

Advancing Personalized Driver Action Recognition in Federated Learning: User-Centric Approaches

Liangqi Yuan, PhD Student

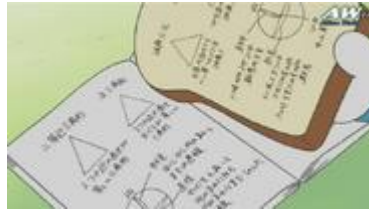
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How to Share knowledge?

How to Share knowledge?



Memory Bread, Doraemon
(https://doraemon.fandom.com/wiki/Copying_Toast)

How to Share knowledge?



A teacher in a classroom at a secondary school in Pendembu, Sierra Leone (Teacher, Wikipedia)

How to Share knowledge?



Benefits of Group Work (www.teachhub.com)







How to Share knowledge?

IV2023 IOT IN ITS WORKSHOP MENU

WORKSHOP AGENDA

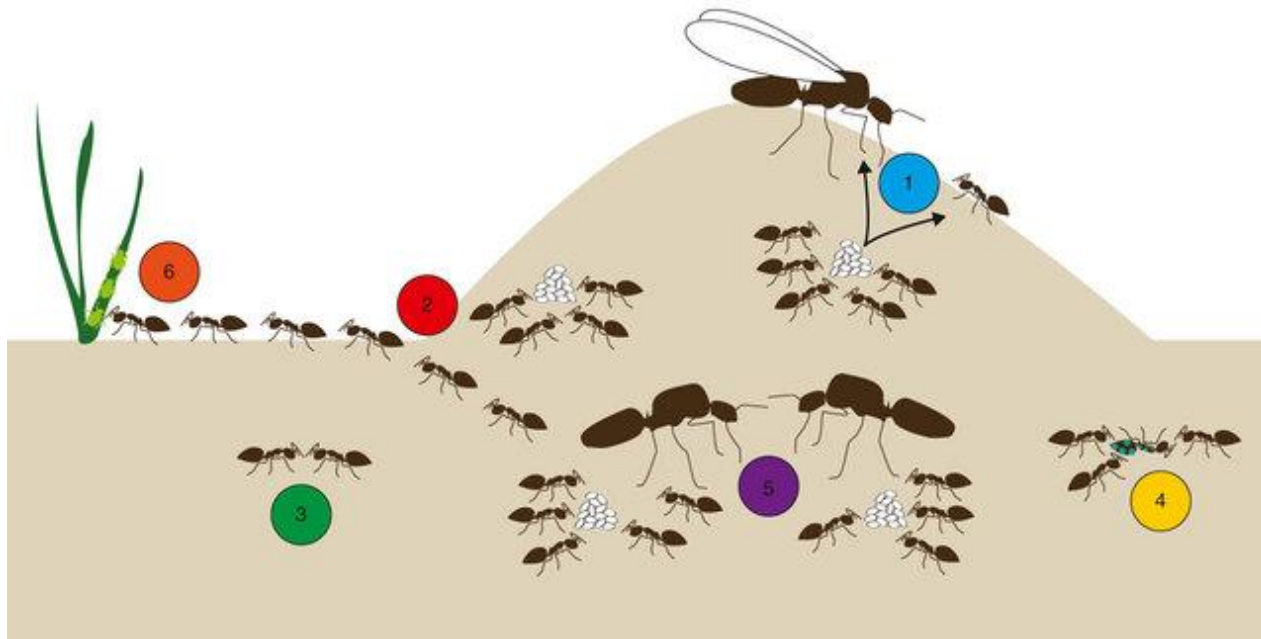
Following talks will be given on Sunday, Jun. 4, 2023 @ 13:40(AKDT), 14:40(PDT)

The following agenda is a draft version, which will be finalized once all invited speakers are confirmed.

-  Qing Yang
13:40 - 14:25, Keynote: Machine Learning based Cooperative Perception for Connected and Autonomous Vehicles
-  Zhengwei Bai
14:25 - 14:55, Lightweight, Scalable, and Heterogeneous Cooperative Perception for 3D Object Detection
-  Yitao Chen
14:55 - 15: 25, Exploring the Capabilities of Mobile Devices in Supporting Deep Learning
-  Hao Gao
15:35 - 16:05, Hierarchical Federated Learning With Mean Field Game Device Selection for Connected Vehicle Applications
-  Runjia Du
16:05 - 16:35, Driver Monitoring-Based Lane-Change Prediction: A Personalized Federated Learning Framework
-  Liangqi Yuan
16:35 - 17:05, Advancing Personalized Driver Action Recognition in Federated Learning: User-Centric Approaches

IV2023 IOT IN ITS WORKSHOP (<https://iot-in-its.github.io/iv2023>)

How to Share knowledge?

