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A Generalizable Anomaly Detection Method in Dynamic Graphs

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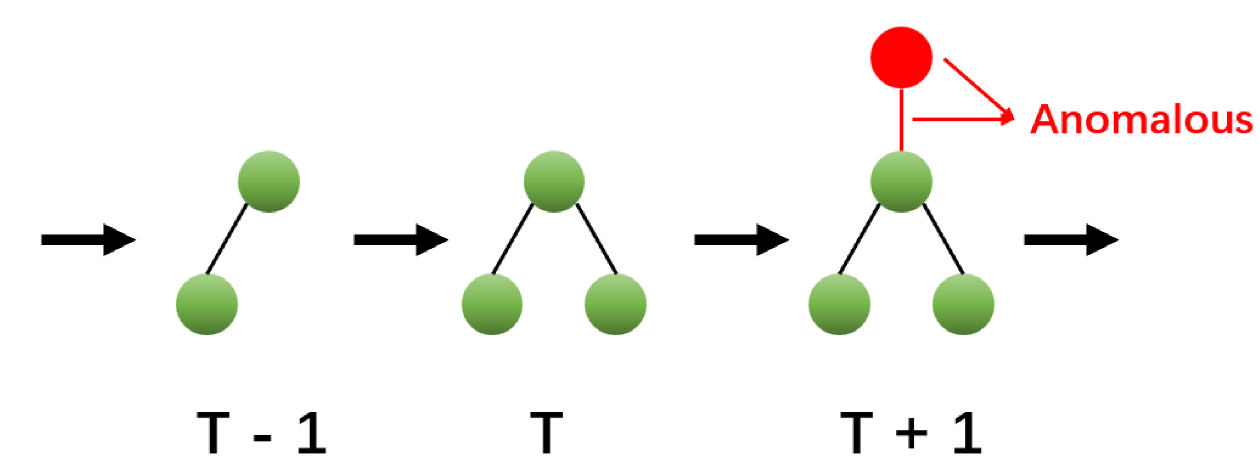
Dynamic Graph Anomaly Detection

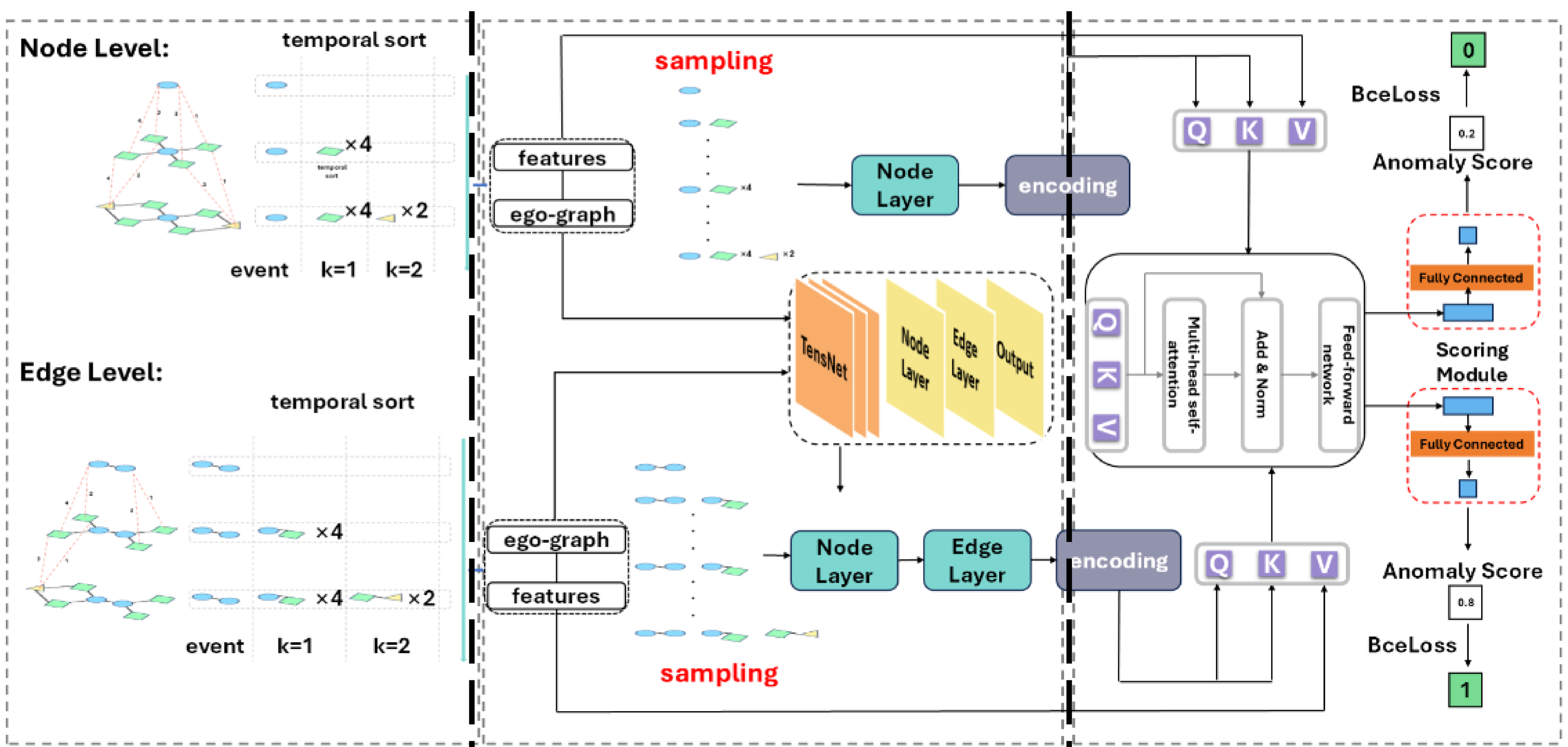
Target: Develop a **generalizable** framework for detecting anomalies in **dynamic graphs**.

