确保数据交易的安全和防篡改，增强设备之间的信任，改善数据完整性。
  - Smart Contracts: Self-executing contracts with the terms of the agreement directly written into code. 智能合约：自执行合约，协议条款直接写入代码中。

        - Benefits: Automates and enforces contract terms, reduces the need for intermediaries, and increases transaction efficiency. 好处：自动化和执行合同条款，减少中介需求，提高交易效率。

IoT Training Session #3

- Supply Chain and Asset Tracking:供应链和资产追踪：
    - Technologies used for asset tracking and their benefits in cost and energy savings.用于资产追踪的技术及其在成本和节能方面的好处。
        - Technologies: RFID, GPS, BLE, LPWAN (e.g., LoRa, Sigfox), and cellular IoT (e.g., LTE-M, NB-IoT).
        - Cost Savings: Low-cost tags and sensors, minimal infrastructure, reduced labor costs. 成本节约：低成本标签和传感器，最少的基础设施，减少劳动力成本。
        - Energy Savings: Long battery life of devices, efficient power management. 节能：设备电池寿命长，高效的电源管理。
- LoRaWAN Architecture: LoRaWAN 架构：
    - Architecture: Consists of end devices, gateways, network servers, and application servers. 架构：由终端设备、网关、网络服务器和应用服务器组成。
    - Adaptive Data Rate (ADR): Automatically adjusts data rates for optimal performance and energy efficiency.自适应数据速率 (ADR)：自动调整数据速率以实现最佳性能和能效。
    - Geolocation: Utilizes triangulation from multiple gateways for location tracking without GPS. 地理定位：利用多个网关的三角定位进行位置跟踪，无需 GPS。
    - Comparison between Sigfox and LoRaWAN. 比较 Sigfox 和 LoRaWAN。
        - Range: Both offer long-range communication, but LoRaWAN can cover longer distances in urban areas. 范围：两者都提供长距离通信，但 LoRaWAN 在城市地区覆盖更远。
        - Data Rate: LoRaWAN provides flexible data rates, while Sigfox has a fixed low data rate. 数据速率: LoRaWAN 提供灵活的数据速率，而 Sigfox 的数据速率固定且较低。
        - Network: LoRaWAN uses a decentralized network architecture; Sigfox uses a centralized one.网络: LoRaWAN 使用去中心化的网络架构；Sigfox 使用中心化架构。
        - Battery Life: Both technologies support long battery life, but LoRaWAN's ADR can optimize power consumption further.电池寿命：两种技术都支持长电池寿命，但 LoRaWAN 的 ADR 可以进一步优化功耗。
- LTE-M and NB-IoT:
    - Essentials and benefits of these cellular IoT standards.基本要素和优点。
        - LTE-M: Supports higher data rates, mobility, and voice services. Suitable for applications requiring frequent data transmission. 支持更高的数据速率、移动性和语音服务。适用于需要频繁数据传输的应用。
        - NB-IoT: Optimized for low power consumption, extended coverage, and deep indoor penetration. Suitable for infrequent data transmission and long battery life. 优化功耗低、覆盖范围广、深度室内穿透。适用于数据传输频率低、电池寿命长的应用。
    - Differences in coverage, energy savings, and modulation technologies. 覆盖范围、节能和调制技术的差异。
        - Coverage: NB-IoT offers better coverage and deeper penetration compared to LTE-M. 覆盖范围: NB-IoT 提供比 LTE-M 更好的覆盖和更深的穿透。
        - Energy Savings: NB-IoT is designed for ultra-low power consumption, making it more energy-efficient. 节能: NB-IoT 设计用于超低功耗，使其更加节能。

