NANYANG TECHNOLOGICAL UNIVERSITY SINGAPORE

Towards Trustworthy Federated Learning

TrustFUL

Trustworthy Federated Ubiquitous Learning

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Self-Introduction

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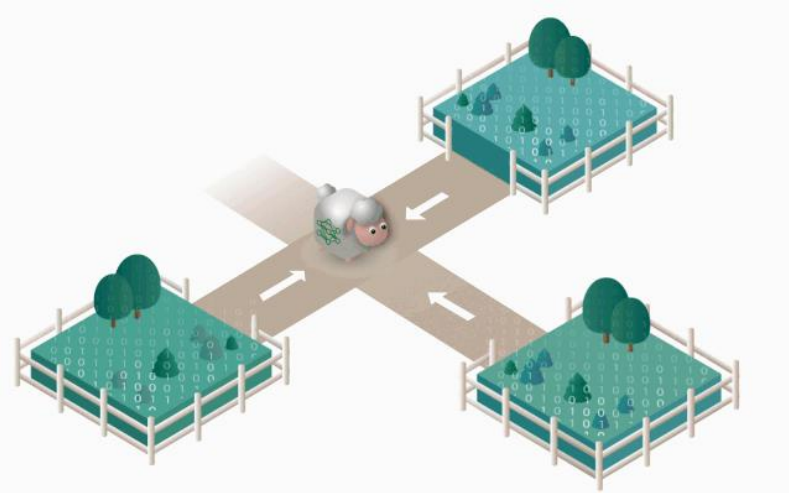
Research Areas:

- Federated Learning
- Multi-Agent Systems

Federated Learning – Privacy-Preserving Machine Learning

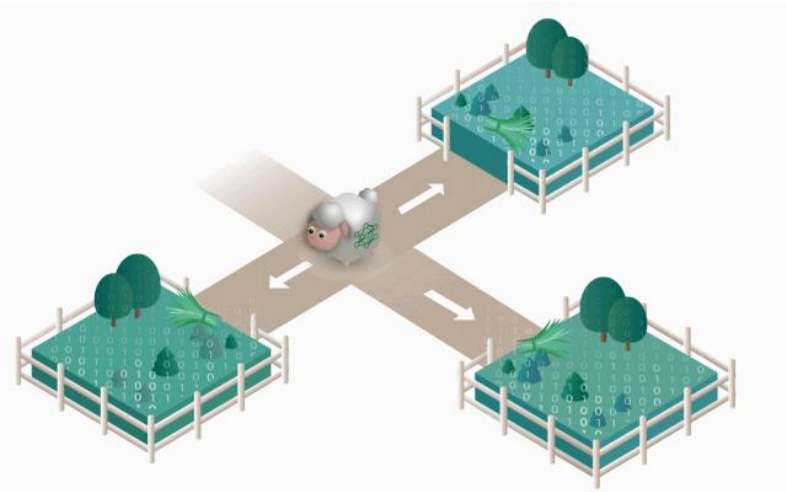


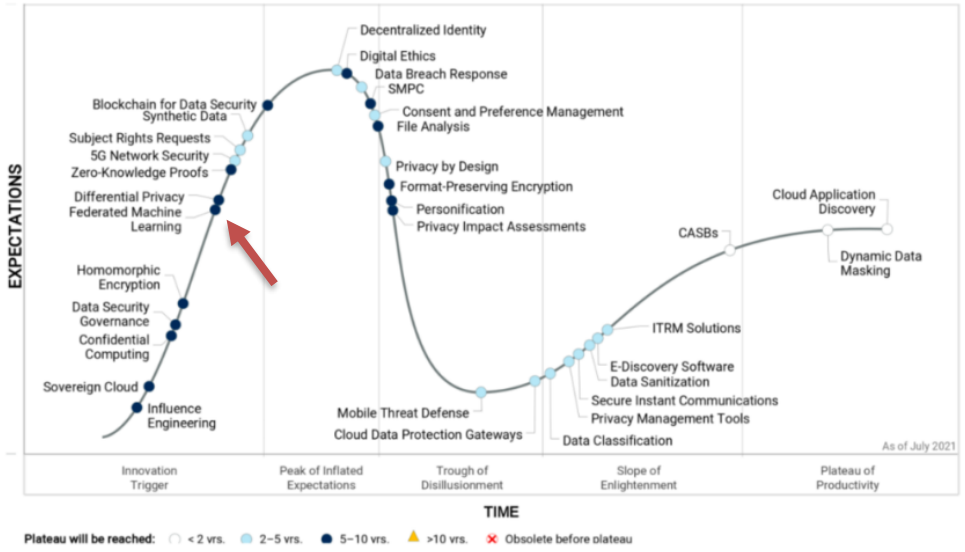
Traditional Machine Learning:

- Moving data to a centralized entity for model training
- Privacy often exposed

Federated Learning:

- Moving model training to where data originate
- Privacy is preserved





An Overview of TrustFUL

https://trustful.federated-learning.org/

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Trustworthy Federated Ubiquitous Learning (TrustFUL) – building trust to enable data providers to participate in AI model co-creation, while protecting their sensitive data.

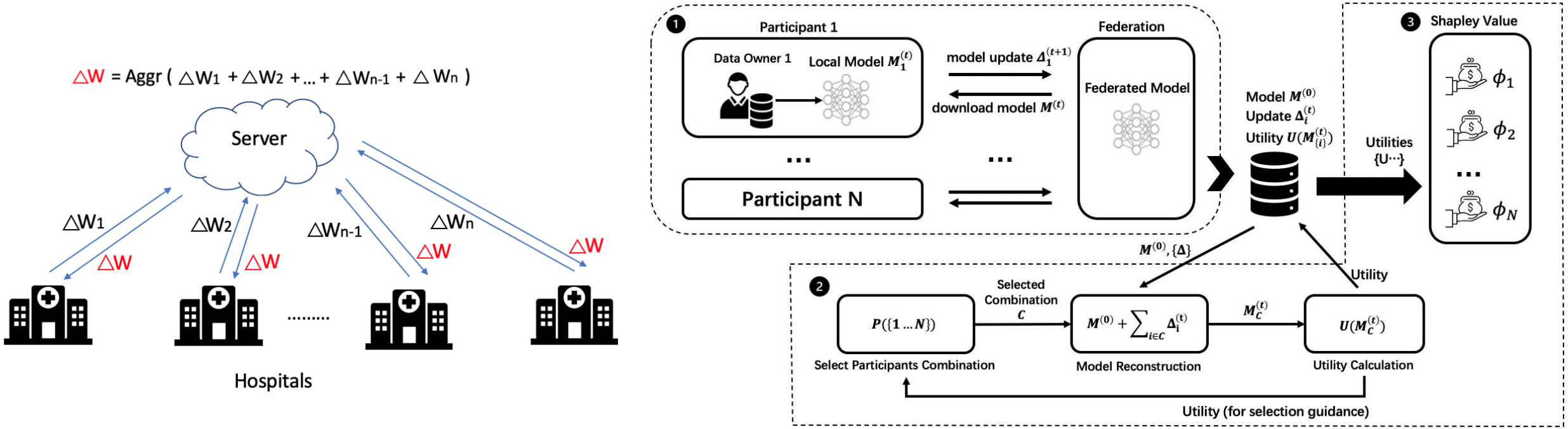
Achieving Trust through:

- Interpretability
  - Data, features, models
- Fairness
  - Opportunities, payoffs
- Robustness
  - Security, scalability

Achieving Ubiquity through:

- Personalizability of models
  - Resource & data heterogeneity
- Transferrability of knowledge
  - Cross country, cross sector, cross tasks

