WESTERN SYDNEY
UNIVERSITY

SERVERLESS AND EDGE COMPUTING: OPPORTUNITIES AND CHALLENGES

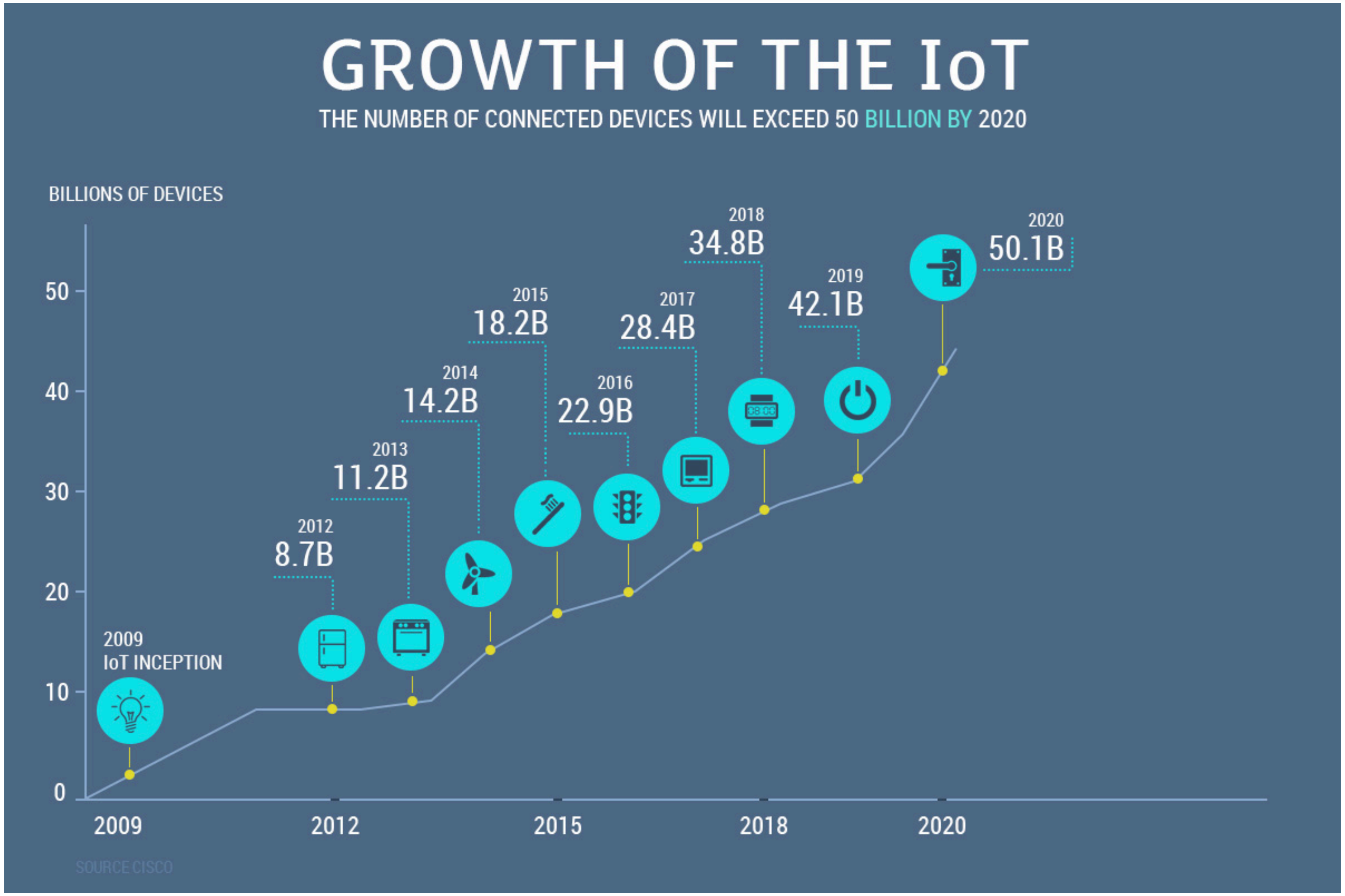
A/Prof. Bahman Javadi
School of Computer, Data and Mathematical Sciences
Western Sydney University, Australia

International Conference on Smart Technologies in Data Science and Communication(Smart DSC-2021), February 2021

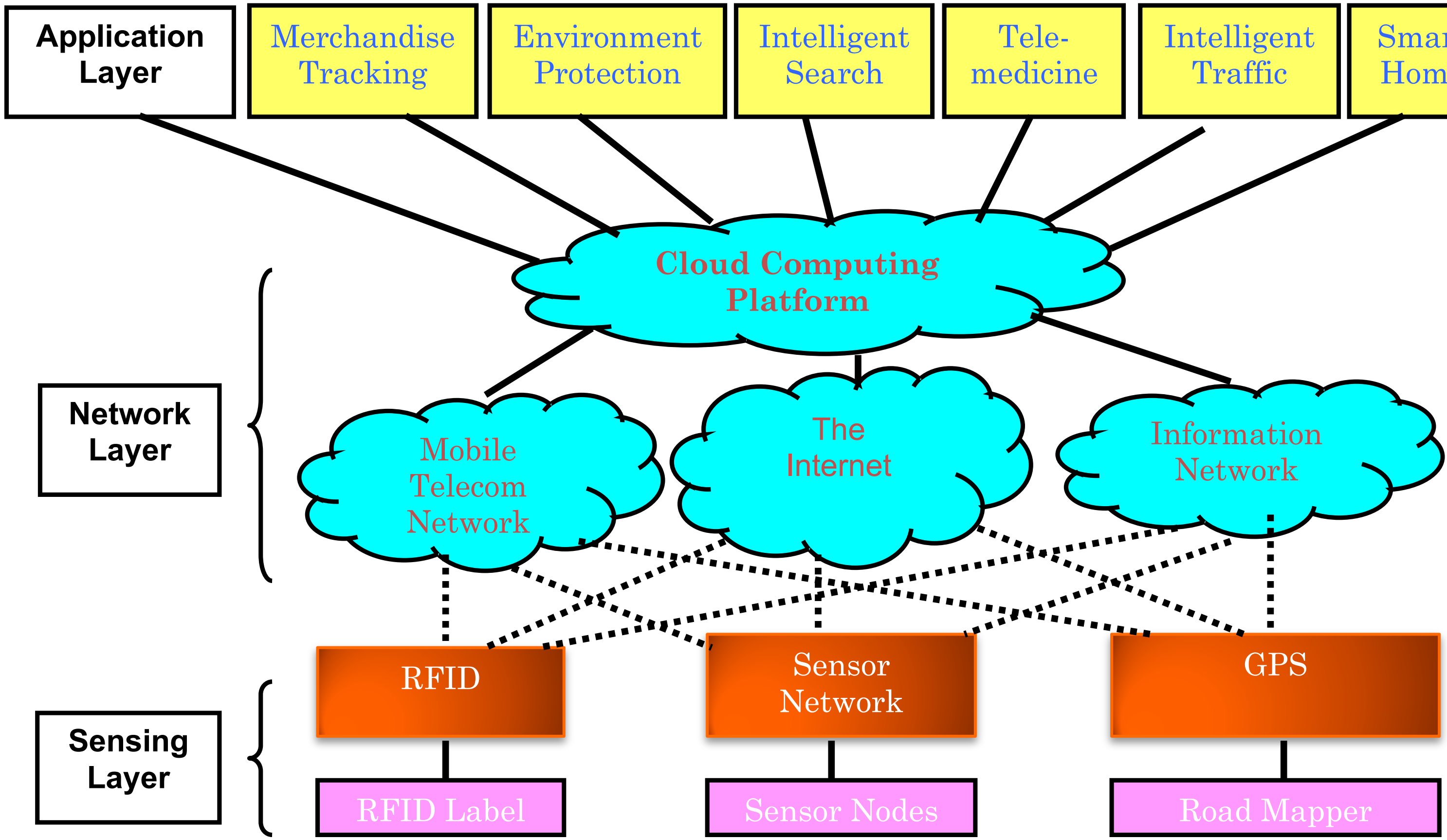
SMART APPLICATIONS

Smart Grid | Safety Security | Connected Home | Building Automation | Lighting Control | Smart Devices | Health Fitness