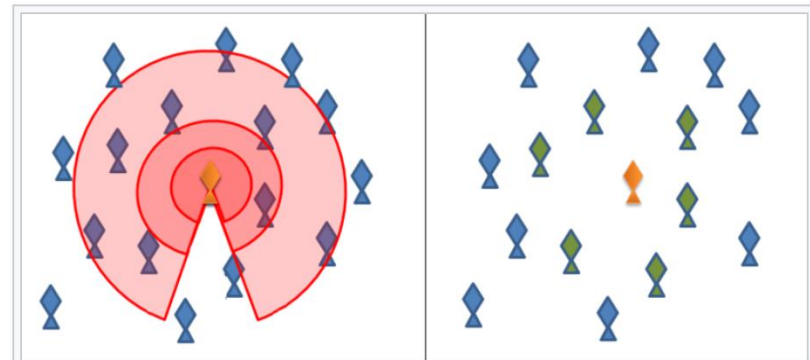


Ant genomics sheds light on the molecular regulation of social organization (Libbrecht, 2013)

How to Share knowledge?



A shoal of fish making way for the blacktip shark swimming in the shallow waters of Heron Island in Queensland, Australia. (www.dailymail.co.uk)



In the [metric distance](#) model of a [fish school](#) (left), the focal fish (yellow) pays attention to all fish within the small zone of repulsion (red), the zone of alignment (lighter red) and the larger zone of attraction (lightest red). In the [topological distance](#) model (right), the focal fish only pays attention to the six or seven closest fish (green), regardless of their distance.

Swarm behaviour, Wikipedia

How to Share knowledge?



Vehicle to Vehicle (V2V)
Connectivity (www.github.org)

How do we share knowledge between vehicles/server?

How to Share knowledge?



Memory Bread (Transmitting raw data)



Vehicle to Vehicle (V2V)
Connectivity (www.github.org)

How do we share knowledge between vehicles/server?

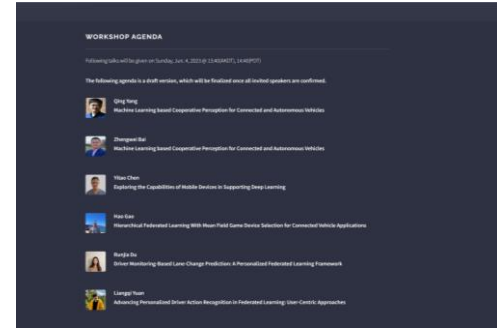
How to Share knowledge?



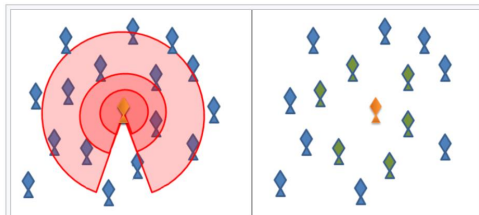
Teacher



Discussion

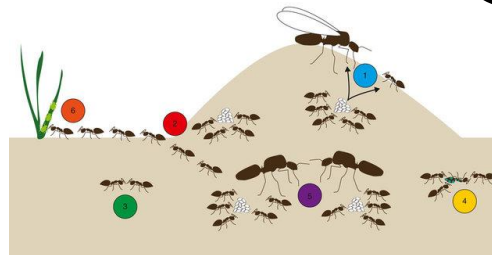


Presentation



In the *metric distance* model of a fish school (left), the focal fish (yellow) pays attention to all fish within the small zone of repulsion (red), the zone of alignment (lighter red) and the larger zone of attraction (lightest red). In the *topological distance* model (right), the focal fish only pays attention to the six or seven closest fish (green), regardless of their distance.

Nighborhood Communication



Management by level



Vehicle to Vehicle (V2V) Connectivity (www.github.org)

How do we share knowledge between vehicles/server?

