Managed Wireless and Internet of Things

TEK5110- Building Mobile and Wireless Networks
Department of Technology Systems
University of Oslo

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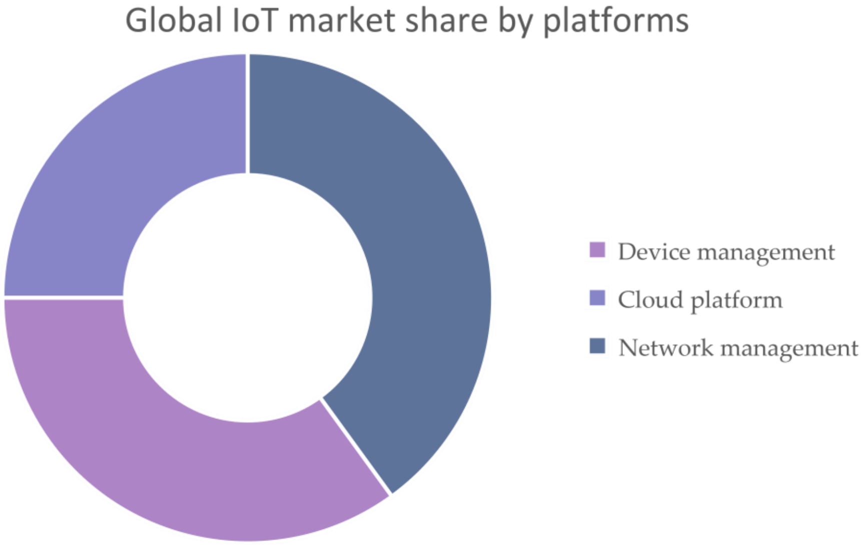
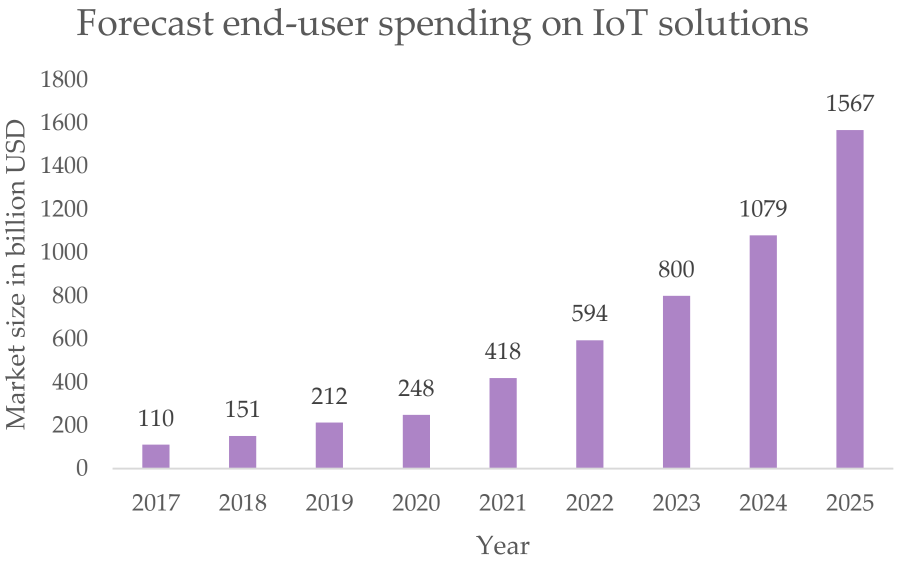
IoT Market





https://www.statista.com/statistics/976313/global-iot-market-size/
https://www.fortunebusinessinsights.com/industry-reports/internet-of-things-iot-market-100307

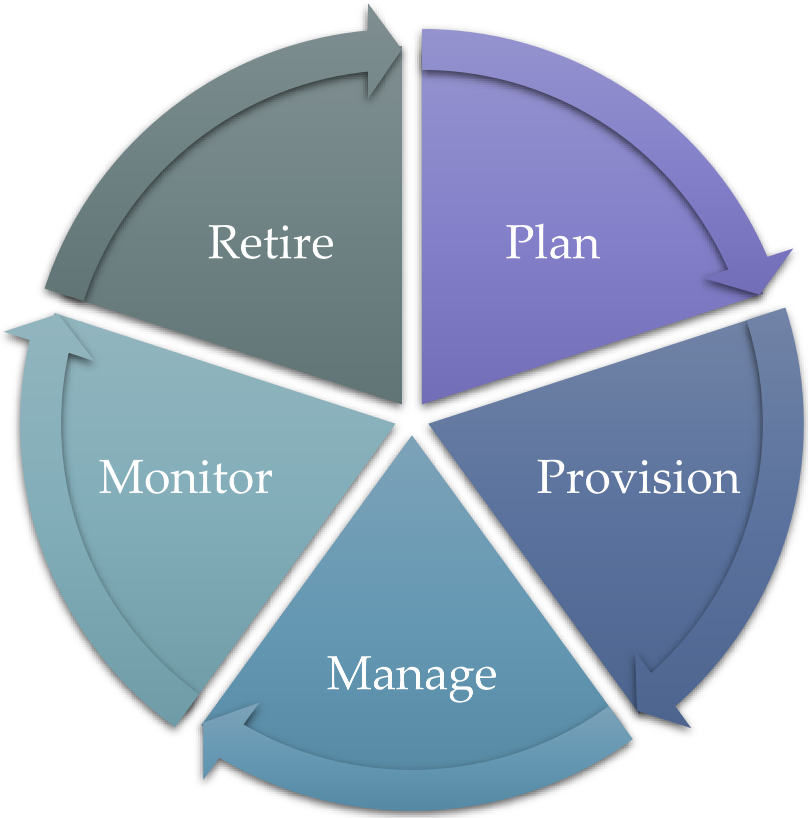
IoT Management Advantages

- Remote provisioning
  - Register and configure many devices simultaneously
- Scalability
  - The platform can scale to manage millions of devices
- Monitoring and diagnostics
  - Minimize device downtime and unforeseen operational problems
- Software maintenance and update
  - Update and maintain device software remotely; allow agile developments
- Configuration and control
  - Force device to certain desired state based on the system it is connected; Reset device to known-good state
- Security
  - Manage security updates and configurations for many devices

IoT Management Challenges

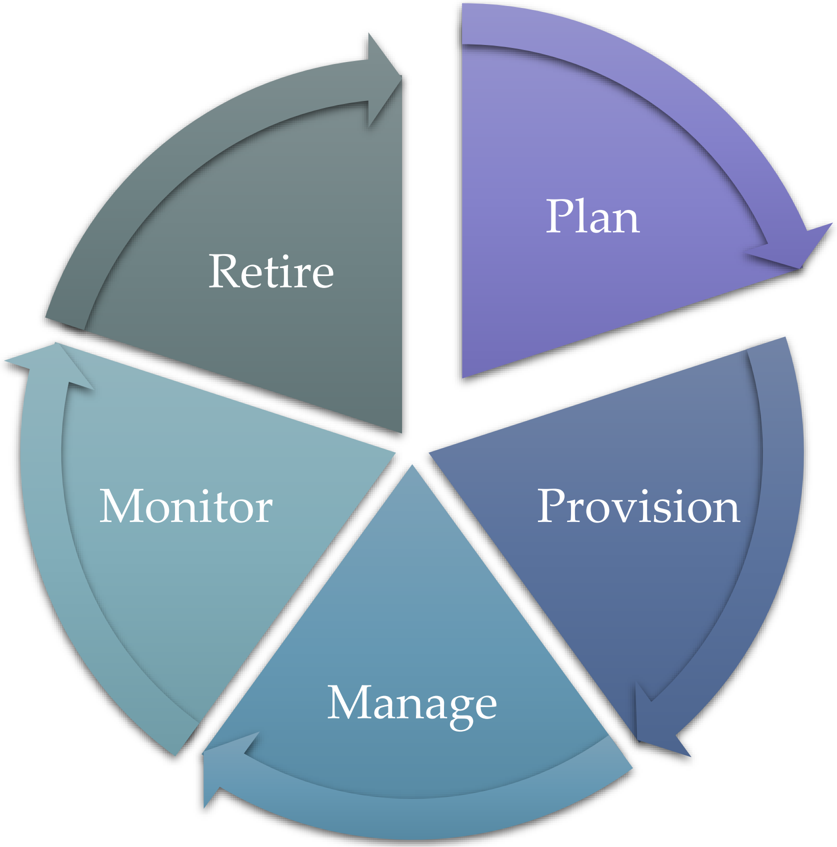
- Power and energy consumption
  - Many IoT devices need to run for years over battery.
- Connectivity
  - Varity of connectivity standards such as Zigbee, Zwave, Bluetooth, etc.
- Computation capabilities
  - Many IoT devices use low-end microchips with very limited capabilities.
- Lack of standard-Interoperability
  - Need to adapt management platform according to each deployed sensor type or manufacturer
- Security and privacy
  - Management platform security and privacy issues will affect millions of devices
- Storage Management
  - Store petabytes of information gathered from IoT devices
- No human-interaction interface