More Connected Devices on the Planet Today Than People



Architecture For Smart Applications



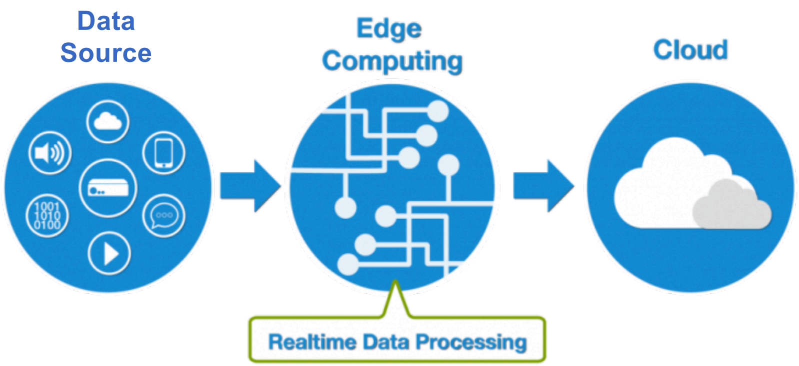
Technical Challenges and Solution

Cloud Computing

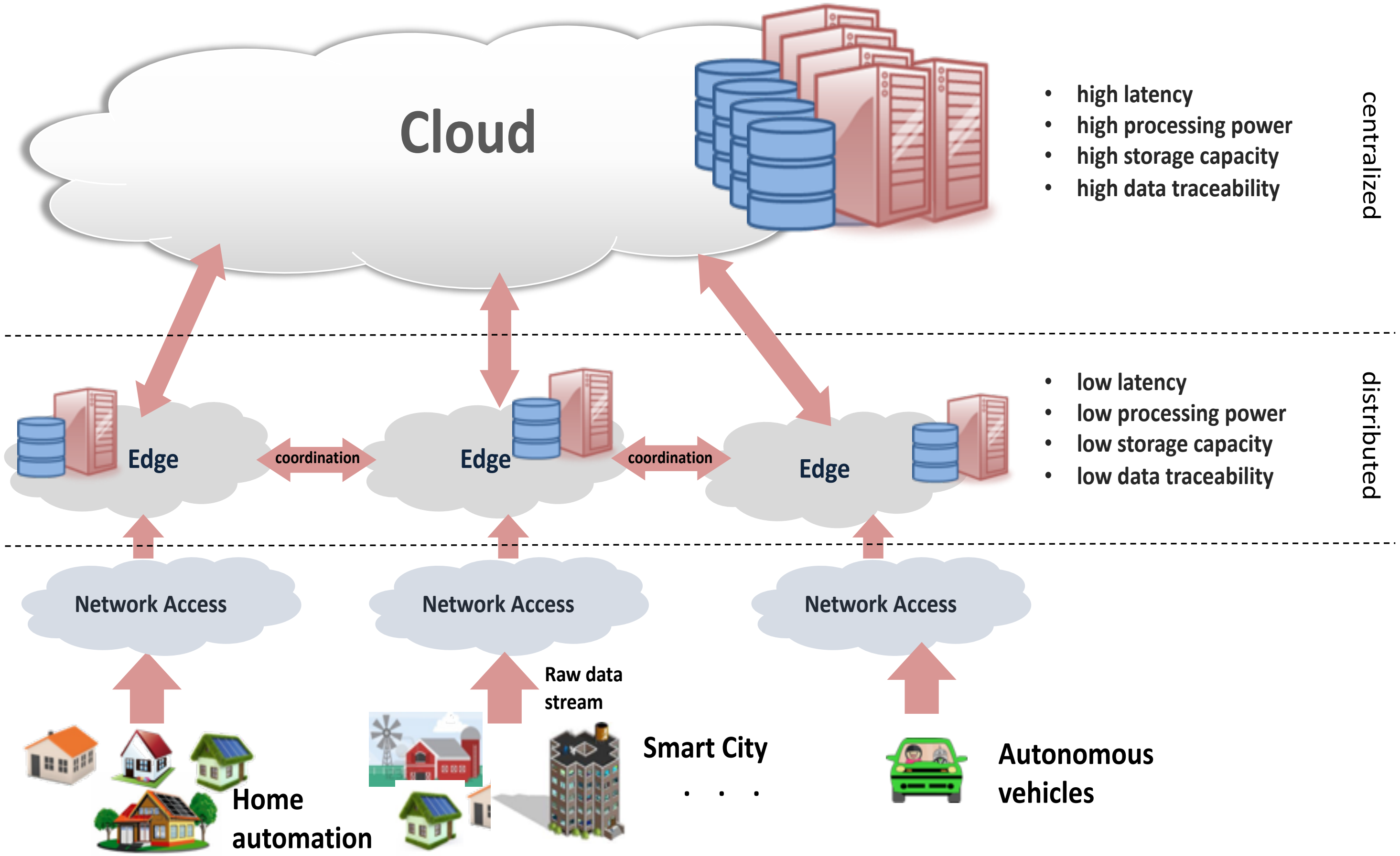
- Network Latency
- Network Bandwidth
- User Quality of Experience (QoE)
- Privacy and Security

Edge Computing

- **Edge computing** is a distributed computing paradigm which brings computation and data storage closer to the location where it is needed, to improve response times and save bandwidth.



