Federated Graph Learning via Structure-Aware Fusion Using a Kalman Framework with Learnable Dynamics

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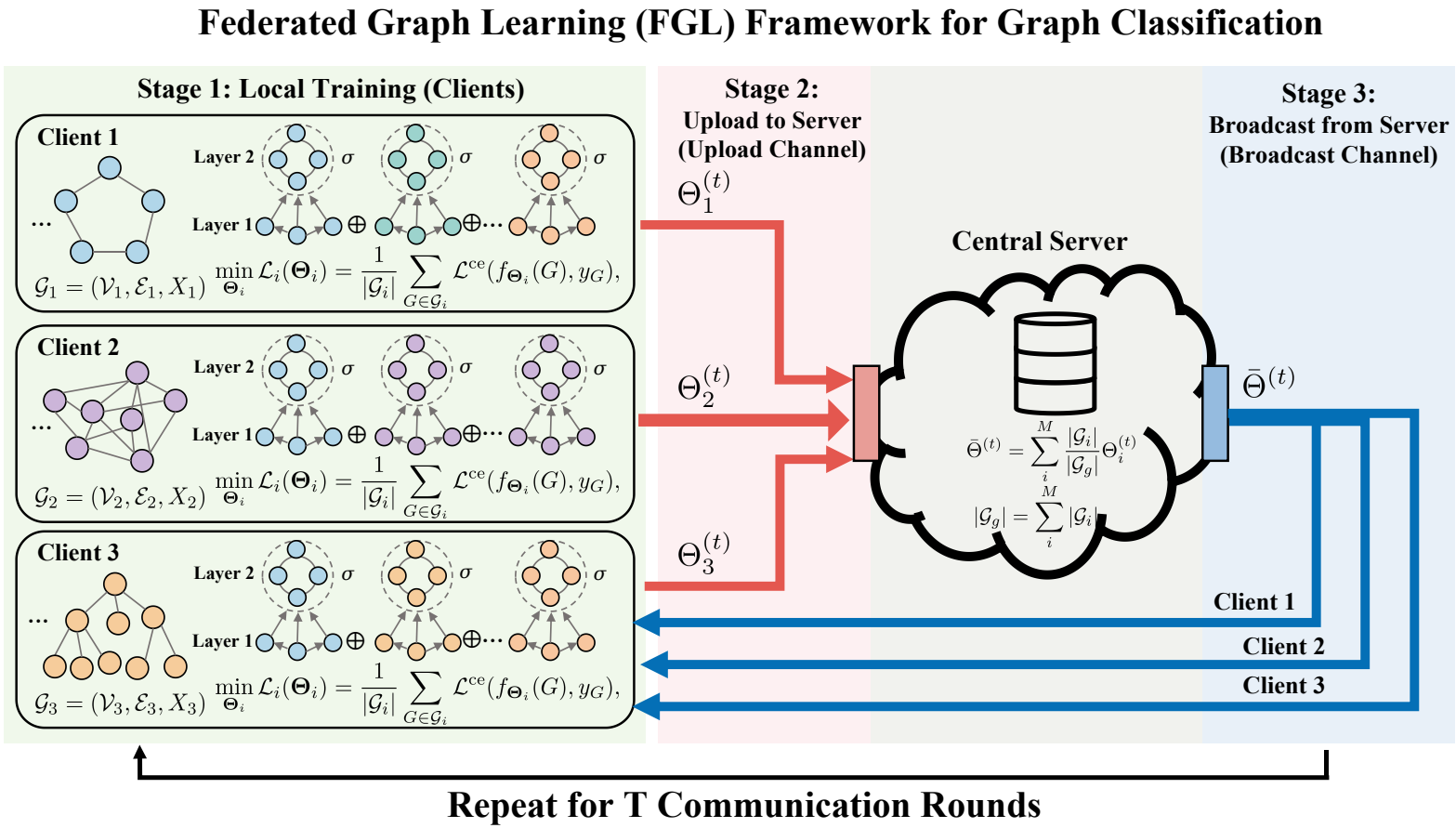
Background

Federated Graph Learning (FGL)



Problem

Critical Limitations of FGL

Existing Problem

- Aggregated feature drift and divergent embeddings degrade model performance.
- Existing methods overlook transferable, domain-agnostic structural priors.
- Noisy node features induce topological bias, blocking effective structure fusion.
- Inability to decouple true structural patterns from feature-induced noise.

