Internet of Things in Agriculture

Dr. Qingzhi Liu

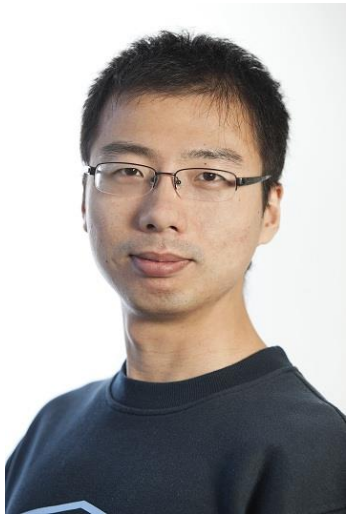
WAGENINGEN
UNIVERSITY & RESEARCH

Who am I?

- **Lecturer**
- **Information Technology Group, WUR.**
  - ✓ Internet of things
  - ✓ Artificial intelligence

- **Post-Doc Researcher**
- **System Architecture and Networking Group, MCS, Eindhoven University of Technology**
  - ✓ AI in resource constrained IoT
  - ✓ Deep reinforcement learning for wireless mesh networks

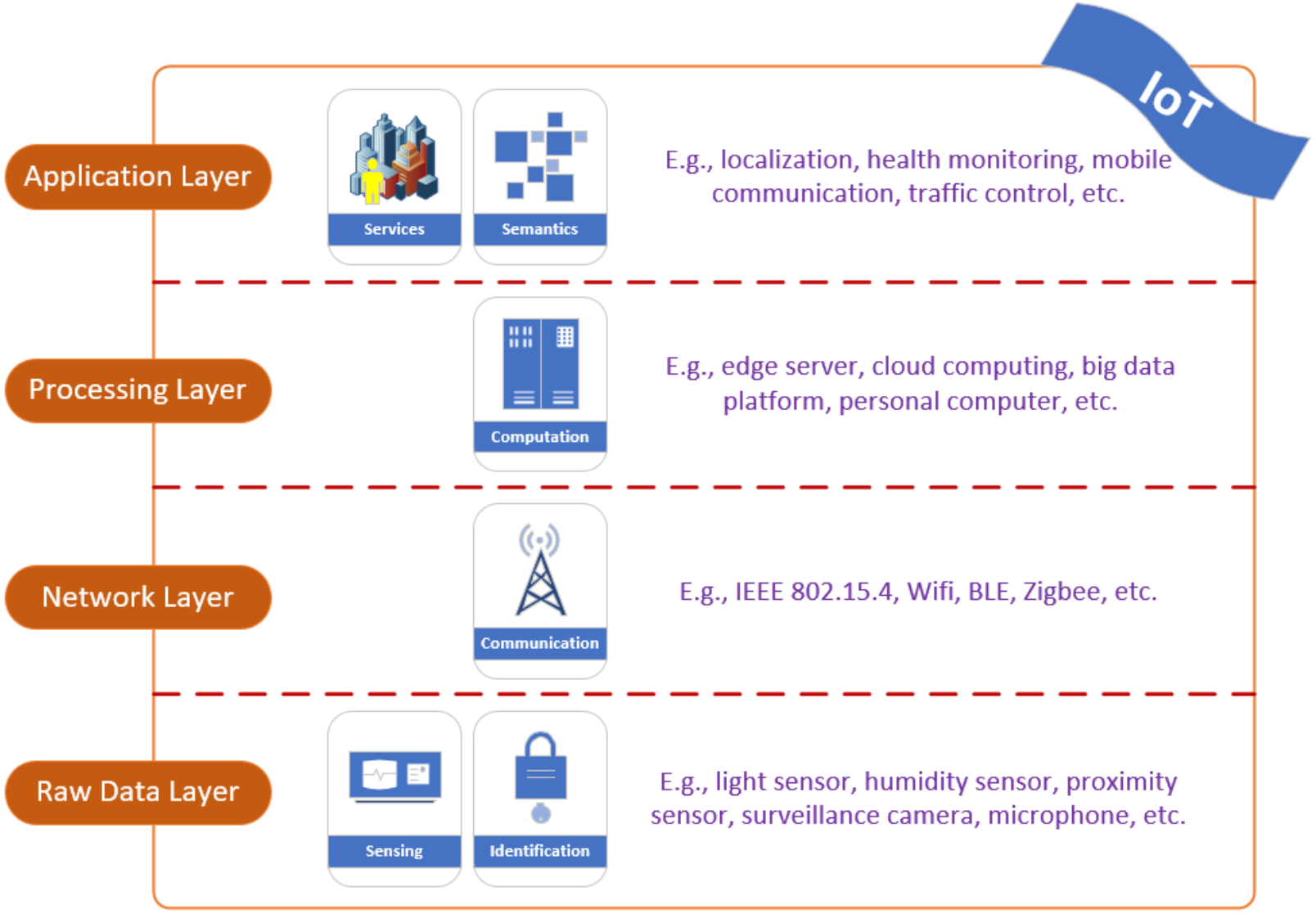
- **PhD in Computer Science**
- **Embedded Software Group, EEMCS, Delft University of Technology**
  - ✓ Swarm Intelligence in IoT
  - ✓ Energy harvesting IoT



Outline

- **Basics of Internet of Things (IoT)**
- **Communication of IoT → Wireless Mesh Networks**
- **Computing of IoT → AI-IoT**