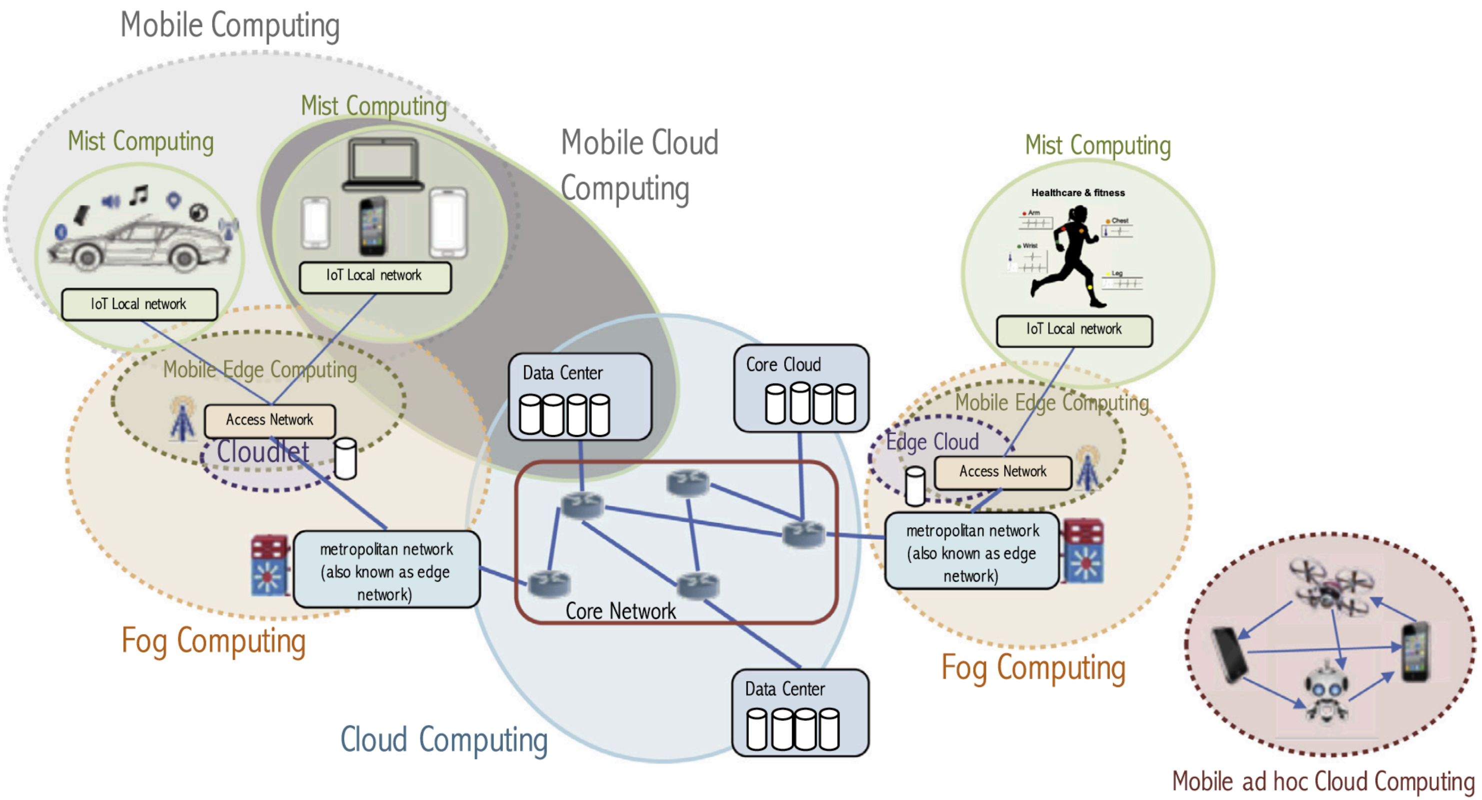
Edge Computing Architecture



EDGE VS. CLOUD

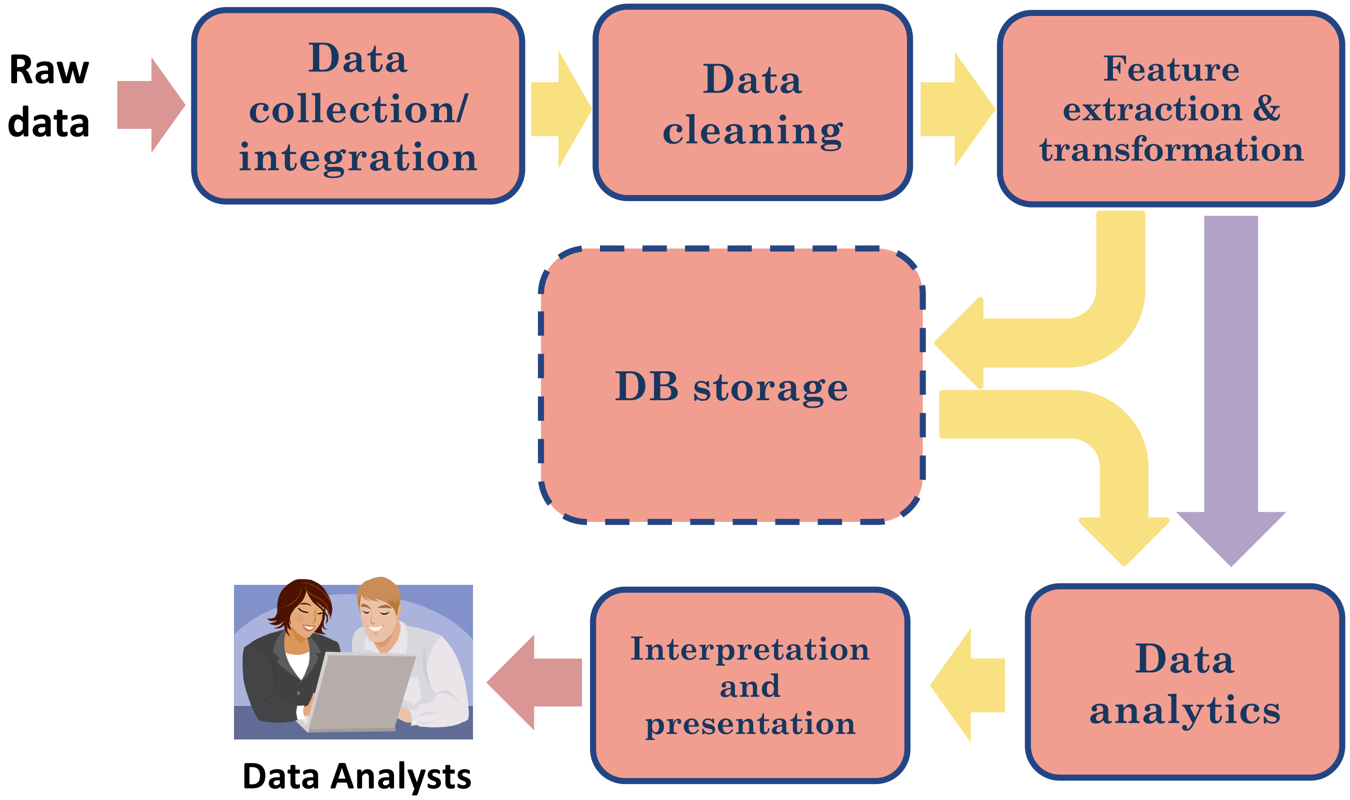
Characteristics	Edge devices	Cloud platform
Processing hierarchy	Local data analytics	Global data analytics
Processing fashion	In-stream processing	Batch processing
Computing power	GFLOPS	TFLOPS
Network Latency	Miliseconds	Seconds
Data storage	Gigabytes	Infinite
Data lifetime	Hours/Days	Infinite
Fault-tolerance	High	High
Processing resources	Heterogeneous (e.g. CPU, FPGA)	Homogeneous (Data center)
Versatility	Only exists on demand	Intangible servers
Provisioning	Limited	Infinite, with latency
Mobility of nodes	May be mobile (e.g. in the car)	None