IoT Device Lifecycle



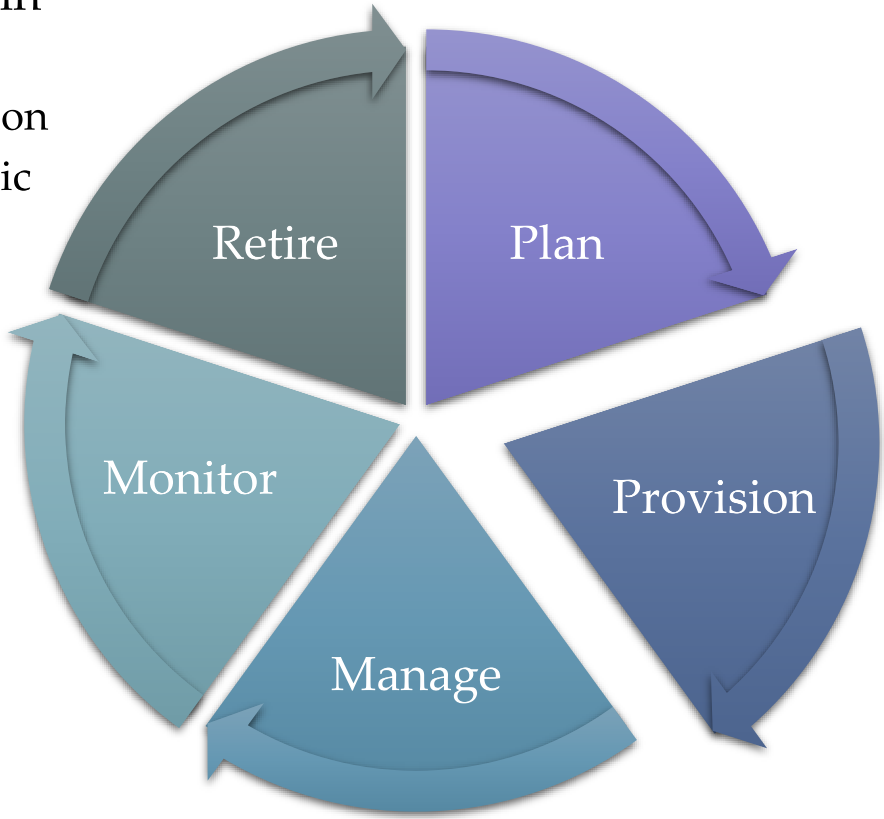
IoT Device Lifecycle-Planning

- Why do you want to manage IoT?
- Plan your IoT devices deployment based on your system requirements
  - Device naming scheme
  - Group devices
  - Define access control policies



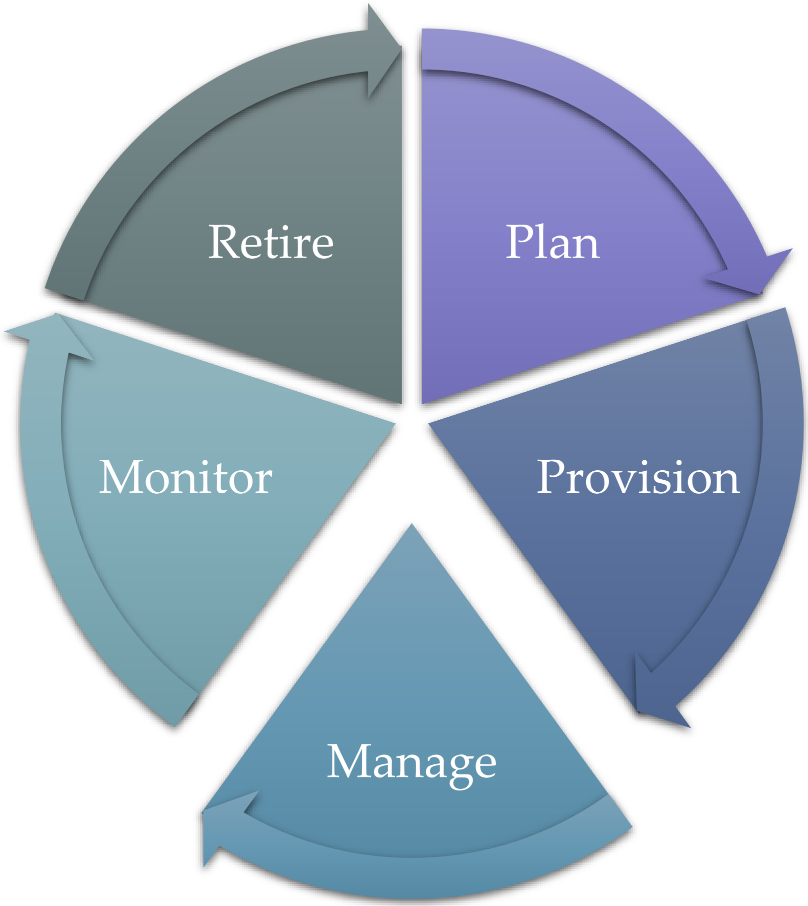
IoT Device Lifecycle-Provisioning

- Authenticate and register IoT devices in the management platform
  - Zero-touch authentication and registeration
  - Public key infrastructure (PKI)- IoT public key and certificate management
    - Key generation
    - Key expiration and reporting (different device different key lifetime)
    - Key destruction
    - Certificate revocation
- Provisioning scenarios
  - Ownership based
  - Geolocation based
  - Load balancing
  - Re-provisioning



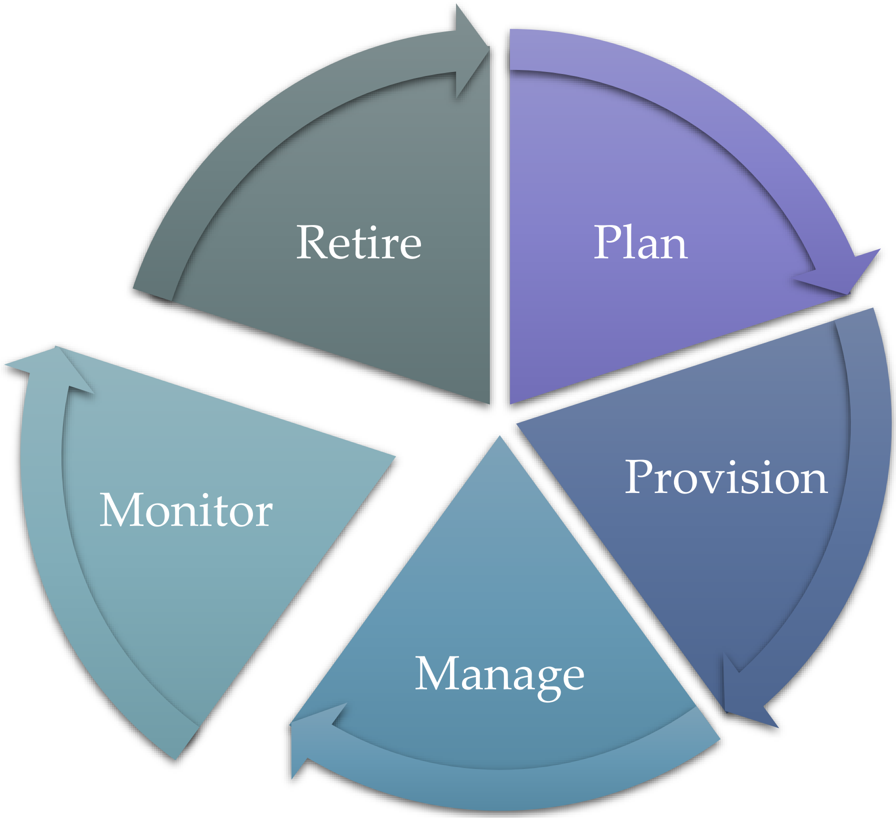
IoT Device Lifecycle-Management

- Force IoT device to a desired state
  - Device configuration
    - Assign IoT device to specific system
    - Change parameters value
  - Device update
    - Firmware update
    - Security update



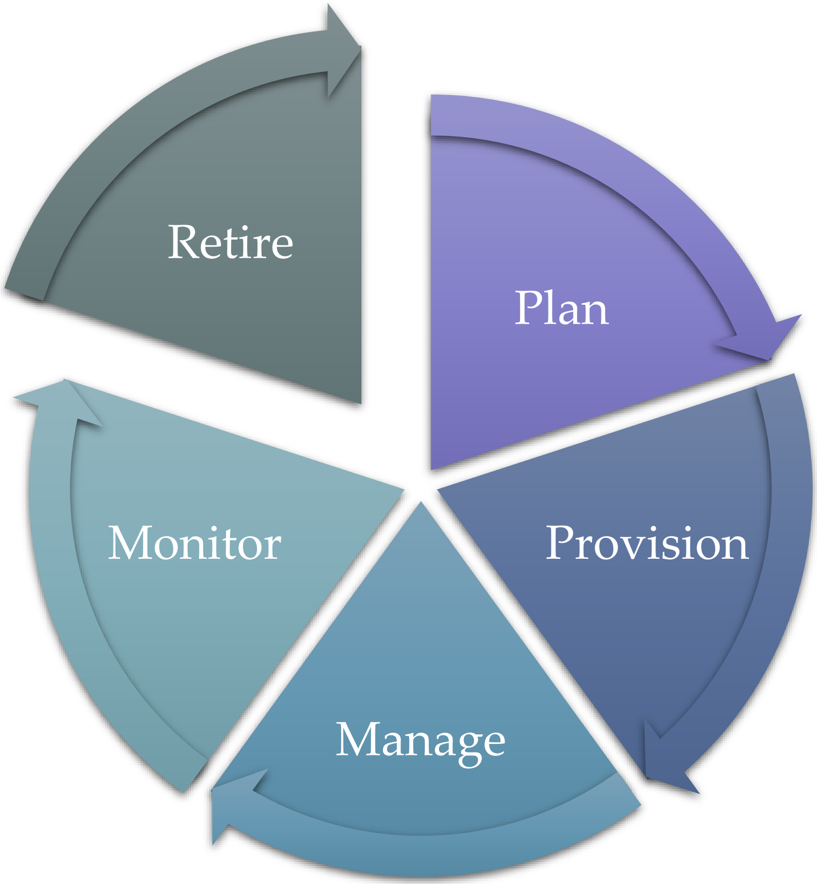
IoT Device Lifecycle-Monitoring

- Monitor devices health and state
  - Monitor device status
    - Wireless connectivity parameters
    - Resource consumption
    - Battery level or power consumption
    - Maintenance planning
  - Monitor security issues
    - Anomaly detection
    - Unauthorized access