        - Modulation Technologies: LTE-M uses OFDMA and SC-FDMA, while NB-IoT uses single carrier FDMA and QPSK modulation.调制技术: LTE-M 使用 OFDMA 和 SC-FDMA，而 NB-IoT 使用单载波 FDMA 和 QPSK 调制。
- IoT Protocols: 物联网协议：
    - MQTT: Lightweight, publish-subscribe protocol for low-bandwidth, high-latency networks. Suitable for constrained devices. 轻量级的发布-订阅协议，适用于低带宽、高延迟网络。适用于受限设备。
    - CoAP: Constrained Application Protocol, designed for machine-to-machine communication with low overhead and simple implementation. 受限应用协议，设计用于机器对机器通信，具有低开销和简单实现的特点。
    - LWM2M: Lightweight M2M protocol for device management, provides efficient communication and resource management. 轻量级 M2M 协议，用于设备管理，提供高效的通信和资源管理。
- Embedded Devices: 嵌入式设备：
    - Focus on hardware design, protection indexes, and enclosure design.
      关注硬件设计、保护指数和外壳设计。
        - Hardware Design: Emphasis on low power consumption, reliability, and integration of sensors and communication modules.
          硬件设计：强调低功耗、可靠性和传感器及通信模块的集成。
        - Protection Indexes: Ensure devices meet IP (Ingress Protection) ratings for dust and water resistance. 保护指数：确保设备符合防尘防水的 IP（入口保护）等级。
        - Enclosure Design: Design enclosures to protect against environmental factors, mechanical damage, and ensure heat dissipation.
          外壳设计：设计外壳以防护环境因素、机械损坏并确保散热。
    - Specifics on sensors and actuators used in IoT applications.
      物联网应用中使用的传感器和执行器的细节。
        - Sensors: Include temperature, humidity, pressure, motion, light, gas, and proximity sensors. Used for monitoring and data collection. 传感器：包括温度、湿度、压力、运动、光线、气体和接近传感器。用于监测和数据采集。
        - Actuators: Include relays, valves, motors, and servos. Used for controlling physical systems based on sensor inputs. 执行器：包括继电器、阀门、电机和伺服电机。用于根据传感器输入控制物理系统。
- IoT Platforms: 物联网平台：
    - Detailed look at platforms from IBM, Microsoft, Bosch, and Siemens.
      详细了解来自 IBM、Microsoft、Bosch 和 Siemens 的平台。
        - IBM Watson IoT: Provides powerful analytics and device management capabilities, integrated through the Bluemix platform, supporting complex IoT applications.
          IBM Watson IoT：提供强大的分析和设备管理功能，通过 Bluemix 平台集成，支持复杂的物联网应用。
        - Microsoft Azure IoT: Offers end-to-end IoT solutions, including device management, data processing, analytics, and prediction capabilities.
          Microsoft Azure IoT：提供端到端的物联网解决方案，包括设备管理、数据处理、分析和预测功能。
        - Bosch IoT Suite: Focuses on device connectivity and data management, providing a flexible development and deployment environment.
          Bosch IoT Suite：专注于连接设备和数据管理，提供灵活的开发和部署环境。