EMERGING COMPUTING PARADIGM



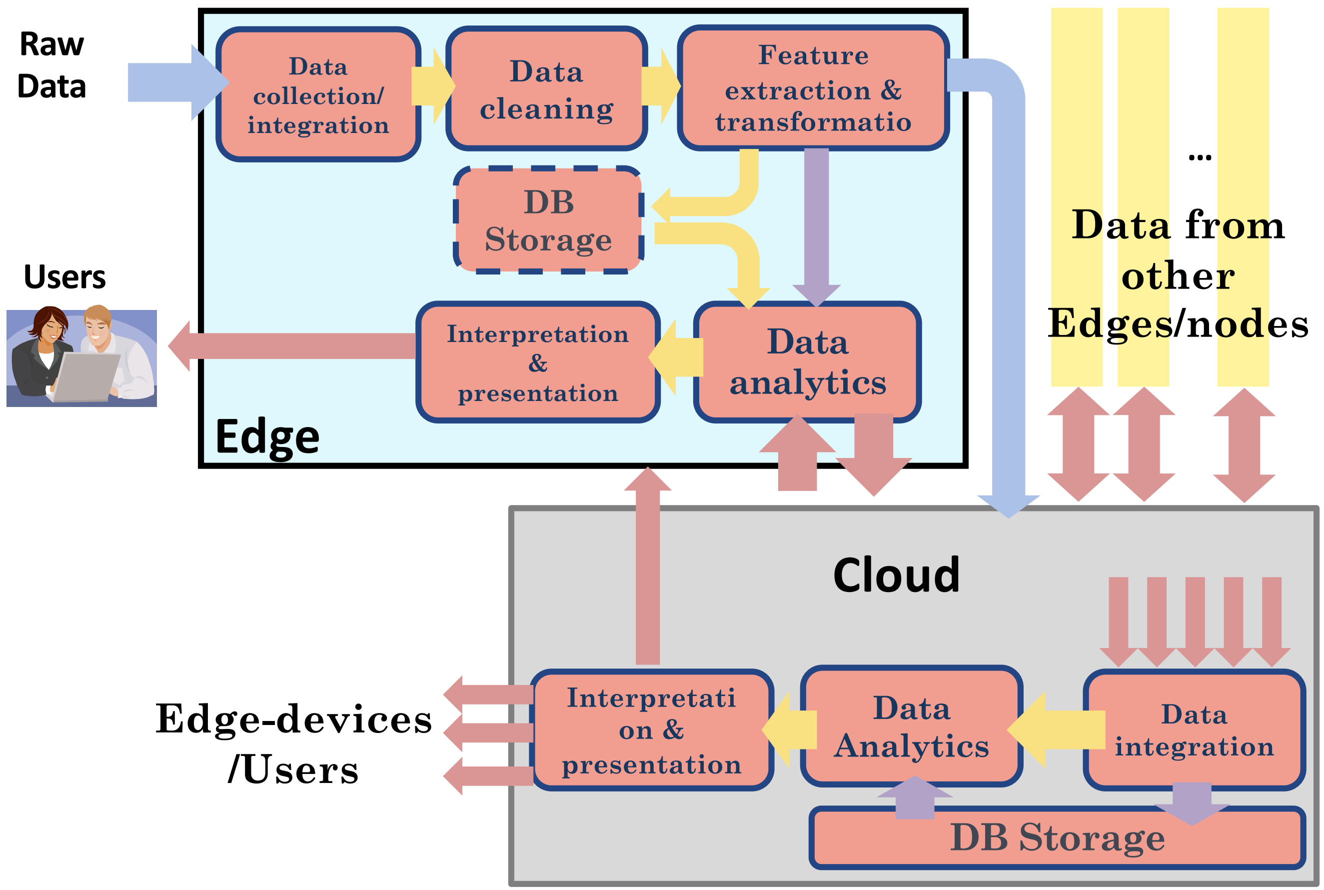
A. Yousefpour, et al, “All one needs to know about fog computing and related edge computing paradigms: A complete survey”, Journal of Systems Architecture, Volume 98,2019, Pages 289-330,

