A very short introduction to AIoT

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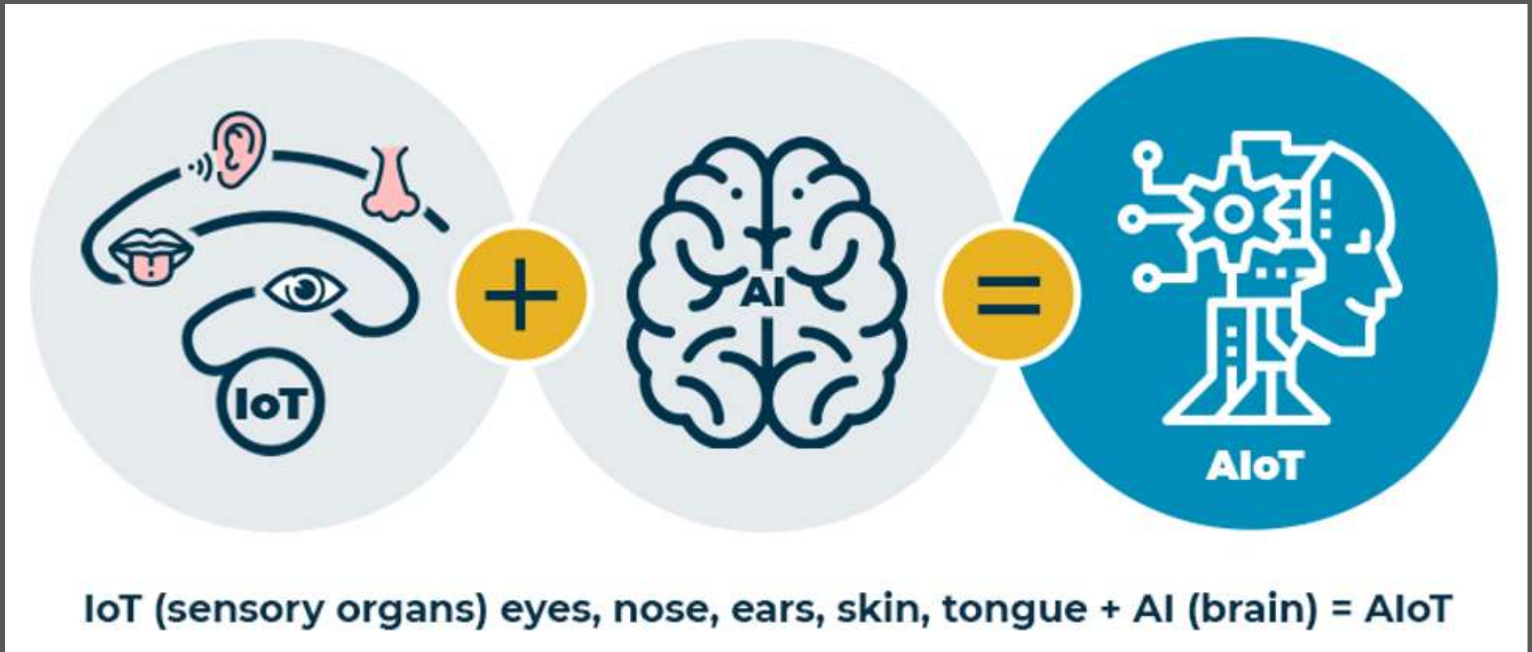
Roadmap

- What is AIoT?
- Why AIoT?
- From IoT
  - Architecture
  - Sensors
  - Transmission
  - Presentation
- To AIoT
  - Server / Cloud side AIoT
  - Edge AI + IoT
- Prospects
  - Applications

What is AIoT?



(Anant Desai, 2020)

Internet of Things + Artificial Intelligence

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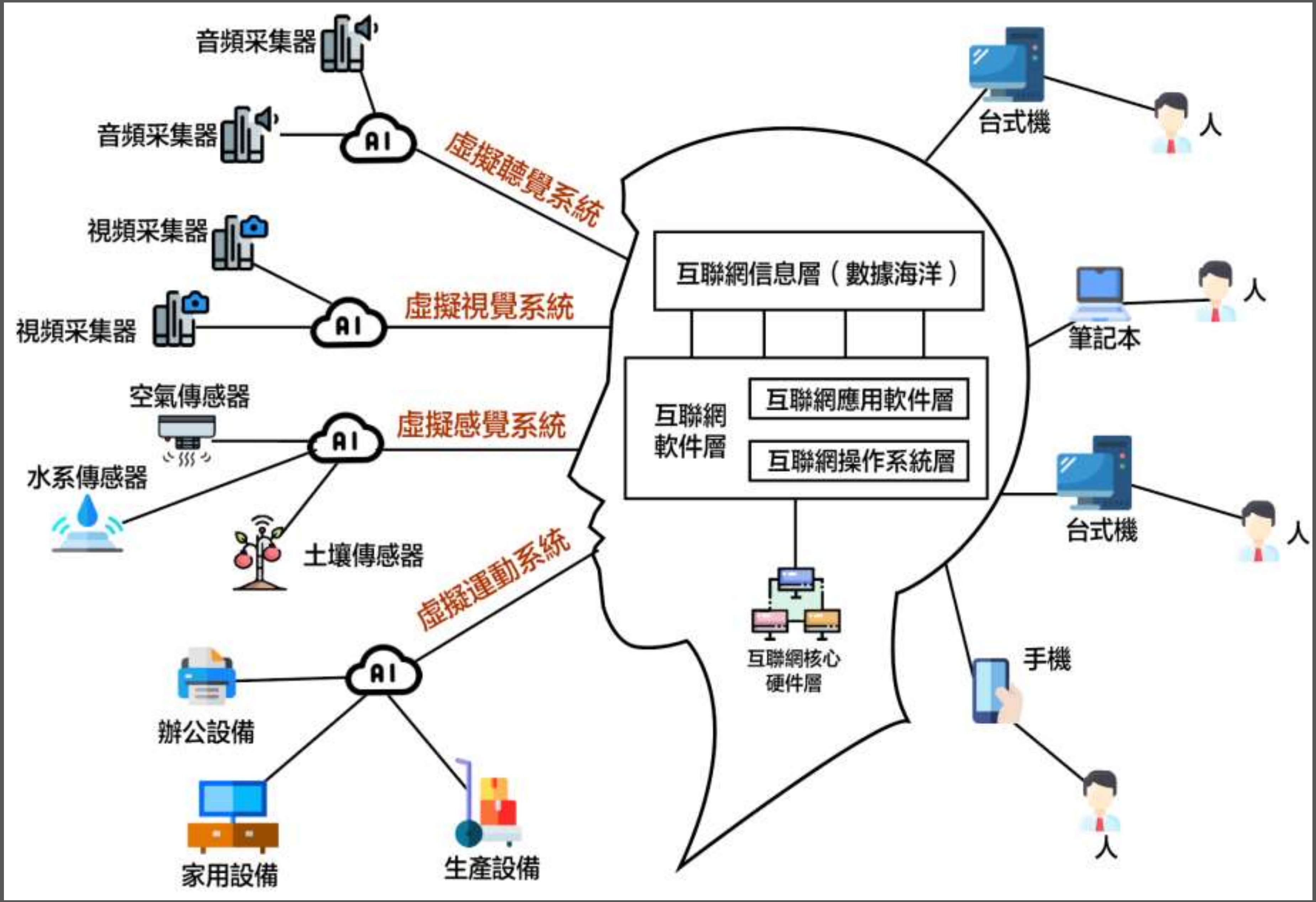
Artificial Intelligence of Things