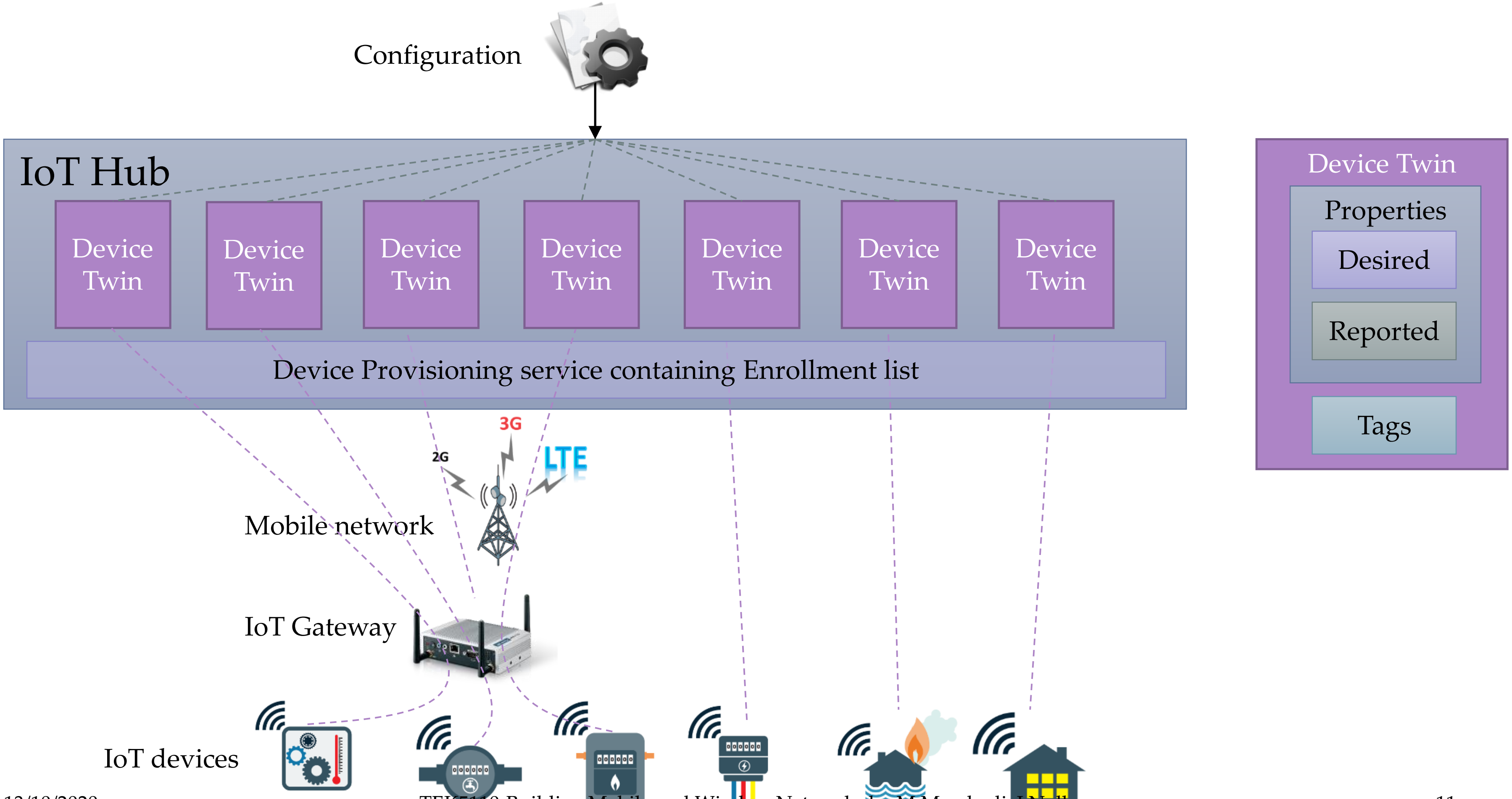
IoT Device Lifecycle- Retirement

- Replace the failed device with new one
  - Device lifecycle is ended
  - Defective devices
  - Device failed
    - Re-provision new replaced device
  - Upgrade to a new model
    - New features and functionalities