Typical Data Analytics

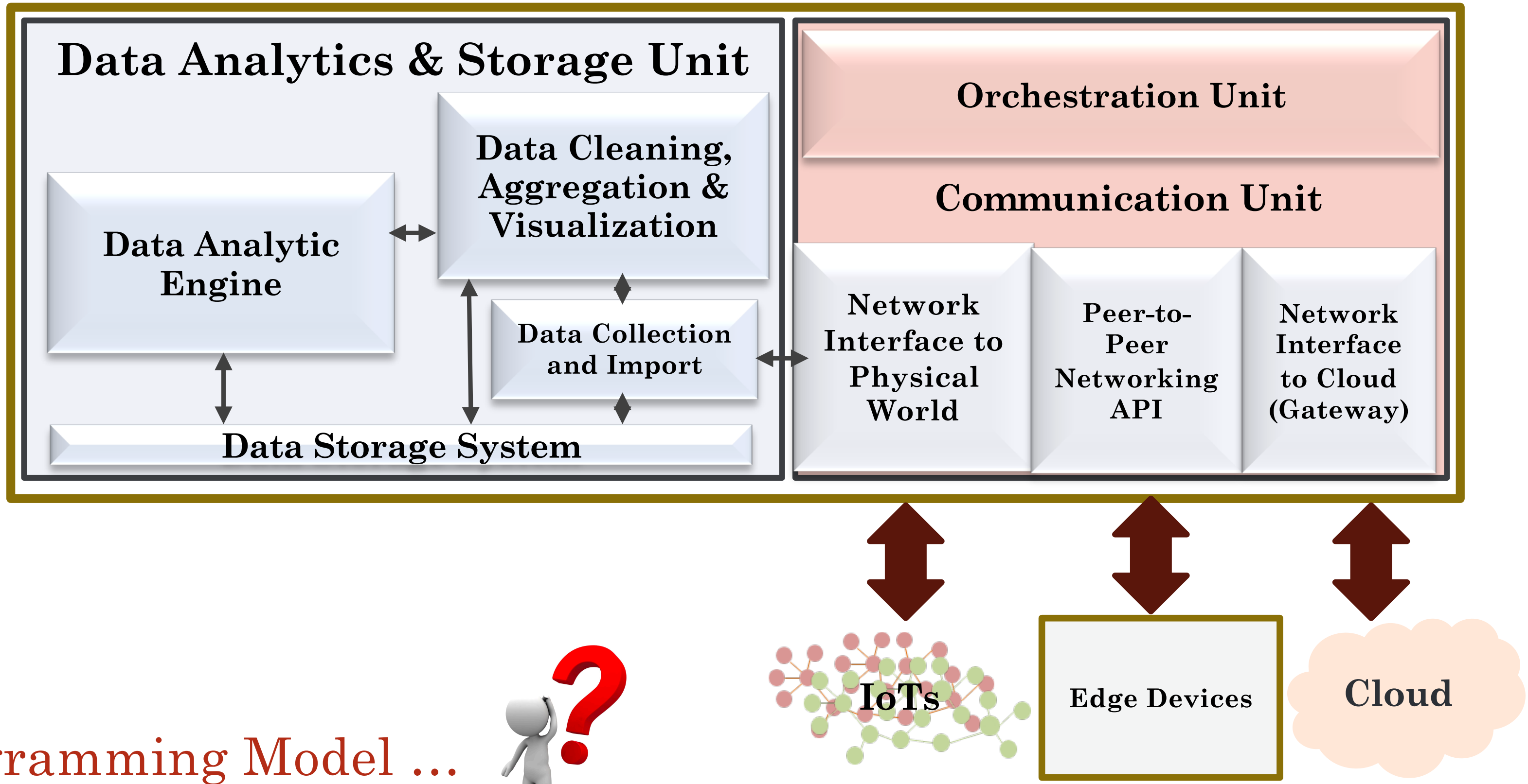


EDGE-BASED DATA ANALYTICS

WESTERN SYDNEY UNIVERSITY



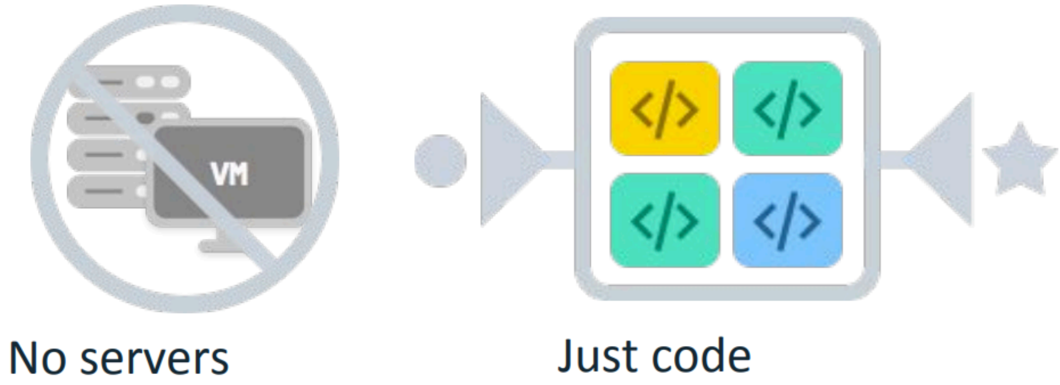
Edge Device Components



Programming Model …

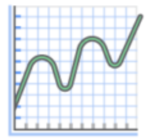
Serverless Computing

- Serverless : Less worry about server
- Runs code only on-demand to response to events
  - Event-programming model



Benefits of Serverless Computing

- No Servers to Manage
- Continuous Scaling
- Dynamic allocation of resources
- Avoid overallocation of resources
- Never Pay for Idle: pay-per-use



Provider	**Languages**
AWS Lambda	Node.js, Java, Python
Google Cloud Functions	Node.js
Azure Functions	Node.js, C#
IBM OpenWhisk	Node.js, Swift, Binary (Docker)
Webtask.io	Node.js
OpenLambda	Python

Serverless Applications

Serverless is **good** for

short-running
stateless
event-driven

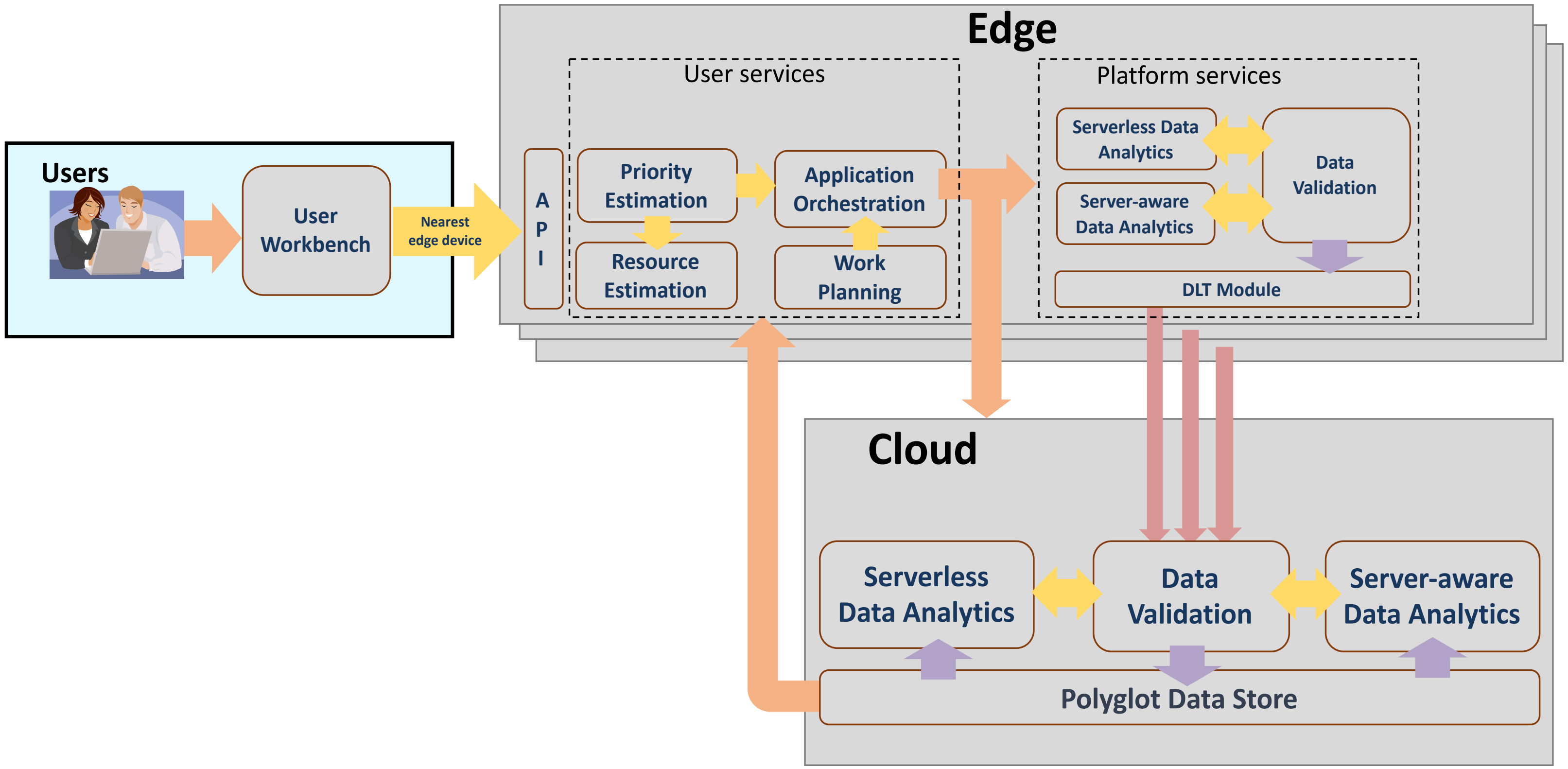
- Microservices
- Mobile Backends
- Bots, ML Inferencing
- IoT
- Modest Stream Processing
- Service integration

