CS5412 Recitation 1

Yifan Wang, Tiancheng Yuan

Contents

- Logistics.
- Computation resources.
- Projects.
- Week 1 Material Revisit.

Logistics

Logistics: Who we are?

- Yifan Wang (yw2399)
  - 3rd-year PhD student, Computer System.
  - Research interest: low-code programming, machine learning engineering, full-stack development.
  - Worked at VMware.

Logistics: Who we are?

- TC Yuan (ty373)
  - 2nd-year MS student
  - Research interests: Federated Learning, MLsys, High Precision Training on Hyperbolic space, Attention Mechanisms, De-centralized Training

Logistics: Who we are?

- Rahul Sharnappa (rb772)
  - MEng student in Computer science.
  - Worked in software industry majorly in Software Defined Networks, Cloud Networking.
- Zack Ashen (za44)

Logistics, cont'd

- What will be covered in the recitations?
  - Course material revisit/discussion.
  - Related technology/research introduction.
  - Projects, hands-on labs, etc.
- We'll record the sessions but will only address "on-premises" questions.
- Not all the contents are examination-related.

Computation Resources

Resources

Azure Account:

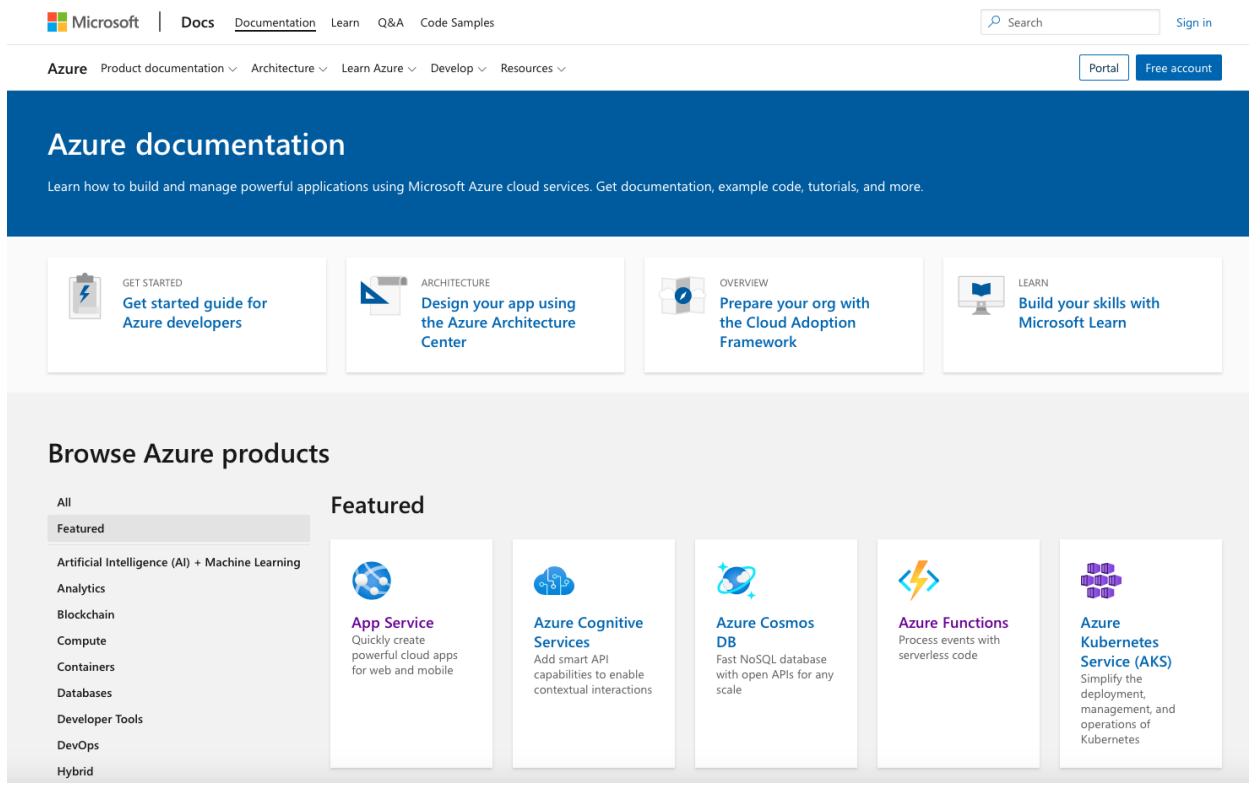
- Once you form groups, you will receive Azure credit for your project
- We will have examples using Azure technologies latter in the course
- https://portal.azure.com

- Other Cloud vendors:

- Aws and other cloud resources may be used. We will not provide funding for them

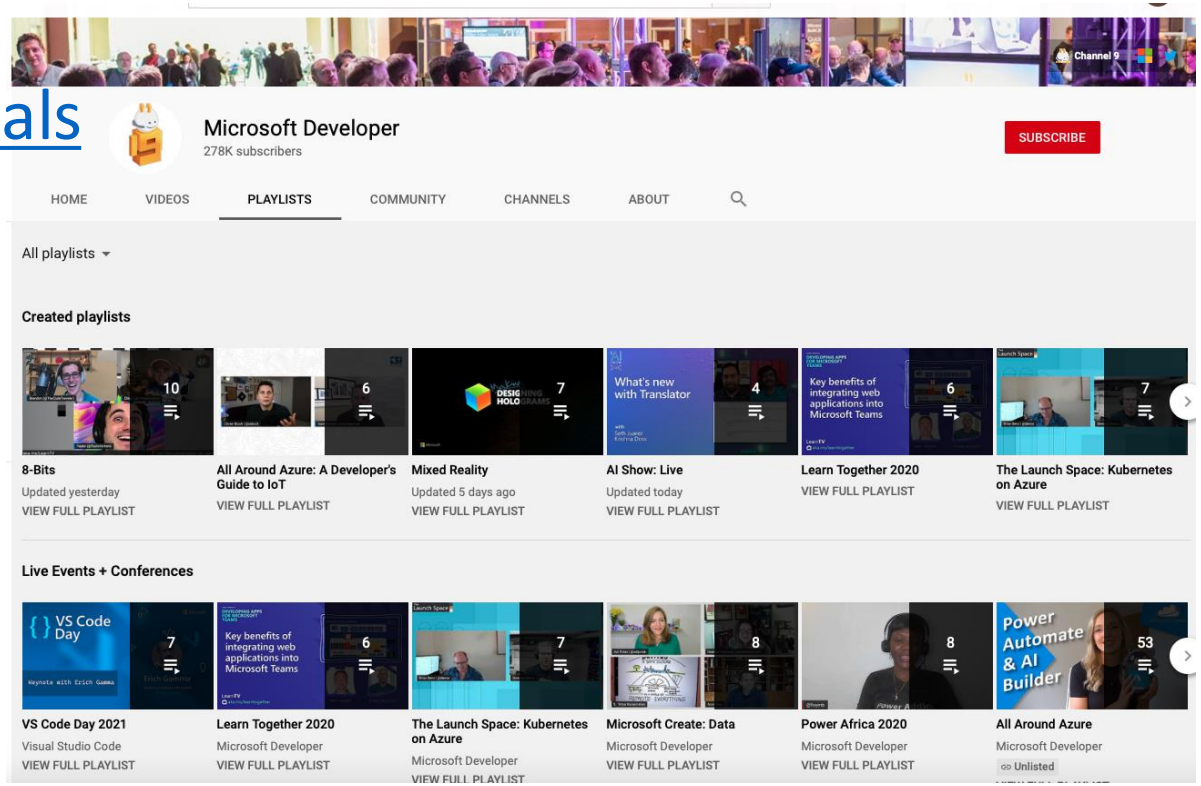
Resources : How to learn to program your own Cloud Computing programs?