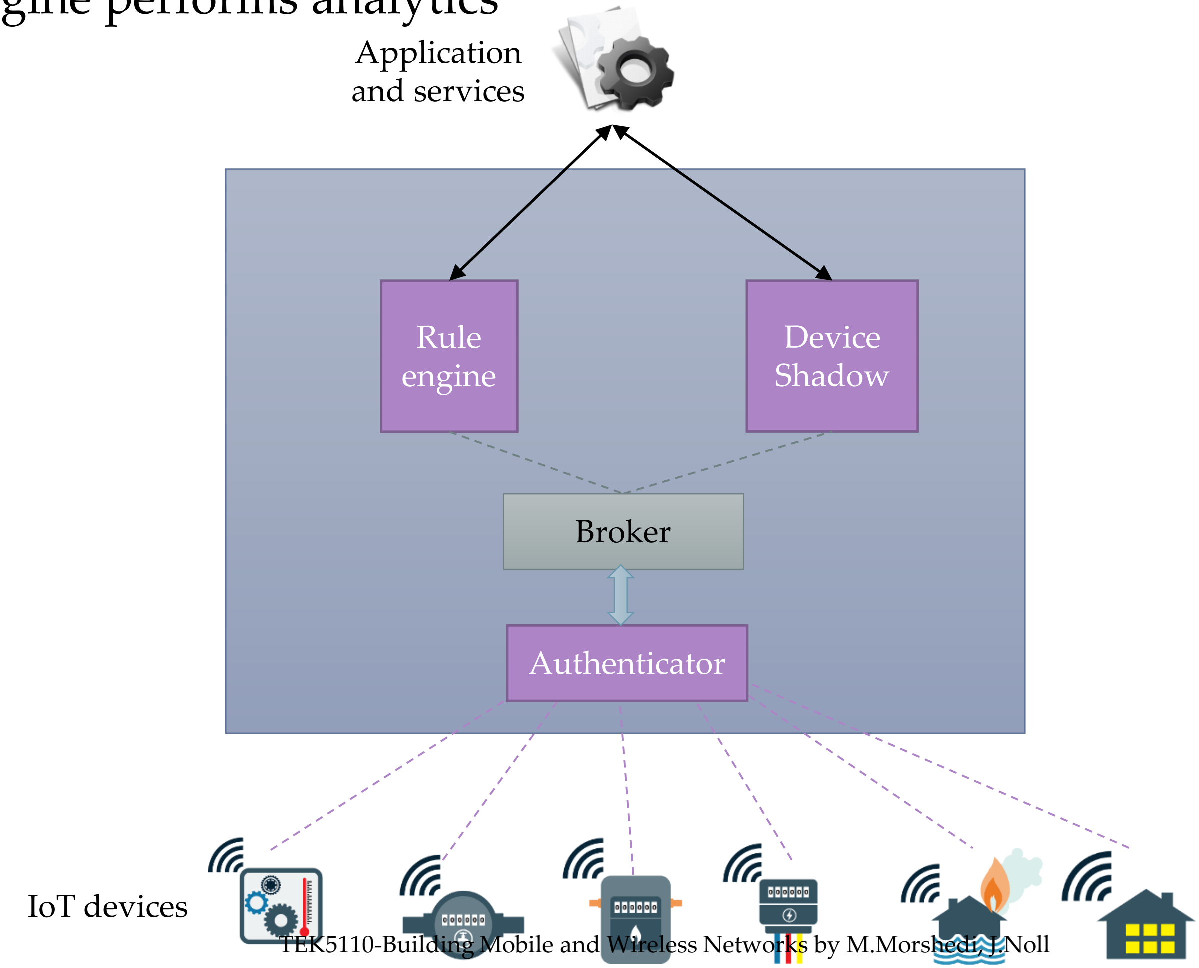
IoT platform 1

IoT devices connect to platform through IoT hub



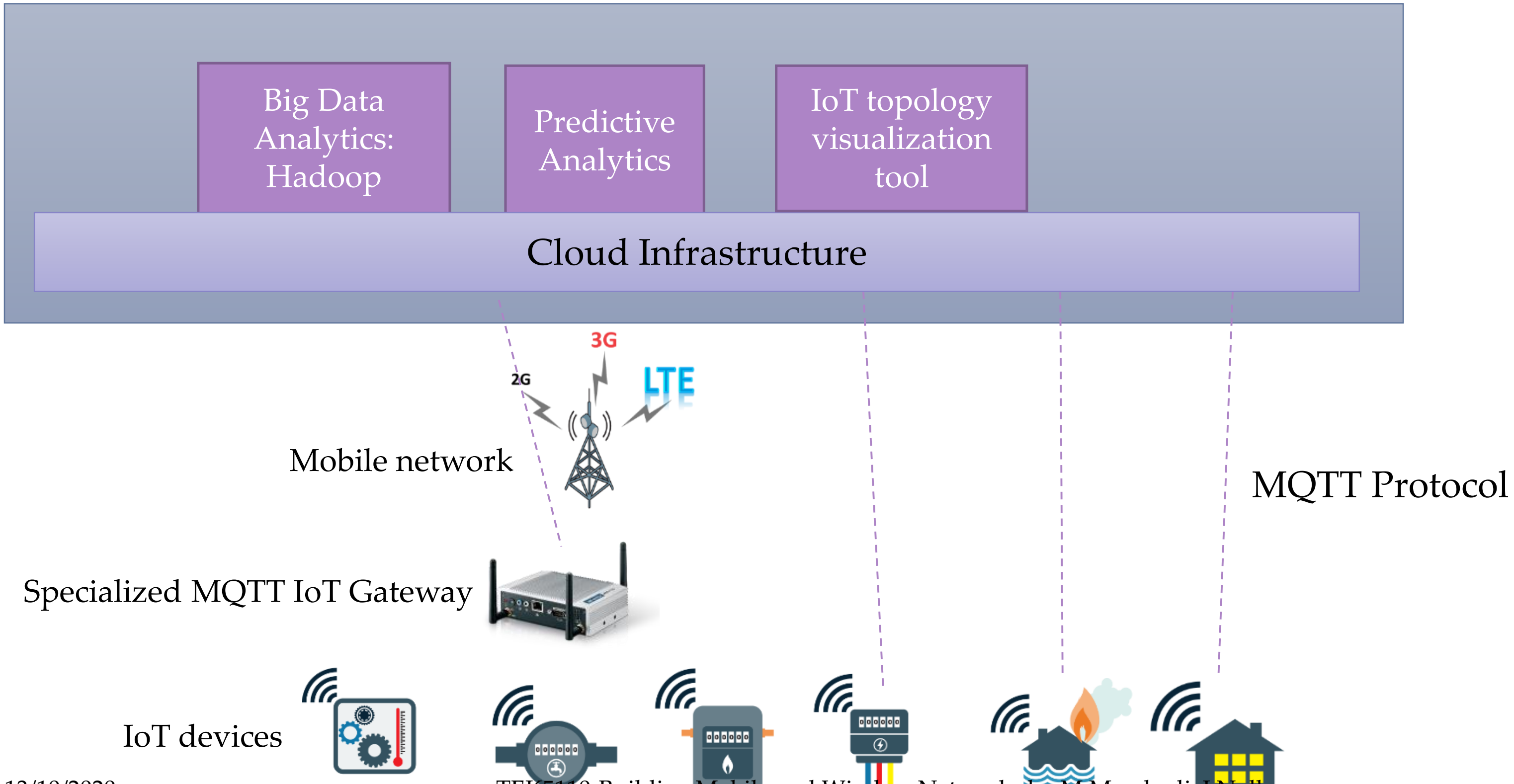
IoT platform 2

- Device shadow is metadata store for device capabilities
- Rule engine performs analytics



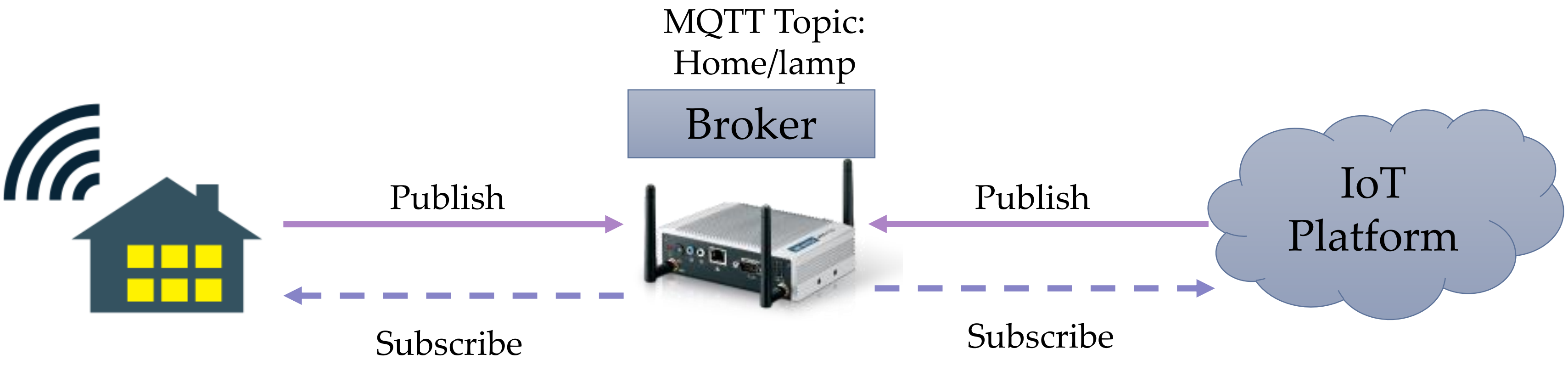
IoT platform 3

- Platform managed IoT devices through specialized gateway
- Platform managed specific IoT devices directly
- MQTT is main protocol connecting IoT to platform


Big Data Analytics: Hadoop
Predictive Analytics
IoT topology visualization tool
Cloud Infrastructure
3G
2G
LTE
Mobile network
MQTT Protocol
Specialized MQTT IoT Gateway
IoT devices

MQTT Protocol – MQ Telemetry Transport

- MQTT is real-time protocol connecting IoT to platform
- MQTT run over TCP/IP protocol
- Designed for limited bandwidth networks
- MQTT has small code footprint so it can run on limited capability devices
- MQTT uses publish and subscribe system
- MQTT topics
  - Interest for incoming messages
  - Specify where to publish



Open Source IoT Platforms

- Kaa IoT Platform
  - Device monitoring, provisioning and configuration
- SiteWhere
  - Easily integrate development boards such as Raspberry Pi
  - Support different communication protocols and perform monitoring using Graphana
- ThingSpeak
  - Analyze and visualize data using MATLAB
  - Compatible with development boards such as Raspberry Pi
- DeviceHive
  - Install on public and private cloud
  - Supports big data solutions such as Elasticsearch and Apache Spark
- Thingsboard.io
  - Provides device management, monitoring, data collection and processing
  - Supports multitenant installations

What to Monitor and Manage in IoT?

RSSI Sensors value SNR

Power consumption Transmit Rate

CPU utilization Memory Certificate

Receive Rate **Encryption key**

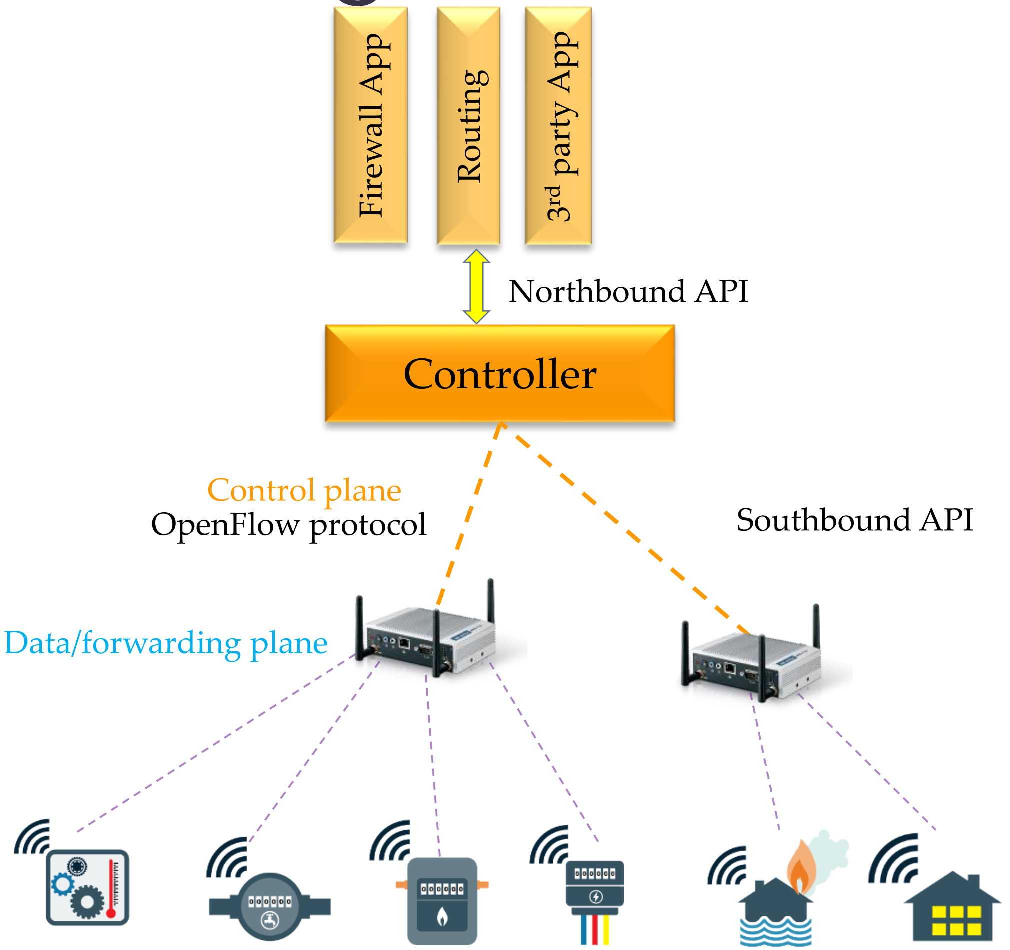
Security logs

Recap: Conventional system administration tools

- Configuration management
  - Puppet
  - Chef
  - Ansible
  - Kubernetes
- Software defined networking (SDN)
- Open standard management protocols
  - NETCONF+YANG
  - CPE WAN management protocol (CWMP)

Can we use conventional system administration tools for IoT management?