Serverless is **not good** for

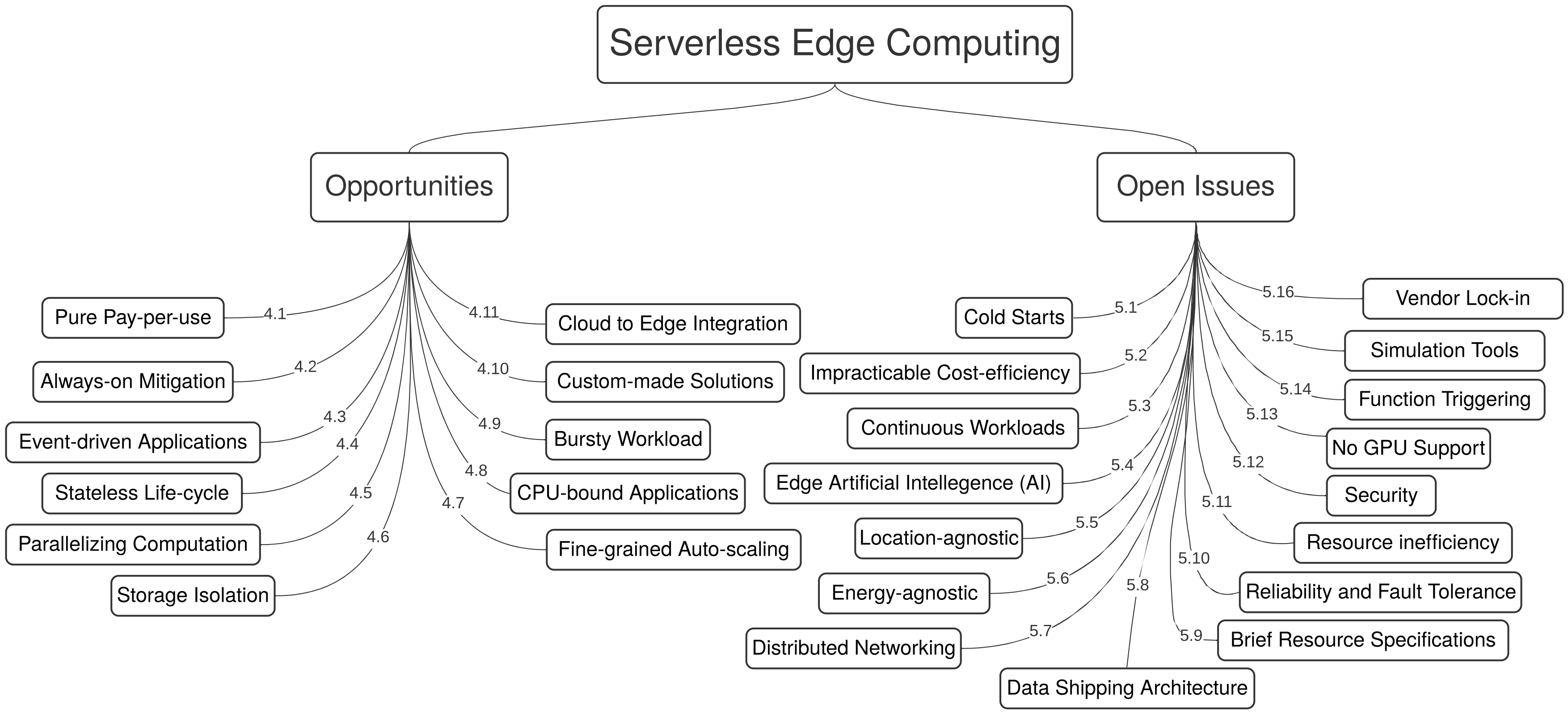
long-running
stateful
number crunching

- Databases
- Deep Learning Training
- Heavy-Duty Stream Analytics
- Spark/Hadoop Analytics
- Numerical Simulation
- Video Streaming

Serverless Edge Computing



Opportunities and Open Issues

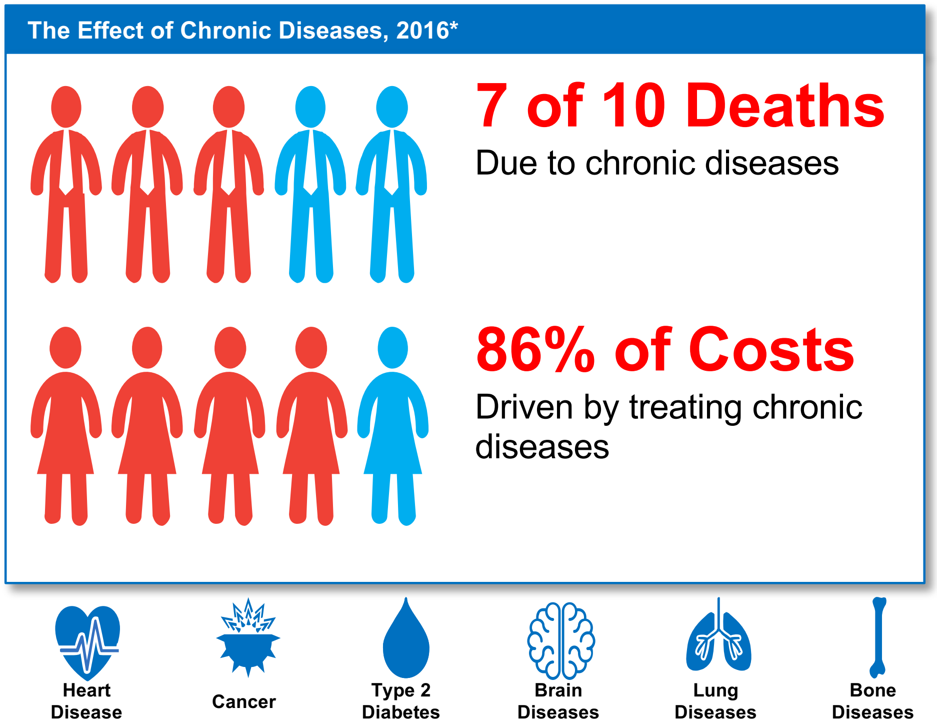


Case Study:
Smart Nutrition Monitoring System

Chronic Diseases

Disease Type	Death per year
Communicable Diseases (e.g. COVID-19)	4 million
Non-Communicable Diseases (e.g. Cancer)	41 million

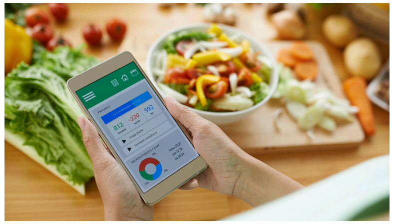
* Ref: World Health Organization (WHO)



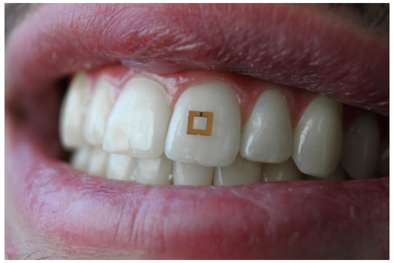
Poor diet and unhealthy food habit is the root cause of many chronic diseases.