- Azure documentations



Resources : How to learn to program your own Cloud Computing programs?

- Azure documentations
- IoT project, cloud application tutorials



Resources : How to learn to program your own Cloud Computing programs?

- Azure documentations
- IoT project, cloud application tutorials
- Example programs

Awesome Azure IoT

awesome | build failing

A curated list of awesome Azure Internet of Things projects and resources.

- IoT Solutions
- IoT Services
- Hardware
- Operating System
- Get started with IoT Hub
- Platforms and Frameworks
- SDKs
- Libraries and Tools
- Learning Material
- Resources

IoT Solutions

- Microsoft IoT Central - A fully managed SaaS offering for customers and partners that enables powerful IoT scenarios without requiring cloud solution expertise.
- Azure IoT Suite Preconfigured Solutions - A set of preconfigured solutions for getting your IoT project faster (Remote Monitoring, Connected Factory, Predictive Maintenance)

IoT Services

- Azure IoT Hub - Connect, monitor, and manage billions of IoT assets. Azure IoT Hub is a fully managed service that enables reliable and secure bidirectional communications between millions of IoT devices and a solution back end.

Contributors 10

Projects

- Group Project.
  - 10% -> Intermediate report
  - 10% -> Peer Reviews
  - 30% -> Final Report
  - 30% -> Presentation
  - 20% -> Demo

Projects: Group Formation & Project Idea

- Finding team members:
  - 2-3 students per group. Larger group size means higher expectation.
  - Posting ad on edstem: https://edstem.org/us/courses/26354/discussion/
  - Team formation event, 4PM, Sep. 8, Gates Hall. Details to be disclosed later.

?

Intermediate & Final Report

The report should consist of the following sections:

1. Goal / idea (what is the question this project is solving?)
2. Background (what is the current state of research/ industry application of it?)
3. Architecture & implementation
4. Evaluation (System performance, accuracy if using ML models)
5. Conclusions

The intermediate and final report could evolve from previous report

Projects: Group Formation & Project Idea

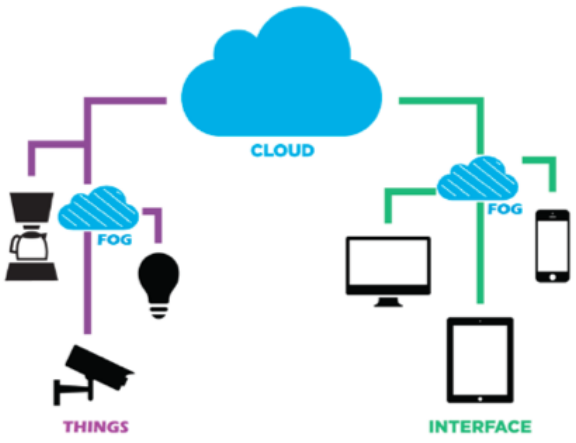
- Group with 2~3 people
- List of group members. (*skills for each member in this project)
  - Name , Net ID
- Two paragraphs about the project idea
  - What is the question the project solves? Which components in Cloud Computing system does this project involve?
  - Briefly plan how you are going to achive this (input data, analysis, platform, etc.)
- [Tentative] If this is an M.Eng. Project mention who is taking the M.Eng. Credits (4999 if not in M.Eng for the extra work) explain extra piece of work for the M.Eng. Project.

Project idea

- Some Questions
  - Real-world questions: Body Condition Score Prediction; Trajectory Estimation ...
  - What kind of tasks: classification, generation …
  - Supervised? Semi-supervised? Un-supervised?
- Promising Models
  - Simple and Effective
  - ViT takes days to train on CIFAR-100
- Dataset

Project Idea – IoT application

- IoT: the Internet of Things is the concept of connecting any device to the Internet and to other connected devices.



Project Idea – IoT application

- **Sensing and power :** sensors, cameras, real-time systems on the devices

Project Idea – IoT application

Architecture

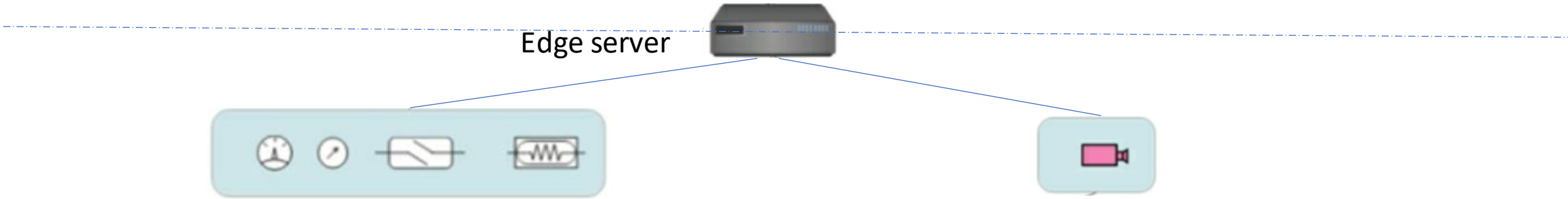
Edge Layer

Project Idea – IoT application

- **Sensing and power :** sensors, cameras, real-time systems on the devices
- **Edge computing :** distribute computing from cloud data centers to the sources of data