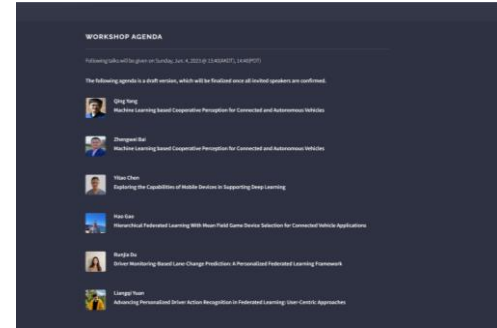
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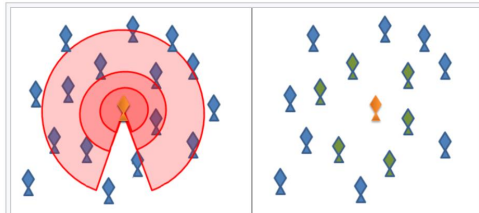
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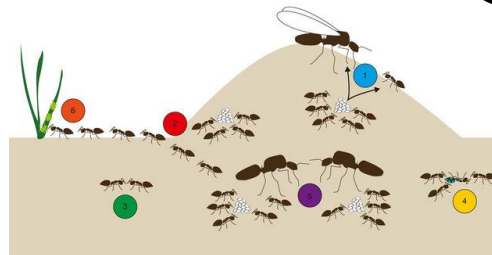


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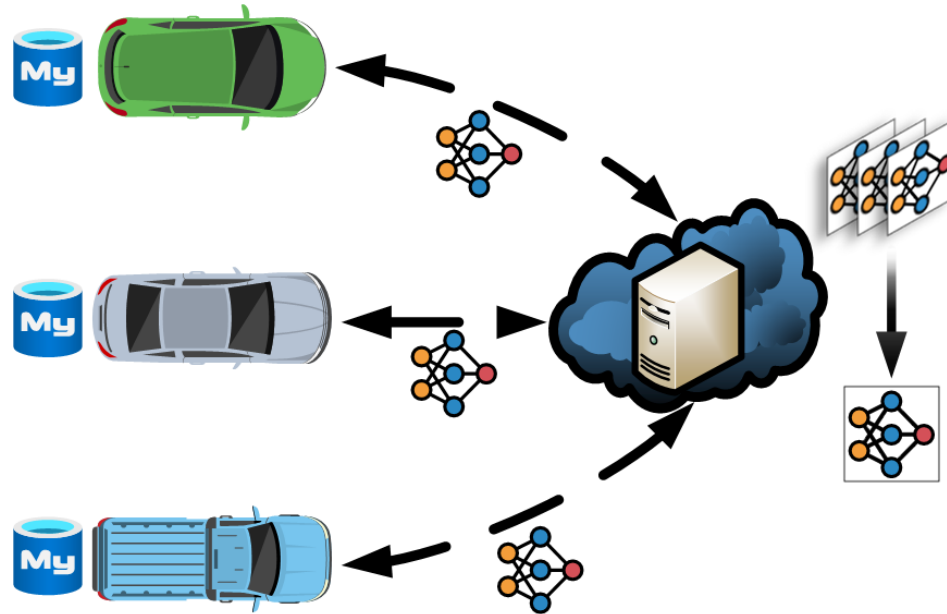


Vehicle to Vehicle (V2V) Connectivity (www.github.org)

How do we share knowledge between vehicles/server?