Nutrition Monitoring System

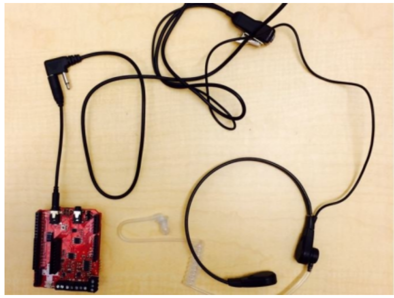
- Manual methods
  - 24 hour recalls
  - Food frequency questionnaires
  - Smartphones



- Automatic methods
  - Sensor-based
  - Environment sensors
  - Removing the participant burden



- Issues
  - Imprecise (lack of food detection)
  - Not practical for free-living style
  - Single dimension
  - Privacy



Smart Nutrition Monitoring System

Project Aim: develop a smart technology that enables users to measure and analyse their food intake in terms of basic nutrients (e.g., Fat, Protein, Carbohydrates)

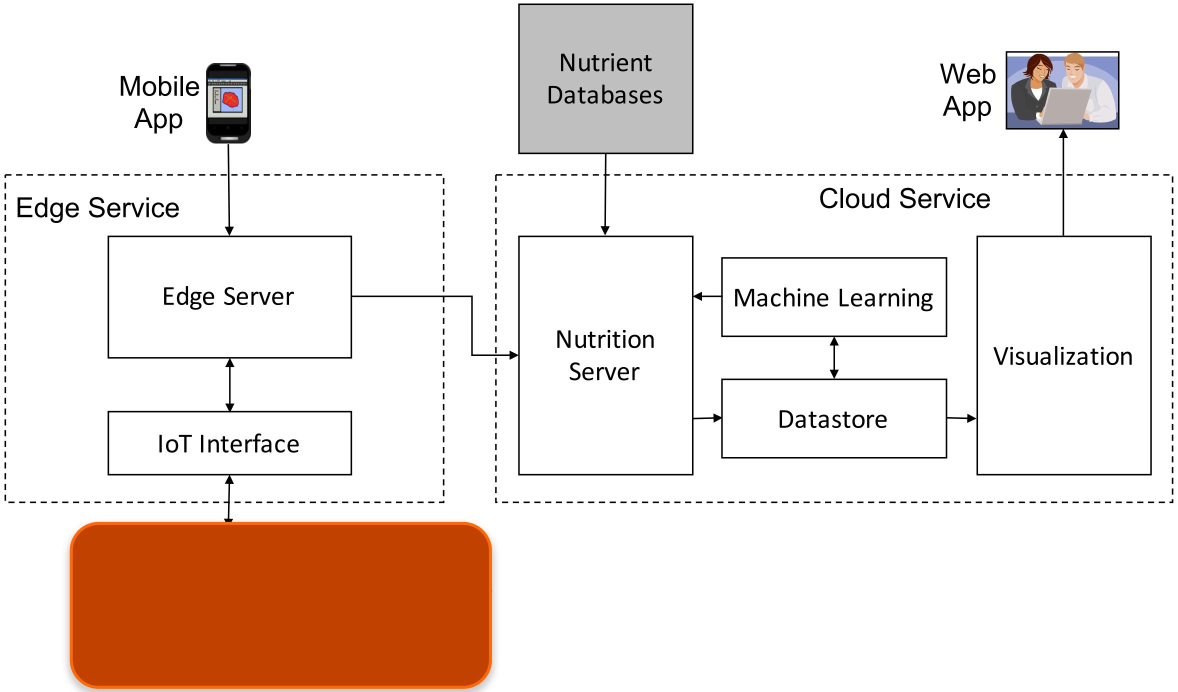
Challenges:

- Participant burden
- Invasiveness
- Low precision
- Low scalability

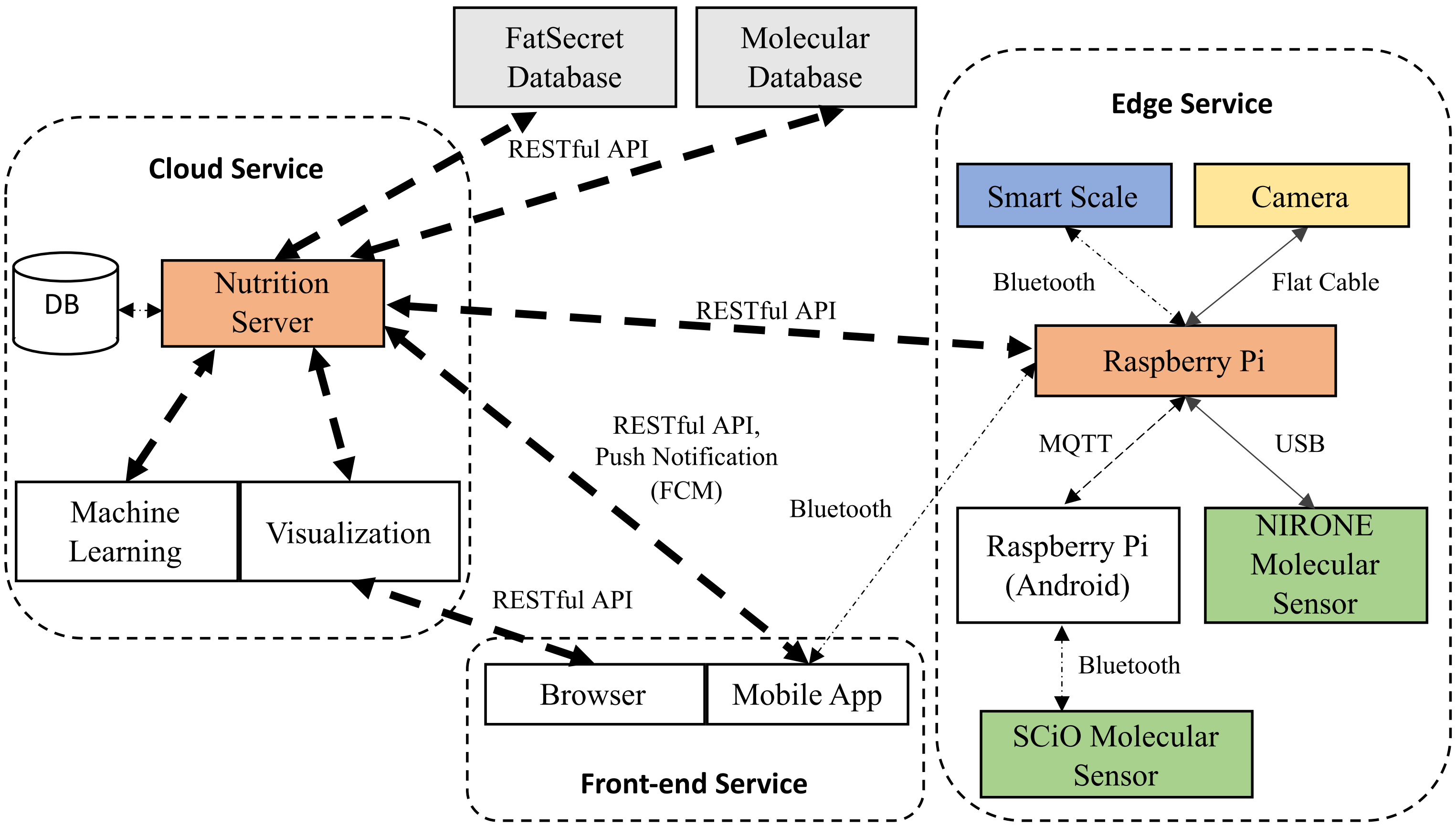
Smart Nutrition Monitoring System using Mobile Edge Computing

Proposed Solution: a smart food scanner with heterogenous Internet of Things (IoT) sensors using Mobile Edge Computing