Project Idea – IoT application

Architecture



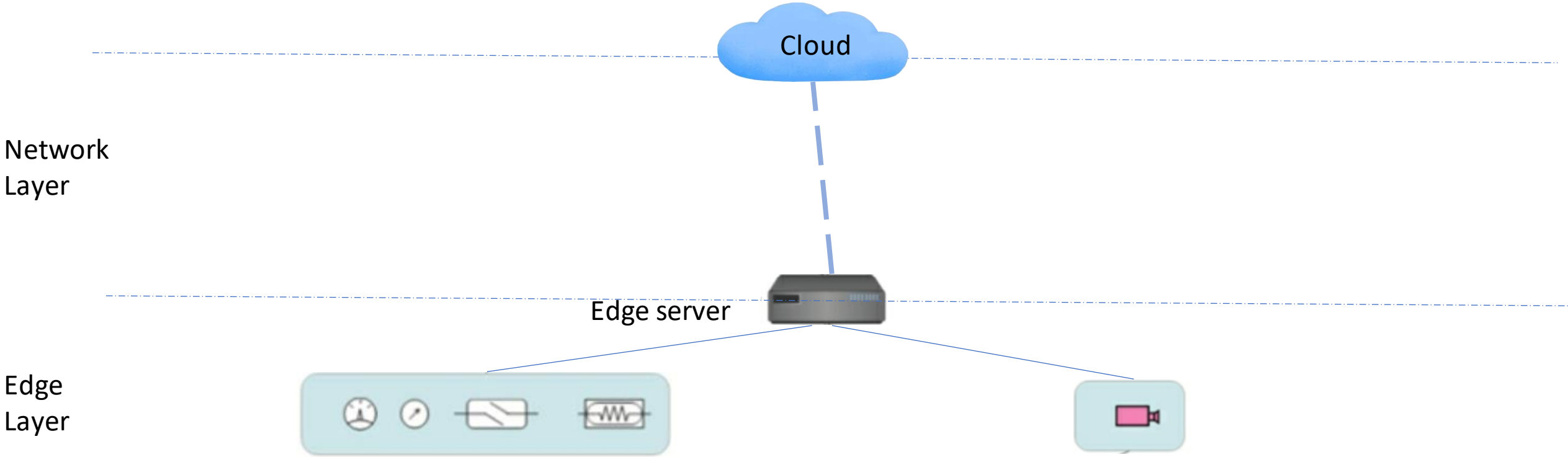
Edge Layer

Project Idea – IoT application

- **Sensing and power :** sensors, cameras, real-time systems on the devices
- **Edge computing :** distribute computing from cloud data centers to the sources of data
- **Data communication :** WPANs (Wireless Personal Area Network) , LANs (Local area network);
  - how will the data transfer between the edge and the internet?

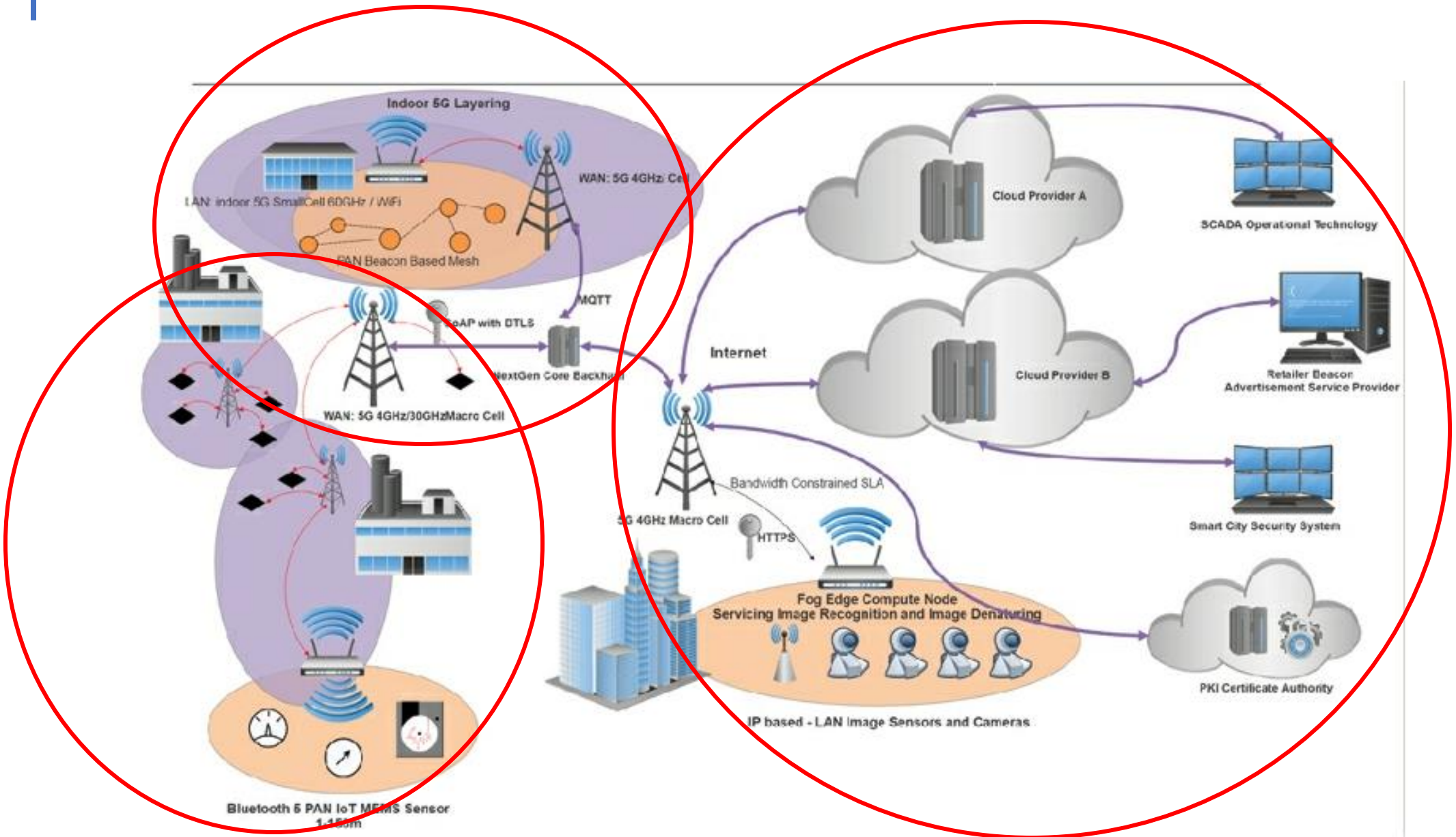
Project Idea – IoT application

Architecture



[2]. IoT and Edge Computing for Architects: Implementing edge and IoT systems from sensors to clouds with communication systesm, analytics, and security, 2nd Edition