Methodology

Fed-Kalter

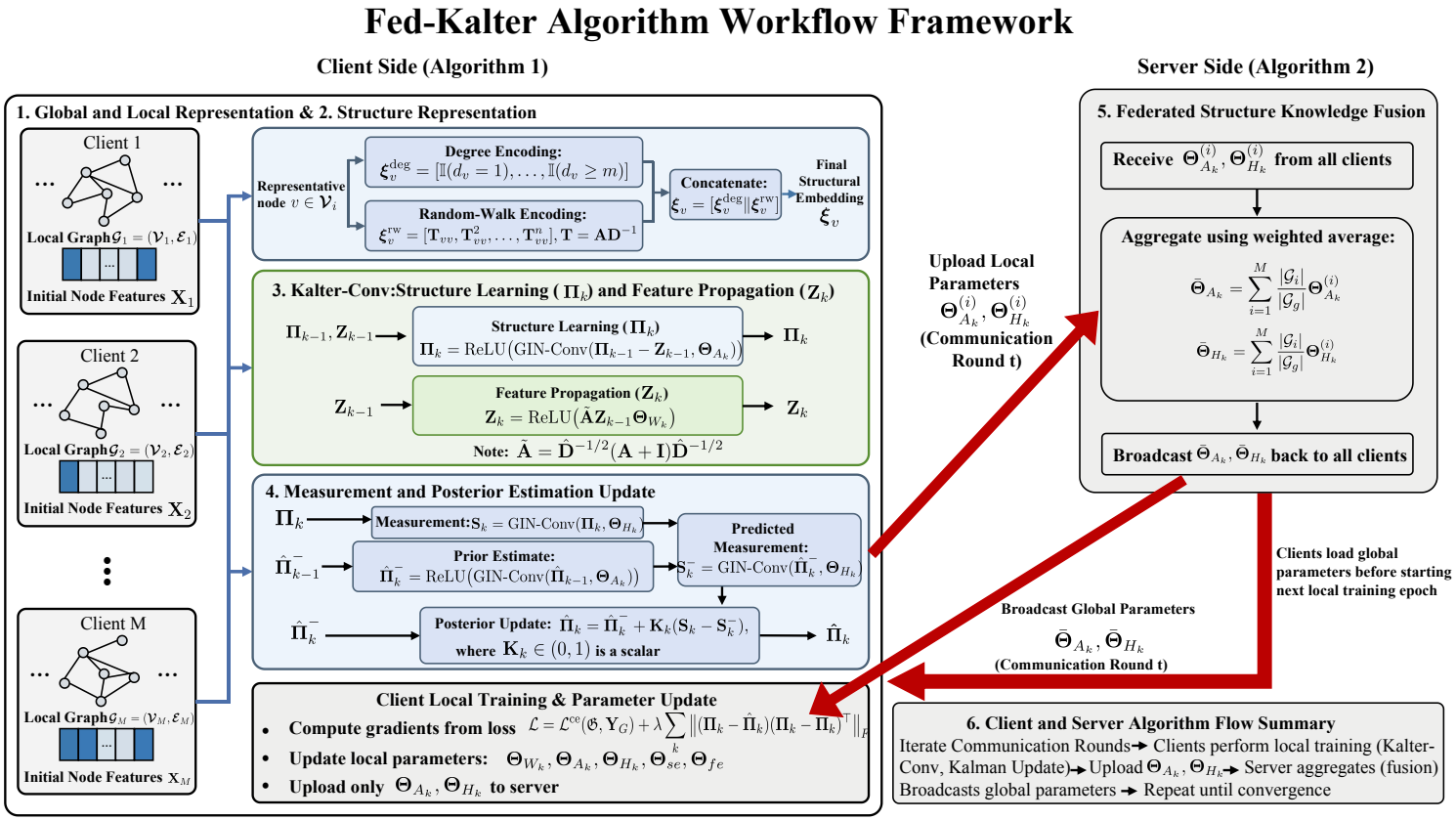


Figura: An overview of the proposed Fed-Kalter framework.

Experiments

Graph Classification Accuracy

Setting (#Domain)	CHEM-BIO	CHEM-SN	CHEM-CV	BIO-SN	BIO-CV	SN-CV	AVG.
Datasets	10	10	10	6	6	6	–
Local	71.72±1.76	73.48±2.48	75.82±2.22	64.98±2.05	71.43±1.46	72.85±0.88	71.71
FedAvg	70.74±1.89	72.62±1.79	72.47±1.56	62.82±1.64	65.88±2.84	69.61±1.22	69.02
FedProx	70.28±2.42	72.66±1.74	72.69±2.51	57.79±10.99	66.23±1.78	68.03±1.83	67.95
FedPer	71.02±2.46	74.14±2.95	72.69±1.27	63.03±1.67	66.06±1.80	68.95±1.50	69.32
FedSage	70.07±2.39	72.94±1.00	76.84±2.83	62.78±1.60	72.27±2.72	72.54±2.29	71.24
GCFL	71.39±2.09	72.96±2.07	72.44±1.36	63.47±1.43	66.68±3.24	68.68±1.72	69.27
FedStar	74.68±2.38	74.07±2.53	78.89±2.08	65.89±2.48	70.01±2.47	71.29±2.38	72.47
FedVN	73.17±0.98	73.77±0.82	79.21±0.25	65.21±2.36	72.18±1.06	71.20±1.11	72.46
Fed-Kalter	**74.90±2.54**	**74.71±2.00**	**80.30±1.38**	**66.00±1.83**	**74.53±2.40**	**75.54±1.63**	**74.33**

Figura: Results on two-domain settings.

Summaries

Contributions

- We propose Kalter-Conv, a Kalman-inspired graph convolution that explicitly separates structure learning from feature propagation, mitigating structural heterogeneity caused by local feature bias.
- We present Fed-Kalter, a Federated Graph Learning framework that fuses structural knowledge across heterogeneous domains via selective aggregation of structural modules, enhancing local model performance.
- We conduct extensive experiments on 16 datasets across 4 domains, demonstrating that Fed-Kalter outperforms state-of-the-art FGL methods. Ablation and sensitivity studies further validate its design.

Thanks!