- Automatic
- Non-invasive
- Ingredient level



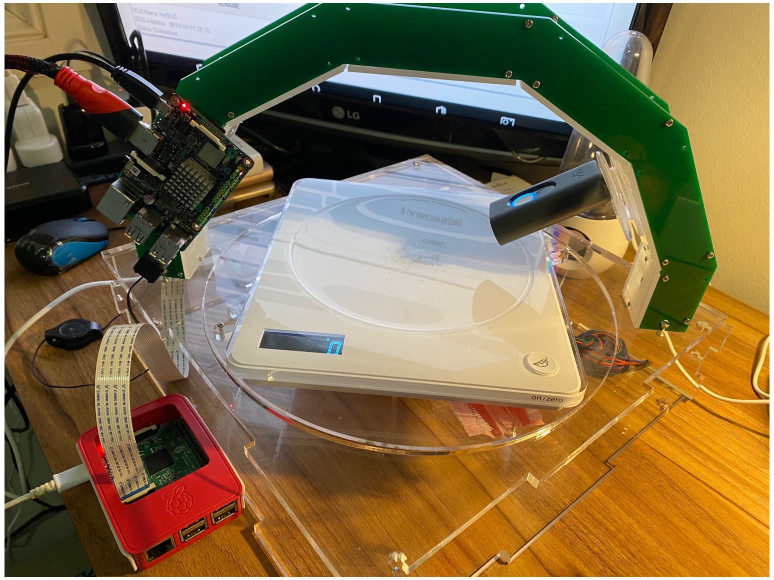
System Prototype



NEAR-INFRARED (NIR) SPECTROSCOPY

Sensor	Wavelength	Scan time	Food Type
NIRONE	750 nm up to 2500 nm	<0.5 seconds, result shows 1.5 to 2 seconds	Homogenous, Raw/Cooked
SCio	700-1100nm	2-5 seconds	Homogenous, Raw
TellSpec	900nm to 1700nm	1 to 3 seconds	Homogenous, Raw/Cooked

Performance Evaluation



Item	Module	Specifications
Mobile	Android Smartphone	1.9Ghz octa-core Exynos CPU, 2GB RAM
Edge	Raspberry Pi Model B	1.4Ghz quad-core ARM CPU, 1GB RAM
Cloud	AWS EC2 Instance	t2.medium, 2 vCPUs, 4GB RAM
ML	AWS EC2 Instance	p2.xlarge, 4 vCPUs, 1GPU, 61GB RAM
Sensor 1	Camera	Raspberry Pi 8MP Camera
Sensor 2	Scale	SITU Smart Scale
Sensor 3	SCiO Sensor	Molecular Sensor 700-1100nm
Sensor 4	NIRONE Sensor	Molecular Sensor 1750-2150nm

Results: Time Analysis

WESTERN SYDNEY UNIVERSITY

TABLE 2. Edge Service Timing (seconds).

Scanner	Camera	Scale	SCiO Sensor	Upload to Cloud
9.85	3.35	6.92	4.79	11.26

TABLE 3. Cloud Service Timing (seconds).

Machine Learning	SCiO Analysis	FatSecret API	DB update
2.15	3.46	0.45	3.35

Results: Power Analysis

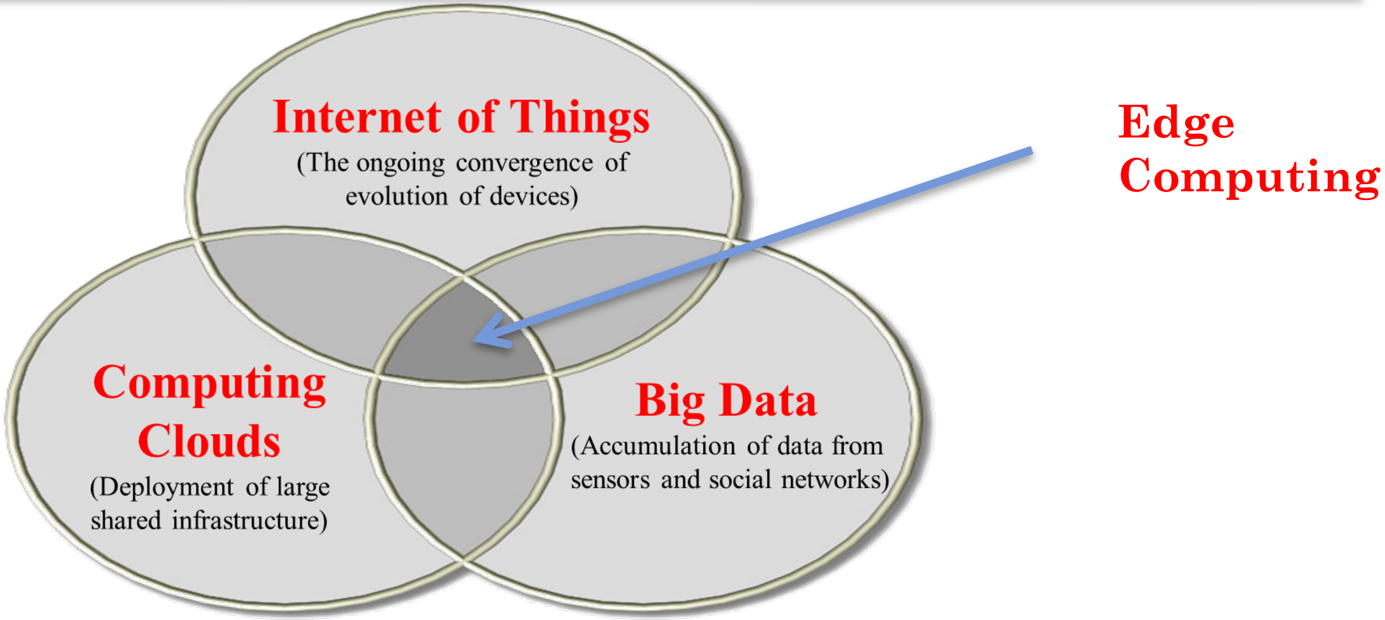
Mobile Edge vs Mobile Cloud

- Flexibility
- Scalability
- Mobile battery saving
- Mobile resource saving

TABLE 4. Mobile Power Consumption (Watt).

Mobile Edge	Mobile Cloud
2.80	8.11

Conclusions



- New Programming Models (e.g., Serverless)
- Innovative Machine Learning Techniques (e.g., Edge Intelligence)
- Decentralized Resource Scheduling
- Reliability and Power Efficiency
- Security and Privacy

REFERENCES

- Aslanpour, Mohammad S., Adel N. Toosi, Claudio Cicconetti, Bahman Javadi, Peter Sbarski, Davide Taibi, Marcos Assuncao, Sukhpal Singh Gill, Raj Gaire, and Schahram Dustdar. "**Serverless edge computing: vision and challenges**." In *2021 Australasian Computer Science Week Multiconference*, pp. 1-10. 2021. **Best Paper Award**

- Bahman Javadi, Jingtao Sun, Rajiv Ranjan, "**Serverless Architecture for Edge Computing**", IET Edge Book, June 2020.

- Bahman Javadi, Q. L. Trieu, K. M. Matawie, and R. Calheiros, "**Smart Food Scanner System Based on Mobile Edge Computing**," IEEE International Conference on Cloud Engineering (IC2E), Sydney, Australia, 2020.

Thank You

Email: b.javadi@westernsydney.edu.au
Twitter: @bjavadi
https://www.linkedin.com/in/bahmanjavadi/