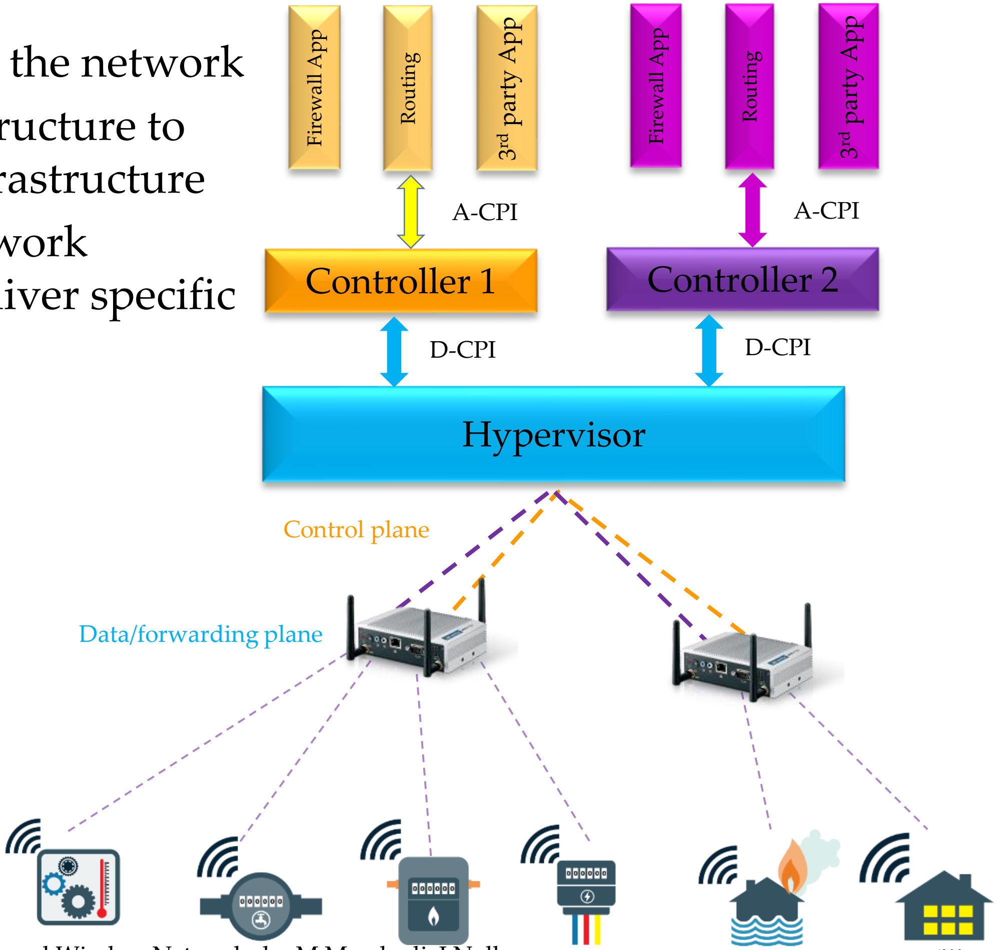
SDN for IoT Management



What would be optimal architecture of the SDN IoT management?
What would be monitoring time interval in SDN IoT management?

Virtualization of SDN

- Enabler for future IoT services
- Isolates different service providers
- Each vSDN corresponds to a slice of the network
- Virtualize given physical IoT infrastructure to allow multiple tenants share IoT infrastructure
- Each tenant can operate its own network operating system in controller or deliver specific services
  - Smart grid services
  - Remote management of smart home
  - Enabler for open data concept

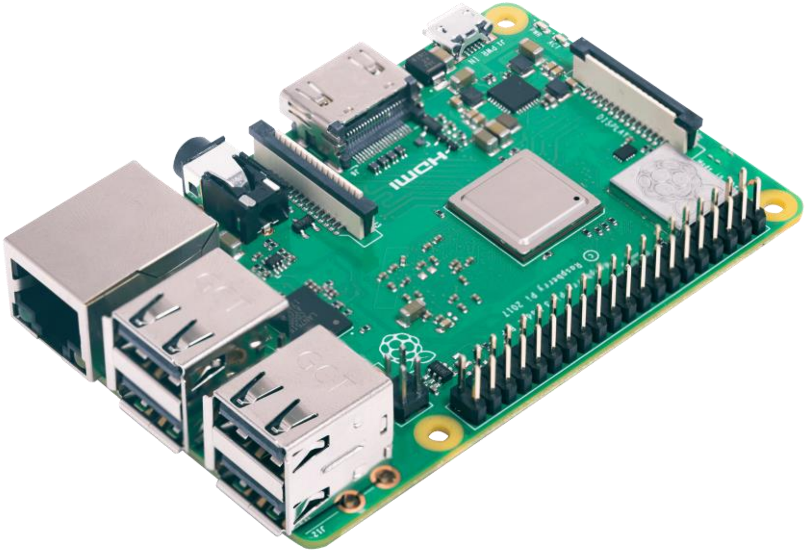


Single board Computers

Board name	Clock speed	Processor	Memory	Radio	Dimension	Price
Asus tinker	1.8 GHz	64bit RK3288	2GB DDR3	Wi-Fi Bluetooth	3.37″*2.125″	60 $
Banana Pi M2 Berry	1 GHz	32bit Quad-core Cortex A7	1 GB DDR3	Wi-Fi Bluetooth	3.6″*2.4″	36 $
BeagleBone black	1 GHz	32bit AM335X ARM Cortex-A7	4GB eMMC	-	3.4″*2.1″	55 $
LattePanda	1.92 GHZ	64bit Intel CherryTrail	2GB/4GB	Wi-Fi Bluetooth	2.75″*3.42″	129/159 $
Nvidia Jetson TX2 Dev Kit	2 GHz	64bit ARM V8	8GB DDR4	Wi-Fi Bluetooth	6.7″*6.7″	599 $
Onion Omega2	580 MHz	32bit MIPS	128 MB	Wi-Fi	1.1″*1.7″	5 $
Qualcomm DragonBoard 410c	1.2 GHz	64bit Snapdragon 410	1 GB DDR3 8GB Flash	Wi-Fi Bluetooth	2.12″*3.35″	75 $
Raspberry Pi B+	1.4 GHz	64bit Broadcom BCM2837B0	1 GB DDR2	Wi-Fi Bluetooth	3.4″*2.2″	35 $
Raspberry Pi zero W	1 GHz	32bit Broadcom	microsd	Wi-Fi Bluetooth	1.18″*2.56″	20 $
Samsung Artik 10	1 GHz	32bit quad core Cortex A15	2GB 16GB flash	Wi-Fi Bluetooth	6.3″*4.13″	150 $
Orange Pi plus 2E	1.3 GHz	32bit Quad core	2GB DDR3/, 16GB flash	Wi-Fi	5″*4″	60 $
Arduino zero (Microcontroller)	48 MHz	32-bit ATSAMD21G18	256 K flash	-	2.7″*2.1″	50 $

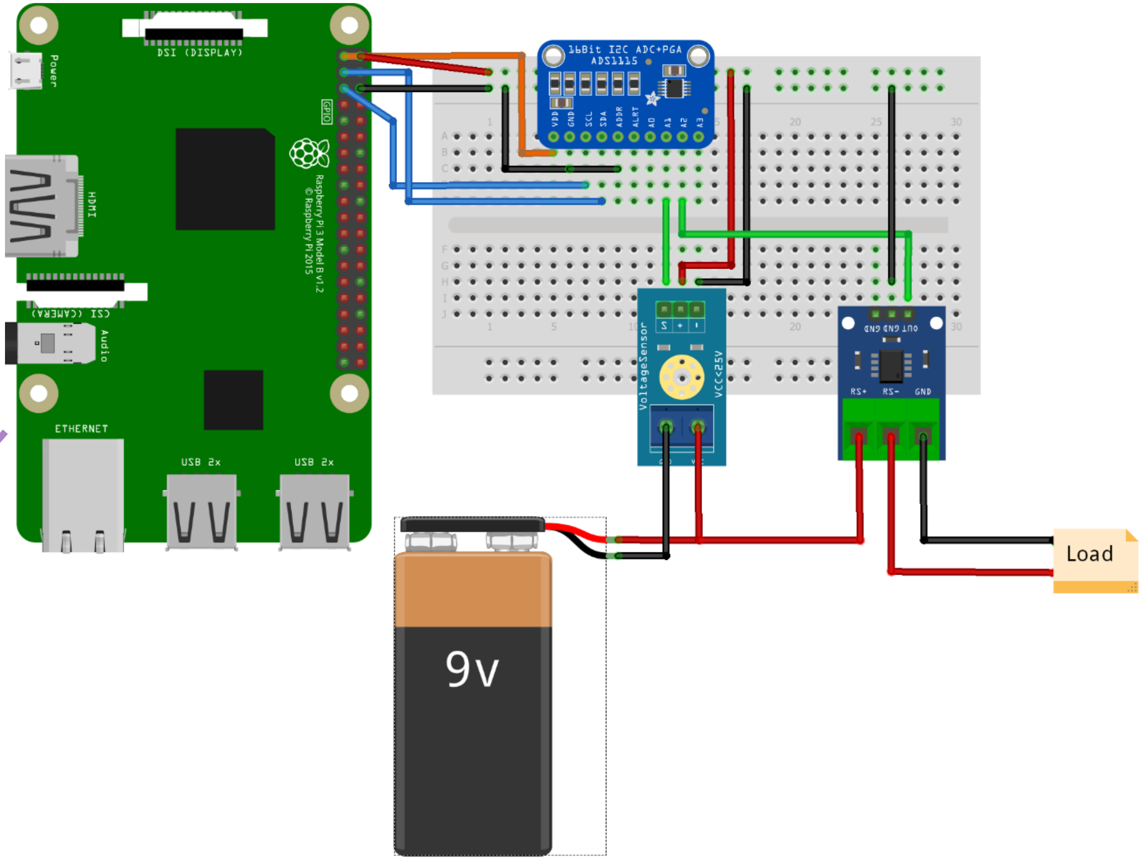
Raspberry Pi 3 B+

- The Pi 3 Model B+ technical specifications :
  - Broadcom BCM2837B0 chipset
  - 1.4GHz 64bit Quad-Core ARM Cortex-A53, 4 cores
  - 1GB DDR2 RAM
  - 4 USB 2.0 ports (via LAN7515)
  - Gigabit Ethernet (via LAN7515, max speed 300Mbps)
  - PoE (power over Ethernet)
  - 40 pin header (26 GPIOs)
  - MicroUSB power connector (5V, 2.5 A)
  - Dual-band (2.4GHz and 5GHz) 802.11ac Wireless LAN and Bluetooth 4.1 (Bluetooth Classic and LE)
  - HDMI
  - CSI camera interface
  - DSI connector for official screen
  - 3.5mm jack connector supporting stereo audio
  - 2-pin reset header
  - Micro SD socket for storage
  - Raspbian OS (Linux)



