Node Embeddings in Dynamic Graphs

Ferenc Béres

Róbert Pálovics

Domokos M. Kelen

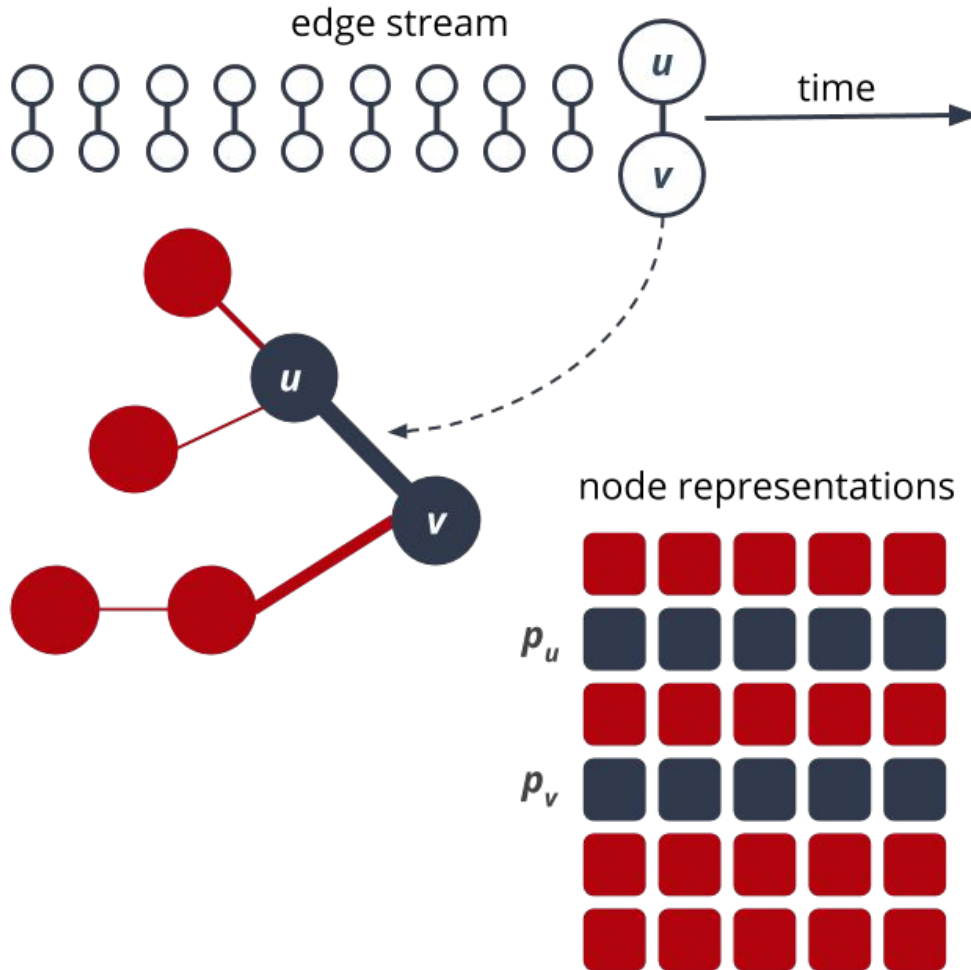Dávid Szabó

András A. Benczúr

MTA **SZTAKI**

Hungarian Academy of Sciences
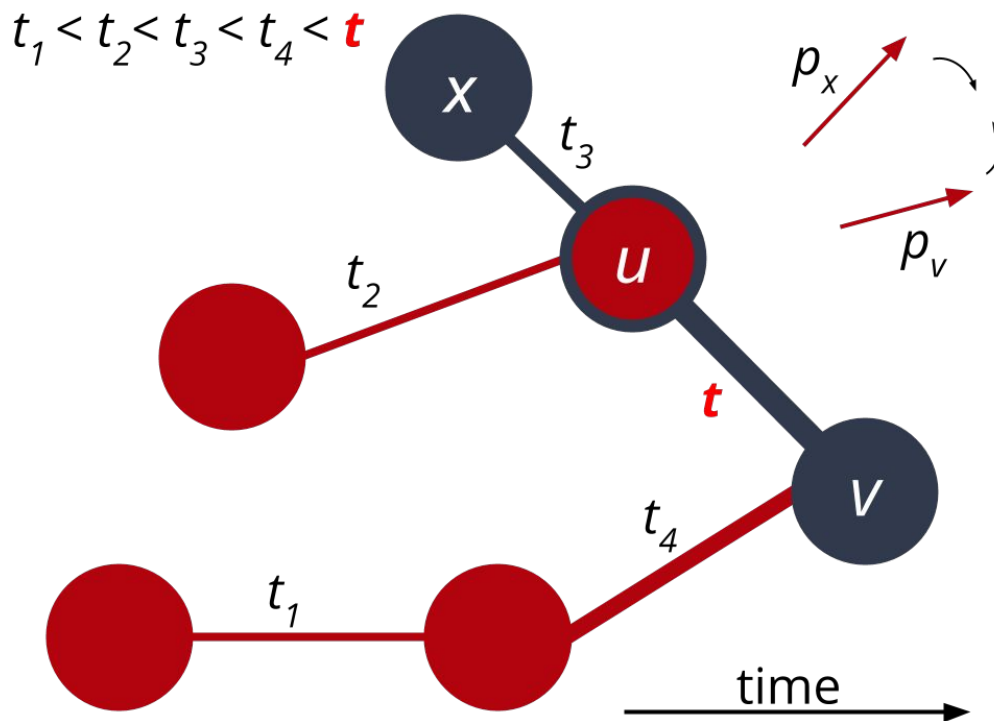Institute for Computer Science and Control

Introduction

Temporal network

- edge stream: (u,v,t) triplets
- multiple edge activations
- no edge deletion

Dynamic node embeddings

- p_u : representation of node u
- p_u is updated every time when u is activated by an edge
- **intuition:** the representation of interacting nodes should be similar

