

# Internet-of-Things Infrastructures and Applications

# What is Internet-of-Things?

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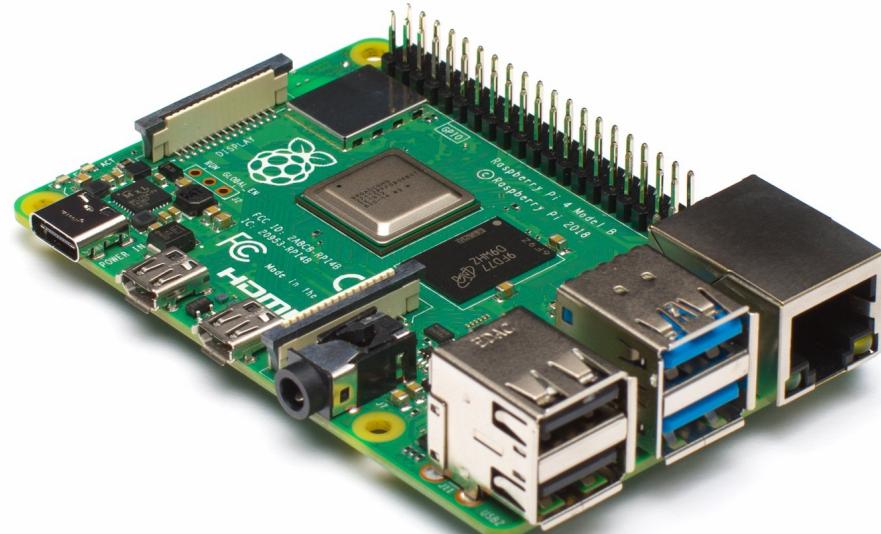
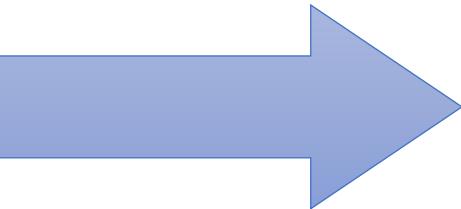
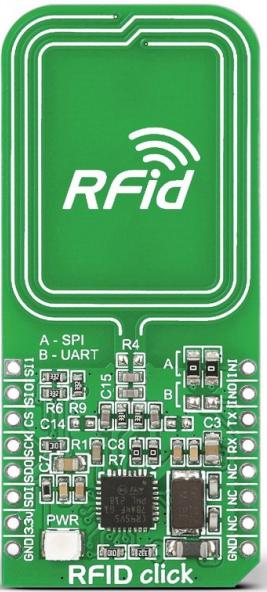
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# Enabling technologies for IoT

- Sensor technologies
- Communication technologies
- AI and data analytics technologies