Raspberry Pi Demo

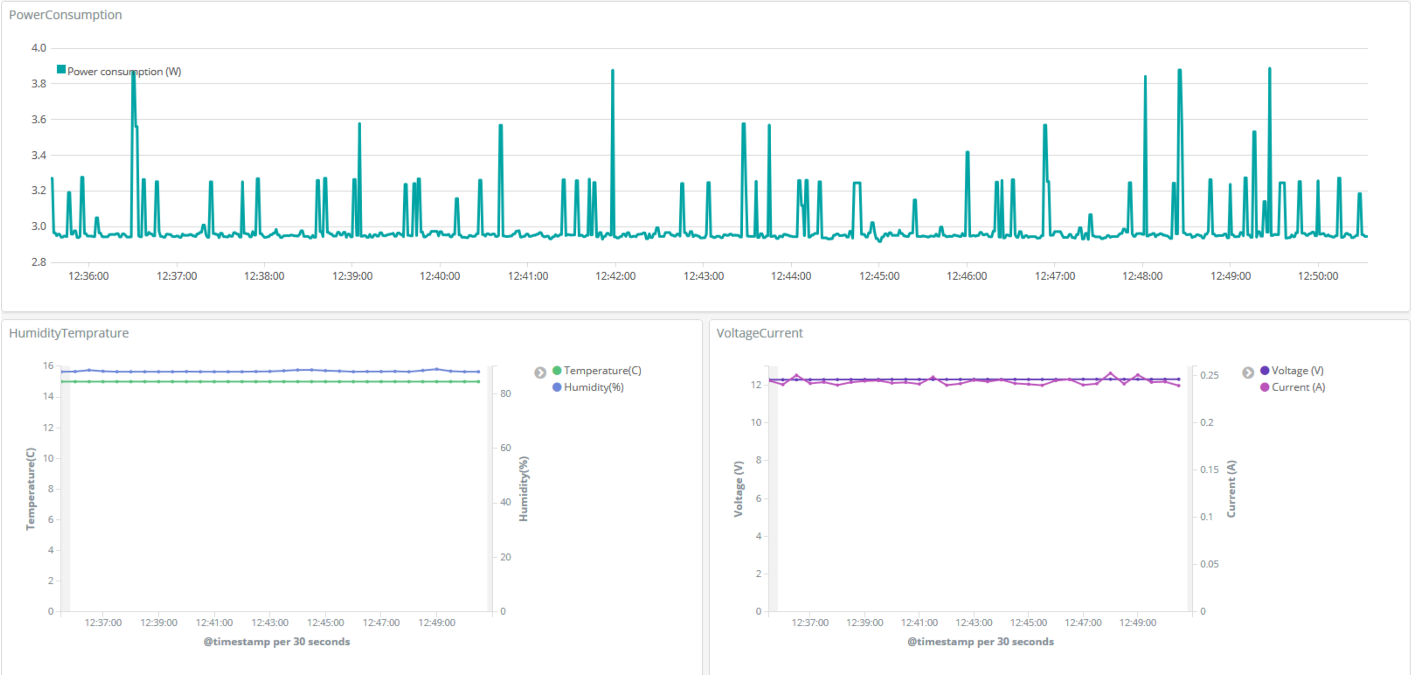
- Battery Voltage and Current monitoring
- Required components:
  1. Raspberry Pi 3 B+
  2. ADS1115
  3. Voltage sensor
  4. MAX471 current sensor
  5. Jumper wires
  6. Breadboard



TEK5110 monitoring Platform

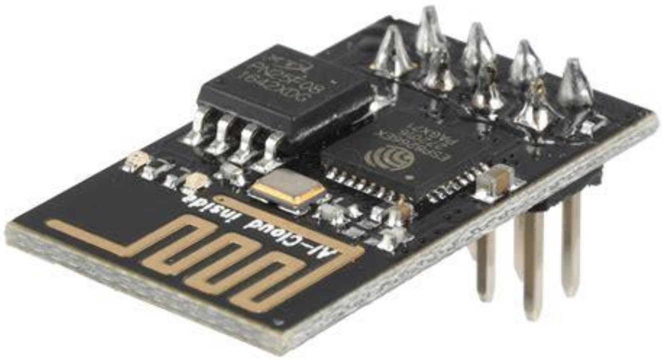
Monitoring BasicInternet infrastructure with Raspberry Pi

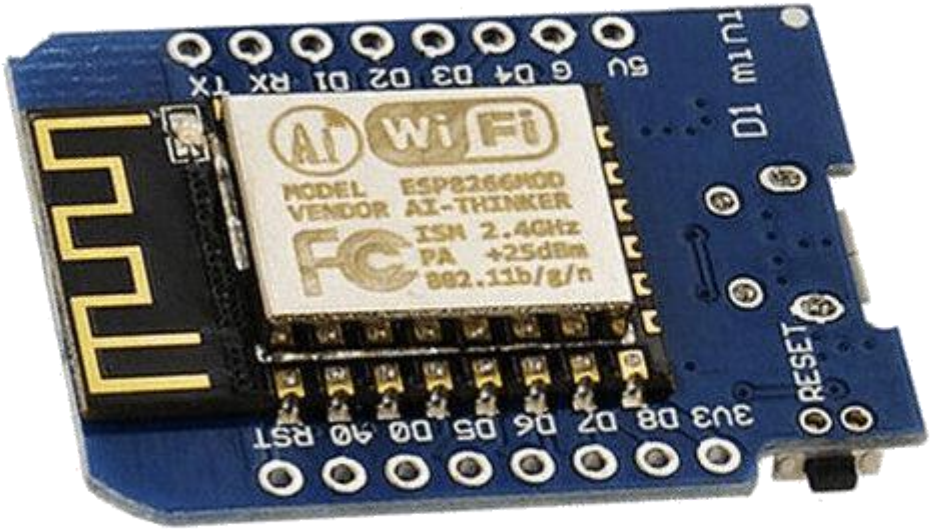
- Monitor BasicInternet solar powered Internet for all Wi-Fi hotspot with Raspberry Pi
  - Battery Voltage
  - Current
  - Temperature
  - Humidity



ESP8266

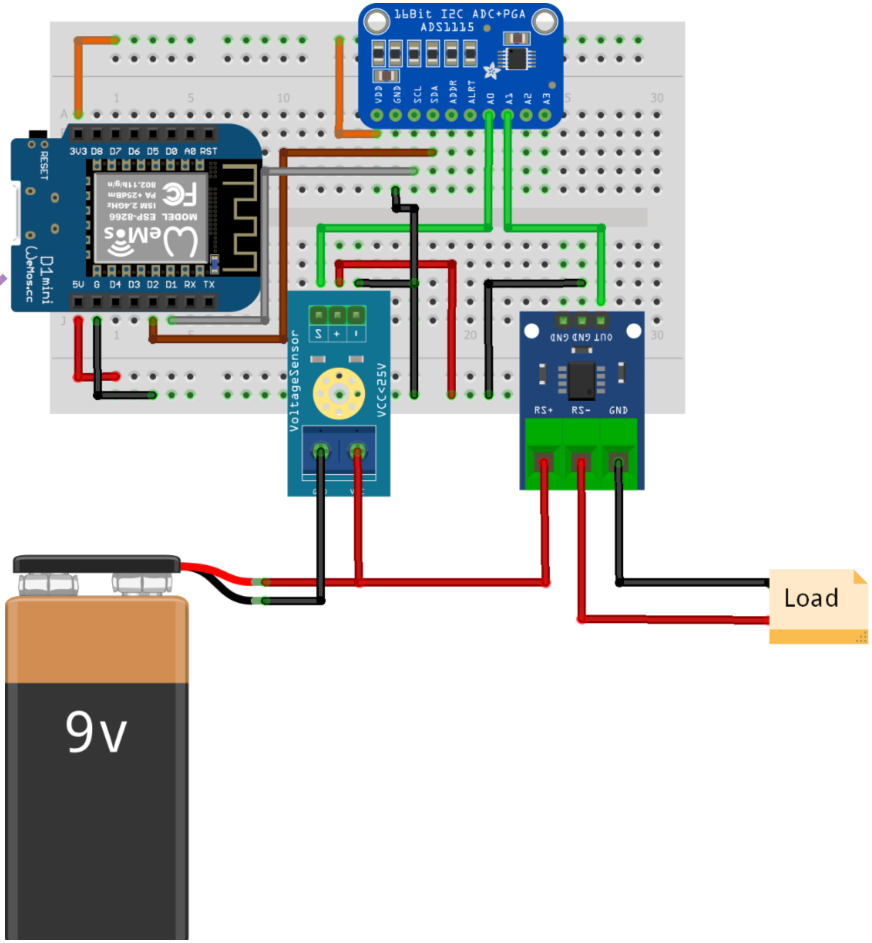
- Low-cost Wi-Fi microchip (30 Kr)
- IEEE 802.11 b/g/n
- Full TCP/IP stack
- Memory:
    - 32 KiB instruction RAM
    - 32 KiB instruction cache RAM
    - 80 KiB user-data RAM
    - 16 KiB ETS system-data RAM
- 10-bit ADC