Unique Merits:

- Adaptability, Efficiency, Robustness, Generalization, etc.
- **Input**: A dynamic graph with temporally evolving **nodes, edges, and attributes** (e.g., timestamps, interaction features).
- **Output**: **Anomaly scores** for nodes and edges, identifying deviations from normal patterns.



Our Approach



Temporal ego-graph sampling | Temporal ego-graph GNN extractor | Temporal-Aware Transformer

1. Temporal ego-graph sampling :

- Contextual representation & hierarchical information
- Temporal k-hop ego-graph

2. Temporal ego-graph GNN extractor :

- Encodes events
- Alternately applying node and edge layers

3. Temporal-Aware Transformer :

- Query and Key : topological structure information
- Value : original event features

Solved Challenges

1. Data Diversity:

- Mapping node, edge, and topological structure information into the feature space

2. Dynamic Feature Capture:

- Incorporating hierarchical tokens

3. Computational Cost

- Sampling temporal ego-graphs to efficiently capture dynamic features

Evaluations

Outperform state-of-the-art methods on Node-Level and Edge-Level datasets

Methods	Bitcoin-Alpha						Bitcoin-OTC					
	1%		5%		10%		1%		5%		10%	
	AUC	AP	AUC	AP	AUC	AP	AUC	AP	AUC	AP	AUC	AP
node2vec	69.10	9.17	68.02	7.31	67.85	9.95	69.51	8.31	68.83	6.45	67.45	4.77
DeepWalk	69.85	8.56	68.74	9.68	67.93	10.78	74.23	10.58	73.56	9.41	72.87	8.22
TGAT	85.32	11.36	84.16	11.08	83.98	12.05	88.87	16.87	87.59	15.24	87.55	15.37
TGN	86.92	13.00	86.78	16.85	86.21	17.00	84.33	11.33	83.49	11.25	83.47	10.79
ADDGRAPH	83.41	13.21	84.70	13.01	83.69	14.28	86.00	16.04	84.98	15.21	84.77	14.21
StrGNN	85.74	12.56	86.67	13.99	86.27	14.68	90.12	18.34	87.75	18.68	88.36	18.10
TADDY	**94.51**	16.51	93.41	18.32	94.23	19.67	94.55	16.10	93.40	18.47	94.25	18.92
SAD	90.69	19.99	90.55	21.08	90.33	22.99	91.88	26.32	90.99	27.33	90.04	26.79
SLADE	90.32	18.78	89.99	22.02	88.71	24.41	91.53	20.32	91.24	22.11	91.01	20.04
GeneralDyG	94.01	**24.00**	**95.41**	**24.02**	**96.28**	**26.73**	**94.66**	**27.89**	**94.86**	**29.97**	**95.59**	**27.13**

