



Information Diffusion at Workplace

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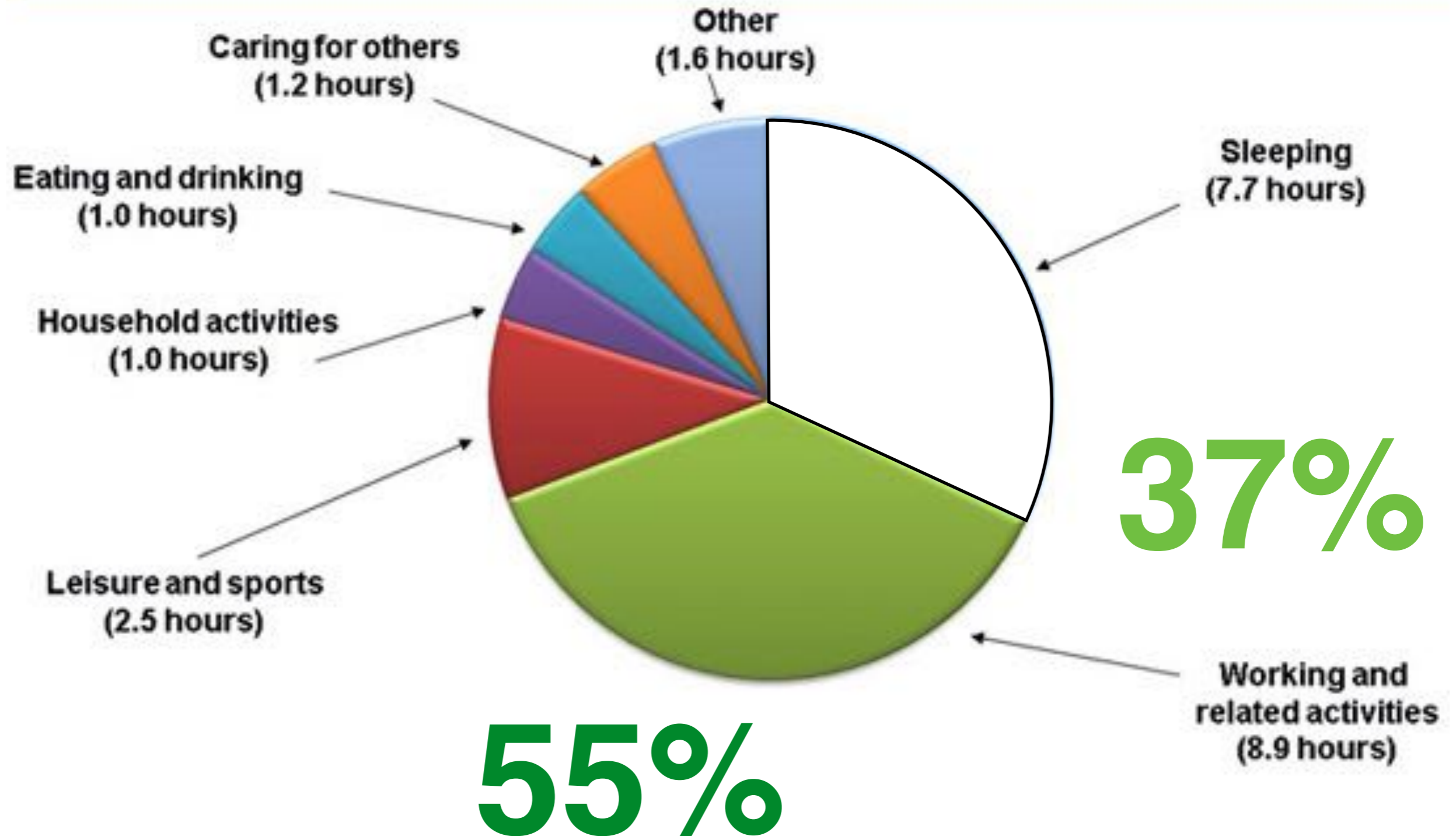
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UIC Microsoft®
Research



Individuals need to spend **a lot of time at workplace**



Workplace has become an important **social occasion** for **information exchange** among employees

**Online
Workplace
Enterprise
Social
Networks**



**Offline
Workplace
meetings,
reports,
office chat**



Enterprise Social Networks(ESNs) are **New** and **Different**



What are Enterprise Social Networks?

- A kind of online social networks that provide employees with various integrated professional services to help deal with daily work issues.

Functions of Enterprise Social Networks

- better project management
- easier communication among employees
- broader information sharing
- more effective cooperators identification
- ...

facebook



Yammer



Different from Traditional Social Networks:

- Facebook: Casual and Personal
- ESN: Formal and Professional

Enterprise Social Networks (ESNs) are Launched in Many Companies (An example: Yammer)

yammer

The Enterprise



Ashok Chandra

Distinguished Scientist

Send Message

+ Follow

Conversations

- Over 8 million registered user
- More than 200,000 companies

fo download vcard
Department: MSR
Location: Silicon Valley
Email: achandra@microsoft.com
Mobile: 408 439 4161
Type: ashokchandra



Ashok Chandra

(Distinguished Scientist) has #joined the Microsoft network. Take a moment to welcome Ashok.

Follow

Like · Reply · Share · More · June 26, 2012 at 8:05am

Joined

Srinivas lyengar likes this.

Groups

Bing
6754 members

MSR
774 members

MSR - Interaction & Intent
10 members

FRD-2014
28 members

Related Works: **Enterprise Social Networks (ESNs)**

- Enterprise context *information fusion and mining (IFM)*
 - Offline data: organizational chart, project documents, etc.
 - Online data: enterprise social networks, online interactions, etc.