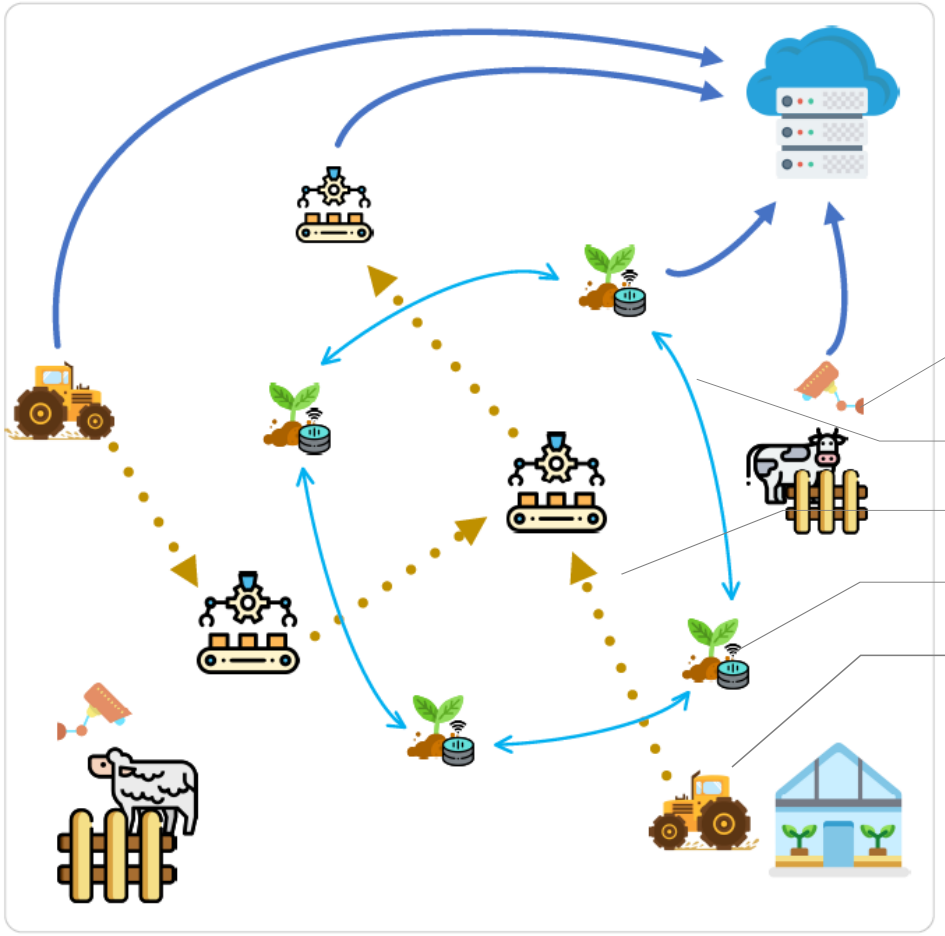
Architecture of IoT



Applications of IoT

Applications	Data Analytics
Transportation	(1) Optimize traffic flow. (2) Minimize traffic congestion. (3) Predict traffic accidents.
Logistics	(1) Schedule route. (2) Optimize allocation of vehicles. (3) Predict consumer requests.
Agriculture	(1) Local weather and environment prediction. (2) Health diagnosis to livestocks. (3) Optimize the use of pesticides.
Healthcare	(1) Prediction and early warning on disease. (2) Health assessment. (3) Control epidemics.

Typical Deployment of IoT on Farms



- Activity monitoring.
- Data aggregation.
- Flow control.
- Data analysis.
- Coordinating vehicles.

Challenges of IoT

- **Challenges:**
  - Unbalanced communication load
  - Computing overload
  - Data structure standard
  - Quality of Service (QoS)

- **For agricultural applications:**
  - Low cost
  - Easy maintenance

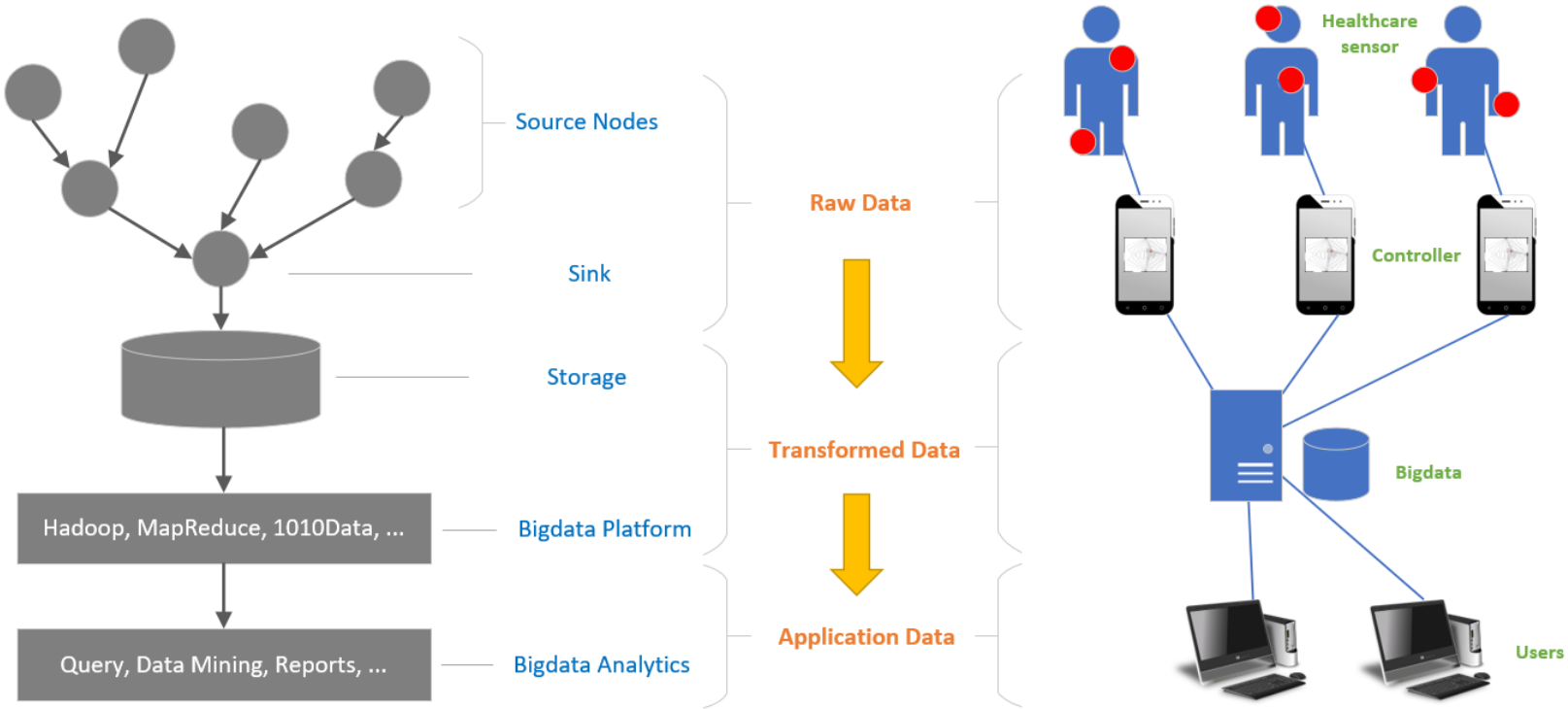
- **Solutions:**
  - Network Infrastructure: Wireless Mesh Networks (WMN)
  - Data Processing: merging AI with IoT (AI-IoT)