Explainable & Fair Federated Learning

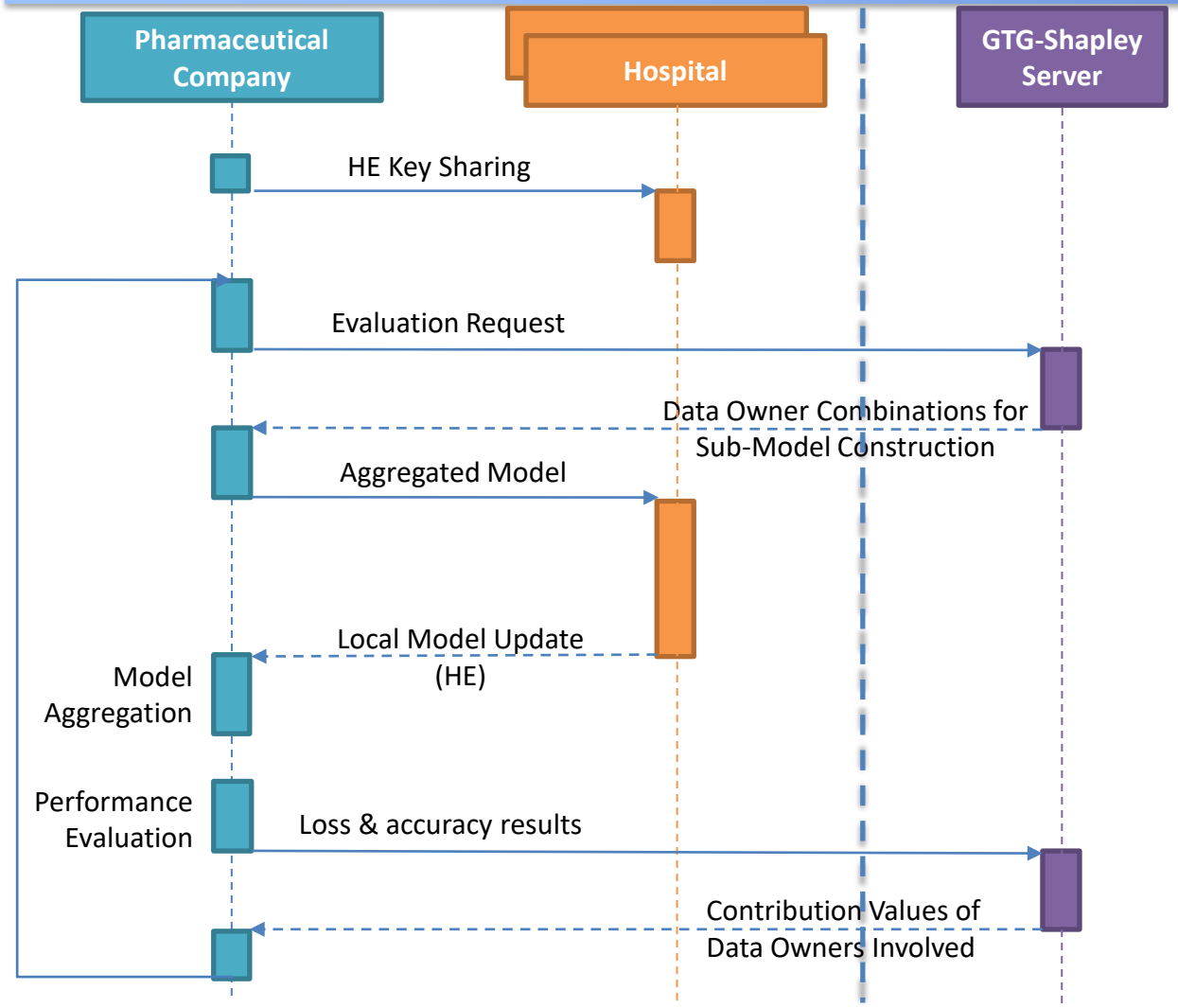


Fair and Efficient FL Participant Contribution Evaluation

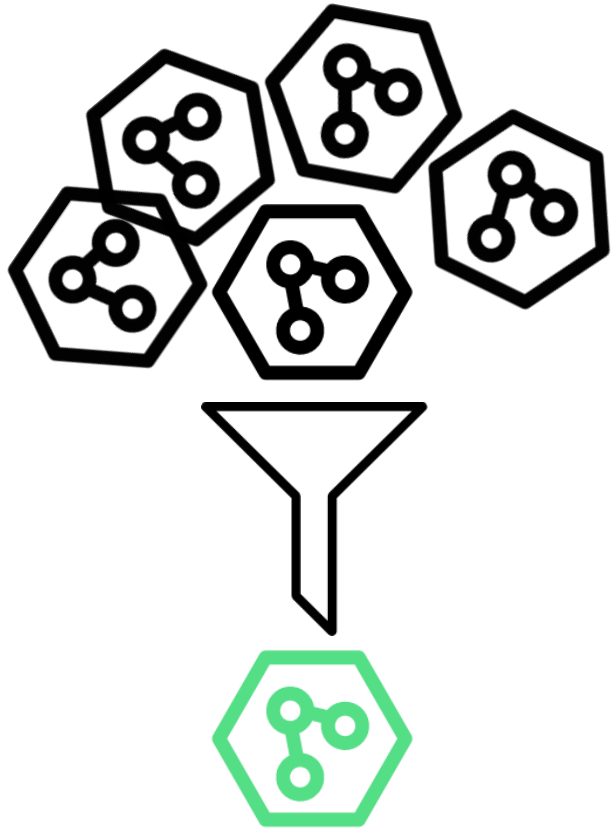
- Developed a fair and efficient algorithm to evaluation FL data owner contributions.
- Significantly enhanced the scalability of Shapley value-based data valuation.