        - Siemens MindSphere: An industrial IoT platform offering data analytics and predictive maintenance, supporting large-scale industrial applications.
          Siemens MindSphere: 工业物联网平台，提供数据分析和预测性维护，支持大规模工业应用。
    - How these platforms integrate and support IoT applications.
      这些平台如何集成和支持物联网应用。
        - Integration Support: These platforms integrate various devices and sensors through APIs and standard protocols, supporting real-time data transmission and processing.
          集成支持：这些平台通过 API 和标准协议集成各种设备和传感器，支持实时数据传输和处理。
        - Application Support: Provides functionalities such as data analytics, predictive maintenance, remote monitoring, and control, supporting a wide range of industry applications like smart manufacturing, smart cities, and smart homes.
          应用支持：提供数据分析、预测性维护、远程监控和控制等功能，支持广泛的行业应用，如智能制造、智慧城市和智慧家居。
- AI and IoT Integration: 人工智能和物联网集成：
    - Application of AI in IoT (AIoT) for enhanced capabilities.
      人工智能在物联网中的应用（AIoT），以增强功能。
        - Enhanced Capabilities: AI integration enables IoT devices to perform automated decision-making, predictive maintenance, fault detection, and optimize operations.
          通过集成 AI，物联网设备可以实现自动化决策、预测性维护、故障检测和优化运营。
        - Application Scenarios: Includes voice recognition in smart homes, machine fault prediction in industry, and smart scheduling in transportation.
          包括智能家居中的语音识别、工业中的机器故障预测、交通中的智能调度等。
    - Machine Learning Techniques: Includes supervised learning, unsupervised learning, and reinforcement learning, applied in data classification, regression analysis, and pattern recognition.包括监督学习、无监督学习和强化学习，应用于数据分类、回归分析和模式识别。
    - Neural Networks: Includes multilayer perceptrons, convolutional neural networks (CNN), recurrent neural networks (RNN), used for image recognition, speech processing, and time series prediction. 包括多层感知器、卷积神经网络（CNN）、循环神经网络（RNN）等，用于图像识别、语音处理和时间序列预测。
- Security in IoT: 物联网中的安全性：
    - Addressing Vulnerabilities: Implement strong authentication, data encryption, regular firmware and software updates, secure coding practices.
      解决漏洞：采用强身份验证、数据加密、定期更新固件和软件、安全编码实践。
    - Best Practices: Implement network segmentation, use firewalls and intrusion detection systems, conduct security audits and penetration testing.
      最佳实践：实施网络分段、使用防火墙和入侵检测系统、进行安全审计和渗透测试。
    - End-to-End Security: Ensures security across the entire data transmission chain from device to cloud, including data encryption, authentication, and access control.
      端到端安全：确保从设备到云端的整个数据传输链路的安全，包括数据加密、身份验证和访问控制。
    - Industry Guidelines: Follow industry standards and guidelines (e.g., ISO 27001, NIST) to ensure compliance and the application of best practices.
      行业指南：遵循行业标准和指南（如 ISO 27001、NIST），确保合规性和最佳实践的应用。

Internet of Things: Low Power Wide Area Networks (LPWAN)

- IoT Wide Area Networks 物联网广域网络
  - Use Cases:用例：
    - Examples include smart cities, logistics, and critical applications like metering and monitoring. 示例包括智慧城市、物流和计量与监控等关键应用。
  - Market Opportunity:市场机会：
    - IoT traffic growth and market potential are highlighted.
      强调了物联网流量增长和市场潜力。
  - Technologies:技术：
    - Legacy Cellular Networks: Provide global coverage, medium to high throughput, high mobility, and low latency, but have shorter battery life and higher costs.
      传统蜂窝网络：提供全球覆盖、中到高吞吐量、高移动性和低延迟，但电池寿命较短且成本较高。
    - Licensed LPWA (e.g., LTE-M, NB-IoT): Offer long battery life, low cost, medium range and throughput, good coverage, and are suitable for critical applications.
      许可 LPWA（如 LTE-M、NB-IoT）：提供长电池寿命、低成本、中等范围和吞吐量、良好的覆盖范围，适用于关键应用。
    - Unlicensed LPWA (e.g., LoRa, Sigfox): Provide long range, low power consumption, low cost, but have lower throughput and are not suitable for real-time applications.
      未许可 LPWA（如 LoRa、Sigfox）：提供长距离、低功耗、低成本，但吞吐量较低，不适合实时应用。
    - Satellite: Offers very high range and coverage, suitable for remote areas, but has high costs, high latency, and shorter battery life.卫星：提供非常高的范围和覆盖，适合偏远地区，但成本高、延迟高且电池寿命较短。
    - Range: Satellite > Unlicensed LPWA > Licensed LPWA > Legacy Cellular.
      范围：卫星 > 未许可 LPWA > 许可 LPWA > 传统蜂窝。
    - Throughput: Legacy Cellular > Licensed LPWA > Unlicensed LPWA > Satellite.
      吞吐量：传统蜂窝 > 许可 LPWA > 未许可 LPWA > 卫星。
    - Mobility: Legacy Cellular > Licensed LPWA > Satellite > Unlicensed LPWA.
      移动性：传统蜂窝 > 许可 LPWA > 卫星 > 未许可 LPWA。
    - Latency: Legacy Cellular < Licensed LPWA < Unlicensed LPWA < Satellite.
      延迟：传统蜂窝 < 许可 LPWA < 未许可 LPWA < 卫星。
    - Battery Life: Unlicensed LPWA > Licensed LPWA > Legacy Cellular > Satellite.
      电池寿命：未许可 LPWA > 许可 LPWA > 传统蜂窝 > 卫星。
    - Cost: Unlicensed LPWA < Licensed LPWA < Legacy Cellular < Satellite.
      成本：未许可 LPWA < 许可 LPWA < 传统蜂窝 < 卫星。
  - Unlicensed vs Licensed LPWA Technologies:未许可 VS 许可 LPWA 技术：
    - 3GPP-Standard Basis: Licensed LPWA technologies (LTE-M, NB-IoT) follow 3GPP standards, providing better integration with existing cellular networks.许可 LPWA 技术（LTE-M、NB-IoT）遵循 3GPP 标准，与现有蜂窝网络更好集成。
    - Spectrum: Licensed LPWA uses dedicated spectrum, reducing interference, while unlicensed LPWA uses ISM bands, which can be more prone to interference.
      频谱：许可 LPWA 使用专用频谱，减少干扰，而未许可 LPWA 使用 ISM 频段，可能更容易受到干扰。
    - Network Benefits: Licensed LPWA benefits from existing cellular infrastructure, offering reliable coverage and quality of service. 网络优势：许可 LPWA 受益于现有蜂窝基础设施，提供可靠的覆盖和服务质量。