Wireless Mesh Networks (WMN) and Agriculture

Network Architecture of IoT

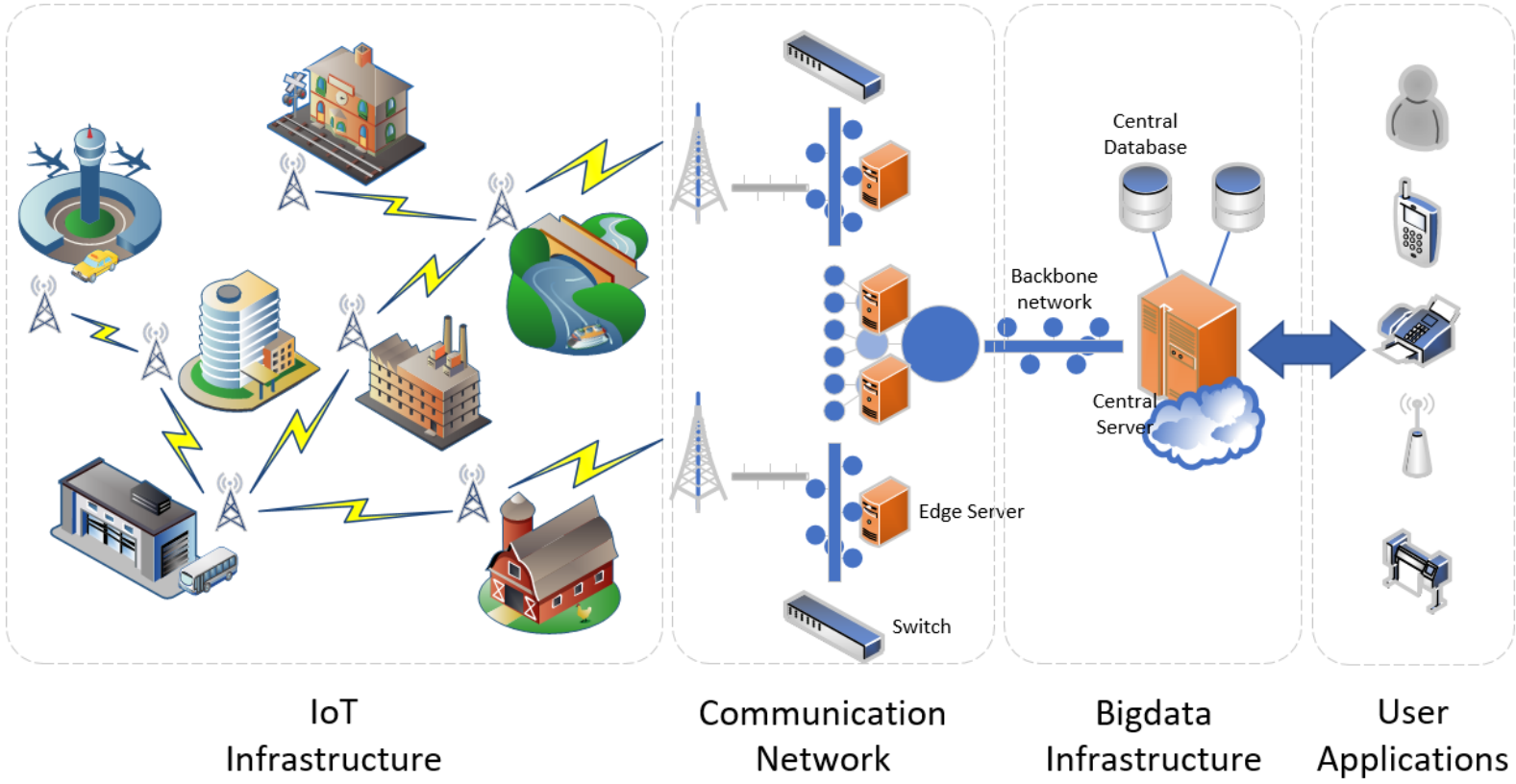
- **Typical structure:**
  1) Sink nodes collect the data from end devices, such as sensor nodes.
  2) Data is processed on platforms.