Project Idea – IoT application

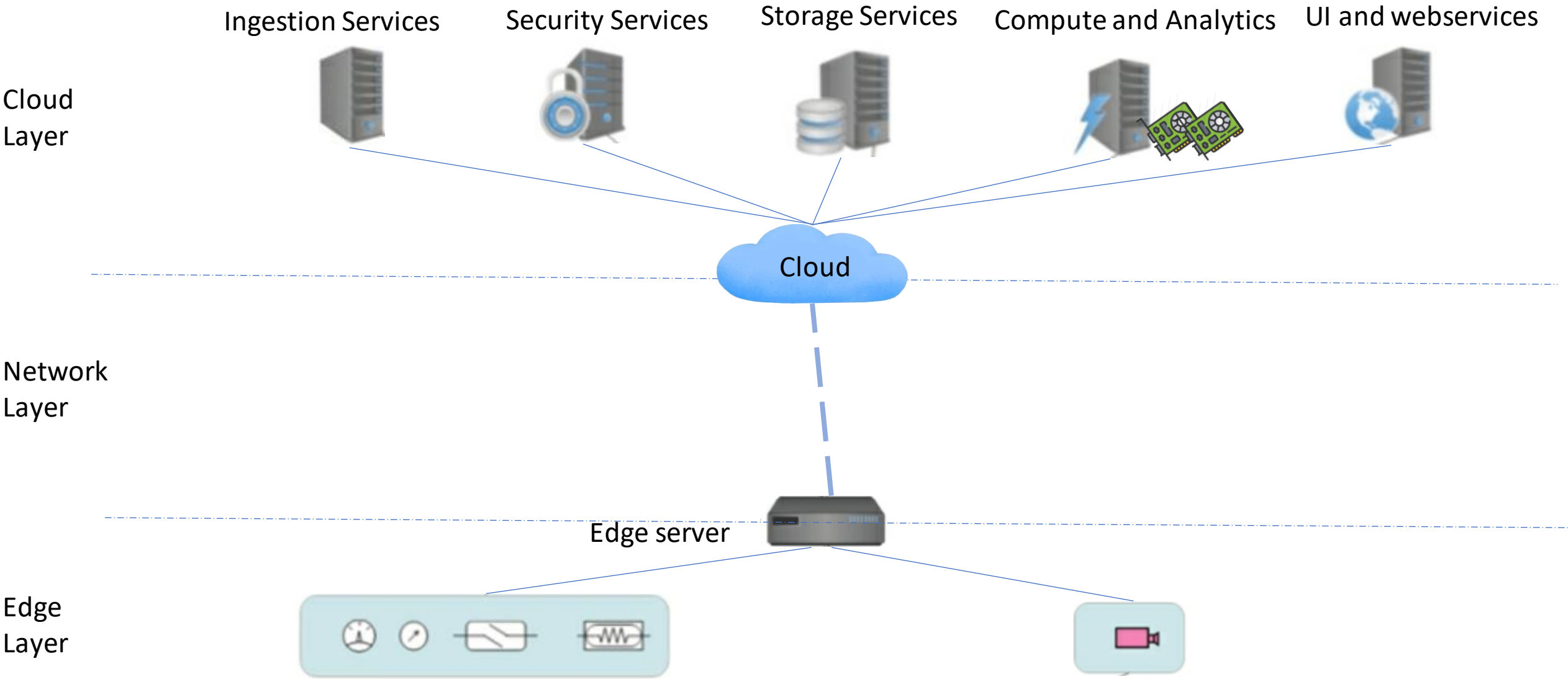


Project Idea – IoT application

- **Sensing and power :** sensors, cameras, real-time systems on the devices
- **Edge computing :** distribute computing from cloud data centers to the sources of data
- **Data communication :** WPANs , LANs; (how will the data get off the edge and on the internet?)
- **Cloud :** infrastructure as a service provider, manage database, streaming and batch processing, support data analytics packages, machine learning services
- **Security :** end-to-end components from physical sensors to the CPU and digital hardware to the communication system needs to ensure security, authenticity, and integrity

Project Idea – IoT application

Architecture



[2]. IoT and Edge Computing for Architects: Implementing edge and IoT systems from sensors to clouds with communication systesm, analytics, and security, 2nd Edition, Perry Lea

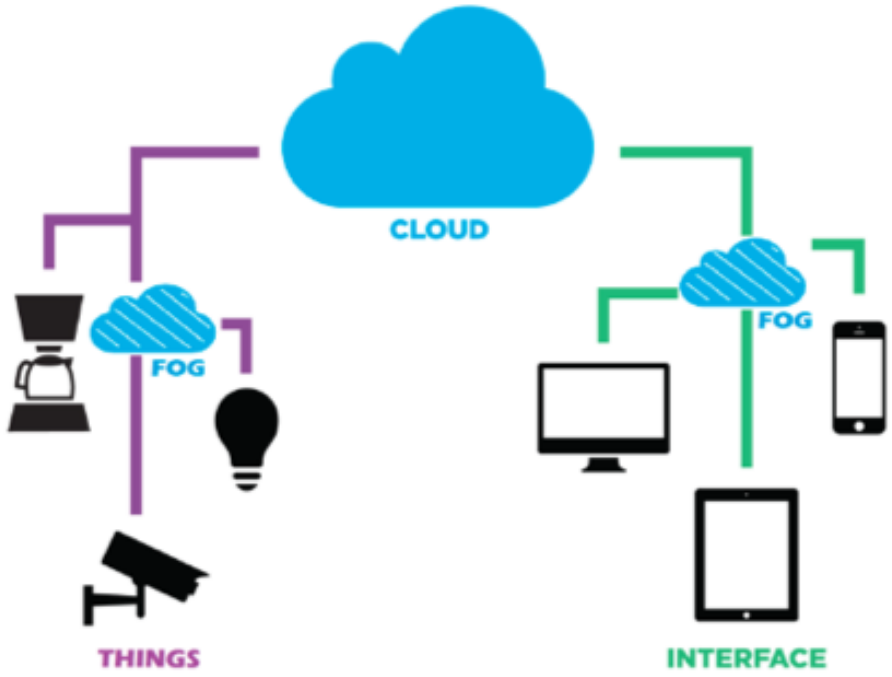
IoT application - Challenges and Opportunities

- Local Hardware:
  - Local devices and sensors installation, and connectivity to the cloud.
- Data Collection:
  - Integrate data from multiple difference resources with different formats and granularity
- Data Analysis:
  - Edge and Cloud Coordination: How to distribute the workloads to improve latency issues, response time
  - Apply machine learning tools to analyze the real-time data
- Scalability:
  - Scale up to million/thousands devices
- Energy-efficient with high resource utilization Solutions

Project Idea – IoT application

For this course, an excellent IoT project need to have edge-cloud interactions:

- It may pull the data from outside source to the cloud in a streaming pattern, and ideally, in a streaming pattern with continuous updates flowing all the time.



