Internet of Things Introduction

Experimental Work in Intelligent IoT Networks

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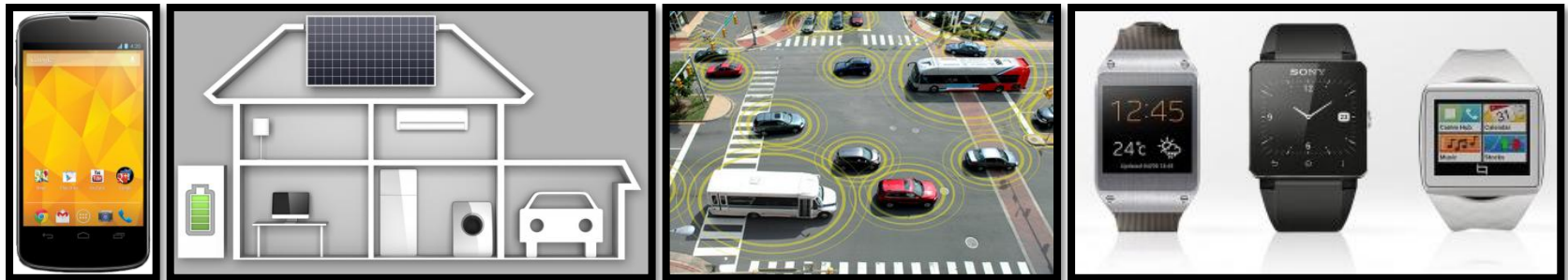Department of Computer and Electrical Engineering (DET)

Overview

- Background
- Things, Sensors, and Actuators
- IoT Communication
- Smart Services

Background

- We are becoming more connected to the Internet

- This sparks a new generation of user friendly services
  - Powered by connected devices and their information

- The Internet-of-Things (IoT)
  - 13.2 billion IoT devices 2022 (Ericsson Mobility report)
  - 34.7 expected in 2028