- Critical Applications: Licensed LPWA is suitable for critical and real-time applications due to lower latency and higher reliability. 关键应用：许可 LPWA 适用于关键和实时应用，因为延迟较低且可靠性较高。
- Interference Coordination: Licensed LPWA has coordinated interference management, while unlicensed LPWA may face more challenges in managing interference.干扰协调：许可 LPWA 具有协调的干扰管理，而未许可 LPWA 在管理干扰方面可能面临更多挑战。

- Licensed LPWA Technologies:许可的 LPWA 技术：
  - LTE-Cat M1: Offers higher data rates (up to 1 Mbps), mobility support, and is suitable for applications requiring frequent data transmission. 提供更高的数据速率（最高 1 Mbps），支持移动性，适用于需要频繁数据传输的应用。
  - NB-IoT: Focuses on extended coverage, deep indoor penetration, and is optimized for applications with low data rates and long battery life.侧重于扩展覆盖、深度室内穿透，优化用于低数据速率和长电池寿命的应用。
  - Reduced complexity, coverage enhancements, and lower transmit power. 降低了复杂性、增强了覆盖范围和降低了传输功率。
- Unlicensed LPWA Technologies:未许可的 LPWA 技术：
  - Sigfox: Ultra-narrowband technology, providing long range and low power consumption with limited data rate.超窄带技术,提供长距离和低功耗,但数据速率有限
  - LoRa: Uses chirp spread spectrum modulation, offering flexible data rates and long range with good penetration capabilities. 使用啁啾扩频调制，提供灵活的数据速率和长距离，具有良好的穿透能力。
  - Weightless: Open standard supporting various modulation schemes, suitable for diverse IoT applications. 支持各种调制方案的开放标准，适用于多种物联网应用。
  - IEEE 802.11ah: Sub-GHz Wi-Fi standard, providing extended range and low power for IoT. 亚 GHz Wi-Fi 标准，提供扩展范围和低功耗用于物联网。
  - Ingenu: Uses random phase multiple access (RPMA) technology, optimized for large-scale IoT networks. 使用随机相位多址（RPMA）技术,优化用于大规模物联网网络。
  - n-wave: Ultra-narrowband technology, offering long range and low power consumption.超窄带技术，提供长距离和低功耗。
  - Dash7-Alliance: Standard for wireless sensor networking, suitable for asset tracking and industrial applications.无线传感网络标准，适用于资产跟踪和工业应用。
- Comparison of Key Technologies:关键技术比较：
  - Frequency: Sigfox and LoRa use sub-GHz ISM bands; LTE-Cat M1 and NB-IoT use licensed cellular bands.频率：Sigfox 和 LoRa 使用亚 GHz ISM 频段；LTE-Cat M1 和 NB-IoT 使用许可蜂窝频段。
  - Bandwidth: Sigfox has narrow bandwidth; LoRa offers multiple bandwidth options; LTE-Cat M1 and NB-IoT have wider bandwidths. 带宽: Sigfox 带宽窄；LoRa 提供多种带宽选择；LTE-Cat M1 和 NB-IoT 带宽更宽。
  - Power: Sigfox and LoRa have low power consumption; LTE-Cat M1 and NB-IoT have moderate power consumption. 功率: Sigfox 和 LoRa 功耗低；LTE-Cat M1 和 NB-IoT 功耗适中。
  - Sensitivity: LoRa and Sigfox have high sensitivity; LTE-Cat M1 and NB-IoT have lower sensitivity compared to unlicensed LPWA. 灵敏度: LoRa 和 Sigfox 灵敏度高；LTE-Cat M1 和 NB-IoT 灵敏度较低。