# Sensor technologies



Raspberry Pi 4

# Sensor technologies

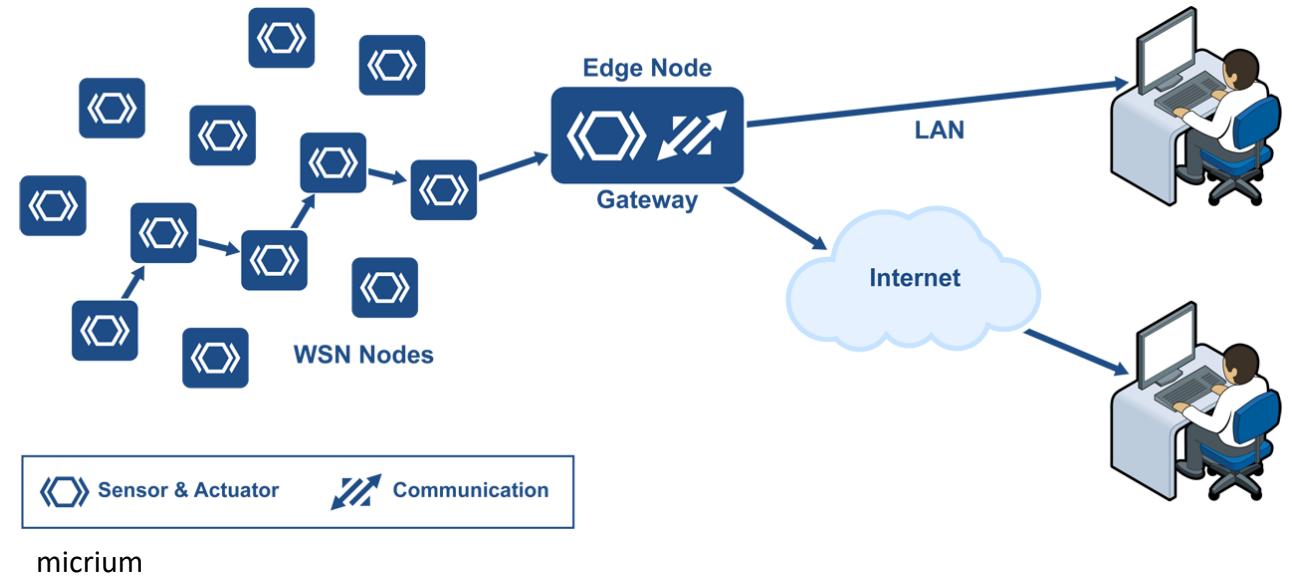
- Integrated circuits with
  - Smaller size
  - Lower cost
  - Higher energy efficiency and reliability



- A barometric altimeter: measure altitude
- An electrical heart sensor: take ECG readings
- An accelerometer: keep tabs on movement
- An optical heart sensor: measure heart rate
- A gyroscope: track movement and rotation
- An ambient light sensor: control the screen brightness

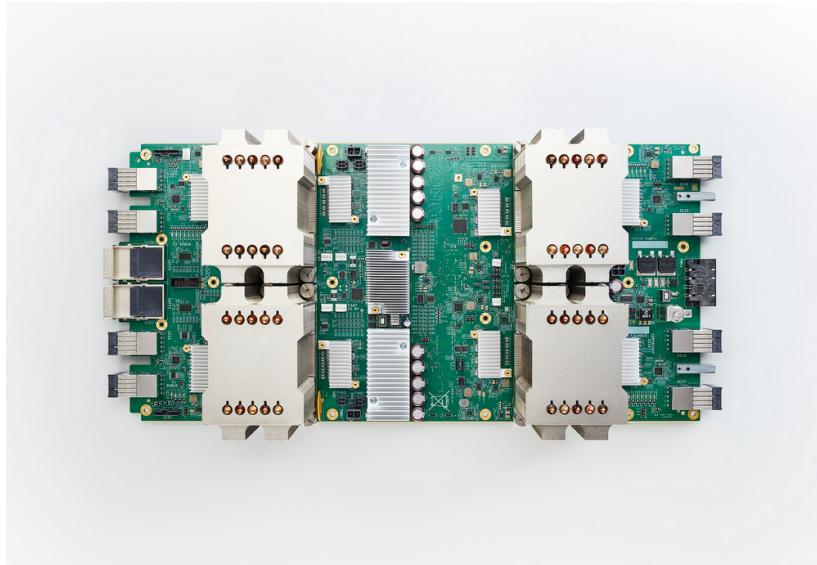
# Communication technologies

- Wireless sensor networks
- Mobile communications
  - Bluetooth
  - WiFi
  - Cellular
- IPv6
- New data formats and protocols
  - Bursty transmission
  - Low-power communication