IoT Vision

- The purpose of the IoT is to help us in our everyday life
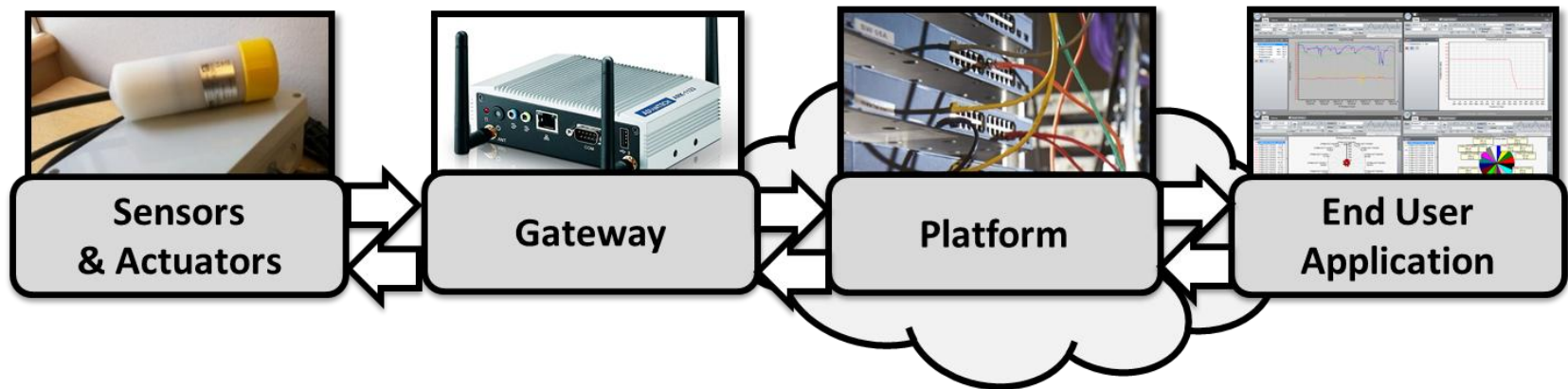 - By attaching sensor and actuators to the things in our surroundings
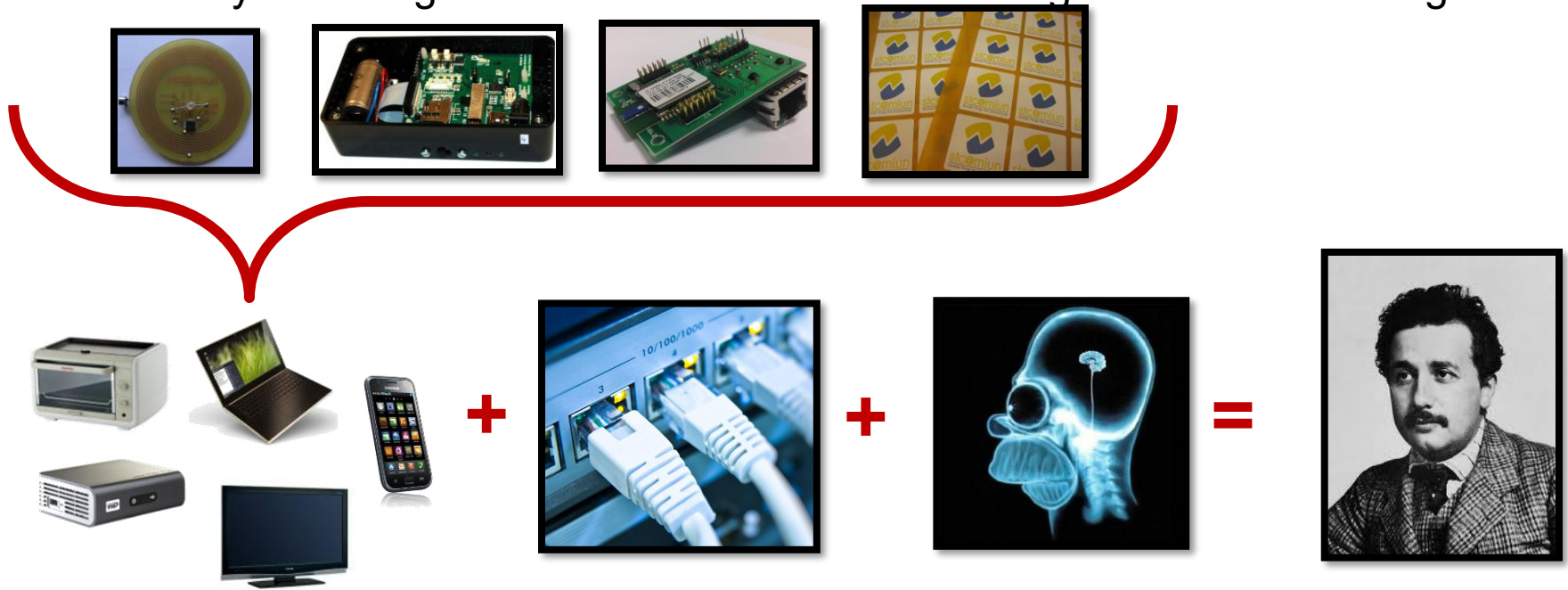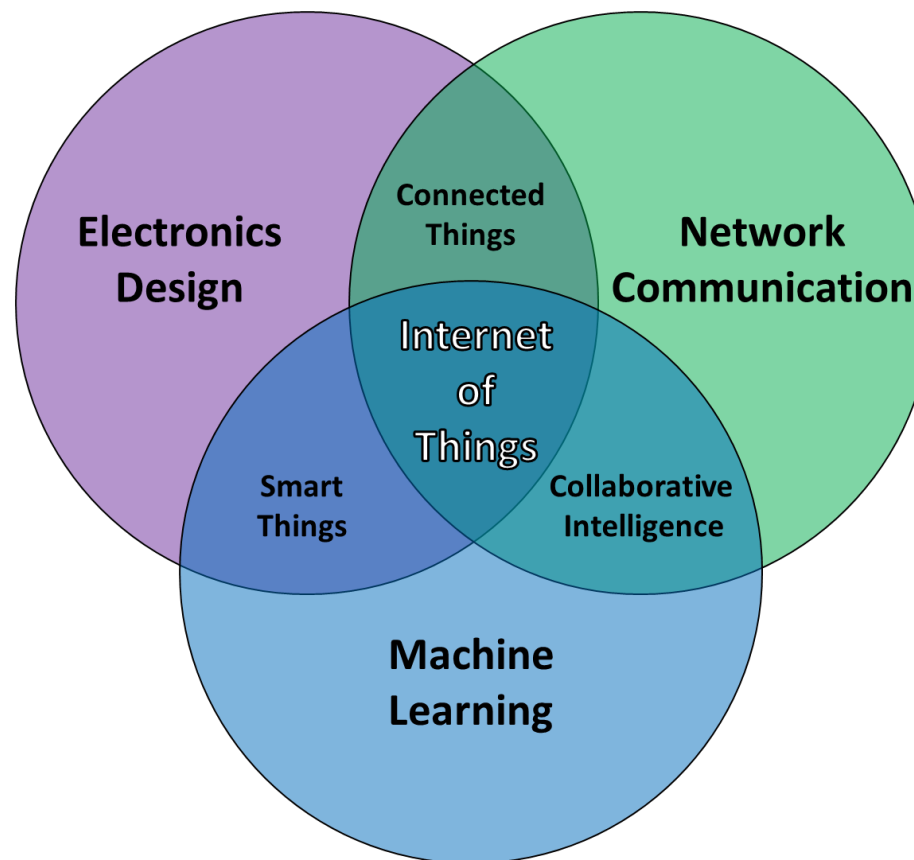
IoT Vision