Federated Learning

Introduction To Federated Learning



How do we share knowledge between vehicles?
Federated Learning

Introduction To Federated Learning



Teacher

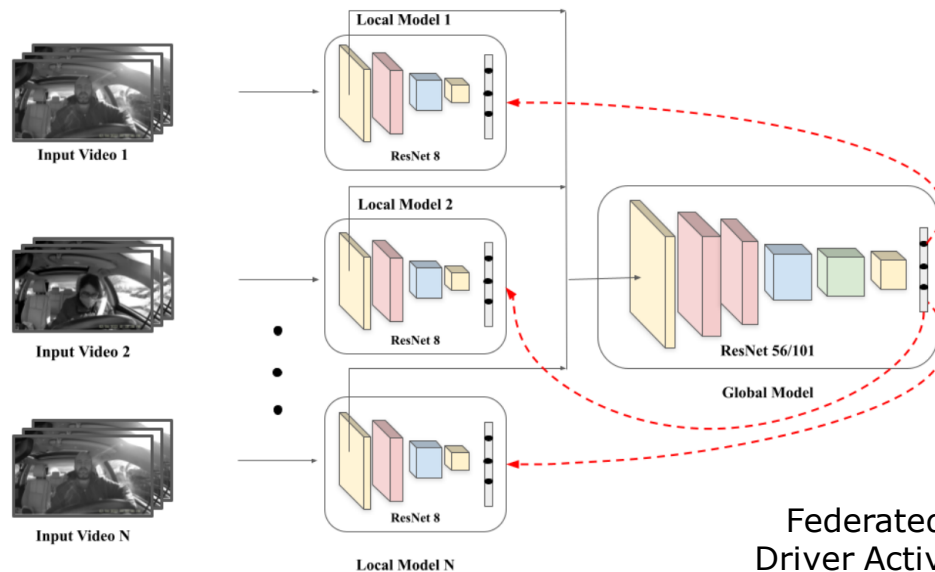
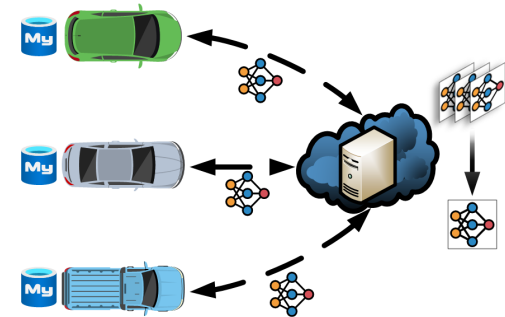


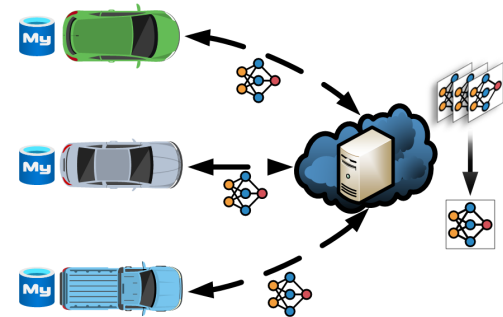
Figure 3. FL Architecture.

Federated Learning-based Driver Activity Recognition for Edge Devices (Doshi, 2022)

Introduction To Federated Learning



Teacher



1. *Who is the server (teacher)?*
2. *Where is the server (teacher)?*
3. *Does the server (teacher) charge?*
4. *How do I trust the server (teacher)? **Fairness?***

Introduction To Federated Learning



This is my fairness.

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Introduction To Federated Learning



This is my fairness.



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Introduction To Federated Learning



This is my fairness.



This is teacher fairness.

The clients (students) and the server (teacher) have different objectives.

1. *Who is the server (teacher)?*
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Methodology

The clients (students) and the server (teacher) have different objectives.



Ways to improve your grades:

1. Review after class
2. Teaching by level

...

Federated Transfer-Ordered-Personalized Learning for Driver Monitoring Application (IEEE IoT J)

Review after class - Personalized Federated Learning

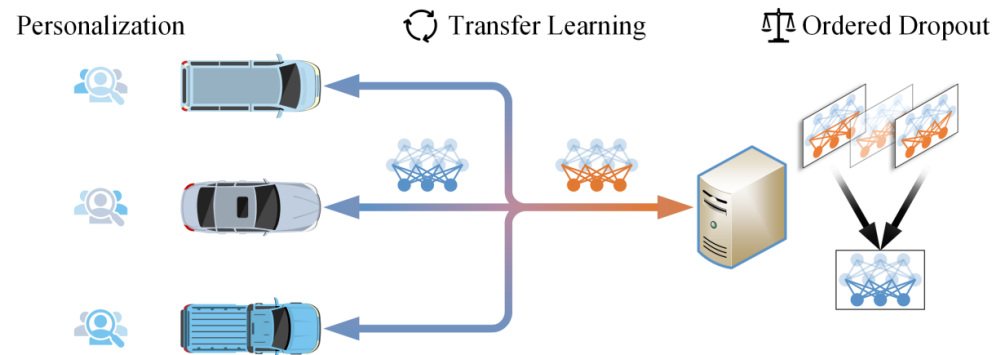


Fig. 3. Schematic diagram of the proposed FedTOP system, where transfer, ordered, and personalized extensions are deployed on the communication, server, and client sides, respectively. They operate independently and do not interfere with each other.