Organizational
Chart Inference
KDD' 15

Enterprise Social Link
Recommendation
CIKM' 15

Information Diffusion
at Workplace
CIKM' 16

**Enterprise
IFM**

Enterprise Employee
Training via Project
Team Formation
WSDM' 17



Problem Studied: Information propagation at workplace



- ***Problem Studied:*** In this paper, we will study how information diffuses via both online and offline communication sources among employees at workplace

- ***Applications:***

- For employees: choose effective and efficient channels for communication, improve work efficiency greatly
- For company: Via a combination of several communication channels, companies can convey important messages to all the employees in the company

- ***Challenges:***

- Diffusion channel extraction and inference
- Diffusion channel aggregation
- Diffusion channel weighting and selection



Information propagation among employees

- Workplace information propagation characteristics:

- **Multiple Sources**

- Online heterogeneous source: online enterprise social network contacts
- Offline heterogeneous source: offline communication
- Hybrid source between online and offline sources

- **Multiple Channels → (types of social interactions)**

- online source: follow, notify(@), reply
- offline source: between managers, peers and subordinates

- **Multiple Topics**

- work related topics: new products, projects, and colleagues
- personal life topics: personal interests, sports, and party





Diffusion Model: MUSE

- *Terminologies:*

- **weight \mathbf{w}** : amount of information of different topics propagated among employees via different channels in different sources
- **threshold θ** : minimum amount of information of certain topics to active employees

- **Activation criteria:**



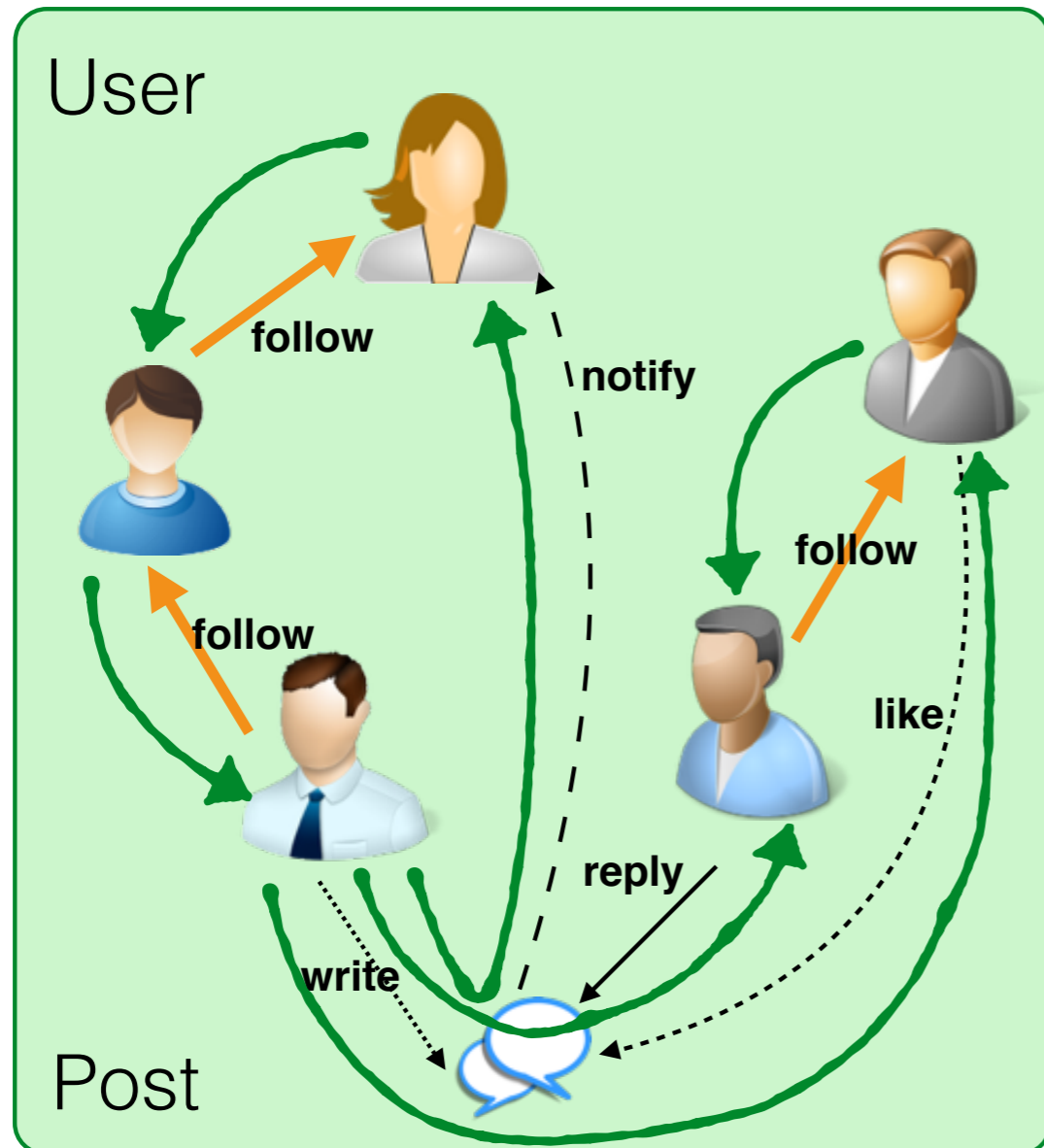
$$f\left(\mathbf{w}^{(on)}(\cdot, u, t), \mathbf{w}^{(off)}(\cdot, u, t), \mathbf{w}^{(hyb)}(\cdot, u, t)\right) \geq \theta(u, t)$$

aggregation function: logistic function

Online Diffusion Channel Extraction



Online ESN

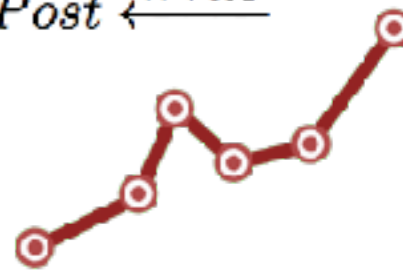


**channel definition
based on meta path**

Online Diffusion Channel Extraction

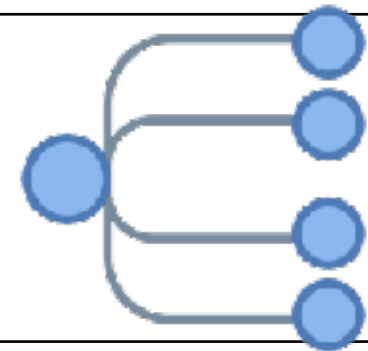
- Meta path based online diffusion channel extraction

- Followee: $Employee \xleftarrow{Social^{-1}} Employee$, whose notation is Φ_1 .
- Followee-Followee: $Employee \xleftarrow{Social^{-1}} Employee \xleftarrow{Social^{-1}} Employee$, whose notation is Φ_2 .
- Reply Post: $Employee \xleftarrow{Reply^{-1}} Post \xleftarrow{Write} Employee$, whose notation is Φ_3 .
- Like Post: $Employee \xleftarrow{Like^{-1}} Post \xleftarrow{Write} Employee$, whose notation is Φ_4 .
- Post Notification: $Employee \xleftarrow{Notify} Post \xleftarrow{Write} Employee$, whose notation is Φ_5 .