- **Node-Level**

Methods	SWaT	WADI
PCA	23.16	9.35
KNN	7.83	7.75
GDN	80.82	56.92
BTAD	81.43	53.77
GRN-100	74.96	48.28
DAGMM	39.37	36.09
MST-GAT	83.55	60.31
FuSAGNet	83.69	**60.70**
LSTM-VAE	73.85	24.82
MTAD-GAT	31.71	16.94
GeneralDyG	**85.19**	60.43

- **Edge-Level**

Contact Us

https://scholar.google.com/citations?user=tfqh-pkAAAAJ&hl=zh-CN

https://github.com/YXNTU/GeneralDyG

https://www.bilibili.com/video/BV1y9c4eyEAk/?share_source=copy_web&vd_source=75dbc686eac0abb2d627148c5043553e

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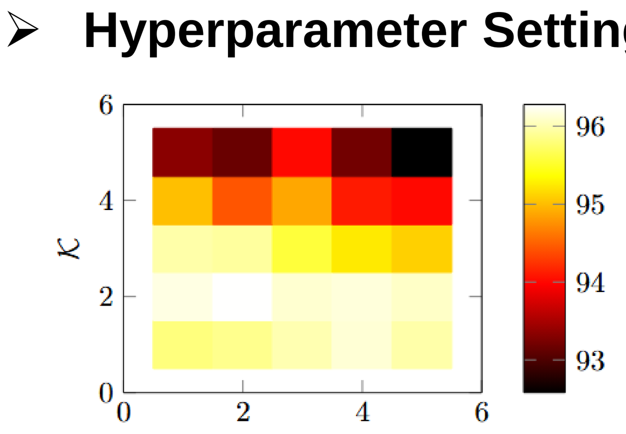
Discussions

Hyperparameter Settings



k	$\mathcal{K}=1$	$\mathcal{K}=2$	$\mathcal{K}=3$	$\mathcal{K}=4$	$\mathcal{K}=5$
1	24.12	26.34	25.80	24.57	22.91
2	25.03	26.73 (peak)	25.63	23.99	22.77
3	24.01	24.45	24.21	23.38	23.01
4	23.21	23.62	22.95	22.84	21.45
5	22.89	22.57	21.88	21.62	21.11

Impact of Special Tokens

Method	Bitcoin-Alpha		WADI
	AUC	AP	F1
GeneralDyG	**96.28**	26.73	**60.43**
no special	96.27	**26.80**	60.11
no sort	95.37	26.09	59.74
no sort & special	95.20	26.11	59.70

Ablation Study

Method	Bitcoin-Alpha		WADI
	AUC	AP	F1
GeneralDyG	**96.28**	**26.73**	**60.43**
w/o ego-graph	96.01	19.33	59.45
w/o TensGNN	92.02	22.63	55.13
w/o Transformer	93.71	20.20	58.46

Generalizability

Node-Level Method	Bitcoin-Alpha		Edge-Level Method	WADI
	AUC	AP		F1
GeneralDyG	**96.28**	**26.73**	GeneralDyG	**60.43**
GDN	83.84	13.28	TADDY	40.05
MST-GAT	86.66	18.97	SimpleDyG	33.24
FuSAGNet	87.76	20.01	SAD	36.75

Ablation Study (Bitcoin-Alpha)

Method	**1%**	**5%**
GeneralDyG (Full)	24.00	24.02
W/o ego-graph sampling	14.72	18.69
W/o TensGNN	17.99	19.90
W/o Transformer	21.78	17.24