Project Idea - Traditional cloud applications

- Real-time data processing and storage systems
- Digital twin applications, such as items tracking
- Cloud based video processing

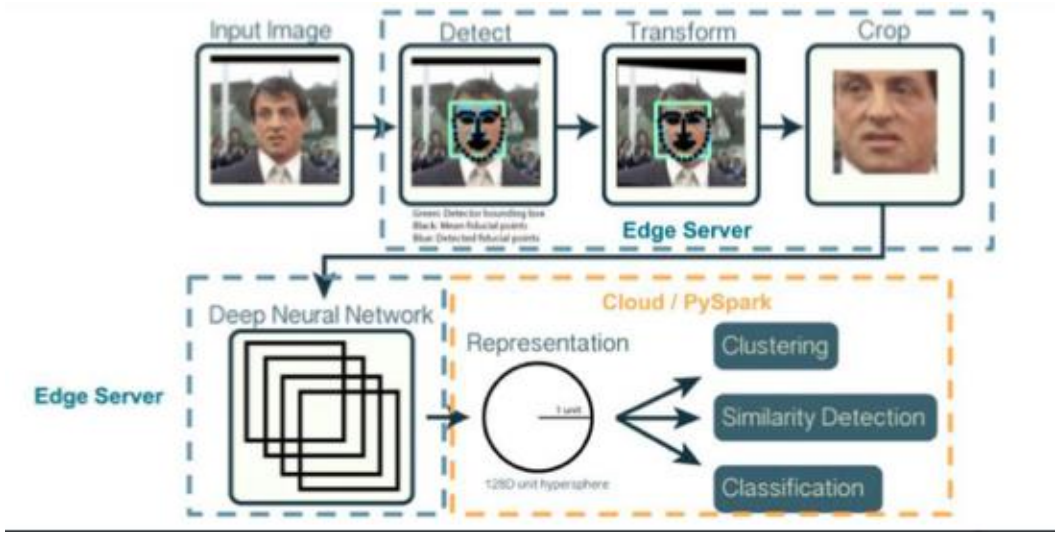
Project direction3 - Traditional cloud researchs

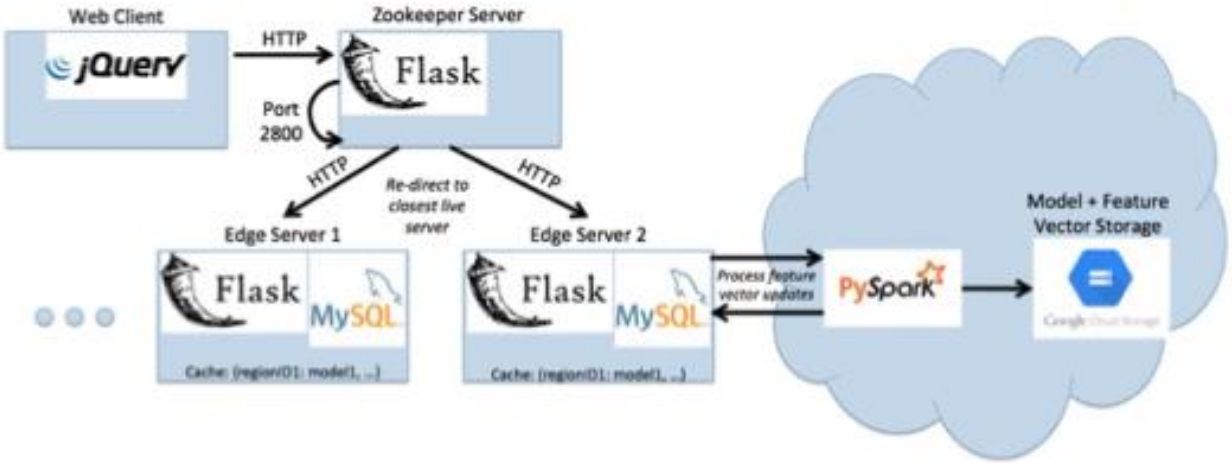
- Examples – key/value store, storage system, banking application etc.
- Distributed system guarantee availability and consistency across farilures
- Manage application membership (sharding/replication/leaves/joins)
- Performance optimization - high throughput with low latency
- Scalability - Scale with the number of users, computing machines, request rates
- Recommended for students interested in pursuing MS/PhD or a career in Systems

Project Examples and Resources

Image-based authentication for banking

Yu Gu, Gloria Xiao, George Li



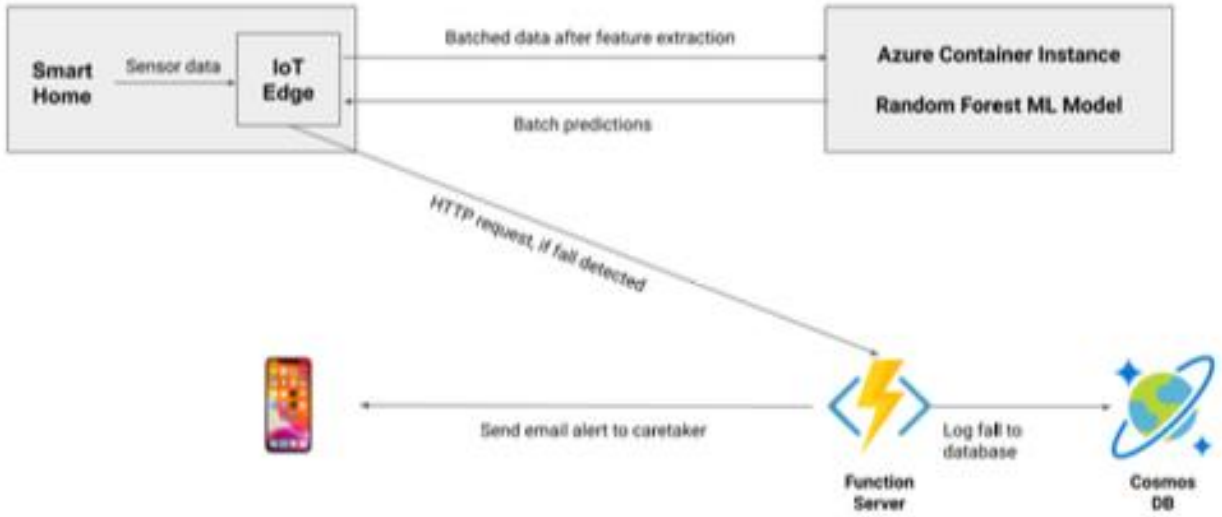


An IoT System for Automatic Fall Detection in Smart Homes

Benjamin Posnick, Arjun Bhalla

Based on sensor data, perform feature engineering -> define trajectory -> train machine learning model -> end-to-end pipeline