        - Range: LoRa and Sigfox offer long range; LTE-Cat M1 and NB-IoT provide good range with better coverage. 范围: LoRa 和 Sigfox 提供长距离；LTE-Cat M1 和 NB-IoT 提供良好的范围和更好的覆盖。
        - Data Rates: Sigfox offers low data rates; LoRa provides flexible data rates; LTE-Cat M1 and NB-IoT support higher data rates. 数据速率: Sigfox 数据速率低；LoRa 提供灵活的数据速率；LTE-Cat M1 和 NB-IoT 支持更高的数据速率。
        - Governing Bodies: Sigfox is governed by Sigfox company; LoRa is managed by the LoRa Alliance; LTE-Cat M1 and NB-IoT are standardized by 3GPP. 管理机构: Sigfox 由 Sigfox 公司管理;LoRa 由 LoRa 联盟管理;LTE-Cat M1 和 NB-IoT 由 3GPP 标准化
- Unlicensed LPWA Technologies 未许可的 LPWA 技术
    - Main Characteristics:主要特点：
        - Low data rate, low power, and high ranges.
          低数据速率、低功耗和高范围。
        - Signal characteristics and sensitivity issues.
          信号特性和灵敏度问题。
    - Global Architecture:全球架构：
        - Network architecture for LPWAN operators like Sigfox and LoRaWAN.
          像 Sigfox 和 LoRaWAN 这样的 LPWAN 运营商的网络架构。
        - Simplified MAC layer and API interfaces. 简化的 MAC 层和 API 接口。
    - Certification and Costs:认证和成本：
        - Certification programs ensure compliance and protect customers.
          认证计划确保合规并保护客户。
        - Lower data plan costs compared to GPRS/3G.
          与 GPRS/3G 相比，数据计划成本较低。
    - Network Bi-directionality:网络双向性：
        - Uplink and downlink communication in the same ISM band.
          在同一 ISM 频段内的上行和下行通信。
        - Constraints and regulations by ETSI.
          ETSI 的限制和规定。
    - Communication Protocols:通信协议：
        - Details on Sigfox and LoRaWAN classes (A, B, C).
          关于 Sigfox 和 LoRaWAN 类别（A、B、C）的详细信息。
- Licensed LPWA Technologies 许可的 LPWA 技术
    - Standardization:标准化：
        - 3GPP and GSMA initiatives for NB-IoT.
          3GPP 和 GSMA 对 NB-IoT 的倡议。
        - Support from major operators, manufacturers, and chipset vendors.
          来自主要运营商、制造商和芯片供应商的支持。
    - Objectives:目标：
        - Improved LPWAN services in licensed cellular spectrum.
          在许可蜂窝频谱中改进 LPWAN 服务。
        - Premium services, higher bit rates, lower power, and standardized deployment.
          优质服务、更高比特率、更低功耗和标准化部署。
    - Use Cases:用例：
        - Various applications ranging from in-car infotainment to industrial monitoring and personal/pet trackers.
          各种应用范围从车载信息娱乐到工业监控和个人/宠物跟踪器。

- Benefits of 3GPP Cellular MTC: 3GPP 蜂窝 MTC 的好处：
  - Advantages like licensed spectrum, carrier-grade QoS, global ecosystem, and scalability.
    许可频谱、运营商级 QoS、全球生态系统和可扩展性等优点。
- NB-IoT Proposals: NB-IoT 建议：
  - Modes of operation, uplink and downlink modulation, and balanced bidirectional service.
    操作模式、上行和下行调制以及平衡的双向服务。