- Information propagation weight quantification

$$\mathcal{C}^{(on)} = \{\Phi_1, \Phi_2, \Phi_3, \Phi_4, \Phi_5\}$$

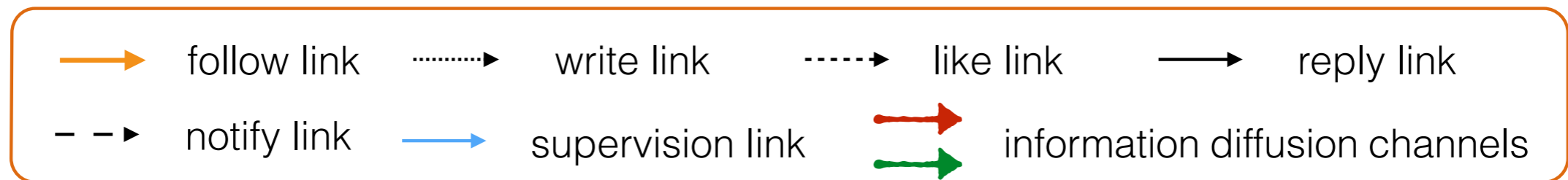


- Online information diffusion channels

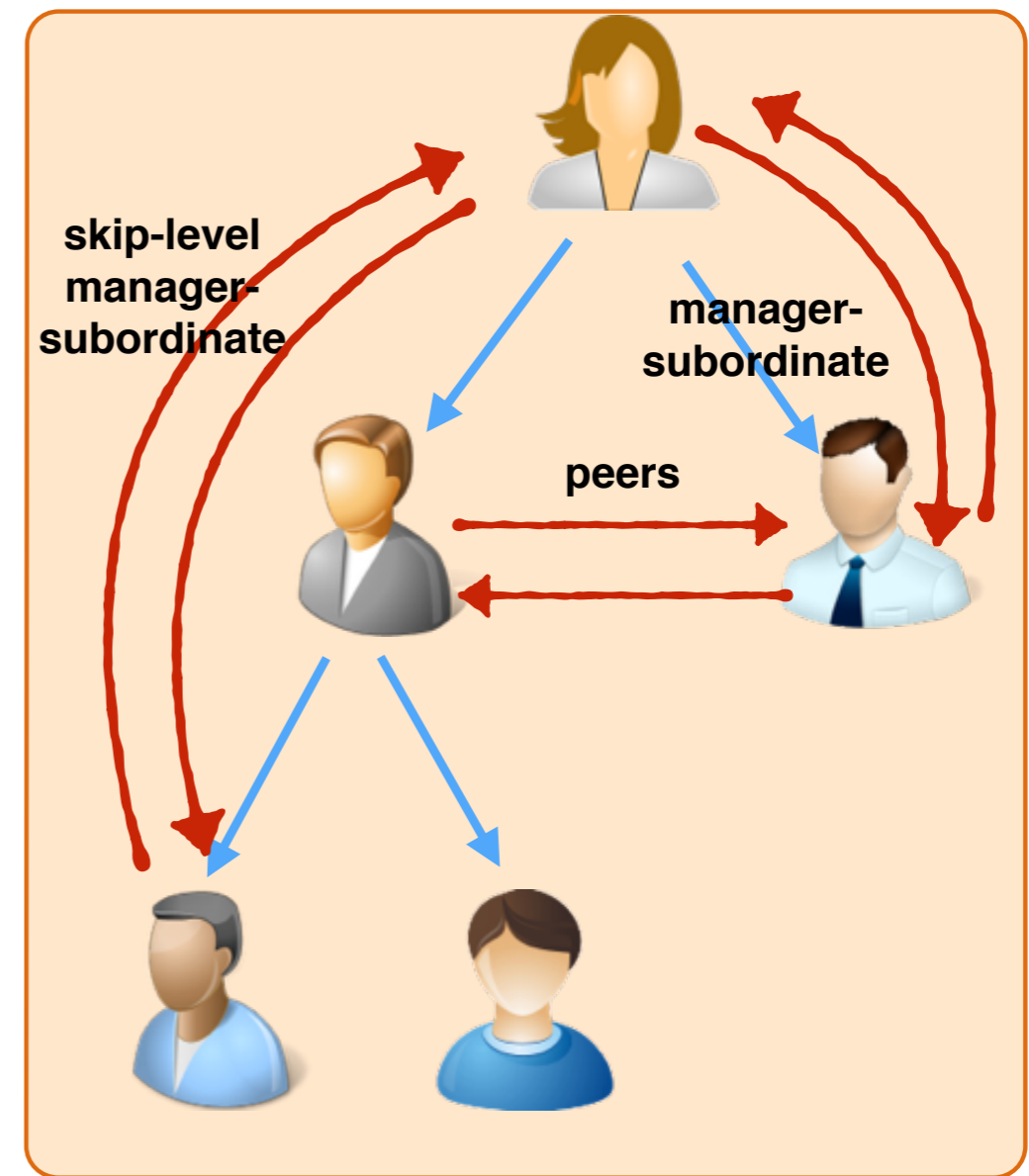
$$w^{(on),i}(v, u, t) = \frac{2 \left| \mathcal{P}_{\Phi_i}^{(on)}(v \rightsquigarrow u) \right| \cdot I(v, t)}{\left| \mathcal{P}_{\Phi_i}^{(on)}(v \rightsquigarrow \cdot) \right| + \left| \mathcal{P}_{\Phi_i}^{(on)}(\cdot \rightsquigarrow u) \right|},$$