- **Can hierarchical IoT cope with complicated large-scale problems?**



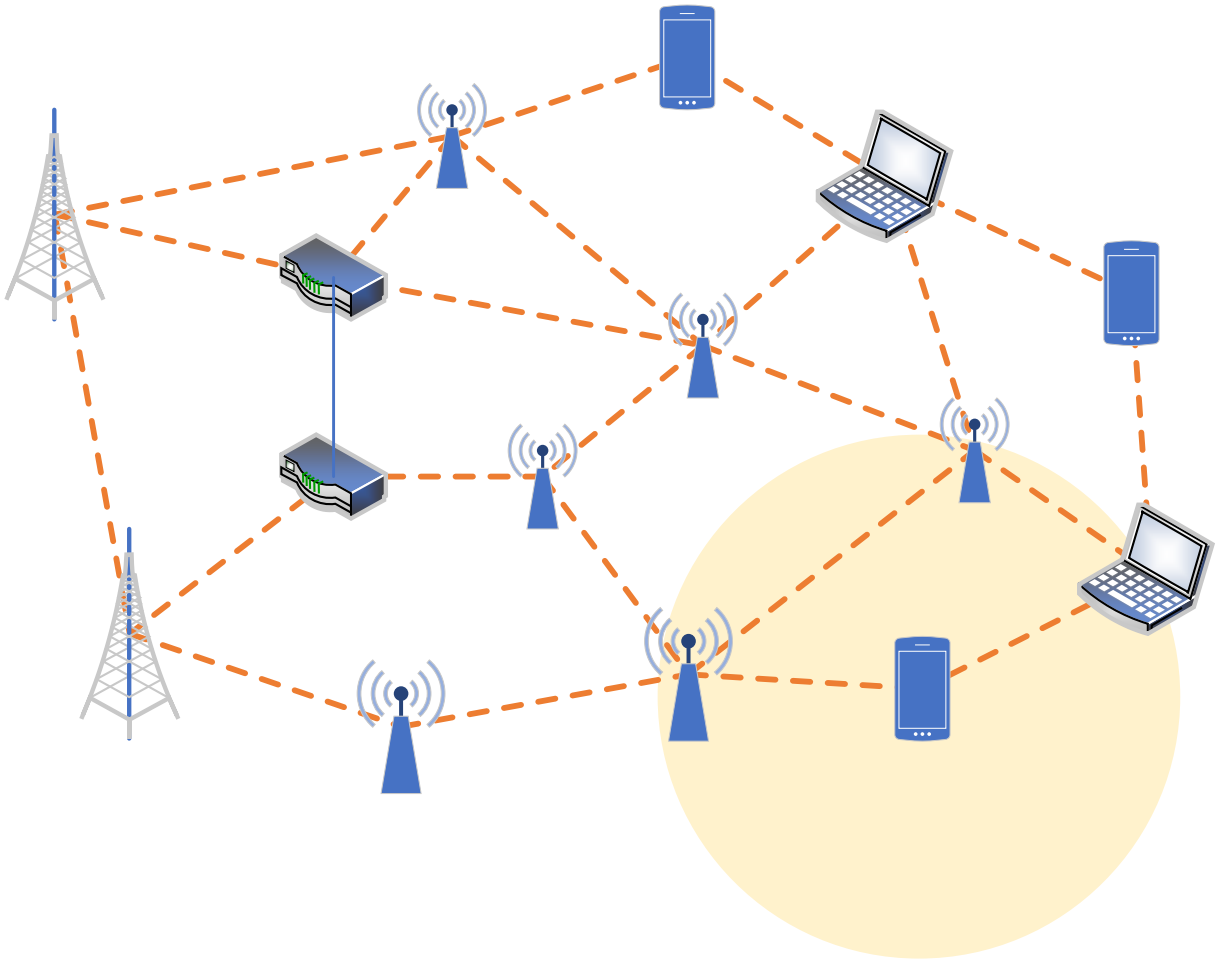
Complex IoT Structure

- **Complexity:**
  1. Multimedia data
  2. Dynamic devices
  3. Hybrid network



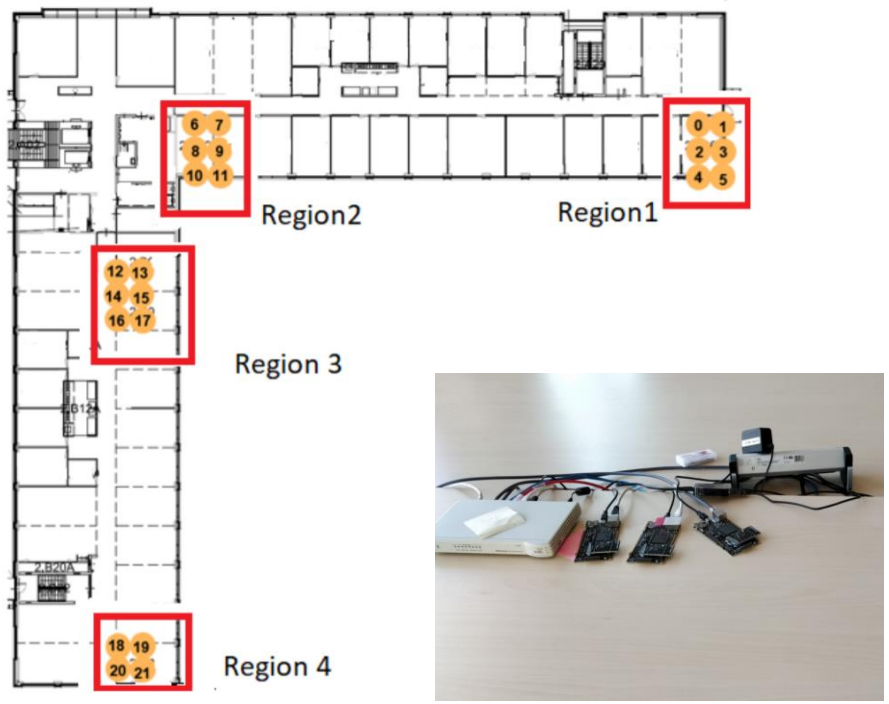
Wireless Mesh Networks (WMN)

- **Advantages:**
  - **Low cost**
    - Self-adaptive
    - Self-organizing
  - **Easy maintenance**
    - Low power consumption