Introduction and Basics of Arduino

Overview of Arduino

- Arduino: An open-source electronic prototyping platform based on flexible, easy-to-use hardware and software. Arduino：一种基于灵活、易用的硬件和软件的开源电子原型平台。
- Microcontroller: A microprocessor with memory, RAM, and other peripherals.
  微控制器：带有内存、RAM 和其他外围设备的微处理器。

Essential Requirements 基本要求

- Hardware: Arduino UNO Starter Kit, wires, resistors, sensors, actuators.
  硬件：Arduino UNO 入门套件、电线、电阻、传感器、执行器。
- Software: C programming background, Arduino IDE. 软件：C 编程背景，Arduino IDE。

Types of Arduino Boards 板类型

- Common Boards: Arduino Mega 2560, Arduino LilyPad, Arduino Uno, DIY Arduino, Boarduino Kit.
  常见板：Arduino Mega 2560，Arduino LilyPad，Arduino Uno，DIY Arduino，Boarduino Kit。

Arduino Uno Specifications 规格

- Features: 14 Digital I/O pins, 6 Analog inputs, USB connection, Power jack, Reset button, On-board LED, SCL/SDA pins. 功能：14 个数字 I/O 引脚、6 个模拟输入、USB 连接、电源插孔、复位按钮、板载 LED、SCL/SDA 引脚。
- Microcontroller: ATmega328 with 32 KB Flash memory, 2 KB SRAM, and 1 KB EEPROM.
  微控制器：ATmega328，具有 32 KB 闪存、2 KB SRAM 和 1 KB EEPROM。

Basic Electrical Concepts 基本电气概念

- Circuits: Importance of avoiding short circuits to prevent damage and overheating.
  电路：避免短路以防止损坏和过热的重要性。
- Ohm’s Law: U=RIU = RIU=RI (Voltage = Resistance × Current).
- Tools: Multimeter for measuring current, voltage, resistance. 工具：万用表。

Common Components 常见组件

- LEDs: Light-emitting diodes.
- Resistors: Various resistance values, color codes. 电阻：各种电阻值，颜色编码。
- Switches: Control current flow. 开关：控制电流流动。
- Breadboards: Used for prototyping and connecting components.面包板:用于原型设计和连接组件。

Simulation and Development 仿真和开发

- Fritzing: An open-source tool for documenting prototypes and creating circuit layouts.
  一种用于记录原型和创建电路布局的开源工具。
- Arduino IDE: Integrated Development Environment for writing and uploading Arduino code.
  用于编写和上传 Arduino 代码的一体化开发环境。

Arduino Programming Basics 编程基础

- Structure: Programs must follow a specific structure. 结构：程序必须遵循特定的结构。
- Serial Monitor: Tool for debugging and displaying data. 串行监视器：用于调试和显示数据的工具。

Practical Application 实用应用

- Sensors and Actuators: Devices that interact with the physical world, providing input (sensors) and output (actuators).
  传感器和执行器：与物理世界互动的设备，提供输入（传感器）和输出（执行器）。

Introduction to IoT Security 物联网安全简介

Overview of IoT Security 物联网安全概述

- Importance: Ensuring the safety of interconnected devices is crucial due to the potential for widespread impact on critical systems.
  重要性：确保互联设备的安全至关重要，因为它可能对关键系统产生广泛影响。

Key Security Concepts 关键安全概念

- CIA Triad: Confidentiality, Integrity, Availability. CIA 三元组：保密性、完整性、可用性。
  - Confidentiality: Protecting data from unauthorized access.
    保密性：保护数据不被未经授权的访问。
  - Integrity: Ensuring data is accurate and unaltered.
    完整性：确保数据准确无误且未被更改。
  - Availability: Ensuring data and systems are accessible when needed.
    可用性：确保数据和系统在需要时可访问。