Zelei Liu, Yuanyuan Chen, Han Yu, Yang Liu & Lizhen Cui. GTG-Shapley: Efficient and accurate participant contribution evaluation in federated learning. *ACM Transactions on Intelligent Systems and Technology*, vol. 13, no. 4, pp. 60:1-60:21, ACM (2022).

CAreFL – Contribution-Aware Federated Learning



FL sub-models



"Best Subset" FL Model

Deployment in the Healthcare Industry

https://demo.federated-learning.org/

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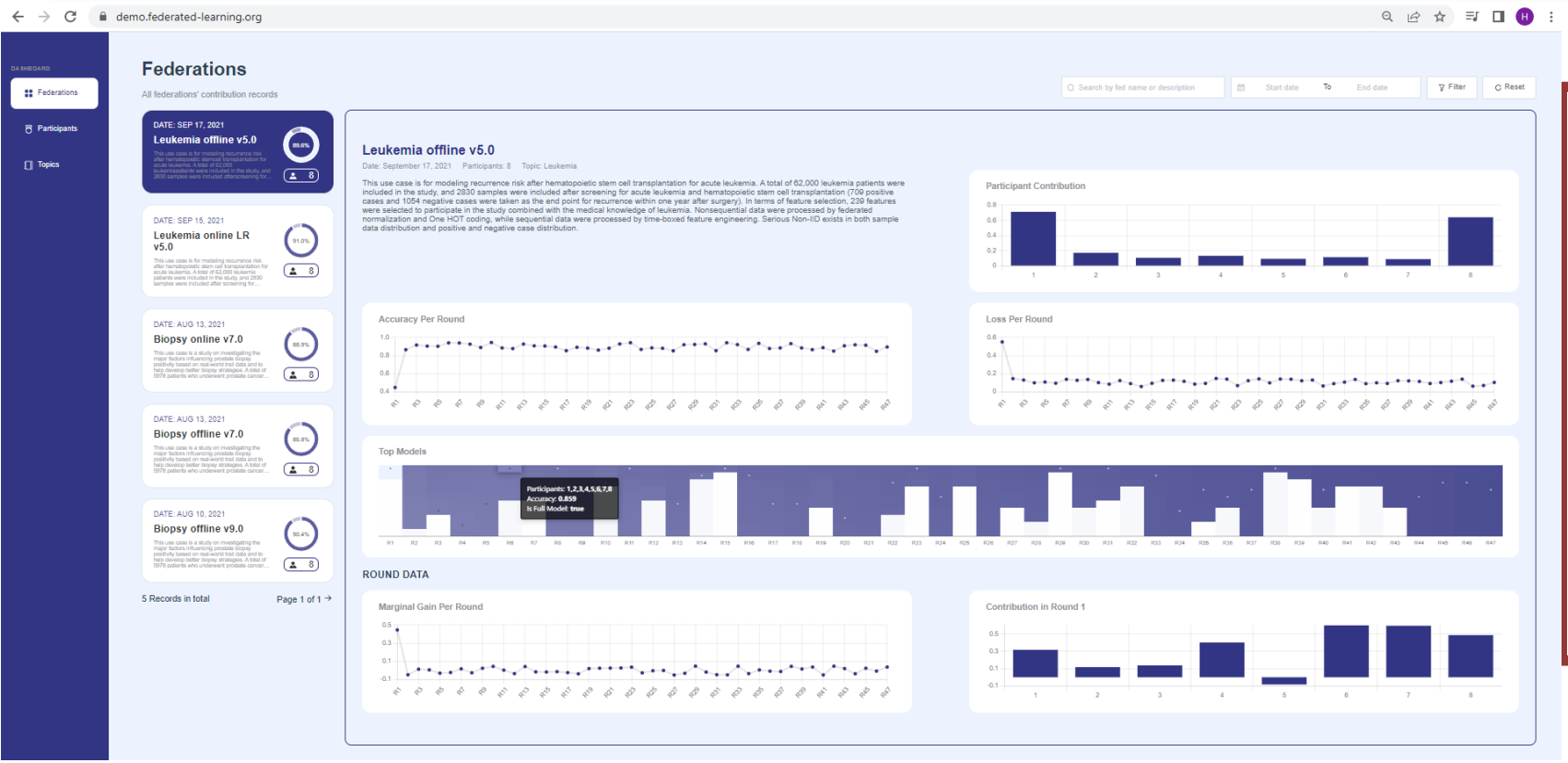
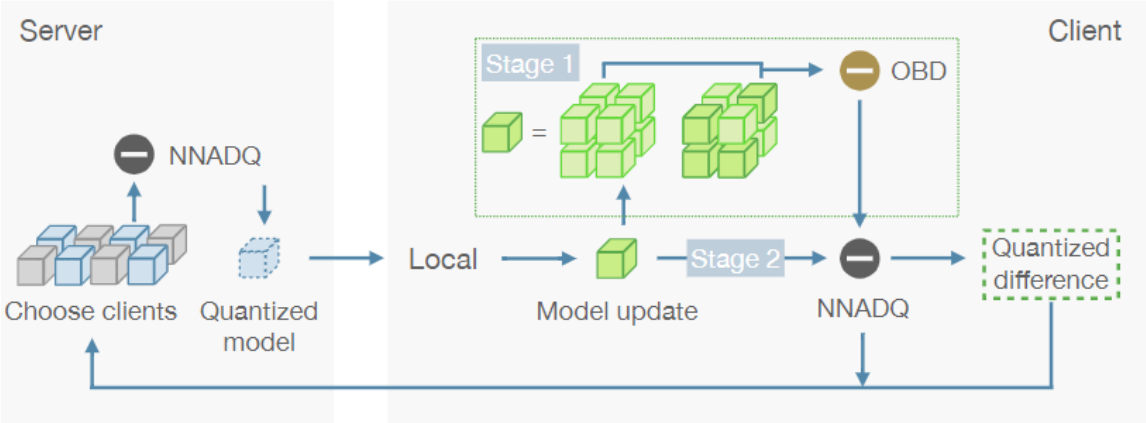