Our Example System 1: WMN for Remote Control

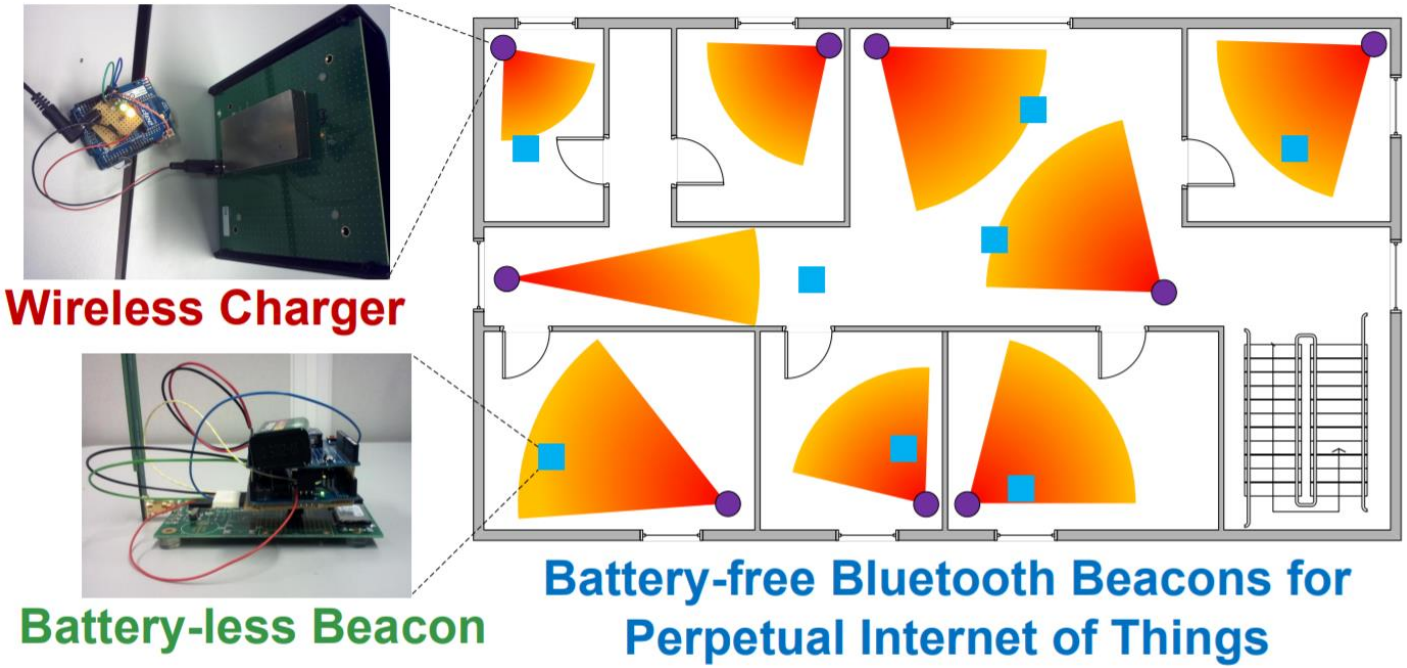
- WMN for controlling the lighting in smart building.
- Key property: self-adaptive and self-organization.



- *Qingzhi Liu, et al.* ***Performance evaluation of thread protocol based wireless mesh networks for lighting systems.*** *International Symposium on Networks, Computers and Communications (Best Paper). 2019.*

Our Example System 2: WMN with Energy Harvesting

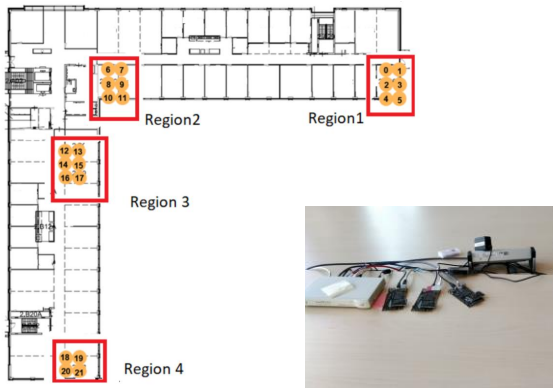
- Battery-free WMN.
- Key property: low power consumption.

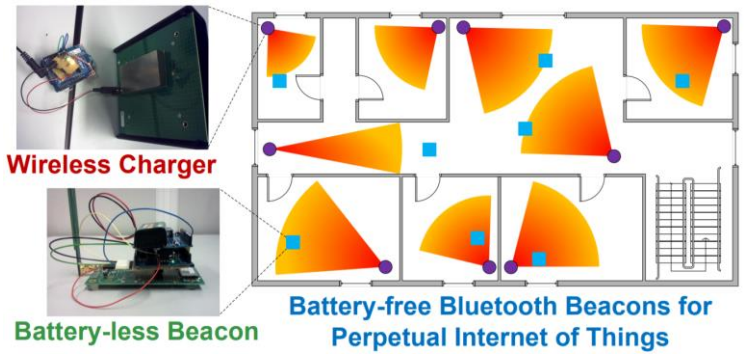


➢ *Qingzhi Liu, et al.* ***Perpetual Bluetooth Communications for the IoT****. IEEE Sensors Journal, 2019.*

WMN for Agriculture

- We are applying the system to agricultural farms using HaLow.
- We aim to reduce the cost and simplify the maintenance of the system.





AI-IoT and Agriculture

Benefits of AI-IoT for Agriculture

- **Aim:**
  - Combine AI and IoT together.