Federated Transfer-Ordered-Personalized Learning for Driver Monitoring Application (IEEE IoT J)

Review after class - Personalized Federated Learning



Personalize the aggregated model

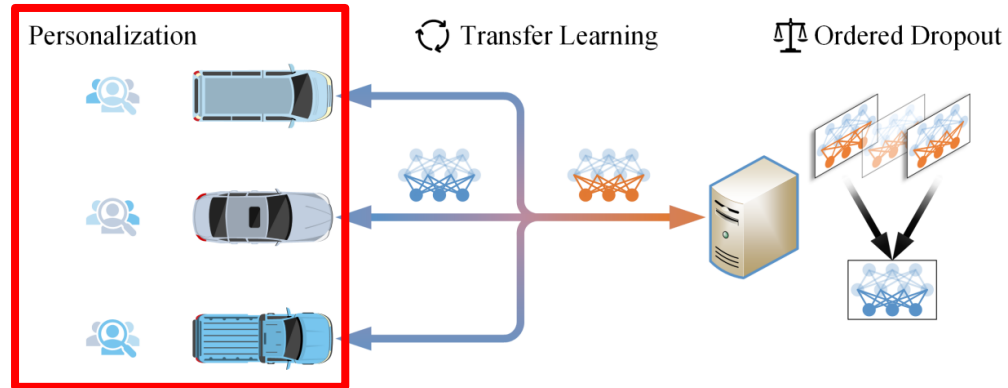


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Review after class - Personalized Federated Learning



Dropout models with high losses

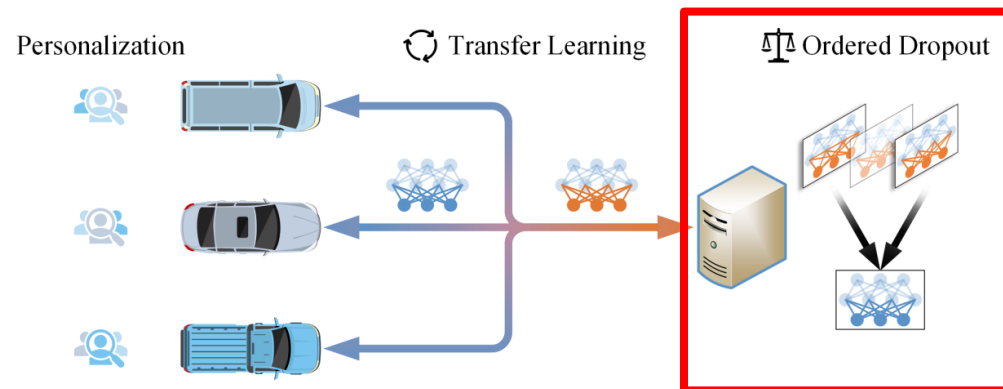


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Review after class - Personalized Federated Learning