$$w^{(on)}(\cdot, u, t)$$

Offline Diffusion Channel Extraction



Organizational Chart



Offline Diffusion Channel Extraction

- Meta path based offline diffusion channel extraction

- Manager: $Employee \xleftarrow{Supervision} Employee$, whose notation is Ω_1 .
- Subordinate: $Employee \xleftarrow{Supervision^{-1}} Employee$, whose notation is Ω_2 .
- Peer: $Employee \xleftarrow{Supervision} Employee \xleftarrow{Supervision^{-1}} Employee$, whose notation is Ω_3 .
- 2nd-Level Manager: $Employee \xleftarrow{Supervision} Employee \xleftarrow{Supervision} Employee$, whose notation is Ω_4 .
- 2nd-Level Subordinate: $Employee \xleftarrow{Supervision^{-1}} Employee \xleftarrow{Supervision^{-1}} Employee$, whose notation is Ω_5 .

- Offline information diffusion channels

$$\mathcal{C}^{(off)} = \{\Omega_1, \Omega_2, \Omega_3, \Omega_4, \Omega_5\}$$

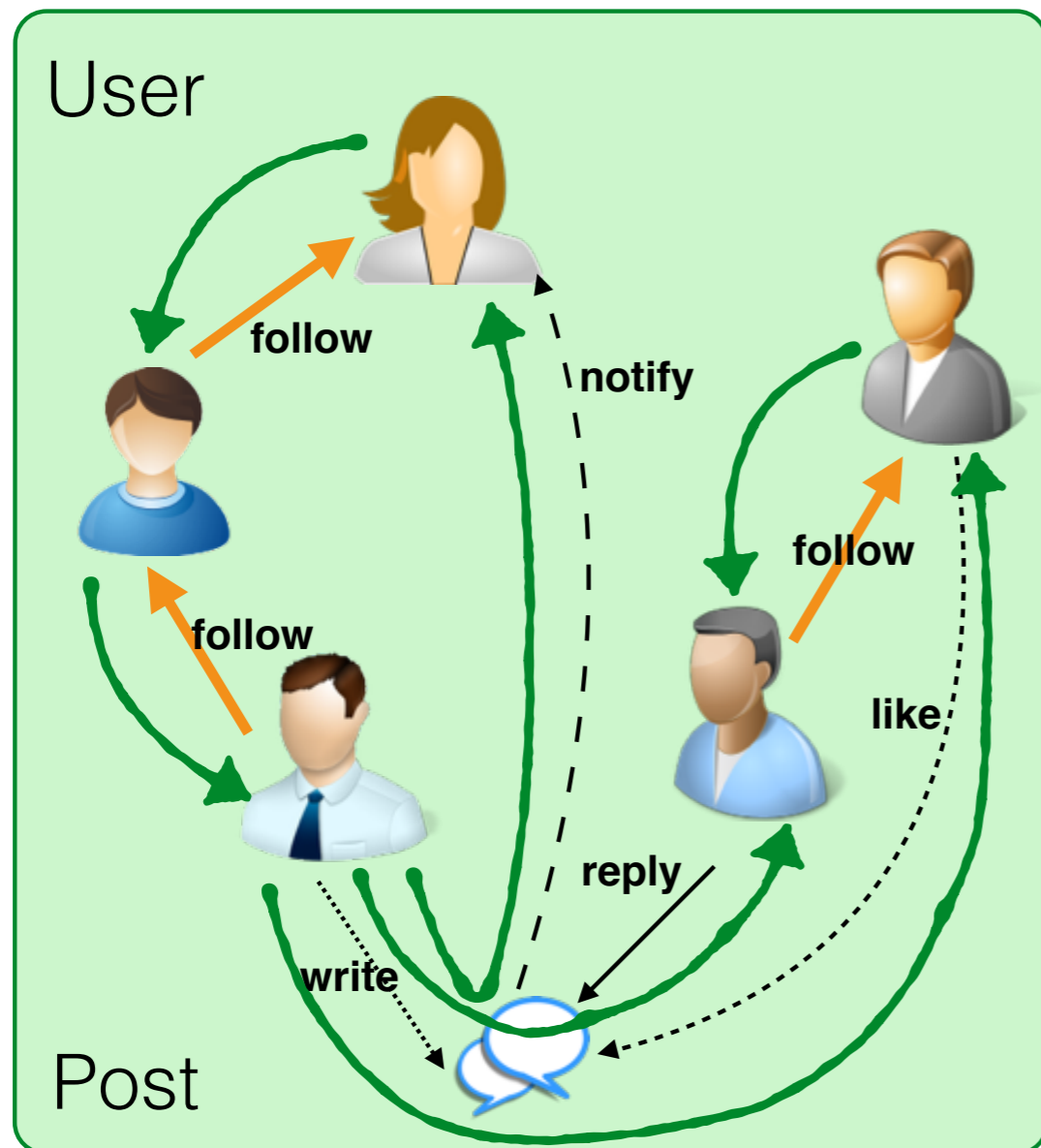
- Information propagation weight quantification

$$w^{(off),i}(v, u, t) = \frac{2 \left| \mathcal{P}_{\Omega_i}^{(off)}(v \rightsquigarrow u) \right| \cdot I(v, t)}{\left| \mathcal{P}_{\Omega_i}^{(off)}(v \rightsquigarrow \cdot) \right| + \left| \mathcal{P}_{\Omega_i}^{(off)}(\cdot \rightsquigarrow u) \right|},$$