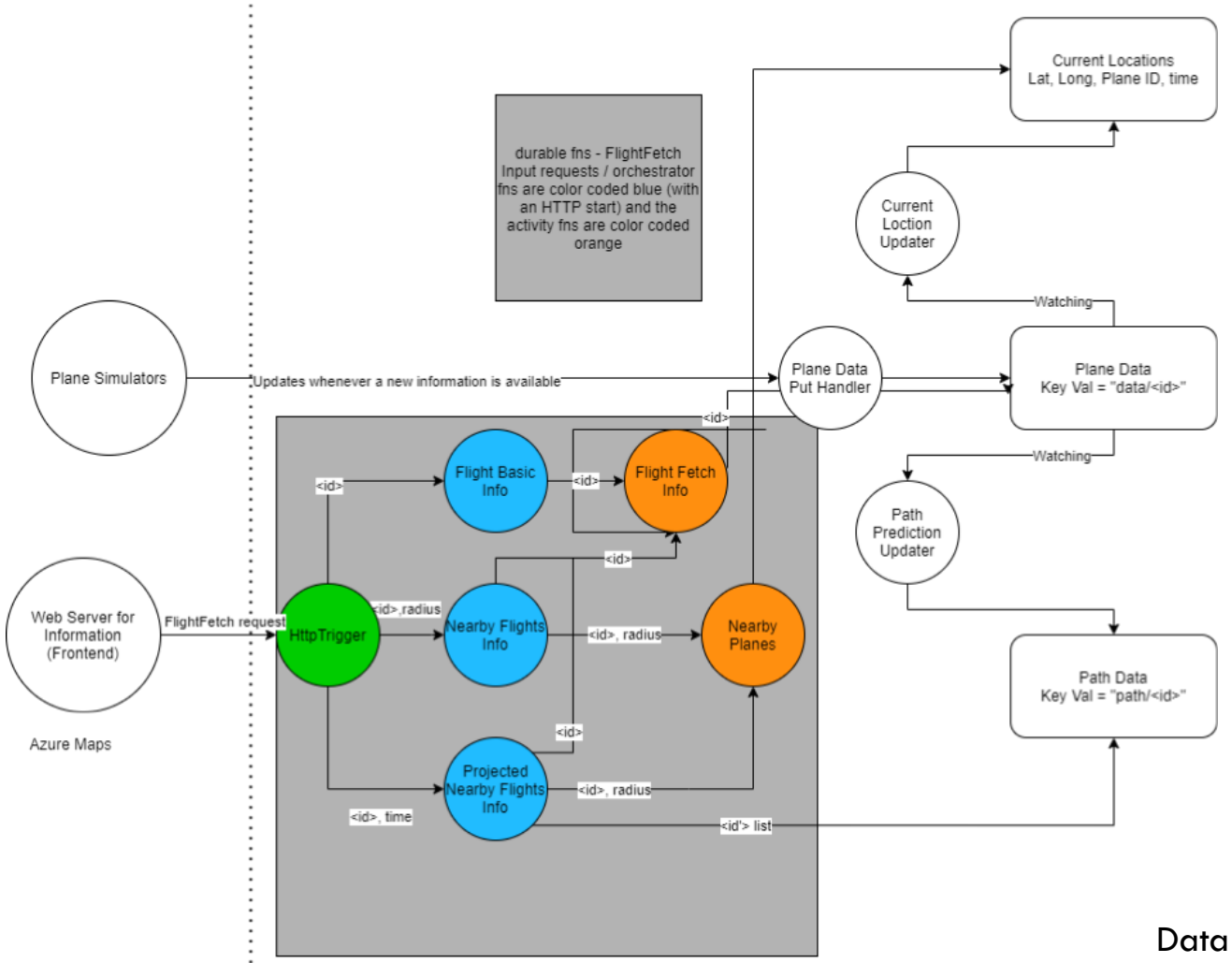
$$\text{trajectory}(a,b,c) = \begin{cases} 1 & \text{if } a < b \text{ and } b < c \\ 0 & \text{if } a < b \text{ and } b > c, \text{ or } a > b \text{ and } b < c \\ -1 & \text{if } a > b \text{ and } b > c \end{cases}$$

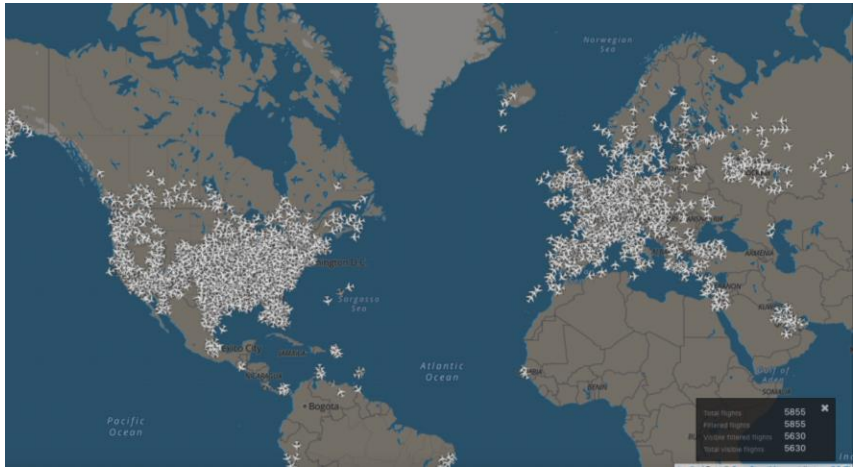


Nearby Plane in Flight Information Service

- Web app to allow those on a flight so see nearby planes' relative locations

Brynn Szczesniak, Freya Ryd, Saleh Hassen





Data input is taken from the OpenSky Network (https://opensky-network.org)

Week 1 Material Revisit

CS5412 Week 1: A Glimpse on Database

- Relational database
  - Data are organized in predefined relations or schemas.
  - Data are stored in tables.
  - MySQL, Postgres, etc.

CustomerID	CustomerName	ContactName	Address	City	PostalCode	Country
1	Alfreds Futterkiste	Maria Anders	Obere Str. 57	Berlin	12209	Germany
2	Ana Trujillo Emparedados y helados	Ana Trujillo	Avda. de la Constitución 2222	México D.F.	05021	Mexico
3	Antonio Moreno Taquería	Antonio Moreno	Mataderos 2312	México D.F.	05023	Mexico
4	Around the Horn	Thomas Hardy	120 Hanover Sq.	London	WA1 1DP	UK
5	Berglunds snabbköp	Christina Berglund	Berguvsvägen 8	Luleå	S-958 22	Sweden

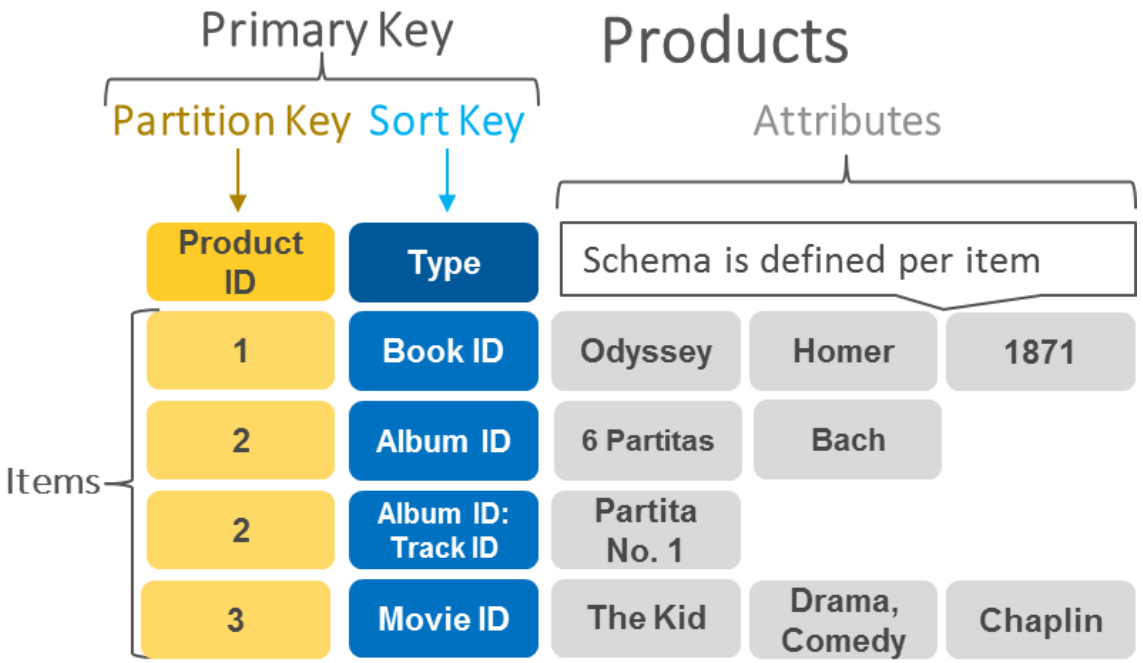
https://www.w3schools.com/sql/default.asp

