Guest Editorial: Special Section on the Latest Developments in Federated Learning for the Management of Networked Systems and Resources

I. Introduction

DRIVEN by privacy concerns and the promise of Deep Learning, researchers have devoted significant effort to exploring the applicability of Machine Learning (ML). In the domains of communication, network, and service management, ML-based decision-making solutions are eagerly sought to replace traditional model-driven approaches, addressing the growing complexity and heterogeneity of modern systems. In this context, Federated Learning (FL) has gained increasing interest as a decentralized approach that overcomes the limitations of centralized systems for data analysis.

FL leverages distributed on-site analysis to learn statistical models while preserving privacy and eliminating data communication overhead. It involves training and testing not only on end devices such as personal computers, smartphones, and tablets but also on edge devices that generate the data. The federated and shared models are then aggregated on a central server, enabling the participants to benefit from collective knowledge.

Recognizing the potential and propriety of applying Federated Learning for decision-making in various real-world applications, this special section of IEEE TRANSACTIONS ON NETWORK AND SERVICE MANAGEMENT (IEEE TNSM) focuses on the latest developments in FL, particularly in terms of System, Network, and Resource Management solutions. It showcases a collection of high-quality papers that have successfully passed a rigorous review process.

The accepted papers in this special section contribute to addressing the challenges associated with employing FL in network and service management. They delve into a range of topics including network management, communication efficiency, client selection and scheduling, resource management, security concerns, privacy concerns, and service management. The authors have proposed innovative techniques and solutions such as data augmentation, active learning, multi-task learning, trust and reputation, multi-objective optimization, reinforcement learning, transfer learning, blockchain, and more. These contributions offer reliable, efficient, secure, and trustworthy collective learning approaches for participants and service providers, paving the way for diverse applications in different fields.

We believe that the knowledge and insights shared in this special section will inspire further research and innovation in the field of Federated Learning. The exploration of its potential applications in Wireless Networks (5G), Internet of Things, Cloud/Fog/Edge Computing and Networks, Vehicular and Mobile Networks, Urban Environments, Smart Cities, Healthcare, and other domains opens up new avenues for transformative advancements. This special section consists of 13 papers out of 84 papers submitted to the call for novel contributions addressing the underlying challenges of embracing federated learning for network and service management.

II. Special Section Overview

In [A1], the authors propose a spatial-temporal graph neural network accounting for semantic correlations and the dynamics of traffic networks. They utilize real-work traffic data to demonstrate the accuracy of their proposed model.

In [A2], the focus is to maintain the privacy of the personal information collected from patients with IoMT. The training is conducted on the spatial-temporal data and knowledge transfer is utilized to obfuscate detailed individual information. The proposed scheme does improve performance and maintain data privacy when realistic data is used.

In [A3], the authors inspire from time-sensitive networking controller frameworks to design intelligent federated learning. The objective is to optimize failure recovery, which is evaluated compared to existing works.

In [A4], a semi-decentralized architecture is proposed for the federated learning process to overcome the limited coverage problem of a single learning server. Training algorithms are formulated for the proposed architecture and the evaluation illustrates the ability of the mechanisms to reduce the inconsistency in trained models as opposed to benchmark mechanisms.

In [A5], the data imbalance problem in federated learning is tackled through proposed client selection and clustering techniques. As a result, the authors were able to minimize the training latency and maintain satisfying performance.

In [A6], the data imbalance problem is also handled but through a reweighting method that accounts for the volume and variance of local datasets. Accordingly, the authors are able to significantly improve the performance of federated learning compared to traditional aggregation methods.

In [A7], the authors focus on image data as their scope when resolving the data imbalance problem. They propose using prior knowledge from images with similar edge information to strengthen the importance of detail features in the image.

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With that, they are able to improve the extraction accuracy as studied on public datasets.

In [A8], the work focuses on using available models to overcome missing ones in federated learning. A methodology influenced by representational learning is proposed where weights are considered to minimize the reconstruction loss during the absence of models. The evaluation presented shows the ability of the proposed scheme to perform well given different exchanged data quantities.

In [A9], the authors handle the personalization of models by mixing global and local models. Users can then decide on the degree to which they want to account for other users' models in the retraining of their own models. In addition, the authors utilize the latent space of autoencoders to minimize the communication overhead when transferring models. The proposed methodology opens the way to personalized models with low communication costs compared to benchmark schemes.

In [A10], the authors tackle task offloading in heterogeneous environments where they formulate an optimization to acquire the offloading decisions. The proposed model in fact results in a faster convergence to an optimal task-offloading decision in the target environments.