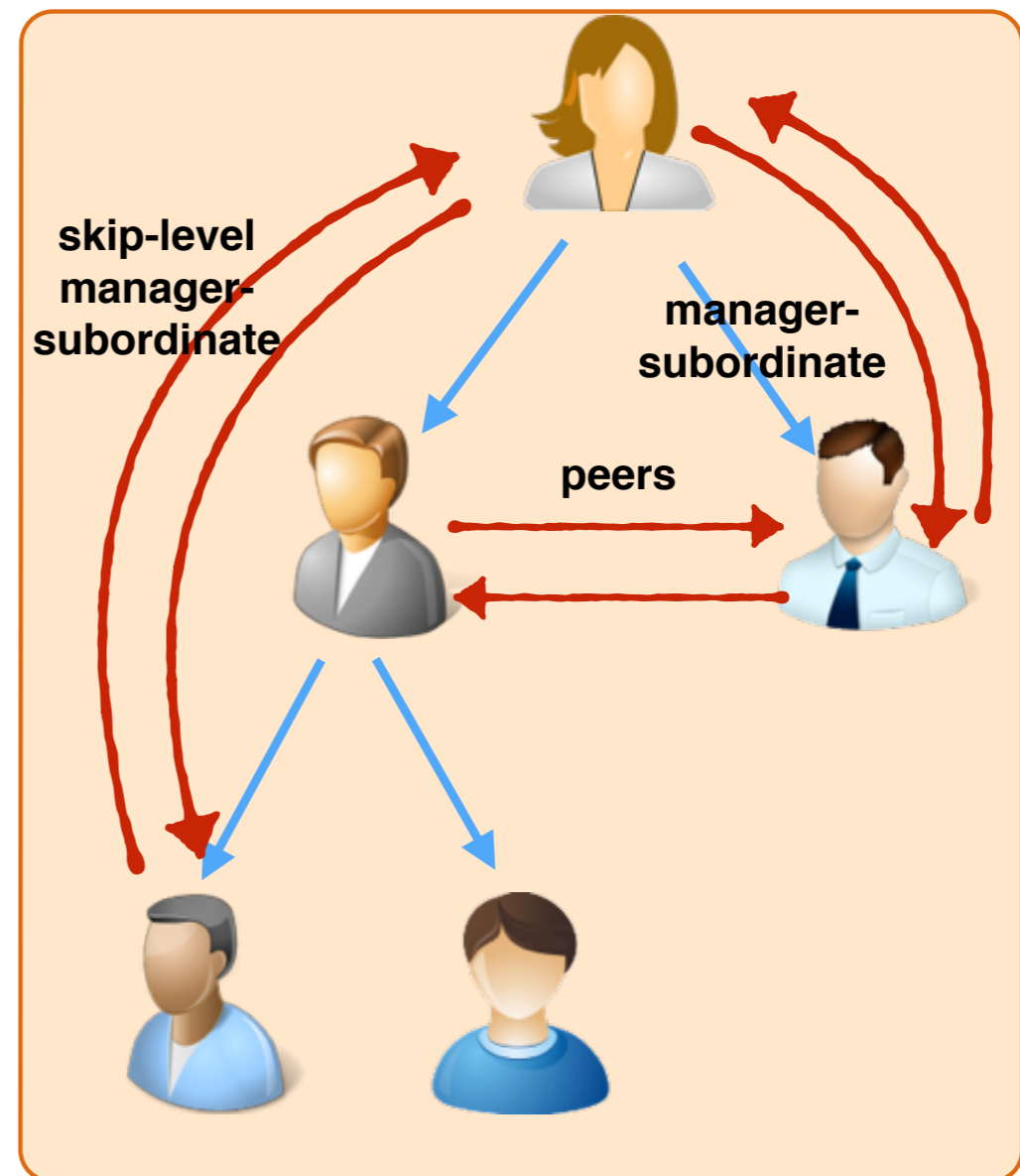
Hybrid Diffusion Channel Extraction



Online ESN



Organizational Chart



Hybrid Diffusion Channel Extraction

- Meta path based hybrid diffusion channel extraction

- Followee-Manager: $Employee \xleftarrow{Social^{-1}} Employee \xleftarrow{Supervision} Employee$, whose notation is Ψ_1 ,
- Followee-Subordinate: $Employee \xleftarrow{Social^{-1}} Employee \xleftarrow{Supervision^{-1}} Employee$, whose notation is Ψ_2 ,
- Manager-Followee: $Employee \xleftarrow{Supervision} Employee \xleftarrow{Social^{-1}} Employee$, whose notation is Ψ_3 ,
- Subordinate-Followee: $Employee \xleftarrow{Supervision^{-1}} Employee \xleftarrow{Social^{-1}} Employee$, whose notation is Ψ_4 ,
- Followee-Peer: $Employee \xleftarrow{Social^{-1}} Employee \xleftarrow{Supervision} Employee \xleftarrow{Supervision^{-1}} Employee$, whose notation is Ψ_5 ,
- Peer-Followee: $Employee \xleftarrow{Supervision} Employee \xleftarrow{Supervision^{-1}} Employee \xleftarrow{Social^{-1}} Employee$, whose notation is Ψ_6 ,

- Hybrid information diffusion channels

$$\mathcal{C}^{(hyb)} = \{\Psi_1, \Psi_2, \Psi_3, \Psi_4, \Psi_5, \Psi_6\}$$

- Information propagation weight quantification

$$w^{(hyb),i}(v, u, t) = \frac{2 \left| \mathcal{P}_{\Psi_i}^{(hyb)}(v \rightsquigarrow u) \right| \cdot I(v, t)}{\left| \mathcal{P}_{\Psi_i}^{(hyb)}(v \rightsquigarrow \cdot) \right| + \left| \mathcal{P}_{\Psi_i}^{(hyb)}(\cdot \rightsquigarrow u) \right|}$$

Diffusion Channel Aggregation Function

$$f\left(\mathbf{w}^{(on)}(\cdot, u, t), \mathbf{w}^{(off)}(\cdot, u, t), \mathbf{w}^{(hyb)}(\cdot, u, t)\right) = \frac{e^{(g(\mathbf{w}^{(on)}(\cdot, u, t)) + g(\mathbf{w}^{(off)}(\cdot, u, t)) + g(\mathbf{w}^{(hyb)}(\cdot, u, t)) + \theta_0)}}{1 + e^{(g(\mathbf{w}^{(on)}(\cdot, u, t)) + g(\mathbf{w}^{(off)}(\cdot, u, t)) + g(\mathbf{w}^{(hyb)}(\cdot, u, t)) + \theta_0)}},$$