IoT

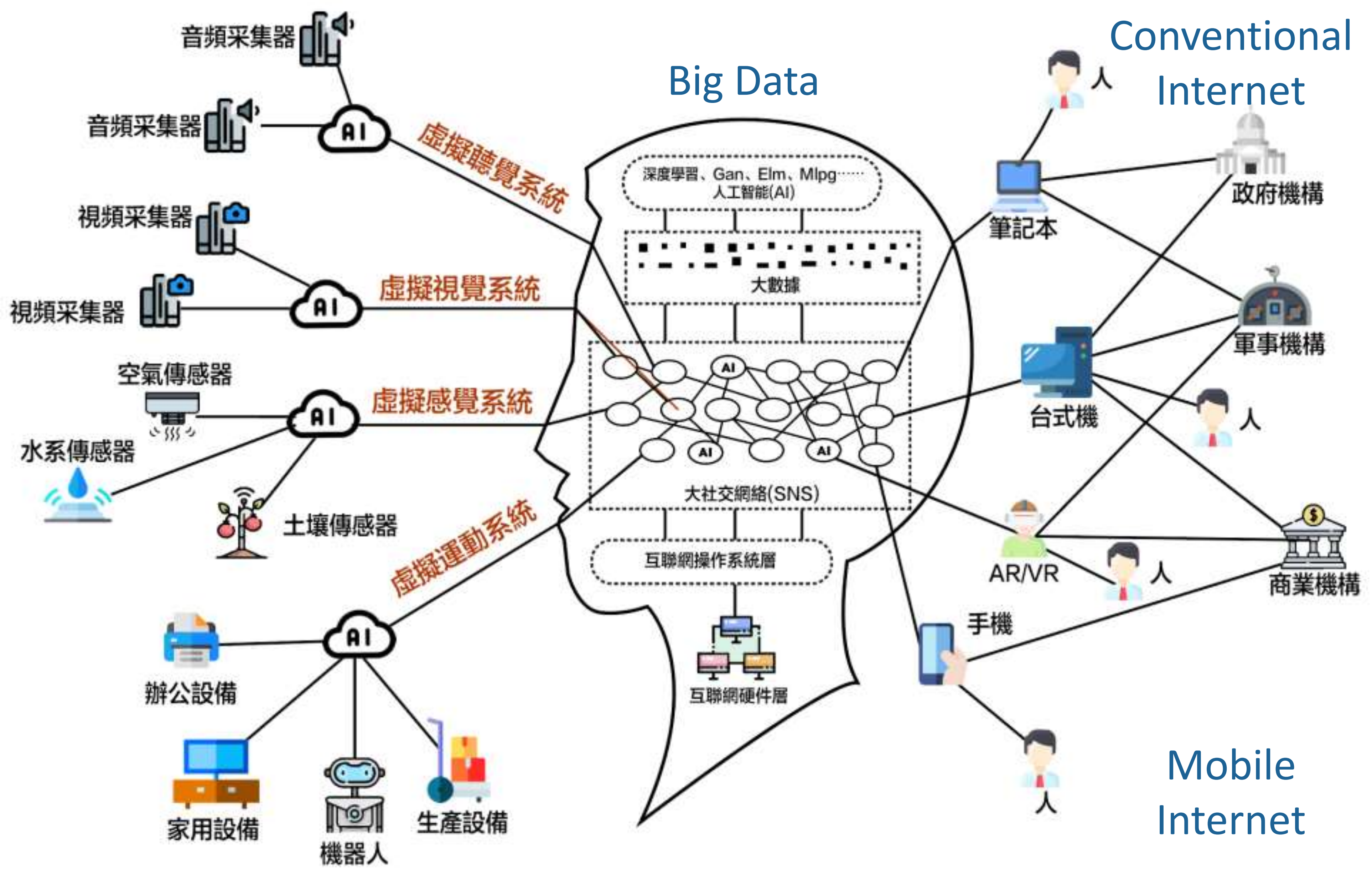


Conventional Internet

Mobile Internet

(zi-media, 2010)