ESP8266 Demo

- Battery Voltage and Current monitoring
- Required components:
  1. WeMos D1 mini
  2. ADS1115
  3. Voltage sensor
  4. MAX471 current sensor
  5. Jumper wires
  6. Breadboard



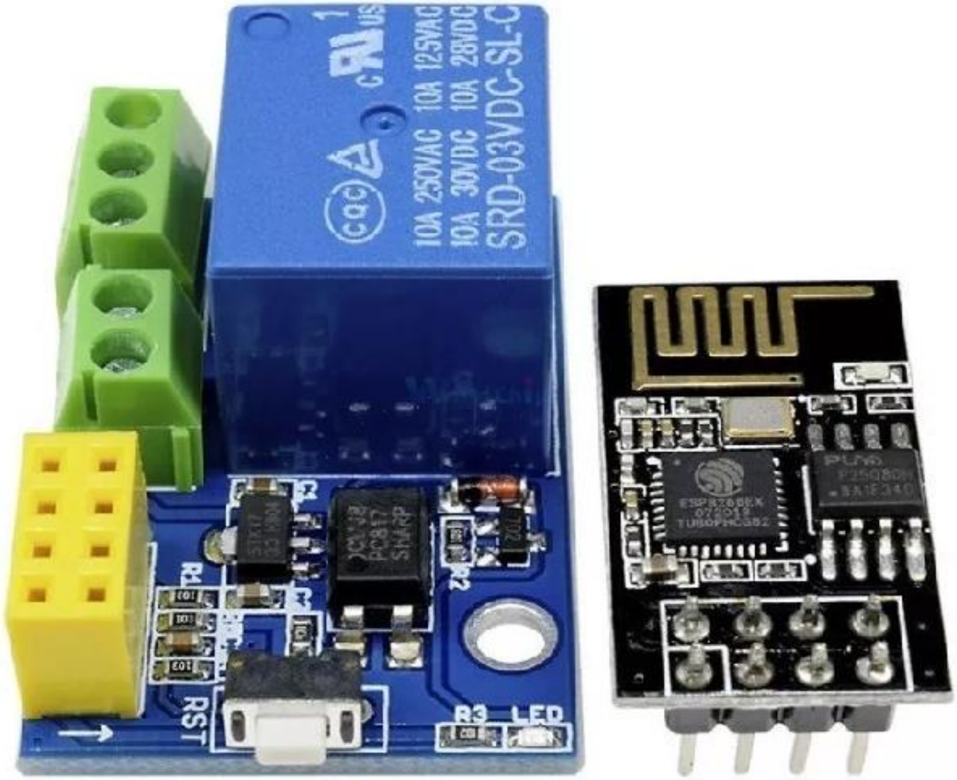
TEK5110 monitoring Platform

ESP8266 Demo

- Temperature and humidity monitoring
- Required components:
  1. DHT11
  2. ESP8266

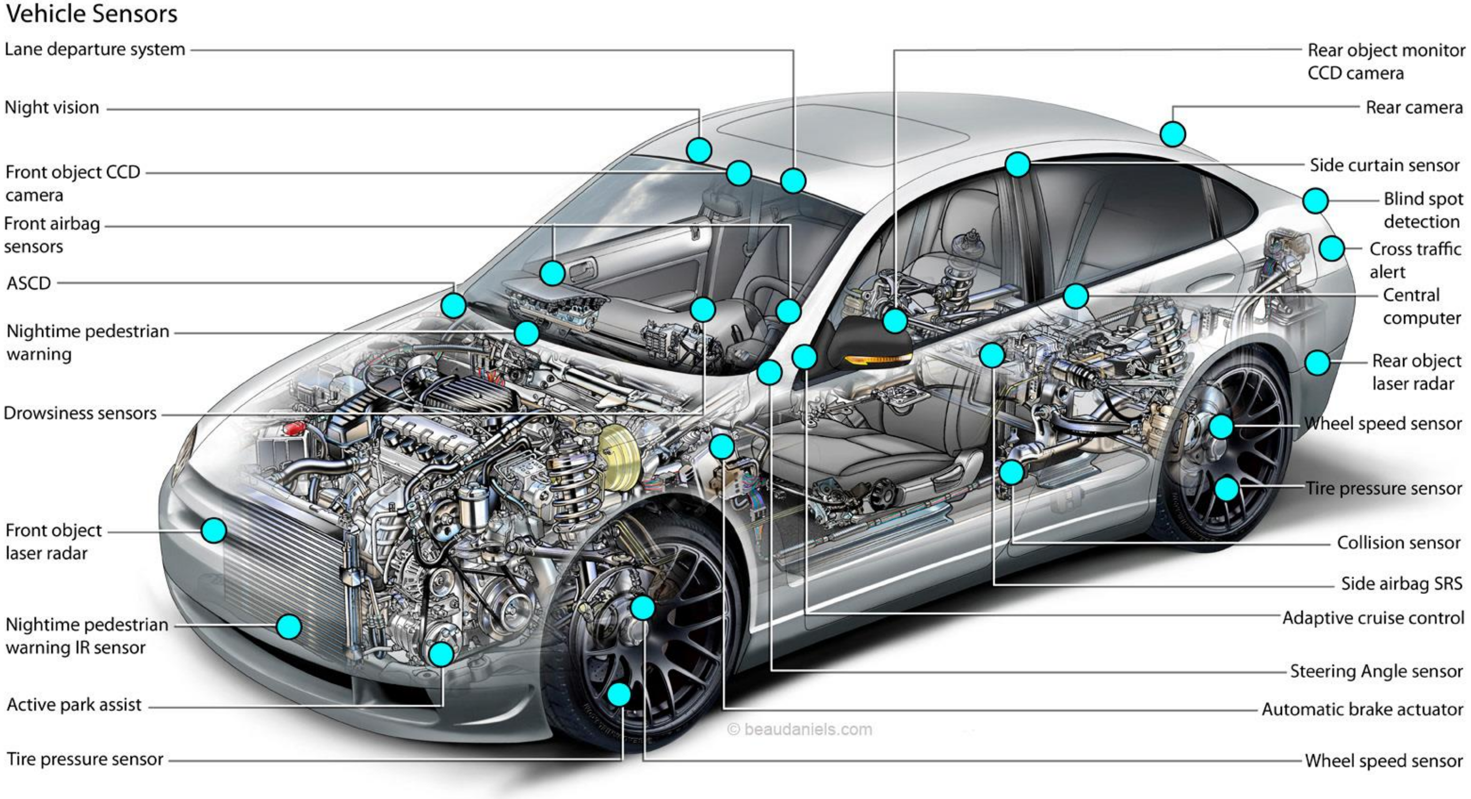
ESP8266 Demo

- AC/DC wireless switch
- Required components:
  1. Relay
  2. ESP8266



IoT Management Example 1

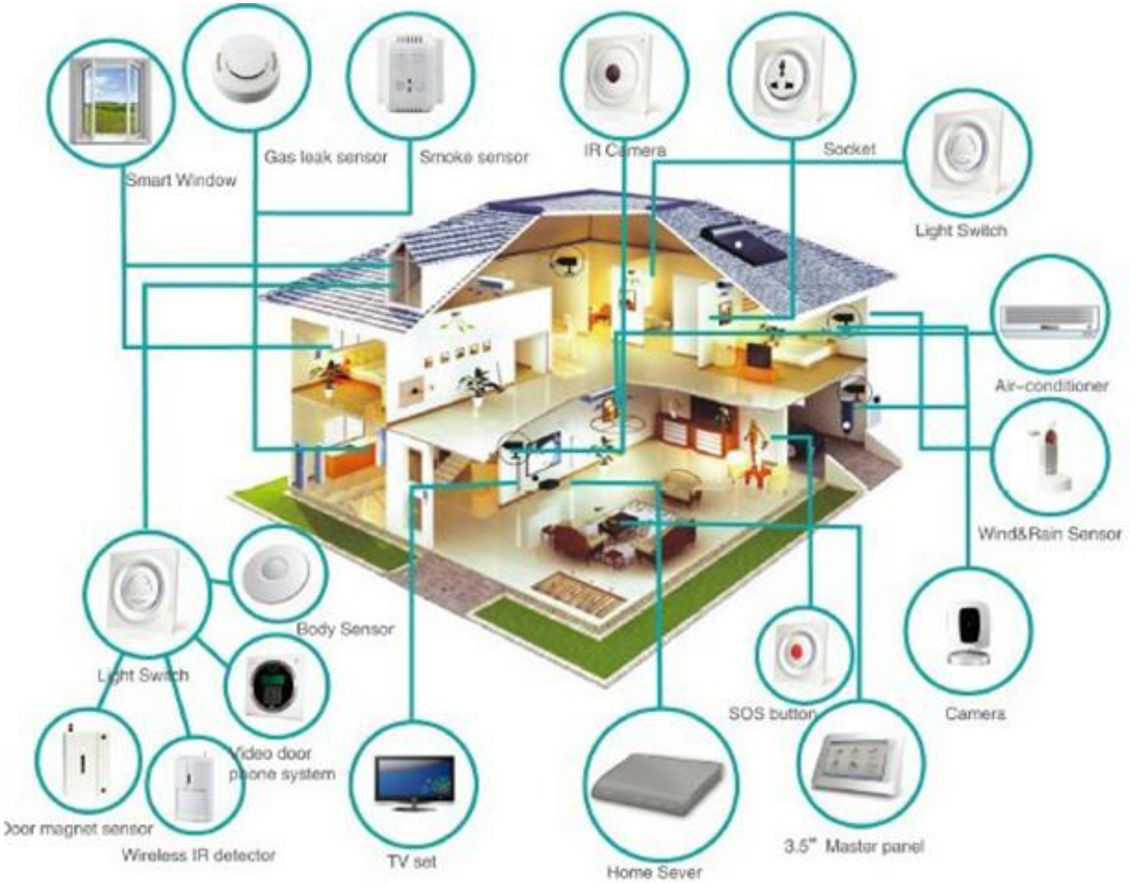
- How do you manage sensors in following use case?