Transfer learning to reduce communication overhead

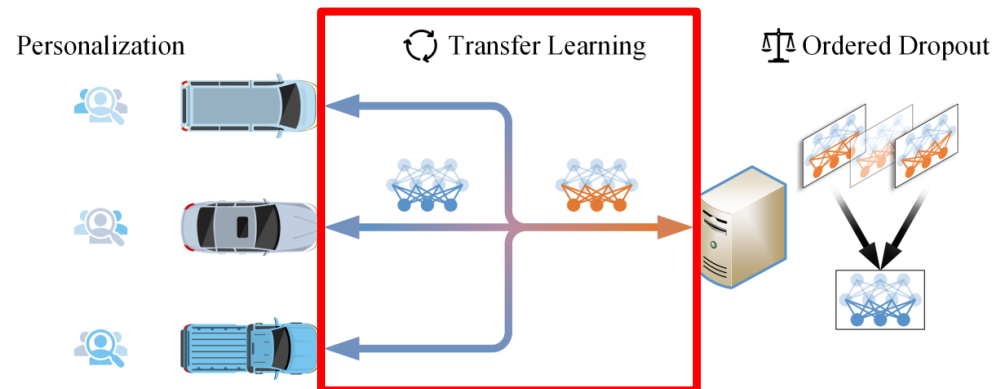


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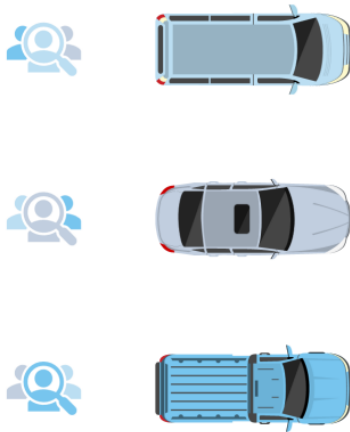
Federated Transfer-Ordered-Personalized Learning for Driver Monitoring Application (IEEE IoT J)

Why is the teacher not enough? Why do we need to review?



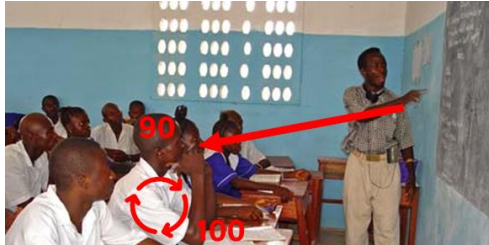
We have different backgrounds
(system heterogeneity)

Personalization



Federated Transfer-Ordered-Personalized Learning for Driver Monitoring Application (IEEE IoT J)

Why is the teacher not enough? Why do we need to review?



We have different backgrounds
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State farm distracted driver detection
(<https://www.kaggle.com/c/state-farm-distracted-driver-detection>)

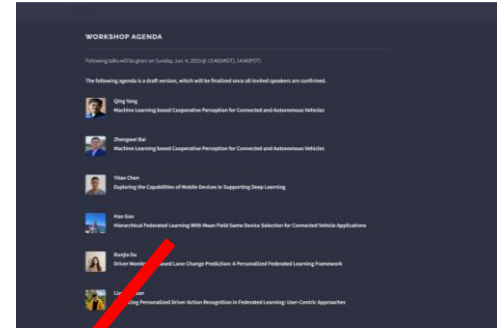
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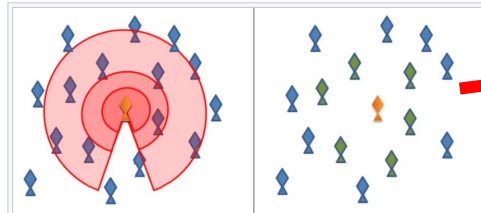
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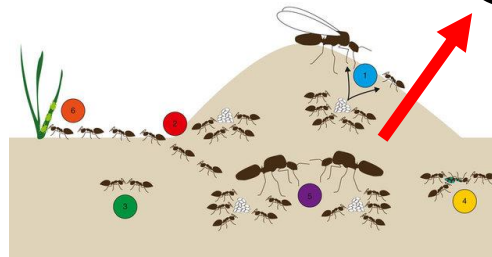


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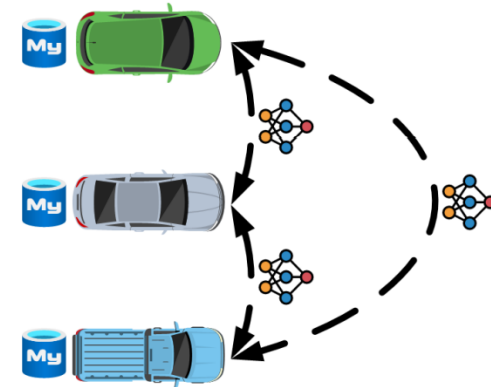
How do we share knowledge between vehicles?
Federated Learning

Peer-to-Peer Federated Continual Learning for Naturalistic Driving Action Recognition (CVPRW 2023)

Gossip - Peer-to-Peer Federated Learning



The Year in Gossip
(<https://hazlitt.net/feature/year-gossip>)