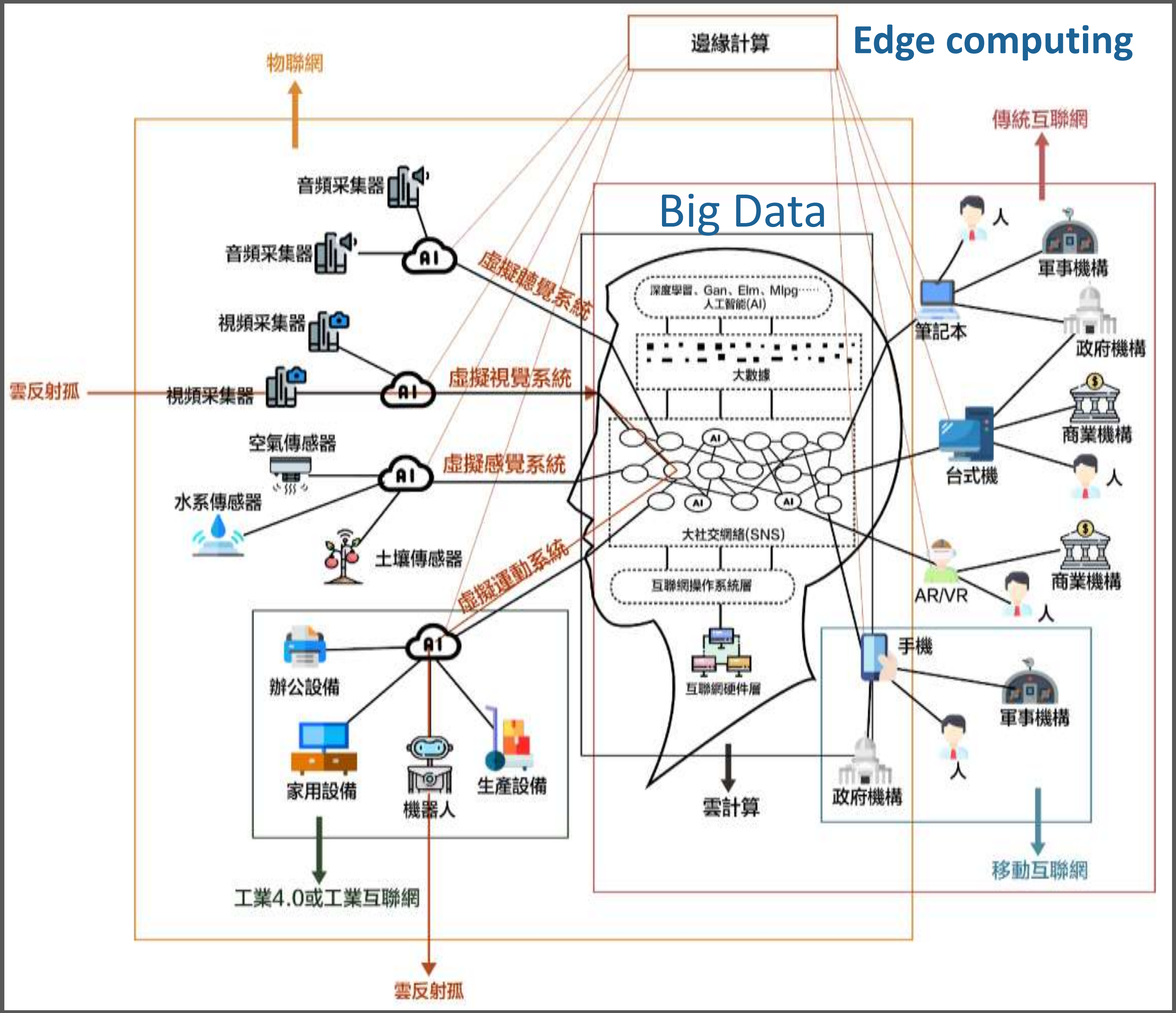
IoT



(zi-media, 2017)

IoT

Industry 4.0



Conventional Internet

Mobile Internet

(zi-media, 2021)

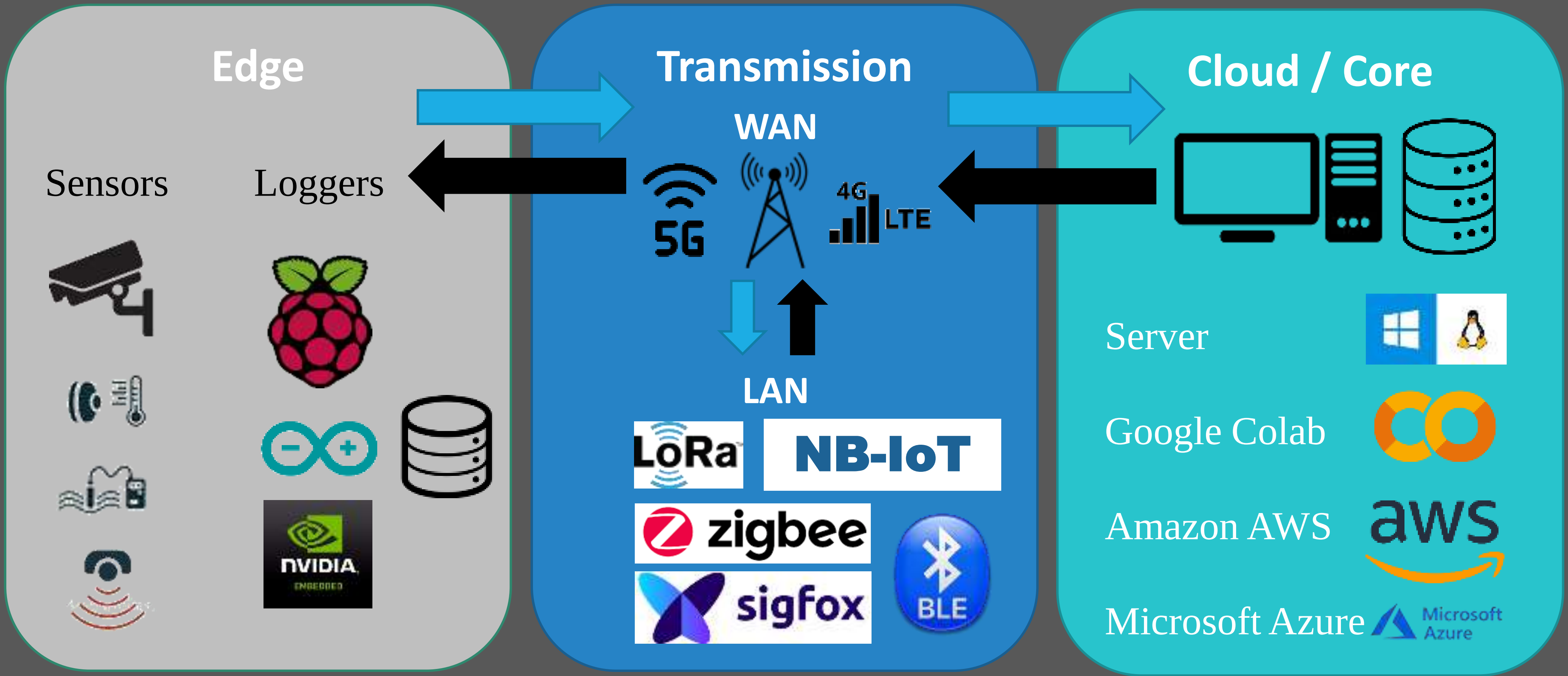
Why AIOT?