https://beaudaniels.com/generic-cutaway-car

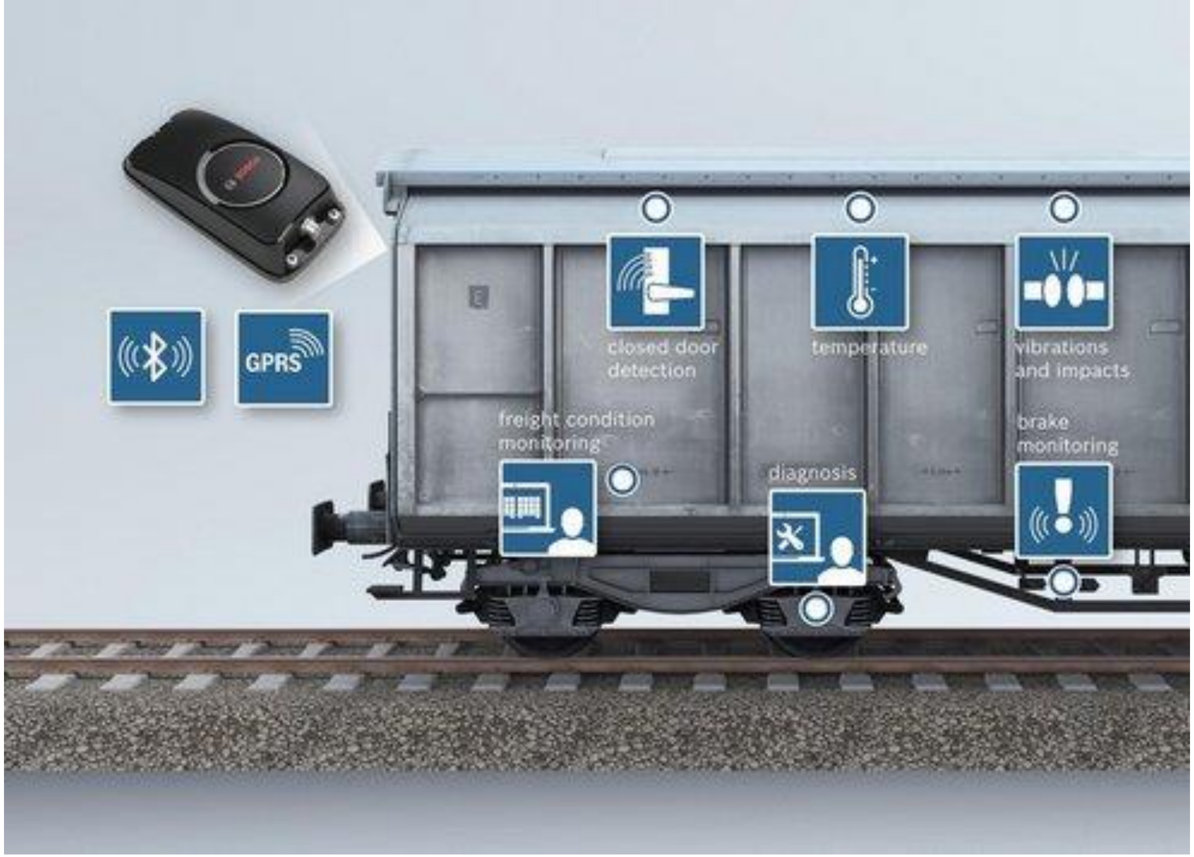
IoT Management Example 2

- How do you manage sensors in following use case?



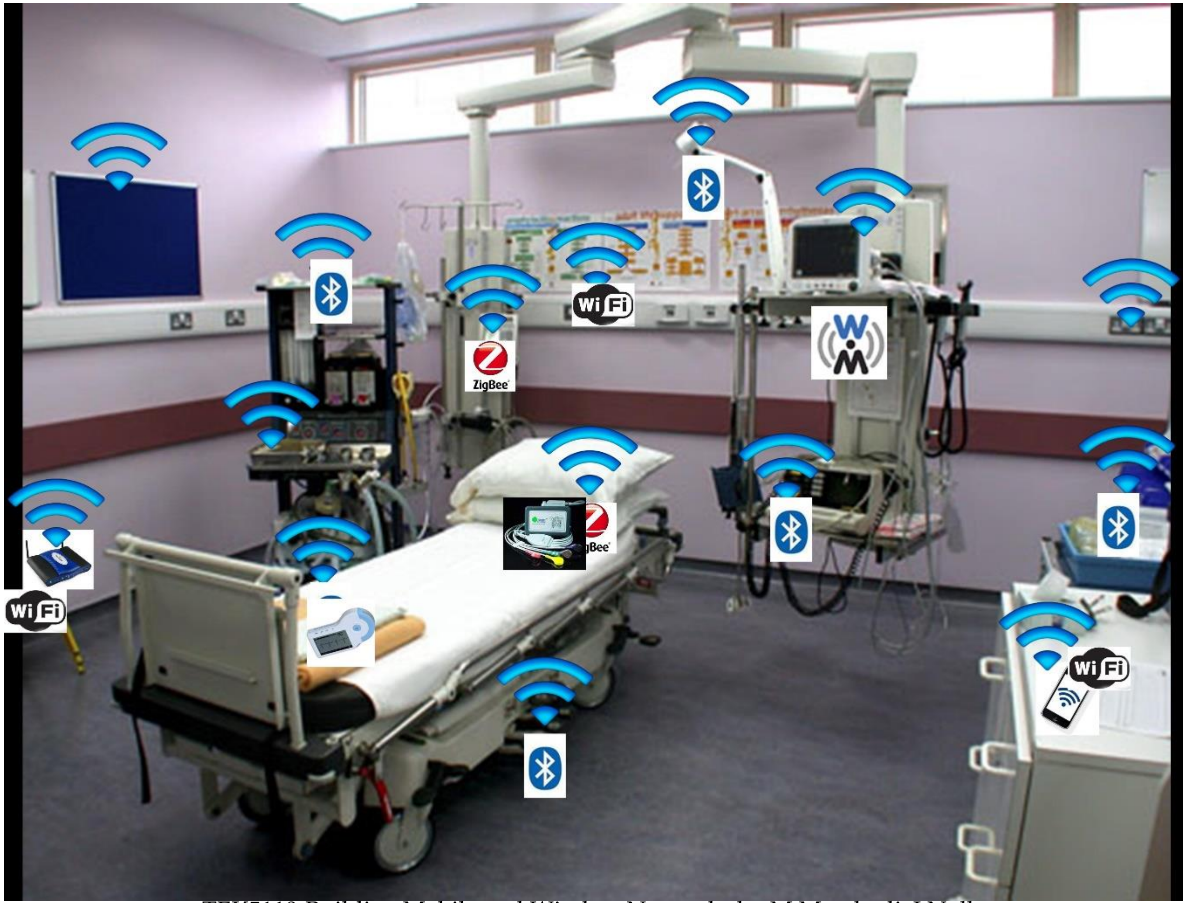
IoT Management Example 3

- How do you manage sensors in following use case?



IoT Management Example 4

- How do you manage sensors in following use case?



Discussion

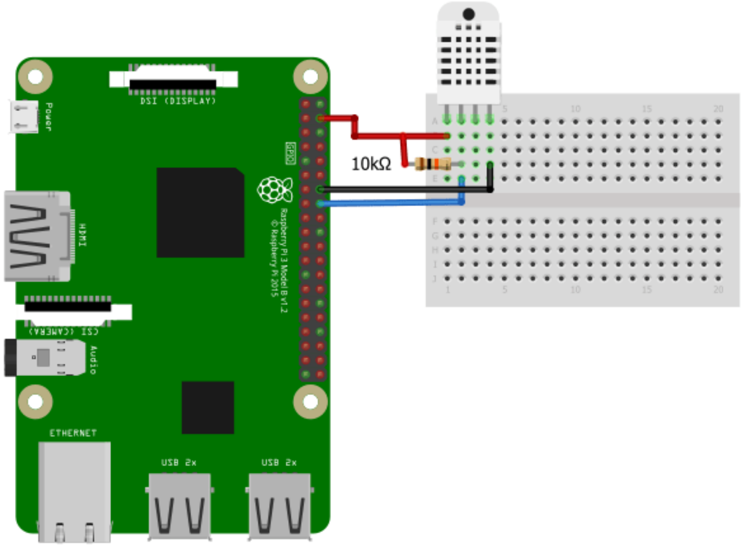
- Why should we monitor and manage IoT?
- What would be optimal monitoring time intervals for IoT?
- What would be optimal IoT management architecture (using gateway or direct connection)?
- Which approach will you use for IoT management in your infrastructure? (configuration management, SDN, open standard protocols or enterprise cloud platforms)
- What are the IoT management security and privacy consideration?

Raspberry Pi Exercise

- Monitoring temperature and humidity project

- Required components:
  1. Raspberry Pi 3 B+
  2. DHT22 temperature and humidity sensor
  3. 10K pullup resistor
  4. Jumper wires
  5. Create an account in ThingSpeak

- Use documentation in ITS-wiki for step by step guide building project



https://electronicshobbyists.com/raspberry-pi-sending-data-to-thingspeak-simplest-raspberry-pi-iot-project//

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