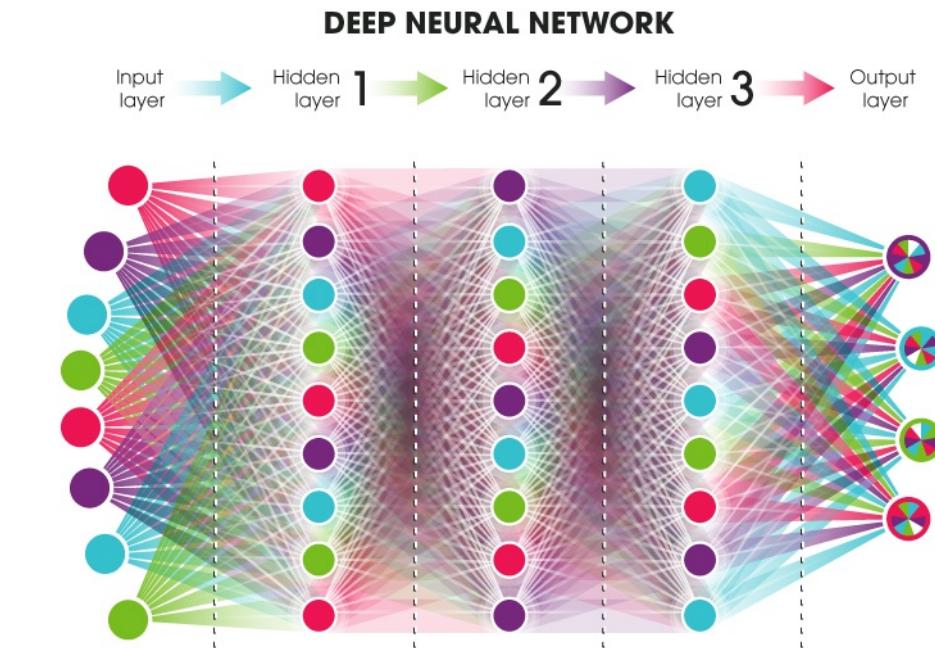


# AI and data analytics technologies

- GPU, TPU
- Deep neural networks
  - CNN, RNN, Transformer
- Algorithms



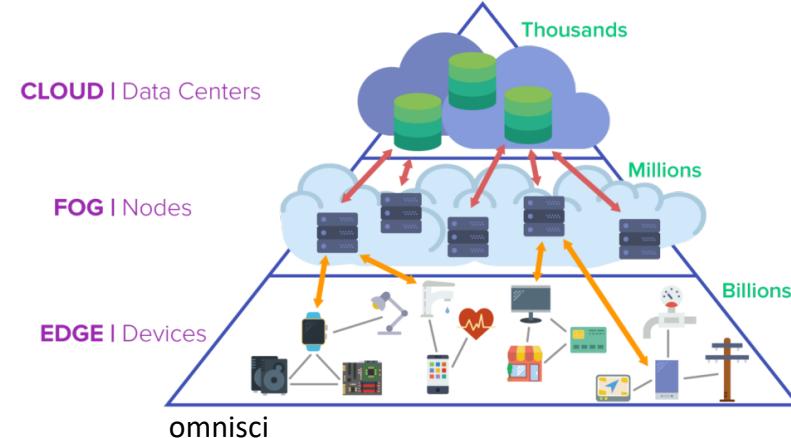
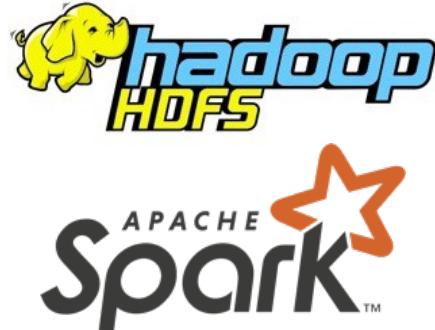
Google cloud TPU