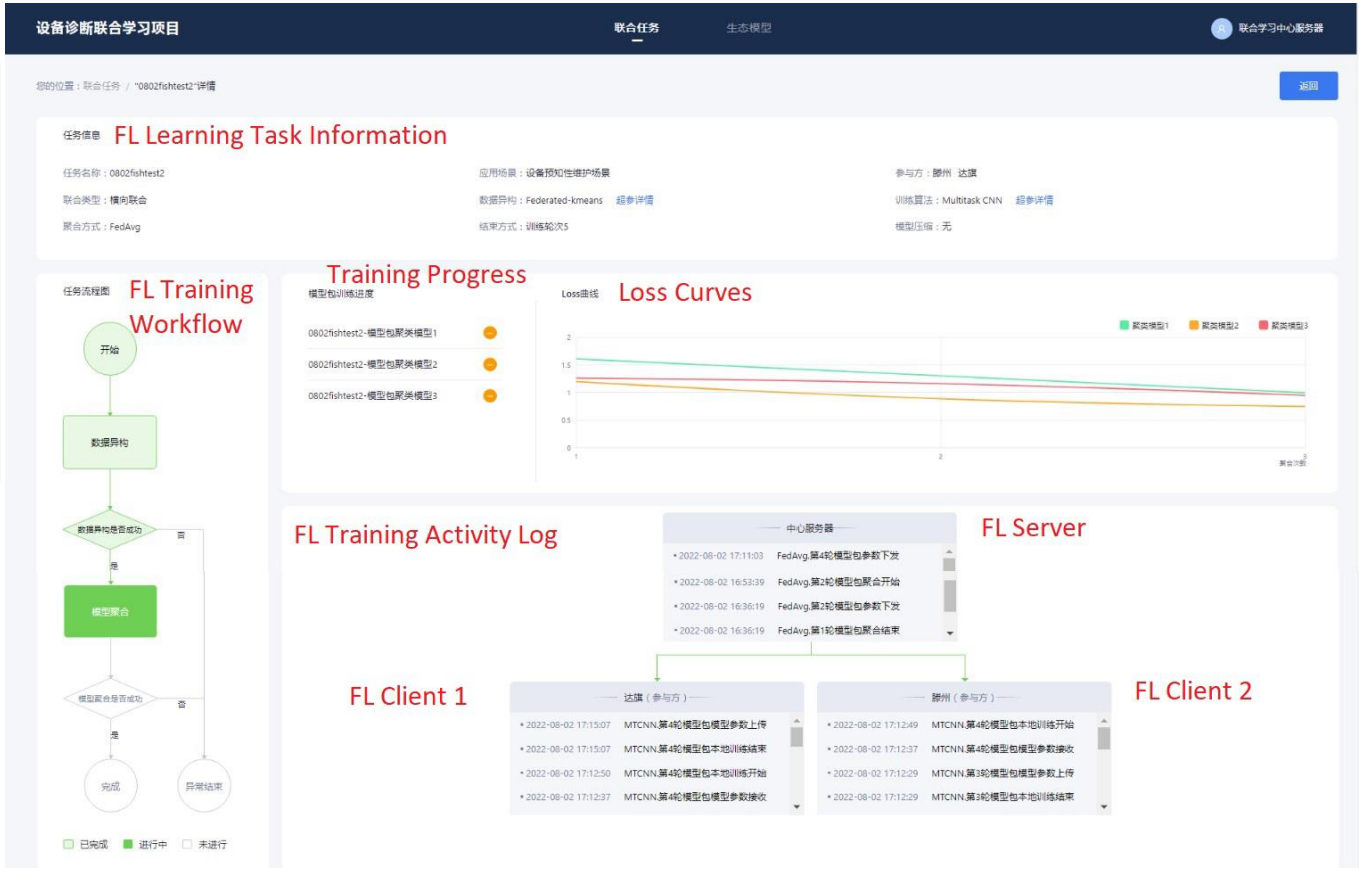
Z. Liu, Y. Chen, Y. Zhao, H. Yu, Y. Liu, R. Bao, J. Jiang, Z. Nie, Q. Xu & Q. Yang, "Contribution-Aware Federated Learning for Smart Healthcare," in *Proceedings of the 34th Annual Conference on Innovative Applications of Artificial Intelligence (IAAI-22)*, pp. 12396-12404, 2022. (**Innovative Application of AI Award**)