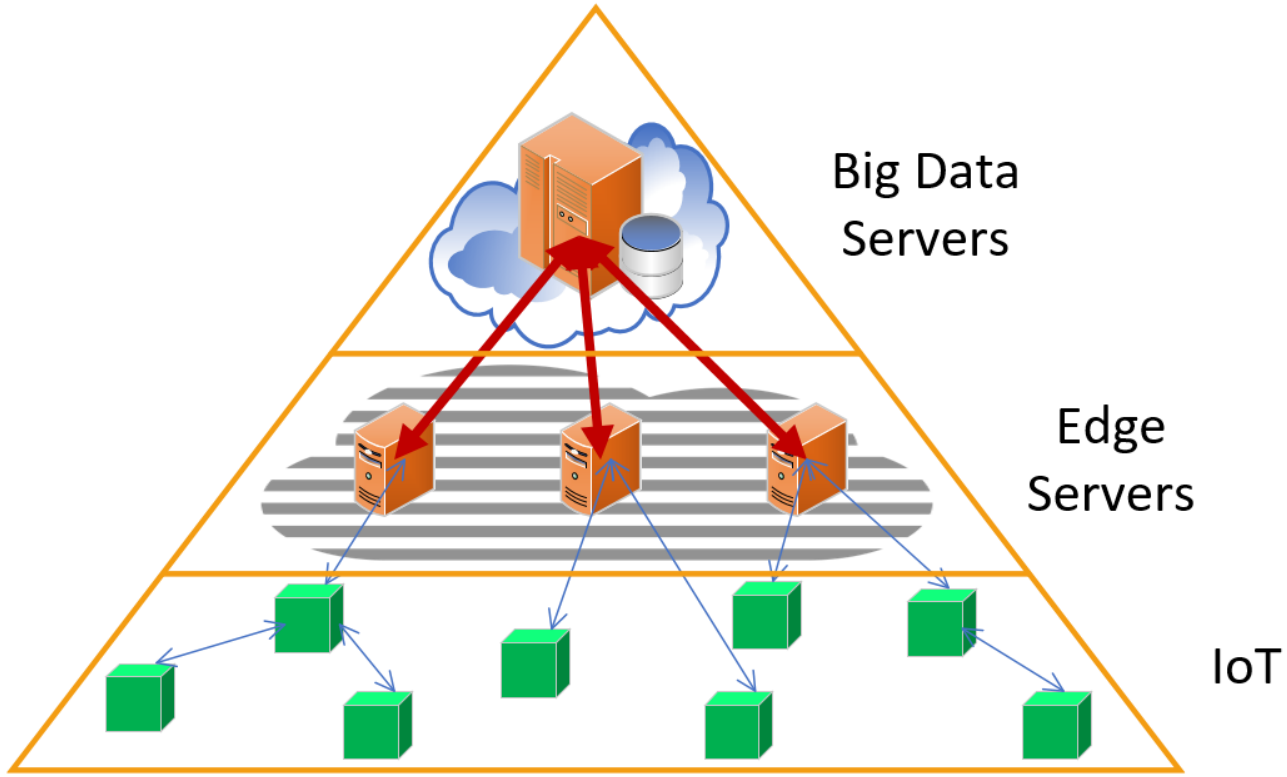
- **Traditional approach:**
  - Data collection on wireless sensor networks.
  - Data processing on servers.

- **Trend of AI-IoT: AI on Resource Constraint IoT Devices**
  - AI-IoT allows **real time operations** without requesting centralized processing.

- **Benefits for Agriculture:**
  - Low cost
  - Easy maintenance

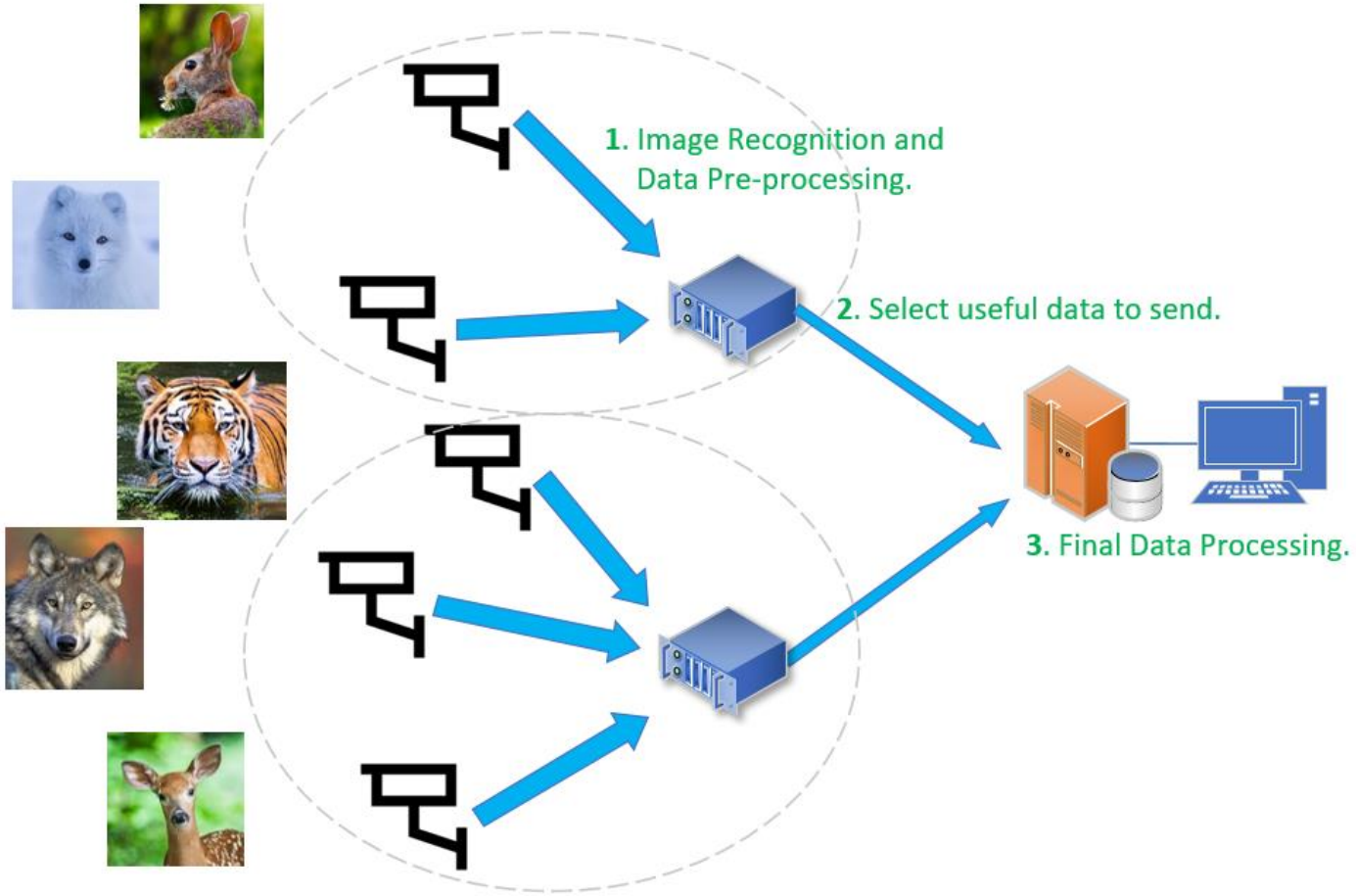
How to Merge AI to Edge IoT Devices?