The IoT Value Chain

- A value chain from sensor/actuator to application and back again

Three parts of the IoT

Venn diagram showing three overlapping circles: Electronics Design, Network Communication, and Machine Learning. Overlap of Electronics Design and Network Communication is "Connected Things"; overlap of Electronics Design and Machine Learning is "Smart Things"; overlap of Network Communication and Machine Learning is "Collaborative Intelligence"; the center overlap of all three is "Internet of Things".

Things, Devices, Sensors, and Actuators

IoT Devices Today
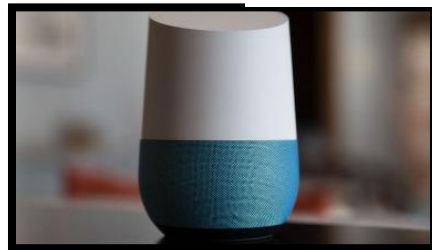
IoT Sensors & Actuators

- Sensors sense the world (producer data)

- Actuators make the world take action (consumes)

- Often simple and cheap
  - Low performance
  - Limited energy and battery operated
  - Hardware close programming (C, C++)
  - Real-time systems

- Aggregation of data to gateways
  - A gateway often handles the Internet communication
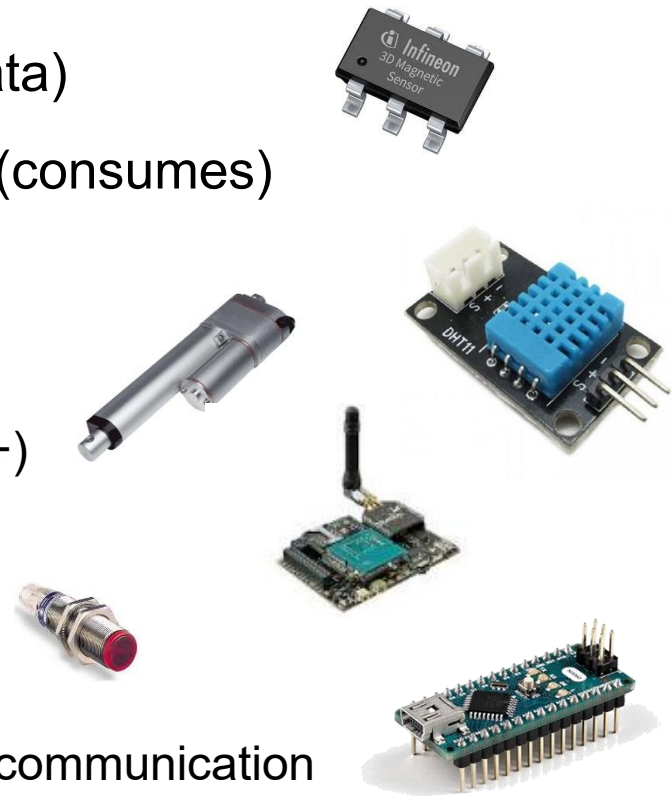
IoT Communication