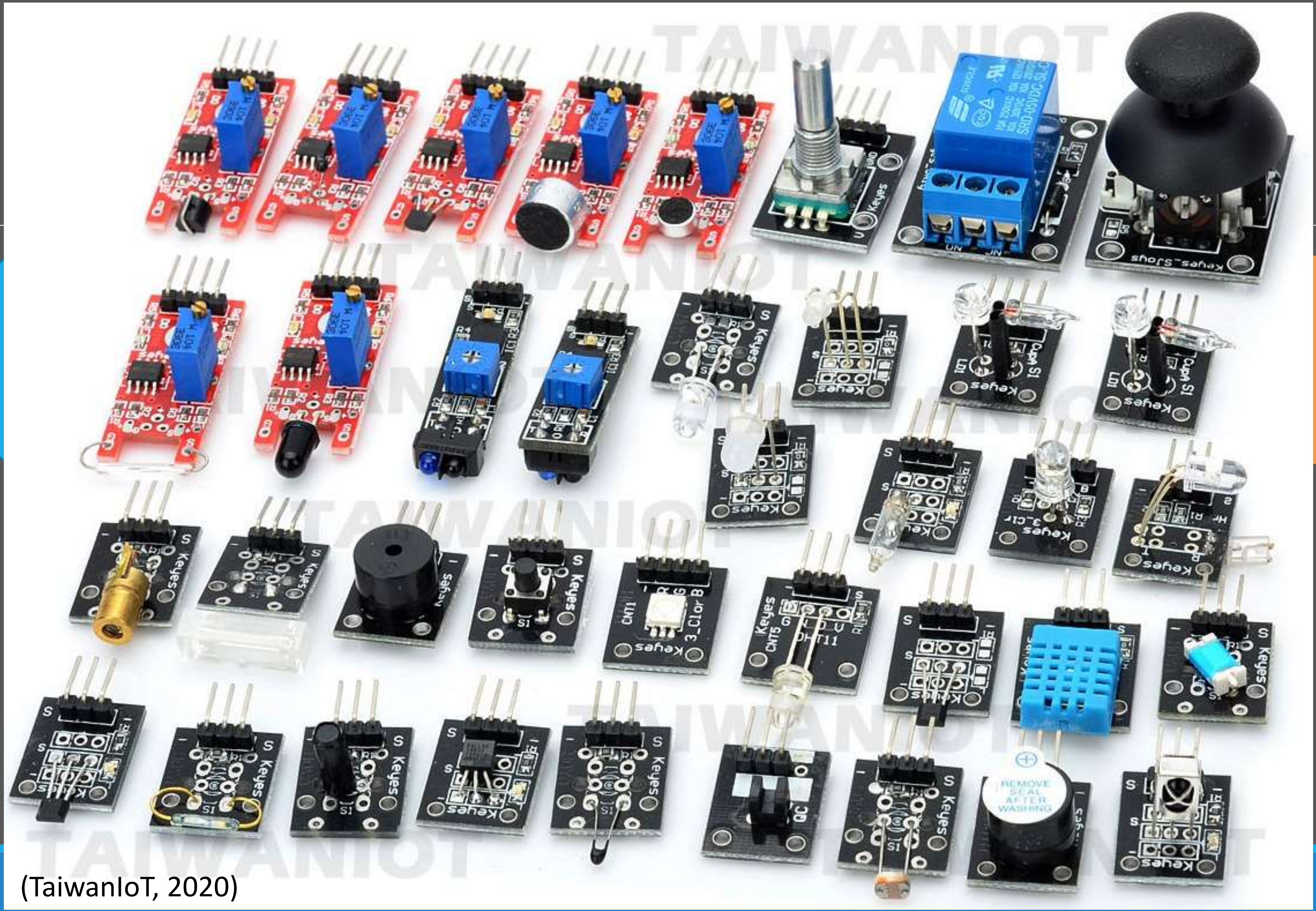
- Progression of computing technology allowed rapid data reduction and even artificial intelligence (AI) inference
- Full automation, less human effort required
  - Increase frequencies of measurement, data reduction, information interpretation
  - Reduce delay in data interpretation
  - Early detection and 24/7 monitoring
  - Cost-effectiveness in mass deployment
- Embrace unknowns through AI

Year	Papers published IoT	Papers published AIoT
2010-2015	23000	0
2016-2017	86300	645
2018-2019	164000	1290
2020	68400	1020
2021	44700	788