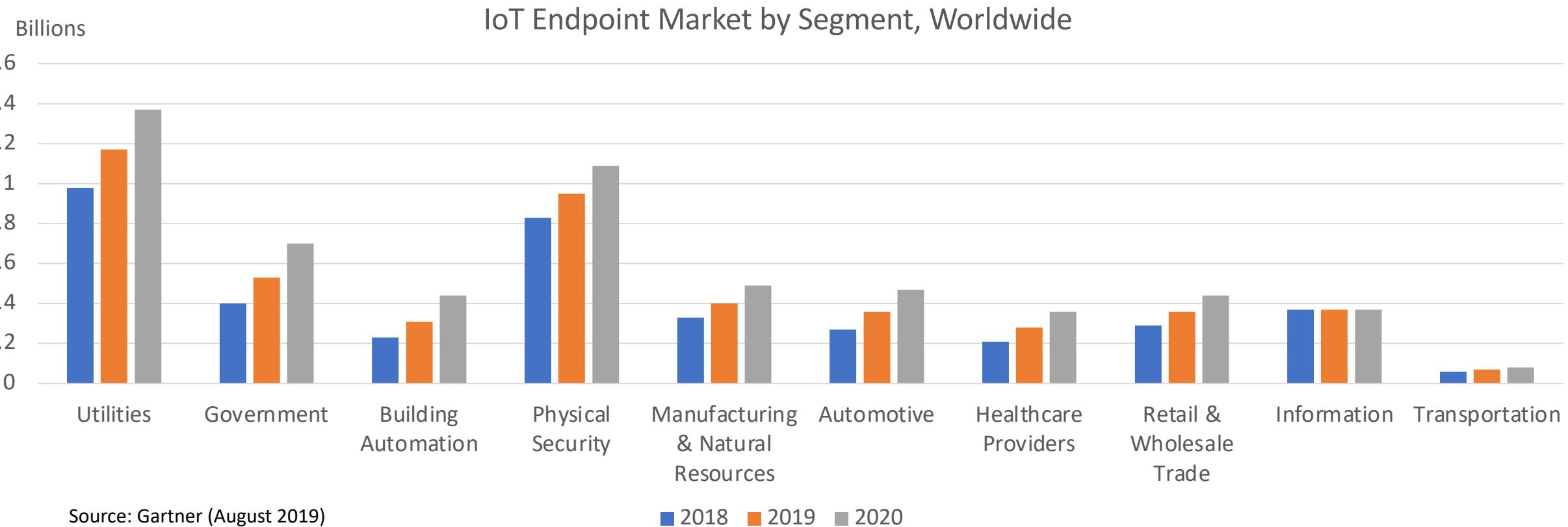
neuralnetworksanddeeplearning.com - Michael Nielsen, Yoshua Bengio, Ian Goodfellow, and Aaron Courville, 2016.

# AI and data analytics technologies

- Computing systems
  - Data storage/management
  - Data processing/mining
  - Service deployment
- Computing paradigms
  - Cloud
  - Edge/Fog
  - Hybrid



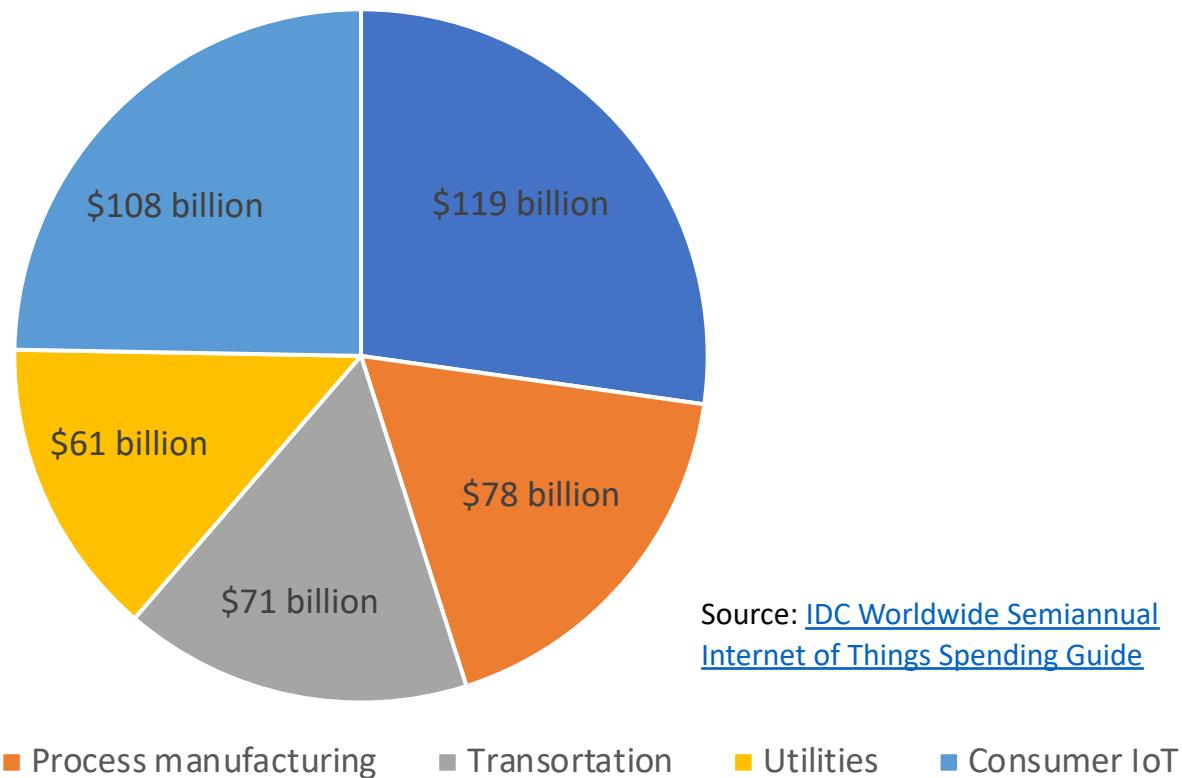
# How big is the IoT market?