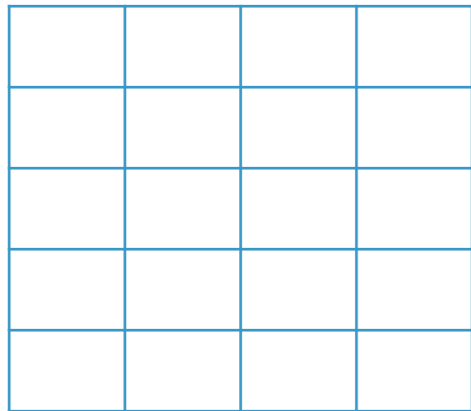
$$g(\mathbf{w}^{(on)}(\cdot, u, t)) = \sum_{i=1}^{k^{(on)}} \alpha_i \cdot \sum_{v \in \Gamma_{out}^{(on), i}(u)} w^{(on), i}(v, u, t),$$

$$g(\mathbf{w}^{(off)}(\cdot, u, t)) = \sum_{i=1}^{k^{(off)}} \beta_i \cdot \sum_{v \in \Gamma_{out}^{(off), i}(u)} w^{(off), i}(v, u, t),$$

$$g(\mathbf{w}^{(hyb)}(\cdot, u, t)) = \sum_{i=1}^{k^{(hyb)}} \gamma_i \cdot \sum_{v \in \Gamma_{out}^{(hyb), i}(u)} w^{(hyb), i}(v, u, t),$$

Diffusion Channel Weighting and Selection

topics



employee

$$\alpha^*, \beta^*, \gamma^*, \theta_0^* = \arg \min_{\alpha, \beta, \gamma, \theta_0} \|\mathbf{F} - \mathbf{H}\|_F^2$$

$$s.t. \sum_{i=1}^{k^{(on)}} \alpha_i + \sum_{i=1}^{k^{(off)}} \beta_i + \sum_{i=1}^{k^{(hyb)}} \gamma_i + \theta_0 = 1.$$

Derivations
in the Paper!

Channels with positive weights will be selected

Experimental Dataset and Settings

- ***Dataset***¹
 - *Yammer* used in Microsoft
 - covers all the user-generated content (such as posts, replies, etc.) and social graphs (such as user-user following links, user-group memberships, etc.)
 - Complete ***organizational chart*** of all employees in Microsoft
 - includes more than 100k Microsoft employees
- ***Task***: to infer the propagation of online social group information among employees
- ***Ground truth***: Real-world employee group membership
- ***Information Topics***: groups of different categories (work related, or personal interest oriented)