From IoT

IoT – Architecture



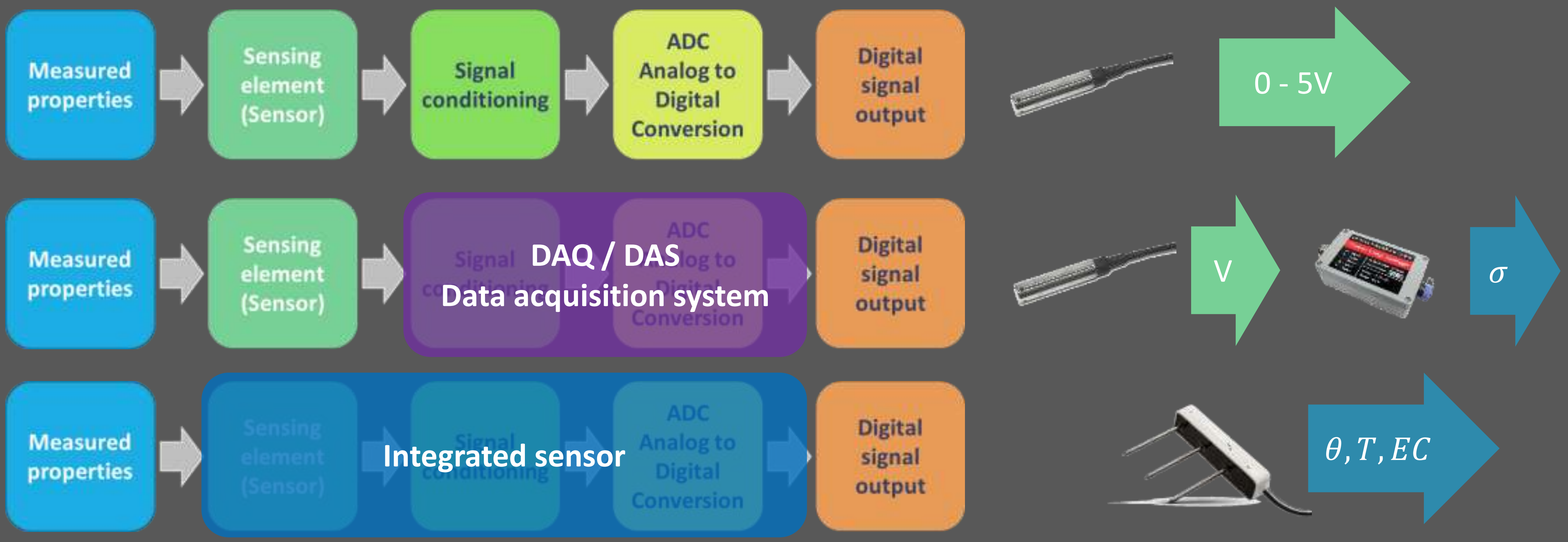


(TaiwanIoT, 2020)

IoT – Sensors

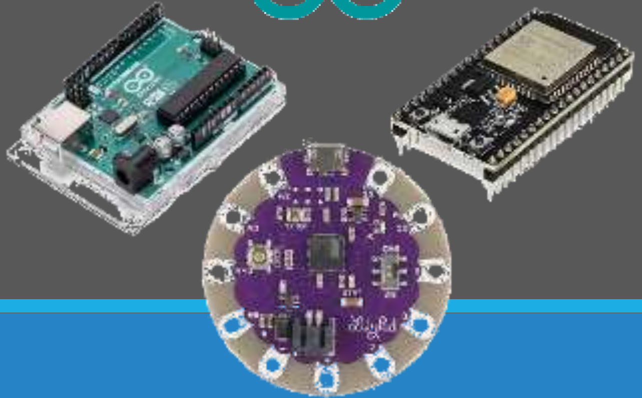
- Geotechnical applications
  - Surveillance image
  - Inclination angle
  - Water level
  - Soil moisture
  - Pressure sensor
    - Overburden / back pressure of soil
  - GPS/GNSS
  - Temperature/humidity
  - Precipitation/rainfall
- Civil engineering applications
  - Vibration sensor (structural)
  - Inclination sensor
  - Flow rate
  - Turbidity

IoT – Sensors + Loggers



IoT – Data loggers

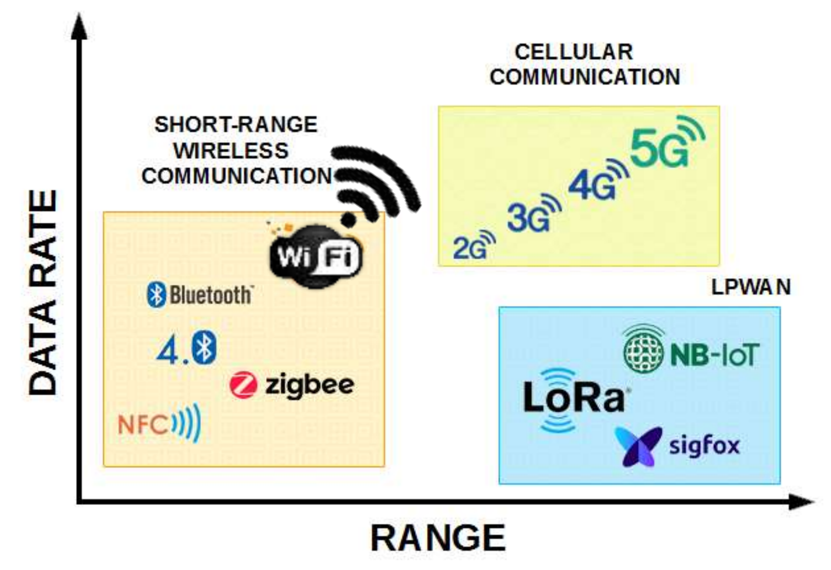
- Data logger is required to store/send acquired data
  - Micro-controllers (μC)
  - Single-board computer (SBC)
  - Embedded system (PC form)
- Ruggedness, small form factor
- Low power consumption
  - Usually 0.1W-10W
- Rich with GPIO (general purpose input/output)
  - ADC
  - Sensor communication interfaces
    - Synchronous
      - SPI : Faster, needs more wiring
      - I2C : Slower, only needs 2 wire
    - Asynchronous : UART, USB, RS-232, RS-485
      - Needs same baud rate
      - 1-to-1 communication, non-blocking, RX-TX concurrent