- **Solution:**
  - Avoid transferring unnecessary data to servers.
  - Edge servers are small-scale servers deployed close to end devices.



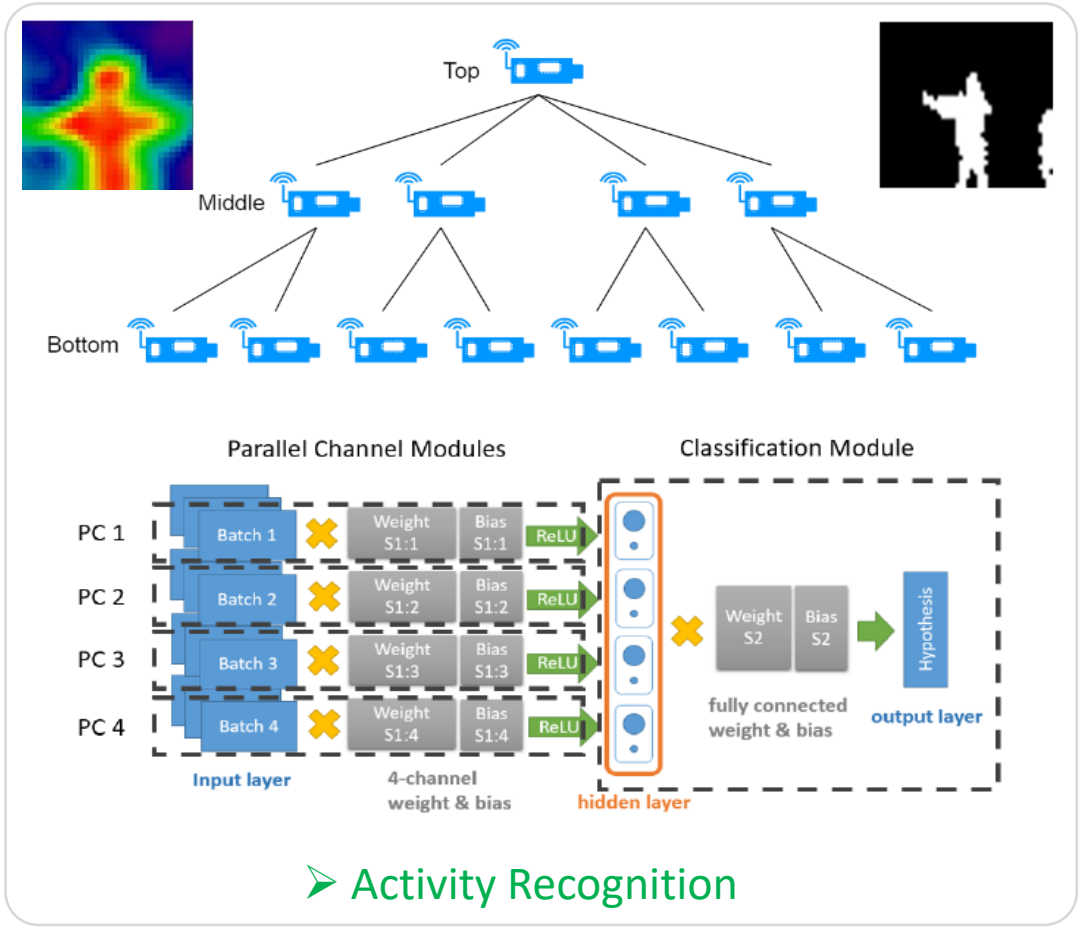
Typical Structure of AI-IoT

- **Edge AI for animal monitoring:**
  - **Step 1:** Cameras send data to edge servers.
  - **Step 2:** Preprocessing to filter out data from unnecessary animals on edge servers.
  - **Step 3:** Transfer data to central server if the data is useful for the animal monitoring.

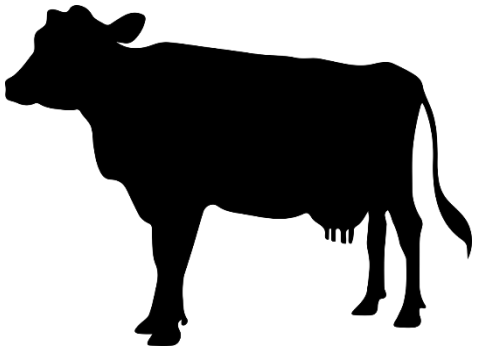


Our Example System 3: Activity Detection

- Activity recognition using resource constrained IoT.
  - Limited resources: memory, CPU/MCU, communication bandwidth, training data.