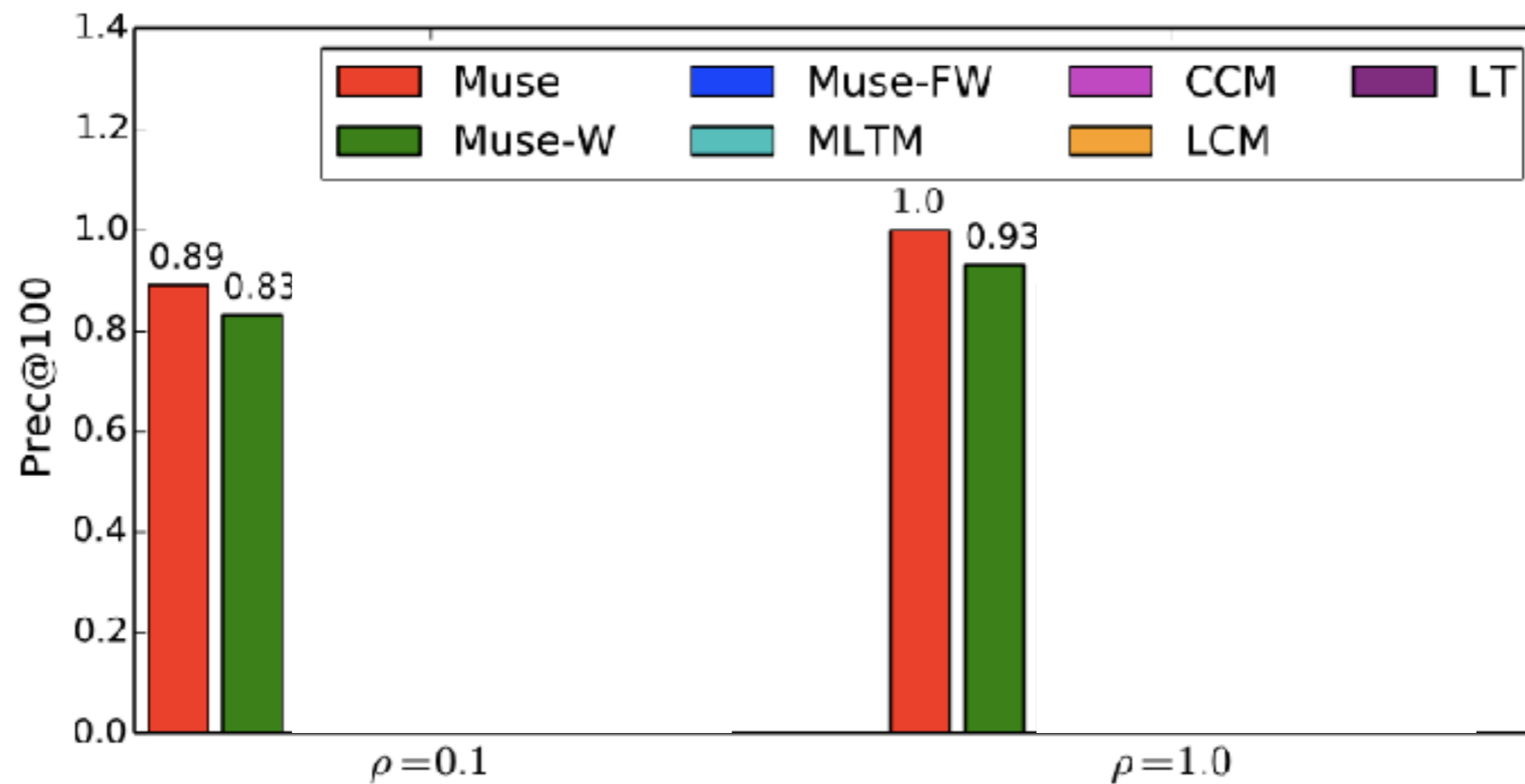
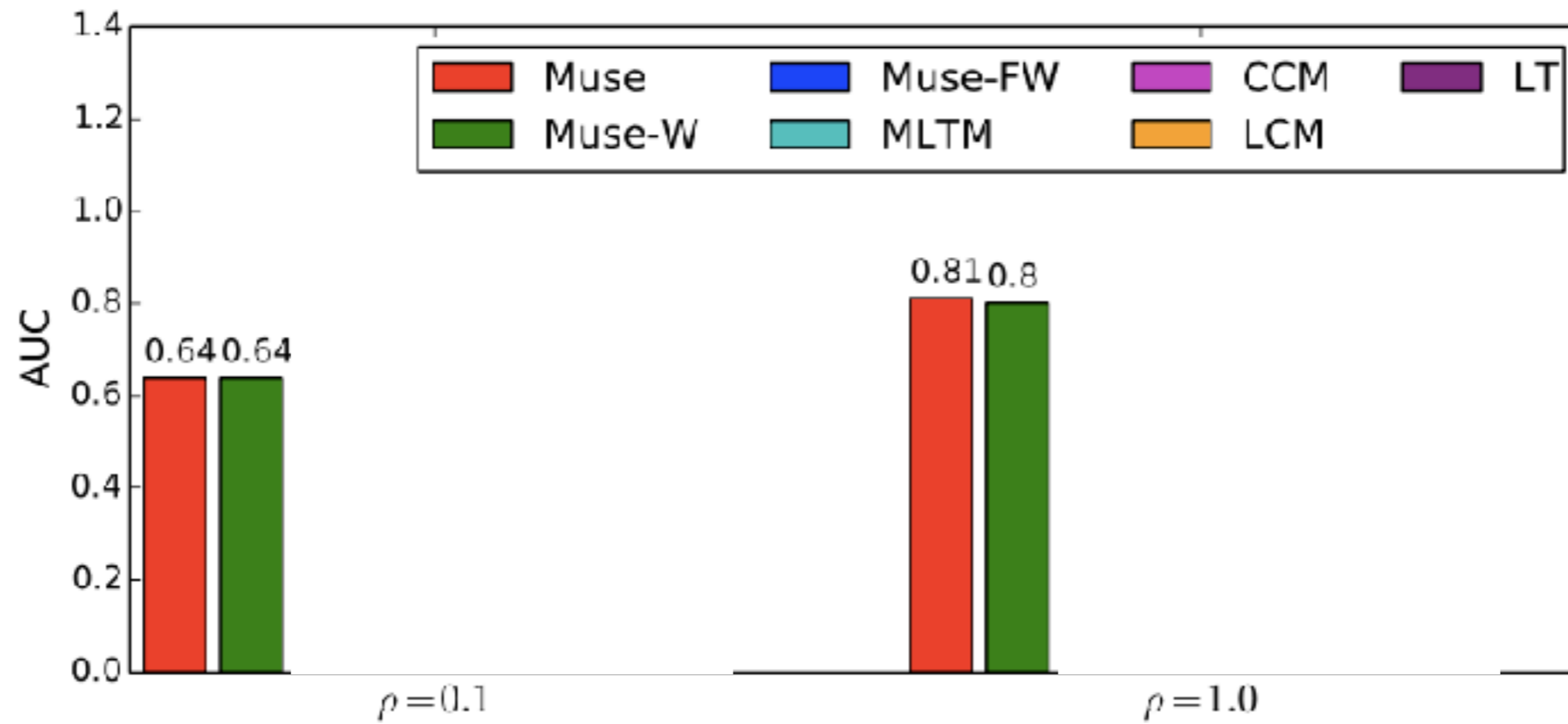
¹ We are not able to reveal the actual numbers here and throughout the paper for commercial reasons.