CS5412 Week 1: A Glimpse on Database, cont'd

- SQL
  - Structured Query Language.
  - A standard language used to query database(s).
  - Even KVS can support SQL queries.
  - Lots of optimizations.
  - E.g., `SELECT CustomerName, City FROM Customers;`

CS5412 Week 1: A Glimpse on Database, cont'd

- KVS
  - Value can represent the design of schemas.
  - There can be multiple levels of keys.
  - NoSQL = not only SQL
  - E.g., DynamoDB …



CS5412 Week 1: A Glimpse on Database, cont'd

- Some operations are really expensive, e.g., join

```
SELECT Orders.OrderID, Customers.CustomerName,
Orders.OrderDate
FROM Orders
INNER JOIN Customers ON Orders.CustomerID=Customers.Custom
erID;
```

OrderID	CustomerID	OrderDate
10308	2	1996-09-18
10309	37	1996-09-19
10310	77	1996-09-20

CustomerID	CustomerName	ContactName	Country
1	Alfreds Futterkiste	Maria Anders	Germany
2	Ana Trujillo Emparedados y helados	Ana Trujillo	Mexico
3	Antonio Moreno Taquería	Antonio Moreno	Mexico

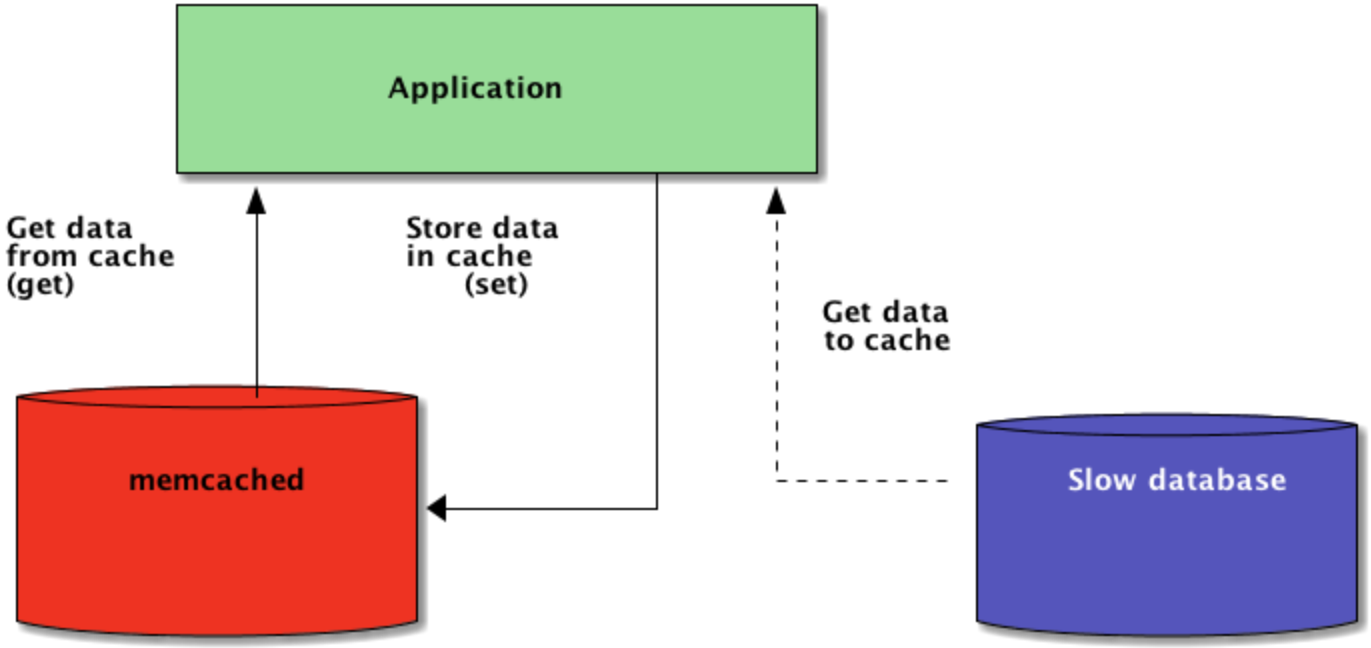
CS5412 Week 1: A Glimpse on Database, cont'd

OrderID	CustomerName	OrderDate
10308	Ana Trujillo Emparedados y helados	9/18/1996
10365	Antonio Moreno Taquería	11/27/1996
10383	Around the Horn	12/16/1996
10355	Around the Horn	11/15/1996
10278	Berglunds snabbköp	8/12/1996

- When your operation impacts multiple tables, the join operation is even more expensive. Schema design is very important.
- For SQL, using efficient queries, like using a proper order of join operation, can greatly enhance performance.
- For KVS, traversing multiple tables is also expensive.