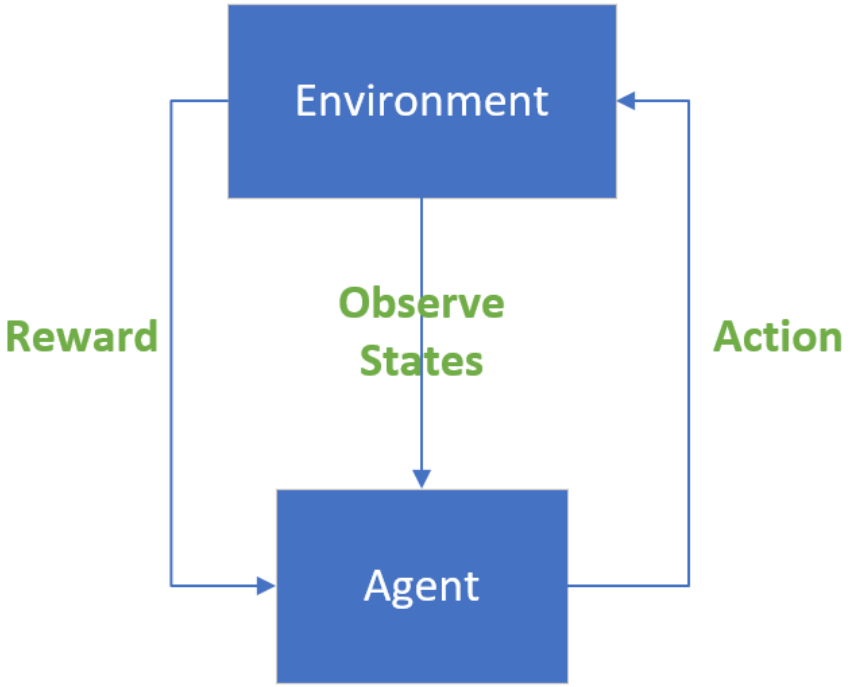
➢ Activity Recognition



➢ *Qingzhi Liu, et al. PCANN: Distributed ANN Architecture for Image Recognition in Resource-Constrained IoT Devices. IEEE Intelligent Environment Conference. 2019.*

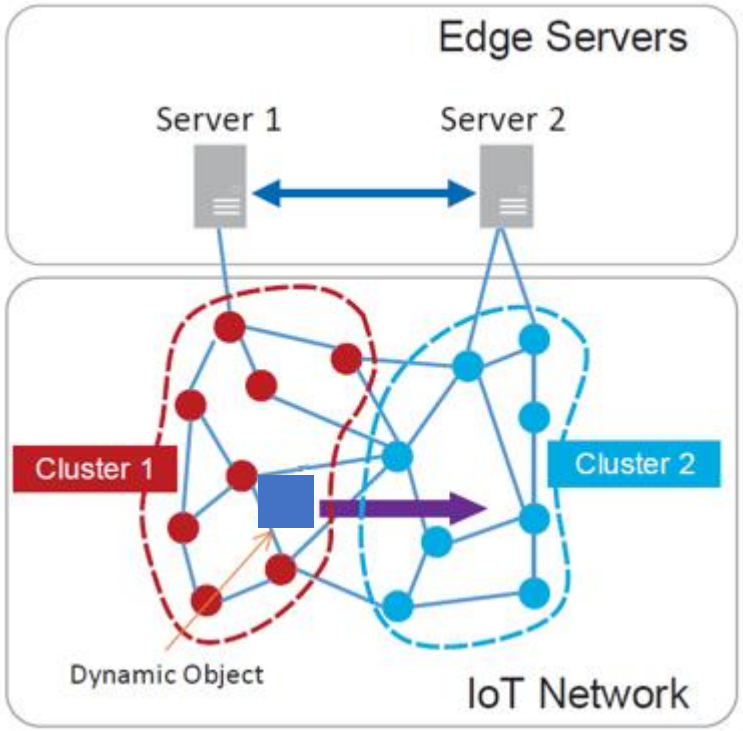
Further Improve AI-IoT

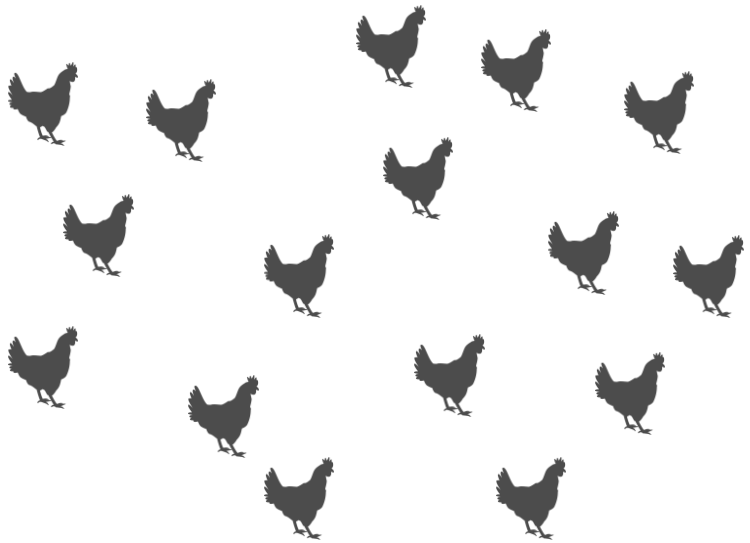
- Decision-making for mobile IoT devices:
  - How to organize the mobile devices?
- **Deep Reinforcement Learning solution:**
  - Alpha-Go (DeepMind)



Our Example System 4: Control Data Collection by DRL

- Schedule clustering for mobile IoT devices.





- *Qingzhi Liu, et al. Deep Reinforcement Learning for IoT Network Dynamic Clustering in Edge Computing. IEEE/ACM International Symposium on Cluster, Cloud and Grid Computing (CCGRID), 2019.*

Summary

- IoT communication and computing are the key topics.
- Wireless mesh network can reduce the cost and simplify the maintenance.
- Compared with traditional AI solutions, AI-IoT has higher benefits for agriculture.

Questions?

Internet of Things in Agriculture

Dr. Qingzhi Liu

WAGENINGEN
UNIVERSITY & RESEARCH