IoT Communication

- To enable the value chain, communication is required between the links
  - Usually wireless and low energy technologies

- Low level protocols and technologies
  - Zigbee
  - Wifi
  - 6LoWPAN
  - NB-IoT
  - LoRa
  - Bluetooth
  - Ethernet
  - Industrial Ethernet / Profinet

- High Level protocols and technologies
  - HTTP/REST
  - MQTT
  - CoAP
  - Matter

IoT Platforms

- The platform saves and brokers data to all interested parties
    - Scalable (billions of devices)
    - Bidirectional (both sensors and actuators)
    - Search and find (naming and listing)
    - Event management (rules, interrupts, chains of events)
    - Storage (database)
    - Security (encryption, authentication, accounting)
    - API (to enable remote access)

- All large cloud providers have their own IoT systems
    - Microsoft Azure
    - Amazon AWS
   - Google Cloud
    - IBM Watson
    - Etc.

Cloud Computing

- Is actually a new market model, not a technological leap
    - "Pay for what you use"

- Infrastructure as a Service (IaaS)
    - Virtual machines running on the cloud systems
    - Replace local hardware with virtual hardware in a remote cloud

- Platform as a Service (PaaS)
    - Offer a virtual software platform to run applications in
    - Not a whole machine, only runtime environment

- Software as a Service (SaaS)
    - Use your web browser to access applications on a remote cloud
    - Replaces installed application on end devices

Fog Computing

- A new concept addressing some of the problems of clouds
    - Their long response times
    - Their central points of failure
    - Internet requirements

- A combination of cloud, edge, and P2P computing
    - "Low flying clouds" close to end user
    - Basically, cloud computing in end devices or near them
    - End devices are becoming more powerful

- Seamless transitions and local processing
    - Only send to cloud if it is a must