CS5412 Week 1: Memcached

- Architecture



https://realpython.com/python-memcache-efficient-caching/

CS5412 Week 1: Memcached, cont’d

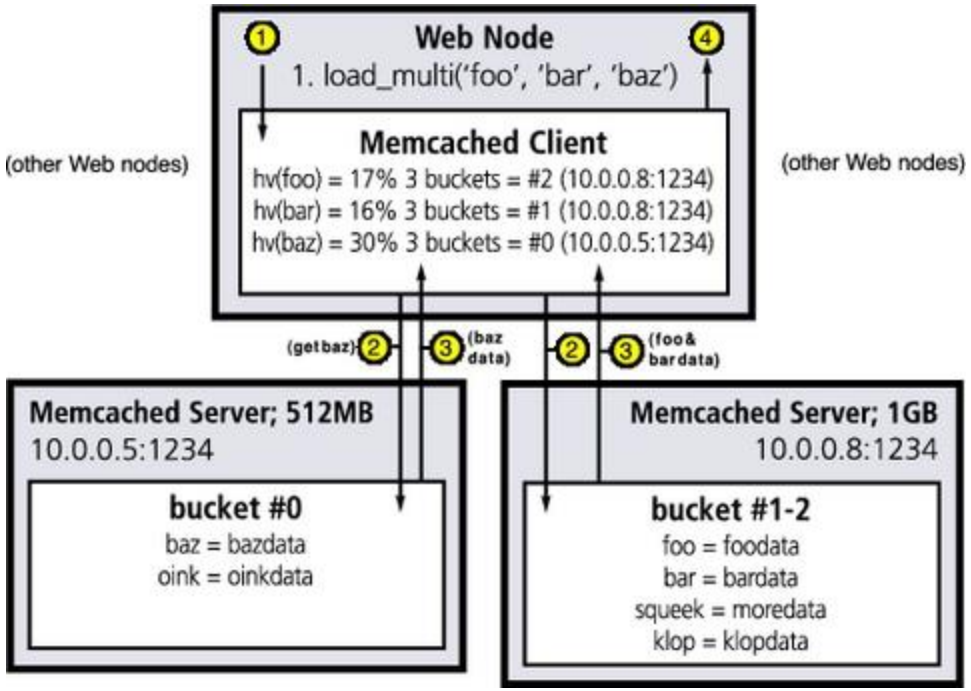
- Very easy to use.

(pip install python-memcached)

```
from pymemcache.client import base
client = base.Client(('localhost', 11211))
client.set('some_key', 'some value’)
client.get('some_key')
```

CS5412 Week 1: Memcached, cont'd

- It can be much more powerful.
  - Distributed cache across multiple hosts.
  - In-memory cache.



https://www.linuxjournal.com/article/7451

CS5412 Week 1: Memcached, cont'd

- There are small "caveats".
  - Size limit per cache line is 1MB. It can be configured to a larger size (memcached -I 5m) or you can: compress and cut your data, build multiple levels of cache, etc....
  - Programmers need to handle data synchronization on their own.
  - Fancy features like versioning, time stamping and etc. do not come out of the box.

CS5412 Week 1: Memcached, cont'd

- You might want try something different.
  - Store the data structure, not a string.
  - Being tired of manually checking and synchronizing data.
  - What if I lost a server? Any data backup?
  - Let's tune our clock from 2003 (Memcached) to 2009

CS5412 Week 1: Redis

- Redis=Remote Dictionary Service
- Features:
  - In-memory data structure storage
  - Address lots of programmers' concerns as mentioned above.
- Developed by
  - Salvatore Sanfilippo
  - VMware/Pivotal Engineer
  - Originate from real problem in 2009
    - Analyzing web log.
    - Traditional database is too slow.

CS5412 Week 1: Redis, cont'd

- Sometimes I
  - Regard Memcached as a light-weight cache layer.
  - But treat Redis as a fully-fledged database.
- It is an effective tool to address Gray's concerns on database scaling, as Ken mentioned in class.
- Nearly all major software companies use Redis at some level of their software stack. Who doesn't?

CS5412 Week 1: Redis, cont'd

	Memcached	Redis
Sub-millisecond latency	Yes	Yes
Developer ease of use	Yes	Yes
Data partitioning	Yes	Yes
Support for a broad set of programming languages	Yes	Yes
Advanced data structures	-	Yes
Multithreaded architecture	Yes	-
Snapshots	-	Yes
Replication	-	Yes
Transactions	-	Yes
Pub/Sub	-	Yes
Lua scripting	-	Yes
Geospatial support	-	Yes

https://aws.amazon.com/elasticache/redis-vs-memcached/

CS5412 Week 1: Redis, cont'd

- After 13 years
  - Redis is still popular and like an industry standard.
  - We get new challengers.

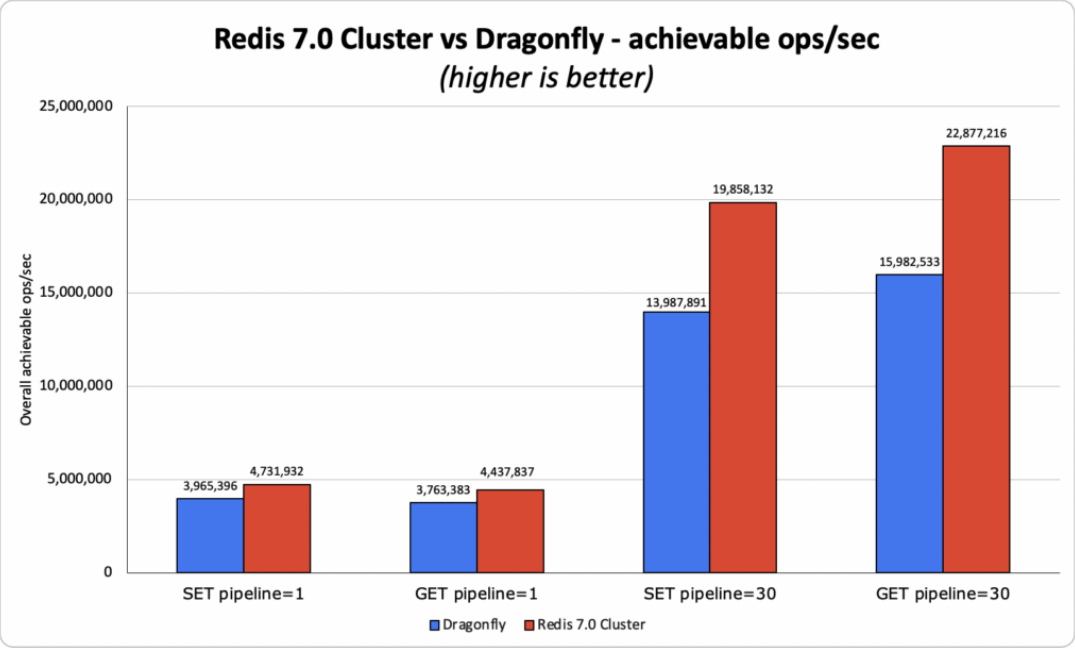
CS5412 Week 1: Dragonfly

Dragonfly VS Redis

Dragonfly is compatible with Redis APIs, implemented by a modern engine architecture. Check out the comparison below. Click the links for more details.

	Dragonfly	Redis
Redis API compatible	✓	✓
Snapshot persistency	✓	✓
Lua	5.4.4	5.1
QPS per instance	3M	200K
Async core	✓	
LRFU eviction	✓	
Memcached API compatible	✓	
Native Open Telemetry	✓	

https://dragonflydb.io/



https://redis.com/blog/redis-architecture-13-years-later/#:~:text=Redis%20vs%20Dragonfly%20%E2%80%93%20Redis%20throughput,we%20were%20able%20to%20reproduce.

CS5412 Week 1: Dragonfly, cont’d

- Open question
  - What is the most popular use case?
  - What is the performance need?