Workplace Recommendation with Temporal Network Objectives

KDD 2023, ADS Track

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Upcoming launch

Let’s make sure that our marketing material for the upcoming launch is ready. I’m meeting with stakeholders next week. Please reply with a quick update on your progress. Thanks!

8 replies from Mona, Colin, Kays, and others

Mona Kane 1:23 PM
All is good on my end. We have a design review tomorrow, and then we'll be in good shape.
We had to make some edits for the client. She initially didn't want us to reference any of the competition, but after looking at the work we did for another client, she agreed to go in that direction.
We've already made the adjustments.

Colin Ballinger 1:25 PM
Daniela, I'm happy to help. Let's put some time on the calendar. Teamwork makes the dream work! Can you send me the slides?

Kapo Mira 1:25 PM
I don't have any issues to report. I've been out for a few days, but I'll be helping Babek and Beth with the studio production work starting tomorrow.
Our goal:
Recommend posts in Microsoft Teams to improve information flow in a company’s communication network, while maintaining relevance.
Problem setting: Microsoft Teams

Organization

Posts

Channels

Teams

Users

Clusters

HR

Sales

Engineering
Modeling information spread in an organization

Temporal communication network
Interacting with posts influences the communication network
Motivation: remote work reduced cross-team communication  
(Yang et al, Nature Human Behavior 2022)
Can we improve cross-cluster information flow by recommending posts?
How do we measure information flow?

**Information latency**  
(Kossinets, Kleinberg, Watts, KDD ’08)

How recently could \( v \) have heard about \( u \)?

\[
IL(G, t) = \sum_{u,v \in V} t - \max_{P \in \mathcal{P}_t(u,v)} d(P)
\]

Temporal paths from \( u \) to \( v \) arriving no later than \( t \)

**Total information**  
(Tomlinson et al., KDD ’23)

What fraction of \( u \)'s state is known by \( v \)?

\[
TI(G, t) = \sum_{u,v \in V} TI(u, v, t)
\]

\[
TI(u, u, t) = 1
\]

Information transmitted along edge

\[
TI(u, v, t) = \min\{1, \lambda TI(u, v, t - 1) + \sum_{(z, v, d, a, w) \in E_t} w \lambda^{t-d} TI(u, z, t - 1, d)\}
\]

Decayed prior knowledge

Edges into \( v \) at \( t \) that departed at \( d \) with weight \( w \)
**Theory: optimizing temporal network objectives**

*Edge addition problems:*
Add best $k$ edges into/out of $u$ to maximize IL/TI now/in the future

<table>
<thead>
<tr>
<th></th>
<th>In-edges</th>
<th>Out-edges</th>
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<tbody>
<tr>
<td><strong>Myopic</strong></td>
<td>NP-hard*</td>
<td>Easy! Greedy is optimal</td>
</tr>
<tr>
<td><strong>Non-Myopic</strong></td>
<td>NP-hard*</td>
<td>NP-hard*</td>
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* Greedy is $(1 - 1/e)$ approximation! (Objectives are submodular)
Temporal Information and Engagement Recommender (TIER)

Recommending to $u$ at time $t$, candidate posts $C$

Network score (TI):

$$n_p = TI(G + (\text{author}(p), u, \text{time}(p), t, w), t) - TI(G, t)$$

// how much would interacting with a post improve cross-cluster information? (Greedy, myopic)

Track TI/IL matrix over time (efficient algorithm)

Relevance score:

$r_p$ from any traditional recommender

Rank posts by:

$$\frac{n_p}{\max_{q \in C} n_q} + \alpha \frac{r_p}{\max_{q \in C} r_q}$$
Data: Microsoft internal communication

- ~ 180,000 users (full-time Microsoft employees)
- 1 month of communication (March 2022)
- Microsoft Teams, Outlook, and SharePoint
  - Posts, chats, emails, file sharing
- ~ 100M edges $(u, v, d, a)$
- clusters from org chart (or clustering alg)
- offline evaluation: simulate user actions on recommendations
LightGBM \cite{Ke2017LightGBM}(relevance only)

More relevant recommendations

Cross-cluster first

Random

Information flow only

TIER

Better information flow

MRR

Mean total information gain
More relevant recommendations

LightGBM (relevance only) (Ke et al., NeurIPS ’17)

Cross-cluster first

Random

Information flow only

mean latency reduction (minutes)

Better information flow
Total information

- Information-out
- CC-first-logit
- TIER

Information latency

- Latency-out

Mean total inf. gain vs. Action probability $\rho$

Mean latency reduction (min.) vs. Action probability $\rho$
Workplace Recommendation with Temporal Network Objectives

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