- Total number of connected IoT devices is expected to reach 41.6 billion by 2025

# How big is the IoT market?

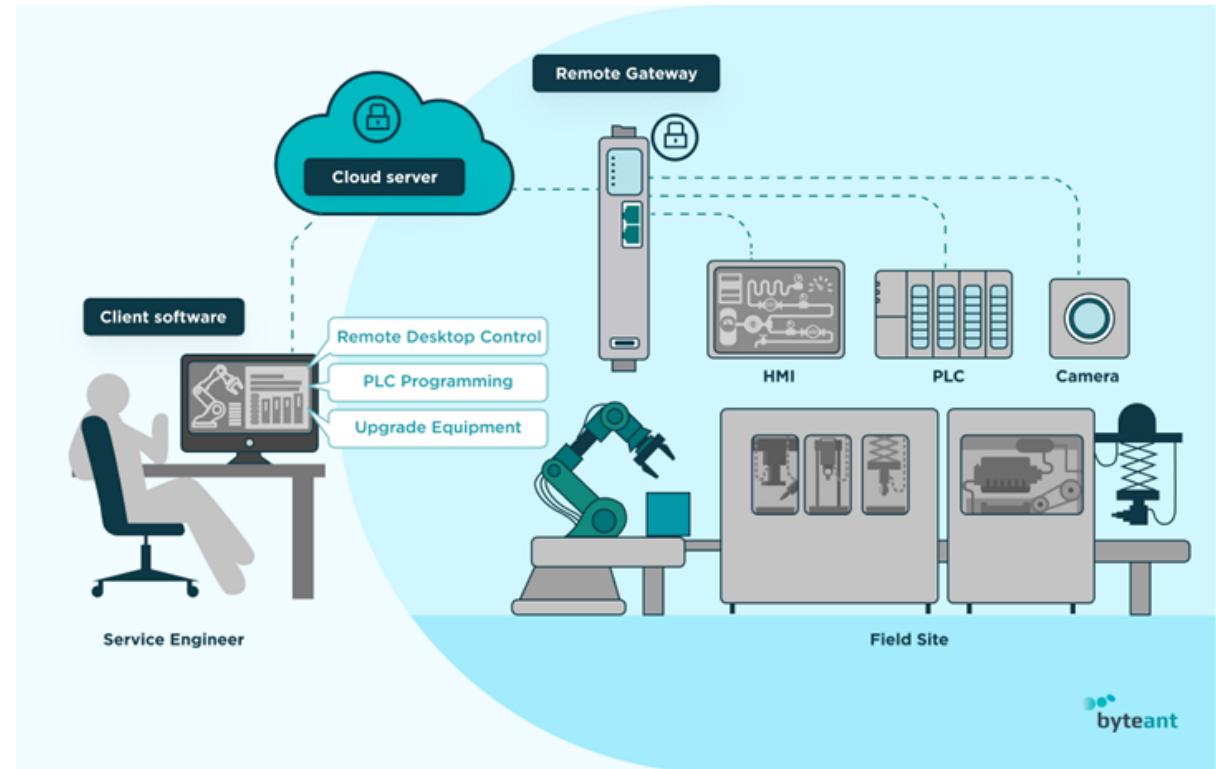
IoT Worldwide Spending in 2019



- IDC expects the worldwide IoT spending to surpass \$1 trillion by 2022

# Use cases: Industrial IoT (Industry 4.0)

- Predictive maintenance
  - Avoid unexpected downtime
  - Prolong device lifetime