Common Security Threats 常见安全威胁

- Vulnerabilities: Weaknesses that can be exploited. 漏洞：可以被利用的弱点。
- Attacks: Actions intended to harm systems (e.g., DDoS, malware).
  攻击：旨在损害系统的行为（例如 DDoS、恶意软件）。
- Examples: 示例：
  - Car hacking via keyless technology. 通过无钥匙技术进行汽车黑客攻击。
  - Mirai botnet causing DDoS attacks. Mirai 僵尸网络引发 DDoS 攻击。
  - Zigbee lightbulb vulnerabilities. Zigbee 灯泡漏洞。

IoT Security Challenges 物联网安全挑战

- Constraints: IoT devices are often low-cost with limited resources (slow processors, small RAM, low power). 约束：物联网设备通常成本低，资源有限（处理器慢，RAM 小，功耗低）。
- Heterogeneity: Vast variety of devices and communication protocols (BLE, Zigbee, etc.).
  异质性：各种各样的设备和通信协议（BLE、Zigbee 等）。

Security Measures 安全措施

- Encryption: Protecting data in transit and at rest. 加密：保护传输和静态数据。
- Access Control: Ensuring only authorized users can access systems.
  访问控制：确保只有授权用户才能访问系统。
- Redundancy and Backup: Preventing data loss and maintaining system availability.
  冗余和备份：防止数据丢失并保持系统可用性。

ENISA Guidelines 指南

- Good Practices: Recommendations for securing IoT and smart infrastructures.
  良好实践：确保物联网和智能基础设施安全的建议。
- Tools: ENISA provides tools for evaluating and improving IoT security.
  工具：ENISA 提供用于评估和改进物联网安全的工具。

Shodan

- Functionality: Search engine for internet-connected devices, useful for identifying vulnerable devices. 功能：用于互联网连接设备的搜索引擎，对识别易受攻击设备有用。
- Usage: Caution is advised to avoid unauthorized access and comply with legal regulations.
  使用：建议谨慎使用，以避免未经授权的访问并遵守法律法规。

题目：

- 5G will just increase the speed of data communications for IoT（×）

➔ 5G will bring much more than speed: lower latency, higher reliability, higher density, etc.

- RF and antenna are the easiest parts to design for any connected object（×）
  ➔ RF and antenna are the trickiest parts to design and require rare skills
- SigFox networks are deployed in 70+ countries.
  SigFox data rates (flat fees) are lower than LoRaWAN's
- IoT edge computing helps to: Compute and react in real time in the field, Keep things securely, on premises, Make decisions locally.
- There are more B2C connected objects than B2B, but the main business value is driven by B2B objects（√）
- You have to be careful with network interferences when mixing various technologies (such as Bluetooth, RFID, WiFi, GPS, LoRaWAN or SigFox) in the same connected object design. （√）
- what are the criteria that matter the most for a connected meter for utility companies (gas, water, electricity： Autonomy, Coverage
- Please check the B2B IoT markets：Industry 4.0, Smart Cities, Smart Agri
- LoRaWAN's spreading factor can vary from SF7 to SF12 to achieve the best trade-off between reachability, throughput, and energy savings（√）
- 5G Profile:
  ➔ 5G will combine eMMB, URLLC… in different slices,
  ➔ 5G has been designed and roadmapped by the 3GPP,
  ➔ 5G latency will be lower than 10 ms in URLLC mode,
  ➔ 5G antennas implement a very efficient beam forming principle,
  ➔ 5G can use multiple spectrums, around 700MHz, 2.6GHz, 3.5GHz and 26GHz
  ➔ LTE-M and NB-IoT are « 5G ready »
- Connected objects often combine various types of sensors（√）
- 匹配：
  ➔ SigFox → LPWAN,
  ➔ LoRaWAN → LPWAN,
  ➔ LTE-M → Cellular IoT,
  ➔ 2G → Cellular
  ➔ Navigo pass or payment → NFC,
  ➔ Very accurate indoor tracking of tools → UWB,
  ➔ Remote surgery → 5G,
  ➔ Boat tracking on oceans → Satellite,
  ➔ Metering / gas, electricity, water → LoRaWAN
  ➔ eMBB → enhanced mobile broadband,
  ➔ URLLC → ultra reliable, low latency communications,
  ➔ mMTC → massive machine type communications,
  ➔ RedCap → reduced capacity