In [A11], blockchain technology is considered to introduce trust in sharing local models between clients in the federated learning process. The authors' evaluation demonstrates their solution's ability to maintain the mutual trust of the users and improve the global model performance.

In [A12], the traceability of the federated learning process is the main issue explored by the authors. As a solution, they propose a smart contract-based training policy control to verify the correctness of the training process, which runs on the blockchain. The proposed framework does in fact perform well when multiple datasets are used for the evaluation.

In [A13], the security of the federated learning process against insiders who poison the global model. The paper proposes the selection of trusted participants based on their reputations and makes them responsible for identifying poisoned models being exchanged. The proposed scheme does identify malicious insiders when evaluated on a real dataset.

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APPENDIX: RELATED ARTICLES

[A1] L. Liu et al., "Multilevel federated learning based intelligent traffic flow forecasting for transportation network management," *IEEE Trans. Netw. Service Manag.*, vol. 20, no. 2, pp. 1446–1458, Jun. 2023.

[A2] X. Jiang, J. Zhang, and L. Zhang, "FedRadar: Federated multi-task transfer learning for radar-based Internet of Medical Things," *IEEE Trans. Netw. Service Manag.*, vol. 20, no. 2, pp. 1459–1469, Jun. 2023.

[A3] V. Balasubramanian, M. Aloqaily, and M. Reisslein, "Fed-TSN: Joint failure probability based federated learning for fault-tolerant time-sensitive networks," *IEEE Trans. Netw. Service Manag.*, vol. 20, no. 2, pp. 1470–1486, Jun. 2023.

[A4] Y. Sun, J. Shao, Y. Mao, J. H. Wang, and J. Zhang, "Semi-decentralized federated edge learning with data and device heterogeneity," *IEEE Trans. Netw. Service Manag.*, vol. 20, no. 2, pp. 1487–1501, Jun. 2023.

[A5] A. Albaseer, M. Abdallah, A. Al-Fuqaha, A. Mohammed, A. Erbad, and O. A. Dobre, "Fair selection of edge nodes to participate in clustered federated multitask learning," *IEEE Trans. Netw. Service Manag.*, vol. 20, no. 2, pp. 1502–1516, Jun. 2023.

[A6] D. M. S. Bhatti and H. Nam, "FedCLS: Class-aware federated learning in a heterogeneous environment," *IEEE Trans. Netw. Service Manag.*, vol. 20, no. 2, pp. 1517–1528, Jun. 2023.

[A7] L. Teng et al., "FLPK-BiSeNet: Federated learning based on priori knowledge and bilateral segmentation network for image edge extraction," *IEEE Trans. Netw. Service Manag.*, vol. 20, no. 2, pp. 1529–1542, Jun. 2023.

[A8] I. Shaer and A. Shami, "CorrFL: Correlation-based neural network architecture for unavailability concerns in a heterogeneous IoT environment," *IEEE Trans. Netw. Service Manag.*, vol. 20, no. 2, pp. 1543–1557, Jun. 2023.

[A9] F. Yu et al., "Communication-efficient personalized federated meta-learning in edge networks," *IEEE Trans. Netw. Service Manag.*, vol. 20, no. 2, pp. 1558–1571, Jun. 2023.

[A10] F. Sun, Z. Zhang, X. Chang, and K. Zhu, "Towards heterogeneous environment: Lyapunov-orientated ImpHetero reinforcement learning for task offloading," *IEEE Trans. Netw. Service Manag.*, vol. 20, no. 2, pp. 1572–1586, Jun. 2023.

[A11] A. Riahi, A. Mohamed, and A. Erbad, "RL-based federated learning framework over blockchain (RL-FL-BC)," *IEEE Trans. Netw. Service Manag.*, vol. 20, no. 2, pp. 1587–1599, Jun. 2023.

[A12] A. P. Kalapaaking, I. Khalil, and M. Atiquzzaman, "Smart policy control for securing federated learning management system," *IEEE Trans. Netw. Service Manag.*, vol. 20, no. 2, pp. 1600–1611, Jun. 2023.

[A13] S. B. Saad, B. Brik, and A. Ksentini, "Toward securing federated learning against poisoning attacks in zero touch B5G networks," *IEEE Trans. Netw. Service Manag.*, vol. 20, no. 2, pp. 1612–1624, Jun. 2023.

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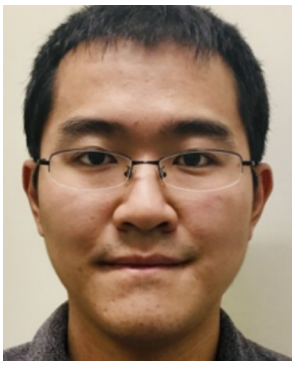

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