The Cloud/Fog/Mist Continuum
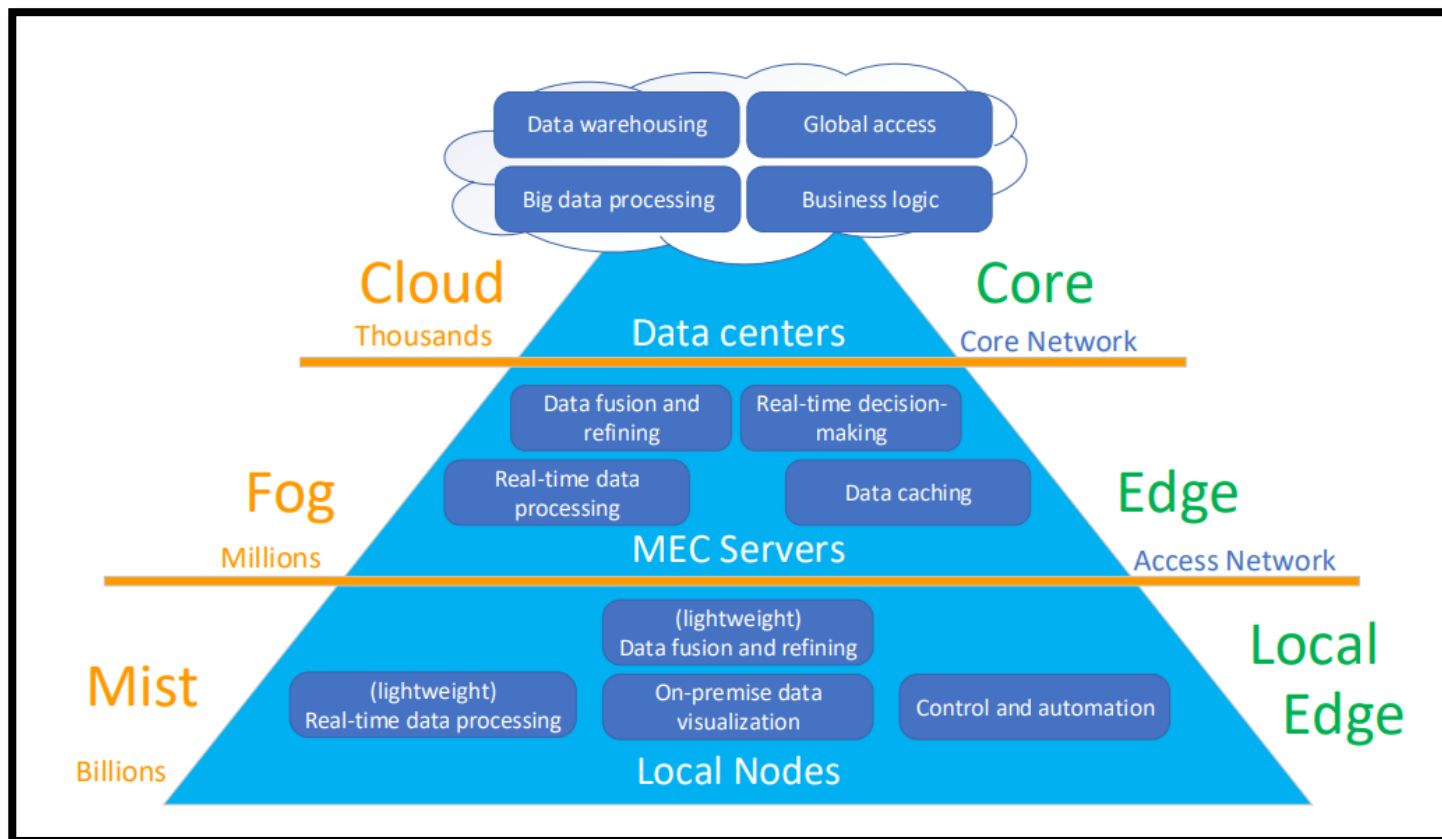
IoT Standards

Many IoT Standards…

Smart Services

Application Development

- Applications are written using the IoT platforms
  - Using its API, library, and functions

- Sensor, actuator and gateway applications
  - Sends and stores data in the platforms
  - Which then manages the data and makes it available

- End user applications presents data
  - Usually on a mobile app or web service
  - To then control actuators based on the sensor values

Data Mining

- Small Data
    - Sensor values
    - Mean nothing on their own…

- Big Data
    - Trying to make use of large amounts of small data
    - Has problems in itself: Storing? Naming? Searching? Etc.

- Data mining is the process of creating information from this data

- Ex: Classification analysis, association rule learning, anomaly or outlier detection, clustering analysis, regression analysis, etc.

Machine Learning

- Is to make a machine learn something from given information
    - To identify things, react to certain events, etc.

- Supervised learning
    - Give data and answers, let it learn by telling it what is right and wrong

- Unsupervised learning
    - Give it a problem and let it solve it by itself

- Ex: Decision tree, SVM, naive bayes, KNN, K-means, random forest, particle filtering, dimensionality reduction, gradient boosting, etc.

Artificial Intelligence

- Is to make machines act intelligently, like a human
  - Processing language and human communication
  - Playing games
  - Making guesses and interpreting probabilities

- Ultimate goal: IoT services that really understand <u>you</u>

- Ex: Heuristics, neural networks, deep neural networks, markov decision process, natural language processing, etc.

IoT Security and Privacy

- We are certain that the IoT will have much data on us
    - Which creates serious security and privacy problems
    - Implications of GDPR?

- What will the IoT information reveal about me?
    - What am I willing to share?
    - Who owns the information?