Efficient Large-Scale Federated Learning

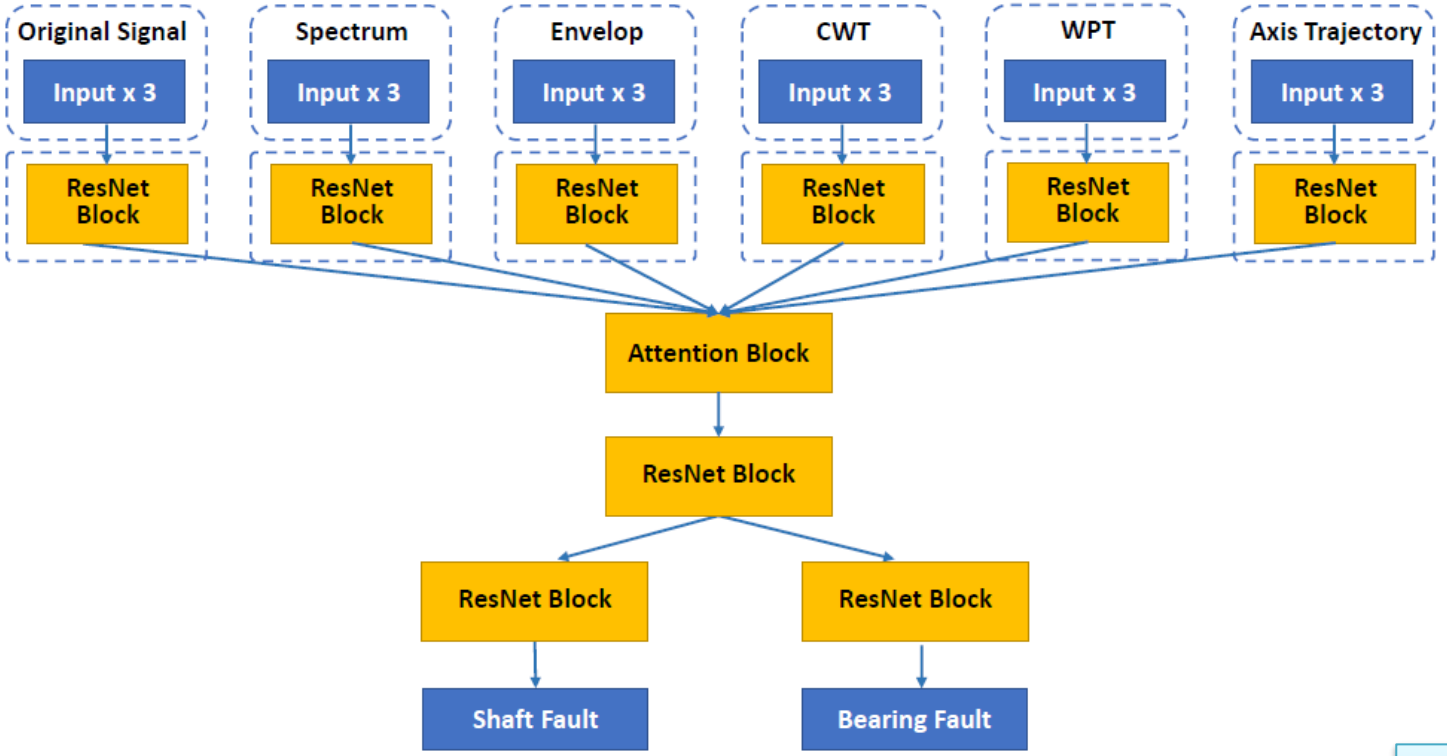


Opportunistic Block Dropout for Scalable FL

- A unique opportunistic semantic block dropout approach to enable only important model blocks to be transmitted.
- Enables efficient training of high-performance large-scale deep FL models.
- Y. Chen, Z. Chen, P. Wu & H. Yu, "FedOBD: Opportunistic Block Dropout for Efficiently Training Large-scale Neural Networks through Federated Learning," *IJCAI*, pp. 3541–3549, 2023.



Deployment with ENN Group



- Training a model with **30 million** parameters.
- Reduced total communication cost from **368 GB** to **104 GB**, while maintaining model performance at 85% F1 Score.
- Reduced model retraining time from **52 hours** to **14.5 hours** (at a limit of 2MB/sec bandwidth allowable for FL training).

Y. Chen, Z. Chen, S. Guo, Y. Zhao, Z. Liu, P. Wu, C. Yang, Z. Li & H. Yu, "Efficient Training of Large-scale Industrial Fault Diagnostic Models through Federated Opportunistic Block Dropout," in *Proceedings of the 35th Annual Conference on Innovative Applications of Artificial Intelligence (IAAI-23)*, pp. 15485–15493, 2023. (**Innovative Application of AI Award**)

Promising FL Research Directions