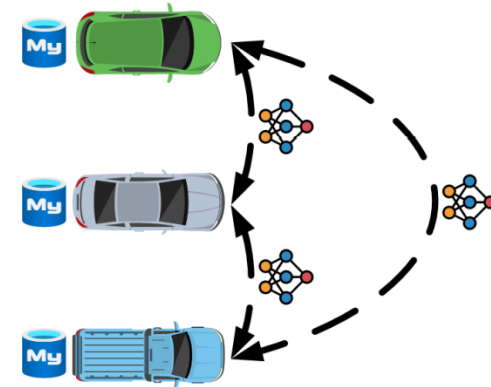
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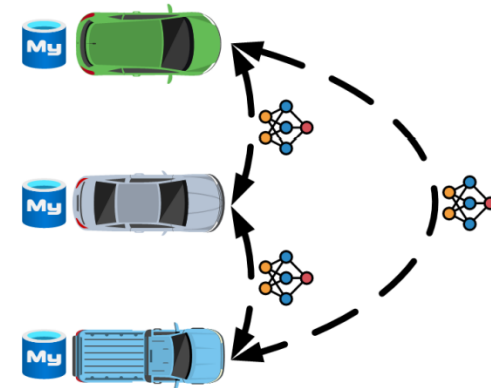
→ My father: LY got an offer from Purdue, a **university located in the middle of the United States.**

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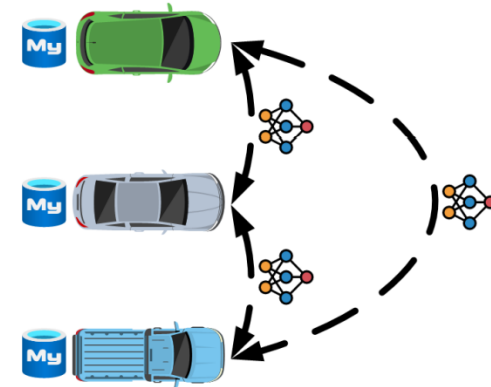
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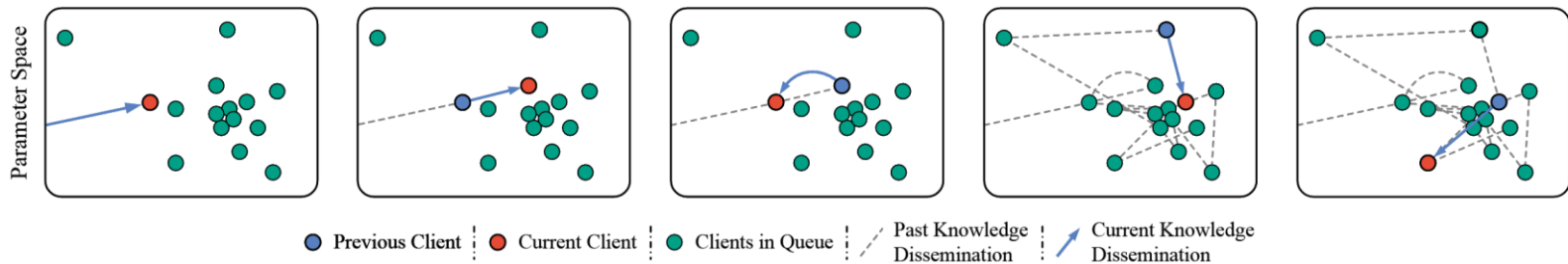
→ My grandmother: LY got an offer from Purdue, **which is well known for its College of Engineering,** a university in the middle of the United States, which is near Chicago.

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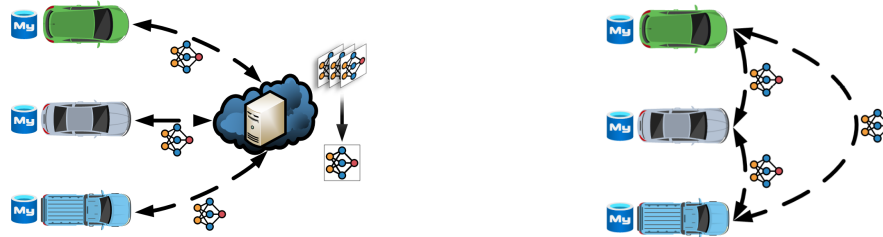
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No server! No aggregation!