ferencberes/online-node2vec

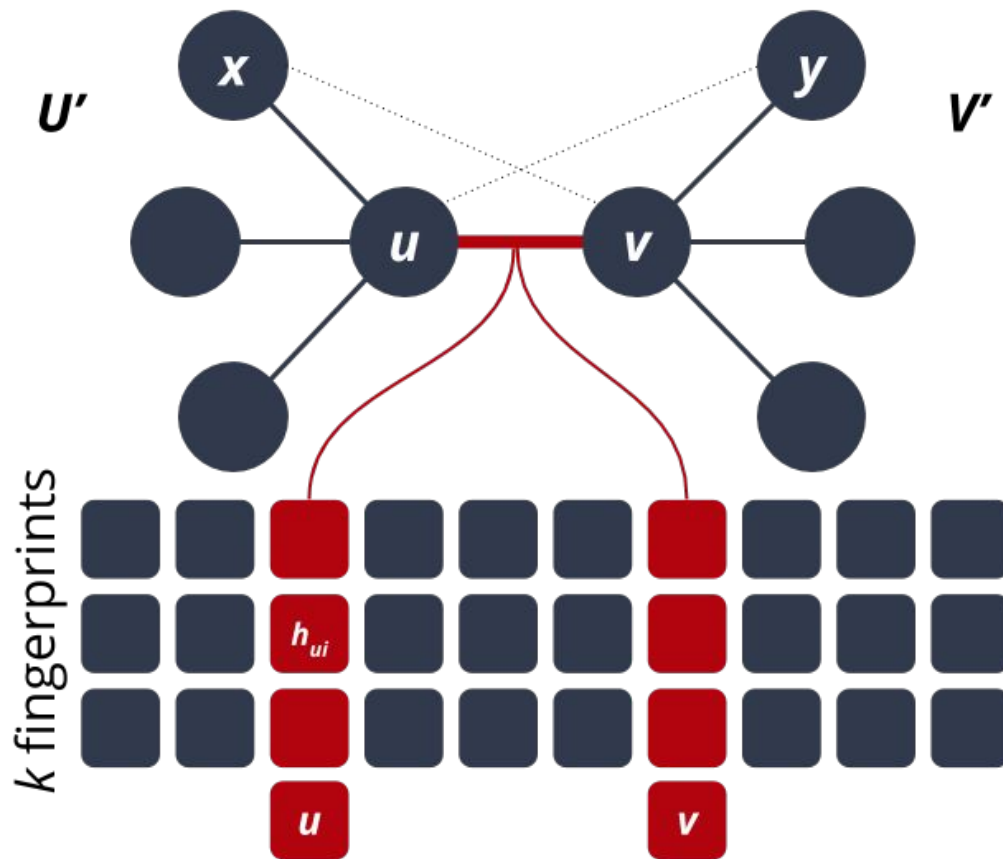# Temporal Walk Algorithm

$t_1 < t_2 < t_3 < t_4 < t$

- edge uv activated at time t

- sample multiple **temporal random walks** ending in edge uv

- end nodes of the walk (x,v) are the training instances for **online Word2Vec**

- the number of random walks generated is proportional to the **temporal Katz centrality**(*) score of node v at time t

(*) Béres, F., Pálovics, R., Oláh, A., Benczúr, A.A.: Temporal walk based centrality metric for graph streams. Applied Network Science 3(1), 32 (2018)

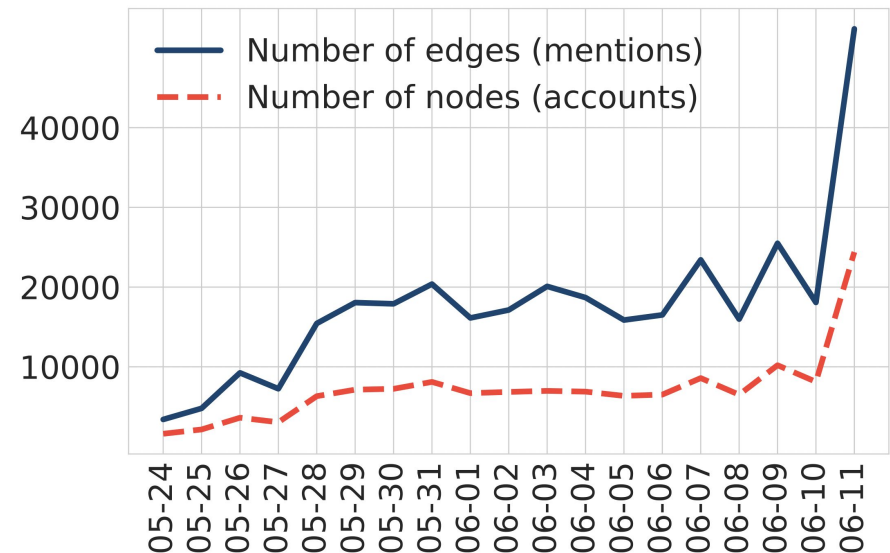**ferencberes/online-node2vec**

Temporal Neighborhood Algorithm

- neighborhood similarity by fingerprinting

- h_{ui} : i^{th} minhash fingerprint of node u ($i=1...k$)

- maintain fingerprints online

ferencberes/online-node2vec

Twitter Data

- **mention network:**
  - nodes are accounts
  - edges are mentions (with timestamp)