Generative AI for Visual Persuasion

- Chang Liu & Han Yu, "AI-empowered persuasive video generation: A survey," *ACM Computing Surveys*, 2023.

Fairness-Aware Federated Learning

- Yuxin Shi, Han Yu & Cyril Leung, "Towards Fairness-Aware Federated Learning," *IEEE Transactions on Neural Networks and Learning Systems*, 2023.

Quantum Federated Learning

- Chao Ren, Han Yu, Rudai Yan, Minrui Xu, Yuan Shen, Huihui Zhu, Dusit Niyato, Zhao Yang Dong & Leong Chuan Kwek, "Towards Quantum Federated Learning," *arXiv preprint arXiv:2306.09912*, 2023.

Verifiable Federated Learning

- Yanci Zhang & Han Yu, "Towards Verifiable Federated Learning," in *Proceedings of the 31st International Joint Conference on Artificial Intelligence (IJCAI'22)*, pp. 5686-5693, 2022.

Privacy and Robustness in Federated Learning

- Lingjuan Lyu, Han Yu, Xingjun Ma, Lichao Sun, Jun Zhao, Qiang Yang & Philip S. Yu, "Privacy and Robustness in Federated Learning: Attacks and Defenses," *IEEE Transactions on Neural Networks and Learning Systems*, 2022.

Interpretable Federated Learning

- Anran Li, Rui Liu, Ming Hu, Luu Anh Tuan & Han Yu, "Towards Interpretable Federated Learning," *arXiv preprint arXiv:2302.13473*, 2023.