Peer-to-Peer Federated Continual Learning for Naturalistic Driving Action Recognition (CVPRW 2023)

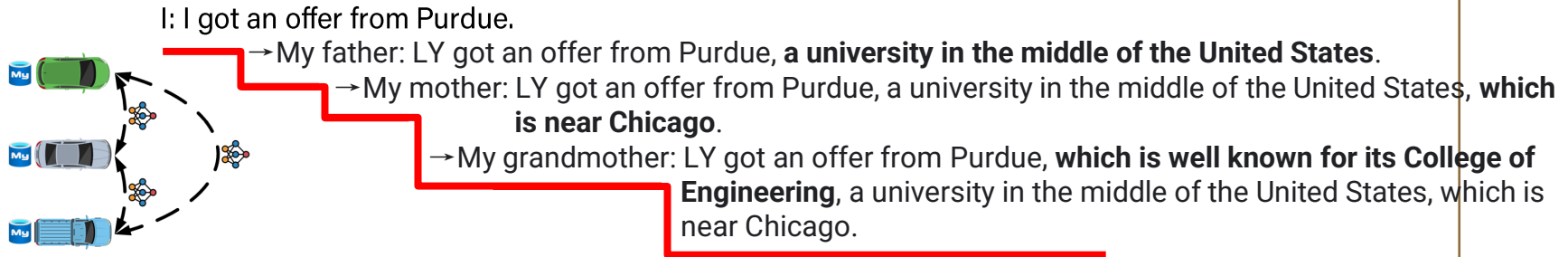
Gossip - Peer-to-Peer Federated Learning



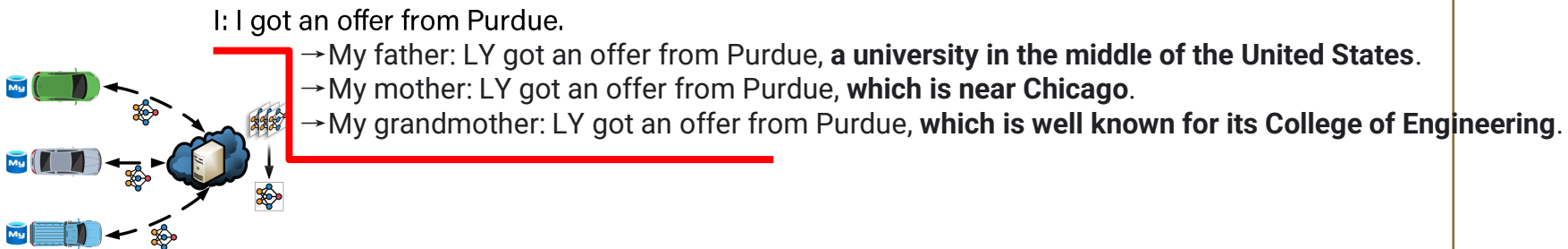
| System | C2S FL (FedAvg) | FedPC (proposed) |
|--------------------------------|---|---|
| Objective | Clients: a personalized model for each client. Server: a single generalized model | Clients: a personalized model for each client. Server: N/A |
| Knowledge Dissemination | Server aggregation and transmission | Continual learning from another client model |
| Communication Complexity | Client: send 1 model per iteration round Server: send $ C $ models per iteration round | Client: send 1 model per iteration round Server: N/A |
| Dissemination Rate | Slow, it needs to wait for the server to receive, aggregate, and transmit the models | Quick, it only requires clients to transmit the model to each other |
| Generalizability | Stronger in IID datasets | Partial generalization with non-IID datasets |
| Compatibility with New Clients | Poor, can be enhanced by personalization | Poor, personalization process may be faster |
| Hardware Overhead | High, it requires server communication, computing and storage resources | Low |
| Hidden Concern | Privacy breach, security, trust, SPoF, and aggregation fairness on the server | Lack of incentives, security, and deadlocks on the clients |

Peer-to-Peer Federated Continual Learning for Naturalistic Driving Action Recognition (CVPRW 2023)

Gossip - Peer-to-Peer Federated Learning



Standing on the shoulders of giants!



Advancing Personalized Driver Action Recognition in Federated Learning: User-Centric Approaches



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Federated Learning

- Privacy concerns
- Rarity of dangerous events
- Non-independent and identically distributed (Non-IID) data



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Personalized Driver Action Recognition

- Personalized actions



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User-Centric

- We focus on the users, not the server



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Personalized Driver Action Recognition

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Future Work

- We focus on underrepresented clients
- We focus on inexperienced clients
- Promoting diversity and sustainability in federated learning

THANK YOU

Questions?



Elmore Family School of Electrical
and Computer Engineering