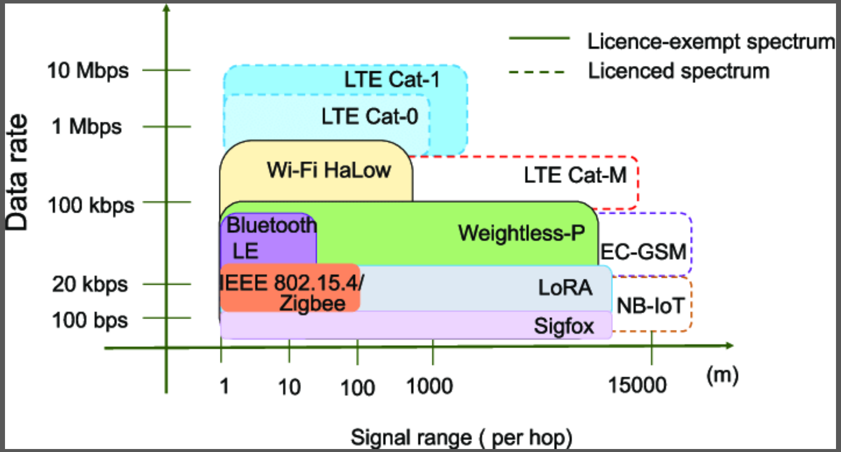
Embedded system

IoT – Transmission

- From data logger to server / cloud service
  - Connect local host/logger to centralized server
  - Involving WAN and LAN
- Some considerations for mass deployment
  - Wireless vs Wired connection
  - Low power consumption
  - Link budget (Transmission distance vs. Data rate)
  - Subscription cost
  - Security

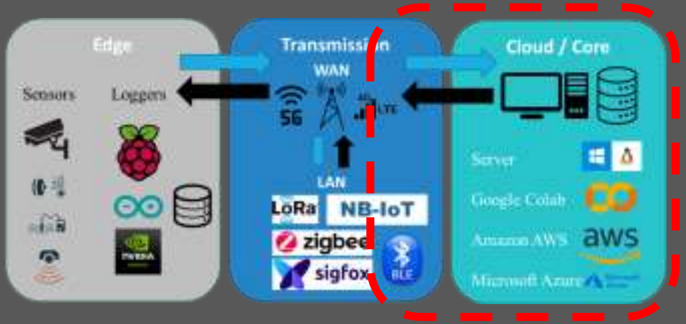


(Arun Kumar V, 2019)

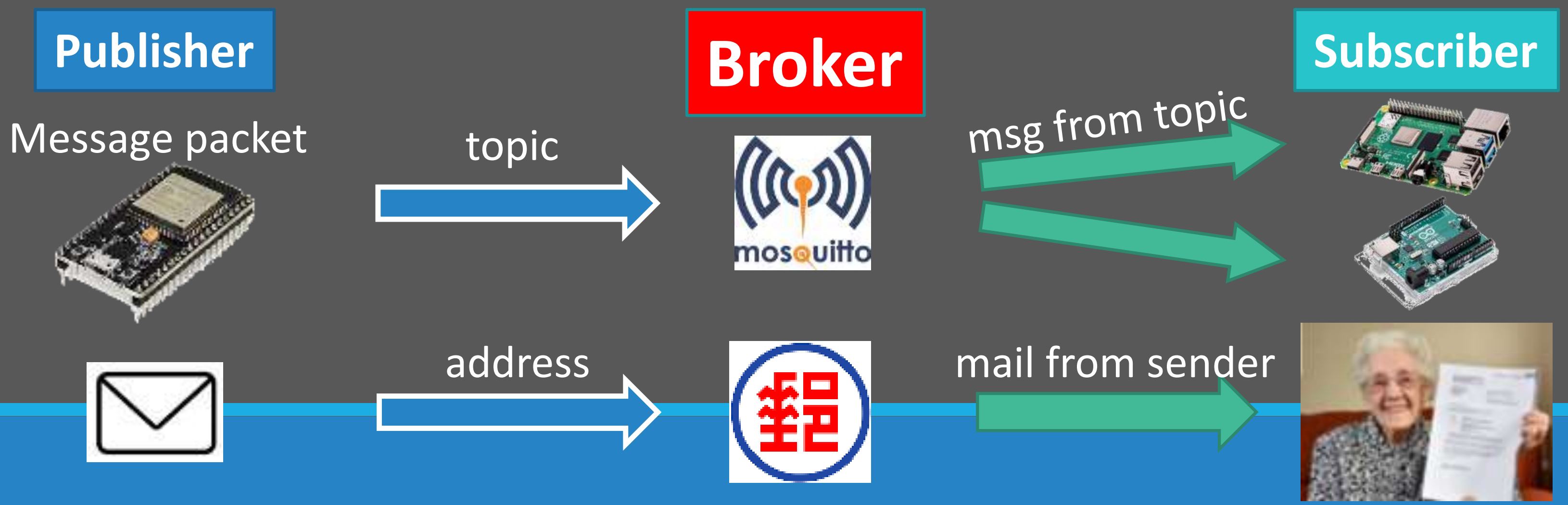


(Nguyen et. al, 2019)

IoT – Interfaces

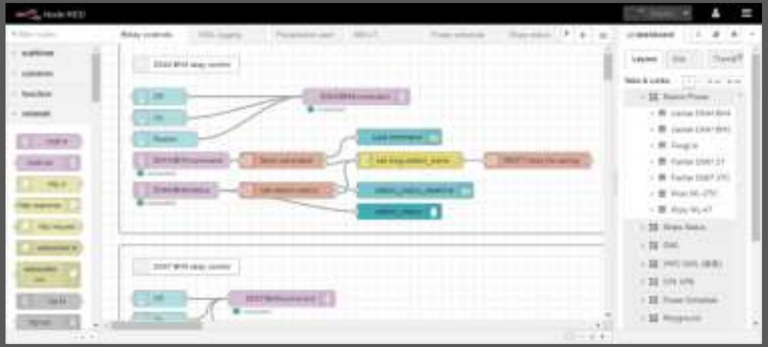


- How to communicate data into database?
- MQTT is the most popular IoT communication protocol
  - Apart from Websocket (http), CoAP, AMQP
  - File synchronization service (Dropbox, Google Drive, OneDrive etc.) is too bulky for IoT
- MQTT is analogous to a post office system



IoT – Presentation

- Presenting IoT data in a meaningful way
- Node-RED
  - Easy, rapid programming tool based on Node.js for wiring IoT components together
  - Hardware devices, APIs and online services
  - Browser-based editor with **flows** that lets user directly visualize data flow directions
  - Easy deployment on local host, device, cloud
- Or other frontend language
  - JavaScript, Python, Java, C++
- Further integration with AI
  - TensorFlow.js, machine learning