- Low power? Secure encryption? Fast communication?
    - You can only pick one!

Making it all come together in the Vision
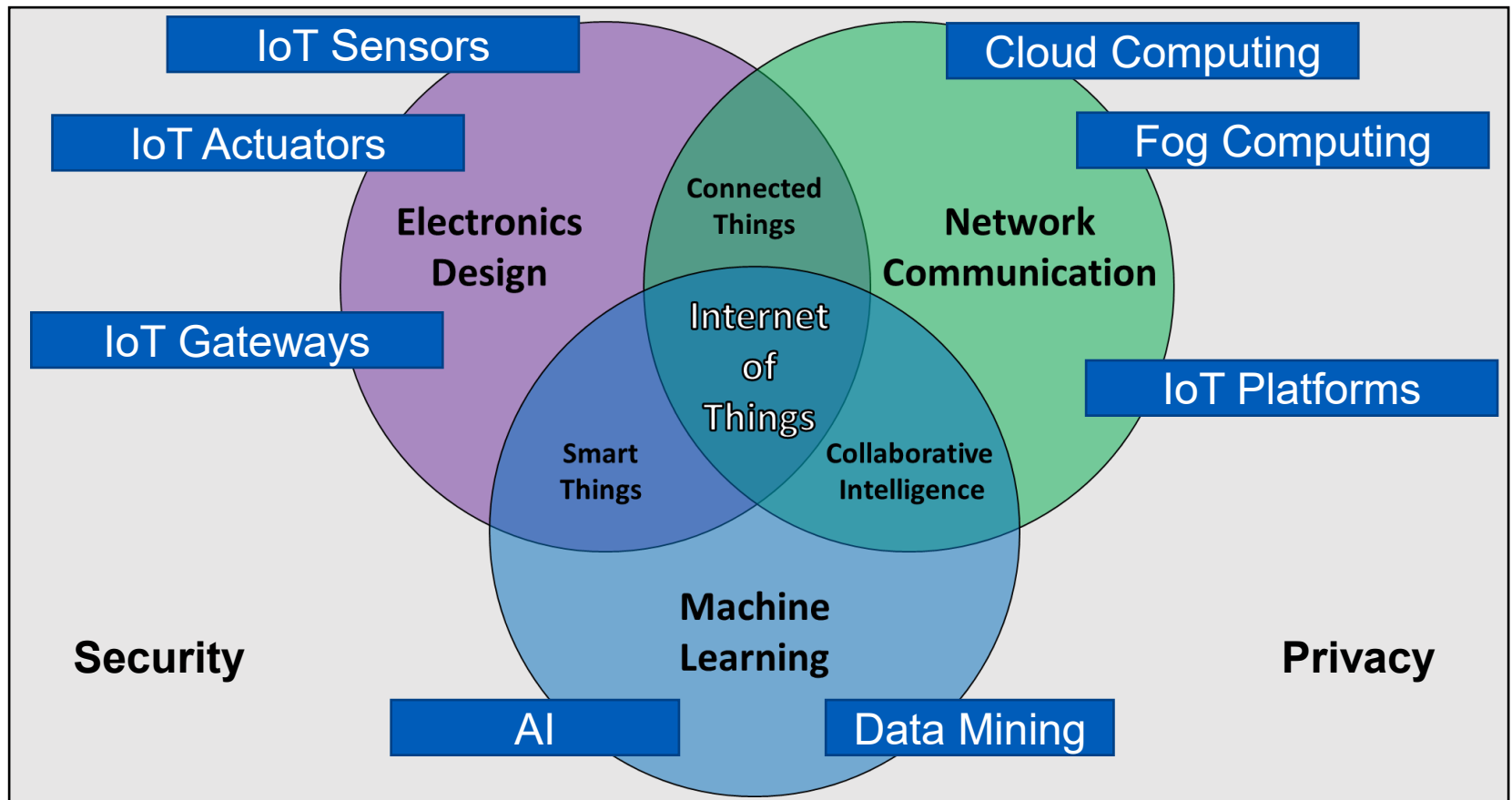
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