  - Reduce maintenance cost
- Logistics management
  - Asset tracking
  - Supply chain optimization
  - Autonomous transportation



# Use cases: Smart city

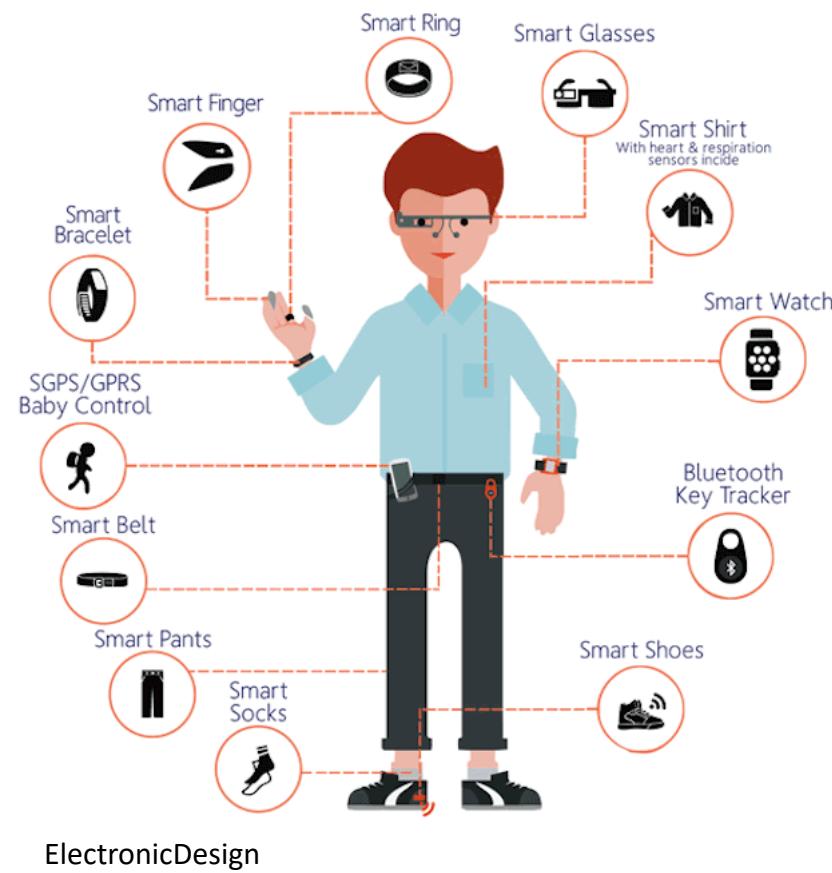
- Transportation
  - Smart traffic lights
  - Connected vehicles
  - Smart parking
- Utility
  - Smart meters
  - Smart homes
- Public safety
  - Environment monitoring
  - Crime prediction/prevention