Domain Adaption in LLM

- Xu Guo & Han Yu, "On the Domain Adaptation and Generalization of Pretrained Language Models: A Survey," *arXiv preprint arXiv:2211.03154*, 2022.

Personalized Federated Learning

- Alysa Ziying Tan, Han Yu, Lizhen Cui & Qiang Yang. Towards personalized federated learning. *IEEE Transactions on Neural Networks and Learning Systems*, 2022.

Federated **Graph Neural Networks**

- Rui Liu, Pengwei Xing, Zichao Deng, Anran Li, Cuntai Guan & Han Yu, "Federated Graph Neural Networks: Overview, Techniques and Challenges," *arXiv preprint arXiv:2202.07256*, 2022.

Auction-based Federated Learning

- Xiaoli Tang & Han Yu, "Towards Trustworthy AI-Empowered Real-Time Bidding for Online Advertisement Auctioning," *arXiv preprint arXiv:2210.07770*, 2022.

Open Collaborative Federated Learning Ecosystem

https://trustful.federated-learning.org/

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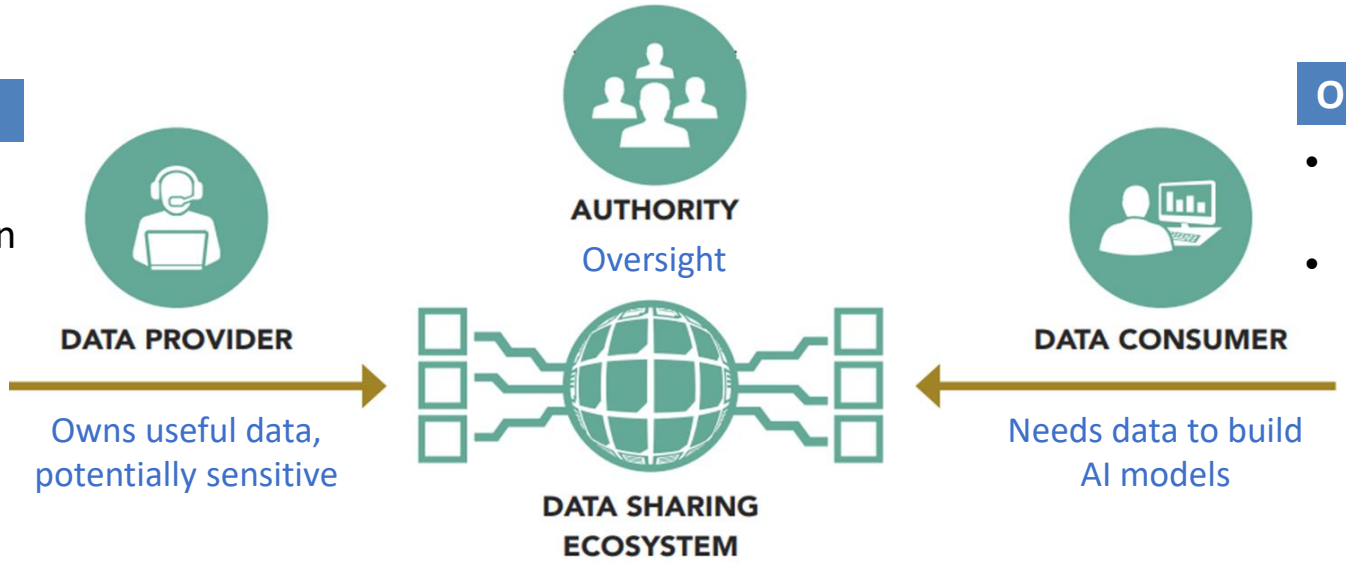
Governance

- Privacy-Preserving Data Valuation/Auditing
- Interpretable FL Training Visualization Monitoring
- Fair Participant Contribution Assessment
- Participant Behaviour Modelling
- Misbehaviour Deterrence Optimization

Operation

- Dynamic FL Collaboration Formation



Operation

- Monetary Incentivization for FL Participants
- Non-Monetary Incentivization for FL Participants

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Thank you!

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SMU SINGAPORE MANAGEMENT UNIVERSITY

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AI SINGAPORE

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UBC THE UNIVERSITY OF BRITISH COLUMBIA