To AIoT

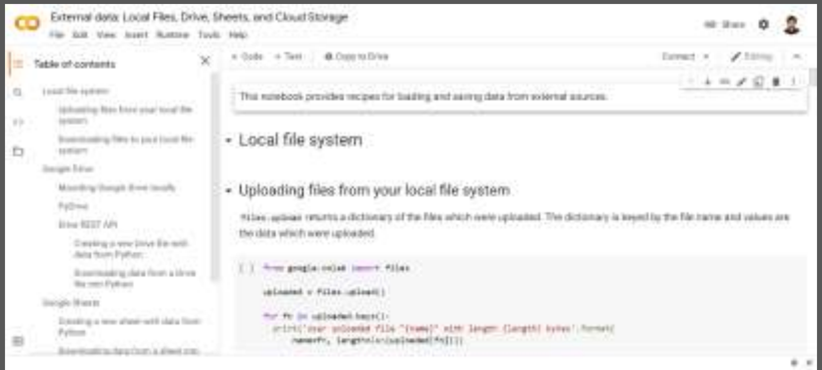
How to AIoT?

- AIoT makes IoT even more useful
  - allows user gain understanding quickly
  - deduce key information from big data
- How to incorporate AI into IoT architecture?
  - Value-added analysis at server/cloud side
  - Edge AI
- AIoT at server/cloud side
  - Deep learning/machine learning on accumulated sensor data
  - Useful information is extracted using AI models from big data
- Edge AI
  - Key info is extracted in edge systems before transferred via IoT
  - No internet is needed

(Kavita Char, 2021)

Server/Cloud AIoT

- AI analysis on IoT data stored at server/cloud services
- Train and implement deep learning/machine learning models on measured sensor data
  - **Extract** data patterns from big data
  - **Interpret** and identify potential pattern from IoT data
  - **Infer** possible outcome when new data arrives
- Performed on either self-hosted server or cloud services
  - Google Colab, Amazon Sagemaker, Microsoft Azure
  - Cloud services offer CPU/GPU resources for deep learning
  - Less maintenance required, pay-as-you-use
- Google Colab is popular amongst AI researcher
  - Training data can be accessed from Google Drive directly
  - Access to PyTorch, Keras, TensorFlow, and OpenCV



Edge AI + IoT

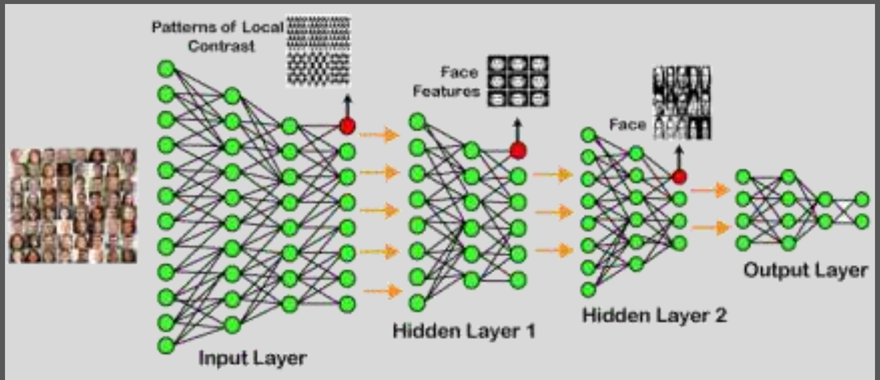
- Most AI applications ran in cloud/serve due to complexity of ML in the past
- **Why Edge AI?**
  - Transmission bandwidth for real-time image / video is too demanding
  - Requires real-time response and interpretation
  - Demand low network latency (low ping)
  - Low power, lower cost
  - Concern to data privacy and security
- Why is it possible now?
  - Higher computational capability on edge devices
  - GPU/TPU/Neuron sticks available to speed up AI computation at the edge

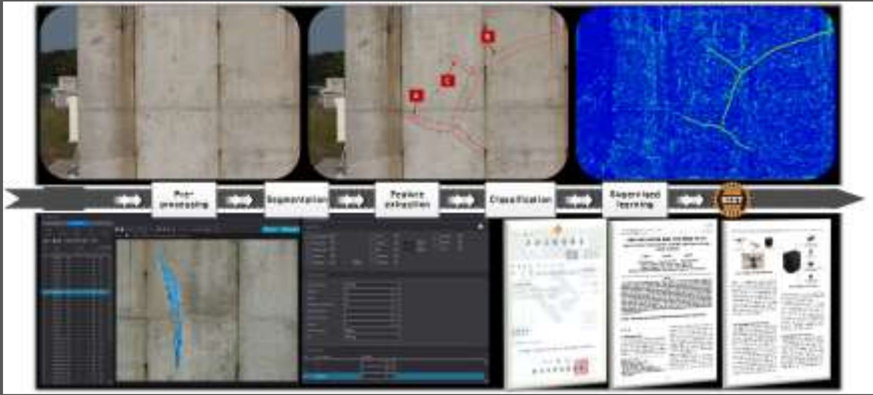
- Common applications
  - Image classification
    - Face recognition
    - Traffic control
  - Autonomous vehicle
  - Vibration analysis
  - Voice processing
  - Computer vision

Prospects

What happens from AIoT?

- Increased operational efficiency
  - AIoT process and detect patterns in real-time data that are not visible to the human eye
  - Instantaneous pattern deduction optimizes production processes and improve workflow
  - Increased efficiency and reduced operational costs
- Improved risk management
  - Risks identification in a timely manner
  - Increase safety and reduce loss
  - E.g. early detection on mechanical faults on airlines and safety risks in machineries
  - Allows for predictive maintenance
  - Reduced unplanned downtime





What happens from AIoT?