scnsoft

# Use cases: Smart wearable

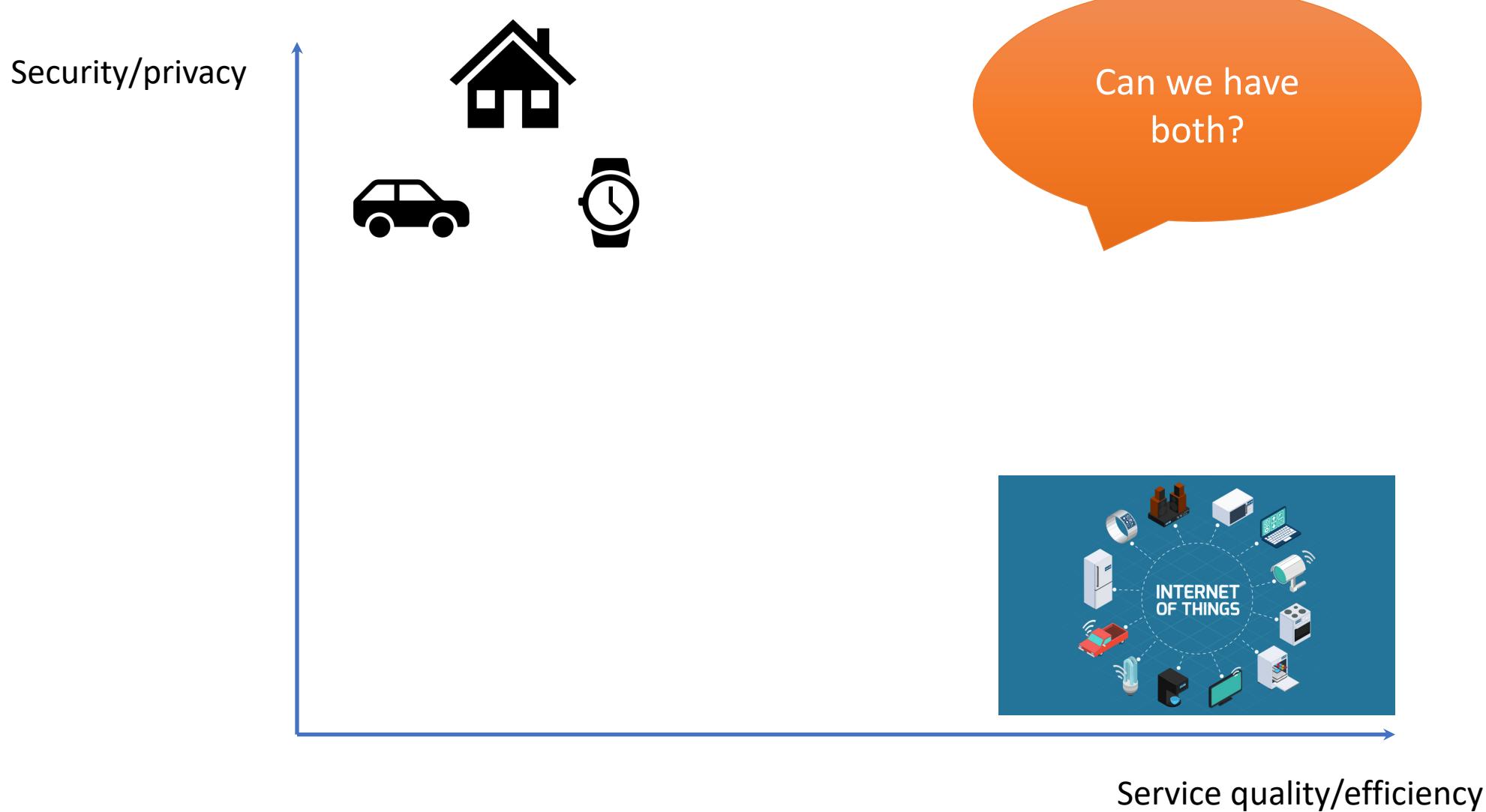
- Smart watches
- Fitness trackers
- Wearable cameras
- Smart glasses



# Challenges and Opportunities

- Privacy
  - Data/privacy breach
- Security
  - Hacked systems
  - Software bugs
  - Serious physical-world consequence