- we assigned tennis players to Twitter accounts

- relevance by tournament timetable

	edges	nodes	days
Roland–Garros	336,234	78,095	19
US Open	482,061	106,920	21

Evaluation

- in every 6 hour

- embedding dimension: 128

- Discounted Cumulative Gain with embedding similarity as a ranking

$$DCG@k = \sum_{i=1}^{k} \frac{rel_i}{log(i+1)}$$

- similarity list of Rafael Nadal generated at 2017-05-31 12:00 (RG17)

- node relevance (rel):
  - daily tennis players (rel=1) - **red**
  - NOT daily players (rel=0) - **blue**
  - other (rel=0) - gray

	Node2Vec	Temporal Walk	T. Neighborhood
1	rolandgarros	rolandgarros	rolandgarros
2	aquiactualidad	tsonga7	Gael_Monfils
3	KikiMladenovic	DjokerNole	DjokerNole
4	TennisChannel	KikiMladenovic	KikiMladenovic
5	emirates	delpotrojuan	stanwawrinka
6	tsonga7	andy_murray	tsonga7
7	Gael_Monfils	Gael_Monfils	FerVerdasco
8	Maly_Tweet	TennisChannel	Simona_Halep
9	N1infoSA	stanwawrinka	andy_murray
10	Simona_Halep	GarbiMuguruza	WTA