- New products and services
  - Process and draw insights from large data
  - New techniques
    - voice recognition, face recognition and predictive analysis
  - New services
    - Autonomous delivery services, smart video doorbells, voice based virtual assistants
    - Predictive maintenance for vehicles or building automation systems
    - Disaster search and rescue operations

- Enhanced / targeted customer experience
  - In retail, AIoT tailors shopping experience and gives personalized recommendations
  - Based on customer behavior, demographic information and customer

Applications

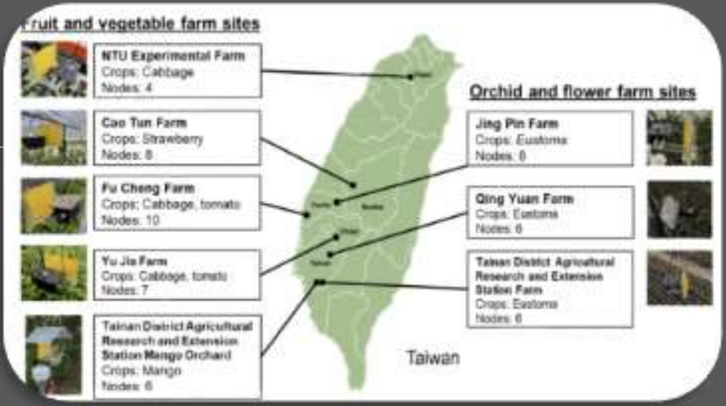
- Intelligent agriculture
- Smart home
- Crowd control
- Traffic detection
- Autonomous vehicle (self-driving cars)
- Healthcare
- Power generation
- Sediment monitoring…

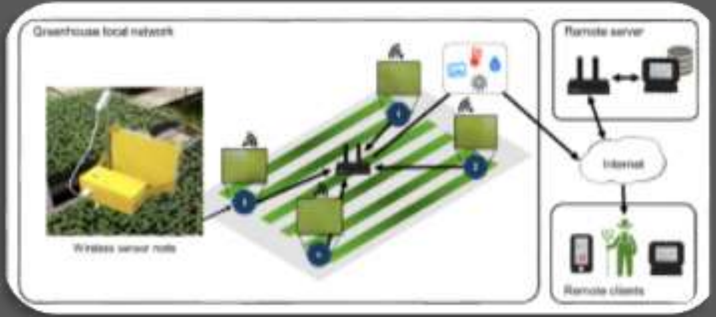
Traffic detection using Yolo v3

Tesla AutoPilot CV

Intelligent agriculture

- Agriculture is one of the earliest sector with IoT involvement, so naturally is AIoT
- Intelligent agriculture system
  - Adjustments based on collected sensor data
  - Weather, water usage, temperature and crop/soil conditions
  - From fuzzy logic to machine learning based action
- AIoT in agriculture
  - Smart management on irrigation, fertilization, pest control
  - Assist in resources utilization, yield enhancement, seasonal forecasting, crop planning
- AI + computer vision (CV) to monitor crops and large farmlands
  - Early detection of pest, intruder, hazard and so forth





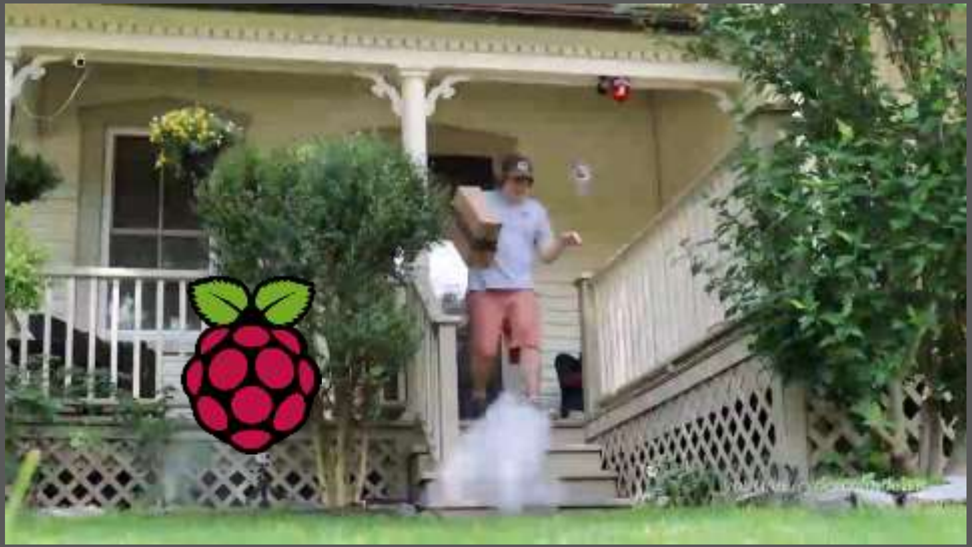
(Lin and Rustia, 2019)

Smart home

- Home assistant
  - Open source system to home automation
  - Rich integration with node-red, MQTT, Zigbee, BLE, IKEA, Google, AWS, so much more
  - **Presence detection**, intruder alert, temperature control, power consumption …
- Closed-source/ proprietary home automation
  - HomeKit (Apple), MiJia (XiaoMi), Amazon Echo, SmartThings
- Interesting example
  - Raspberry Pi controlled intruder alert
  - Identify thieves with AI and CV
  - Custom TensorFlow model => recognize package
  - TF + Python => signal the alarm system

Works with Apple HomeKit

amazon echo



SSC monitoring

- Suspended sediment concentration (SSC) monitoring in reservoir/river
  - Almost AIoT, data is processed at the edge systems, but being transferred through conventional file sync system
  - Current implementation maybe limited by the data amount required for AI inference

- Potential AIoT application
  - Plugging in observation data and simulation data into AI model
  - Connect more multi-variate data, such as flowmeter, water level gauge at multiple sites
  - To predict formation probability of density current/target with predictive hydraulic model
  - Assist in reservoir management

Interested?

- Start from IoT first!
- Node-red + MQTT + Arduino
- Follow-up short courses on 20210930
  - Smart field monitoring with IoT
    - Current practice in slope monitoring
    - Station control
  - A Very Brief Introduction to AI
    - Teachable machine – hosted by Google
    - Hands on Tensorflow : Handwriting recognition
    - TinyML – suitable for Edge AI in small MCU (Arduino Nano 33 BLE Sense, ESP32)

End of presentation

THANK YOU!