# Challenges and Opportunities

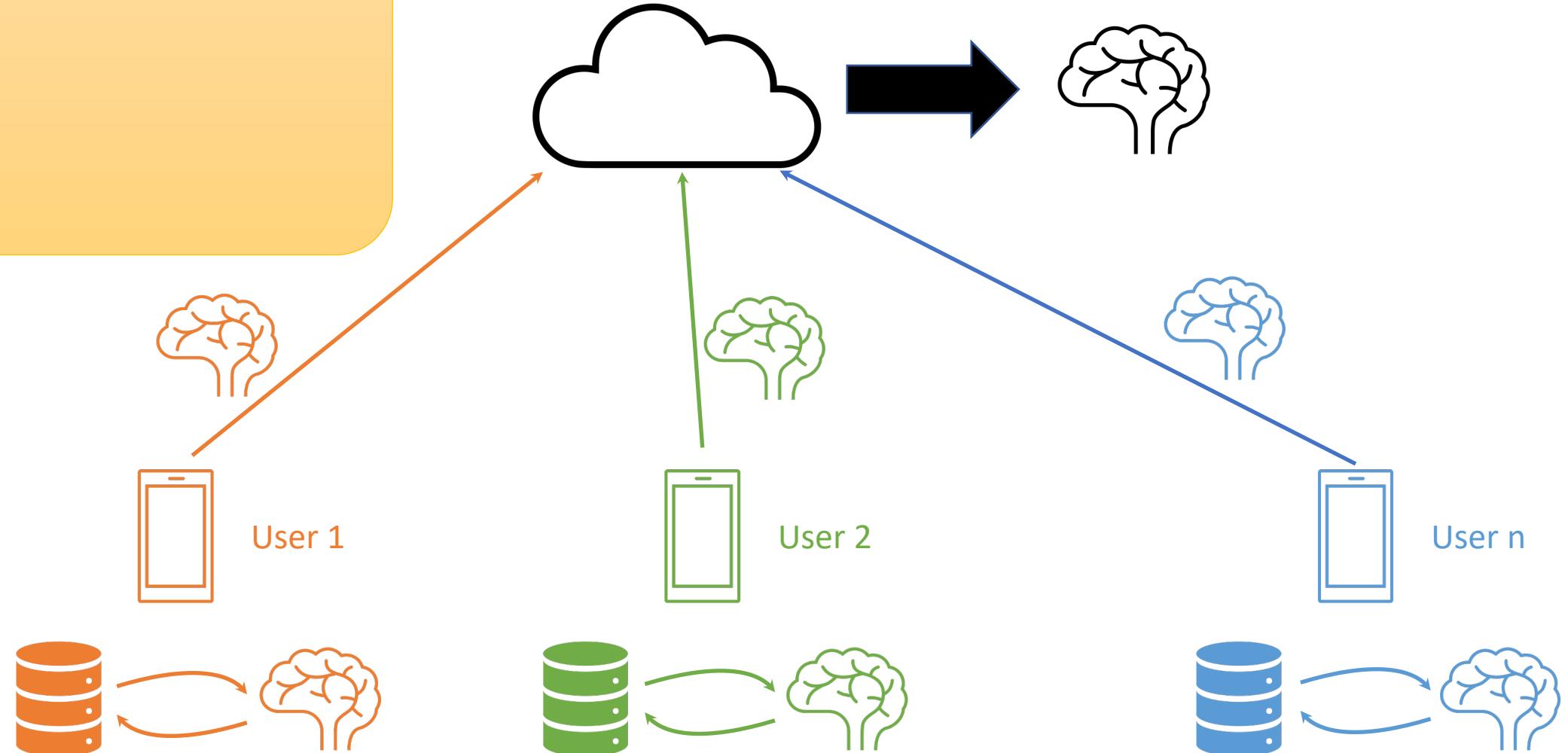


# Research problems

- Data privacy
  - Secure hardware/execution environment (e.g., Intel SGX)
  - Homomorphic encryption, functional encryption
  - Secure multi-party computing
- Secure computation
  - Verifiable computing
  - Zero-knowledge proofs
  - Coded computing

# Federated machine learning

Challenges?



# Federated machine learning

Challenges?

- Non-iid data
- Fairness
- Security
- Robustness
- Scalability