Experimental Setting: continued

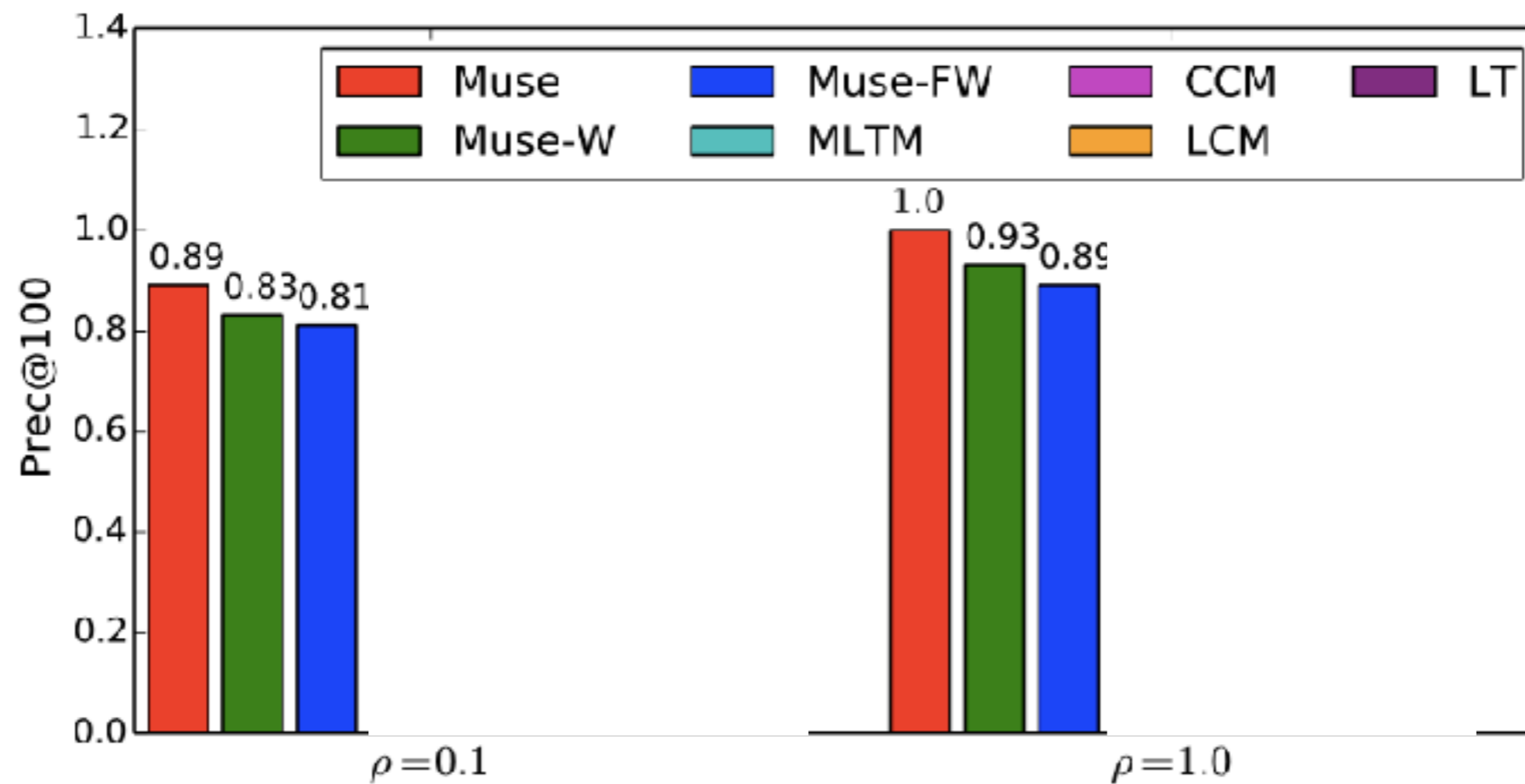
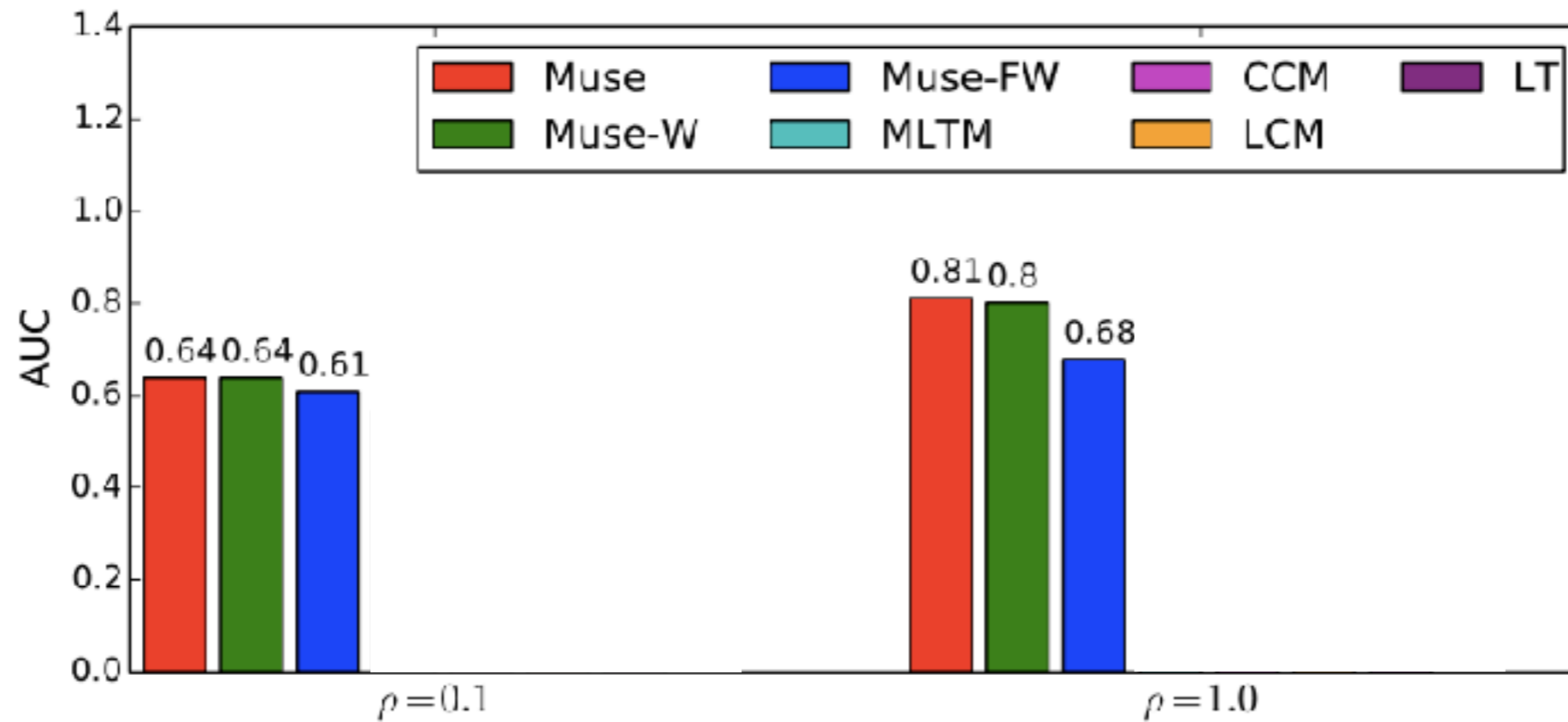
multi-source
multi-channel
multi-topic

- *Comparison Methods*
 - *MUSE*: our method, weight learning + channel selection
 - *MUSE-W*: our variant method, weight learning, no channel selection
 - *MUSE-FW*: our variant method, fixed weight, no learning
 - *MLTM*: **single** heterogeneous network only
 - *CCM*: **single** organizational **chart** only
 - *LCM*: multiple **homogeneous** networks
 - *LT*: **single homogeneous** LT model
- *Evaluation Metrics*
 - *AUC*
 - *Precision@100*

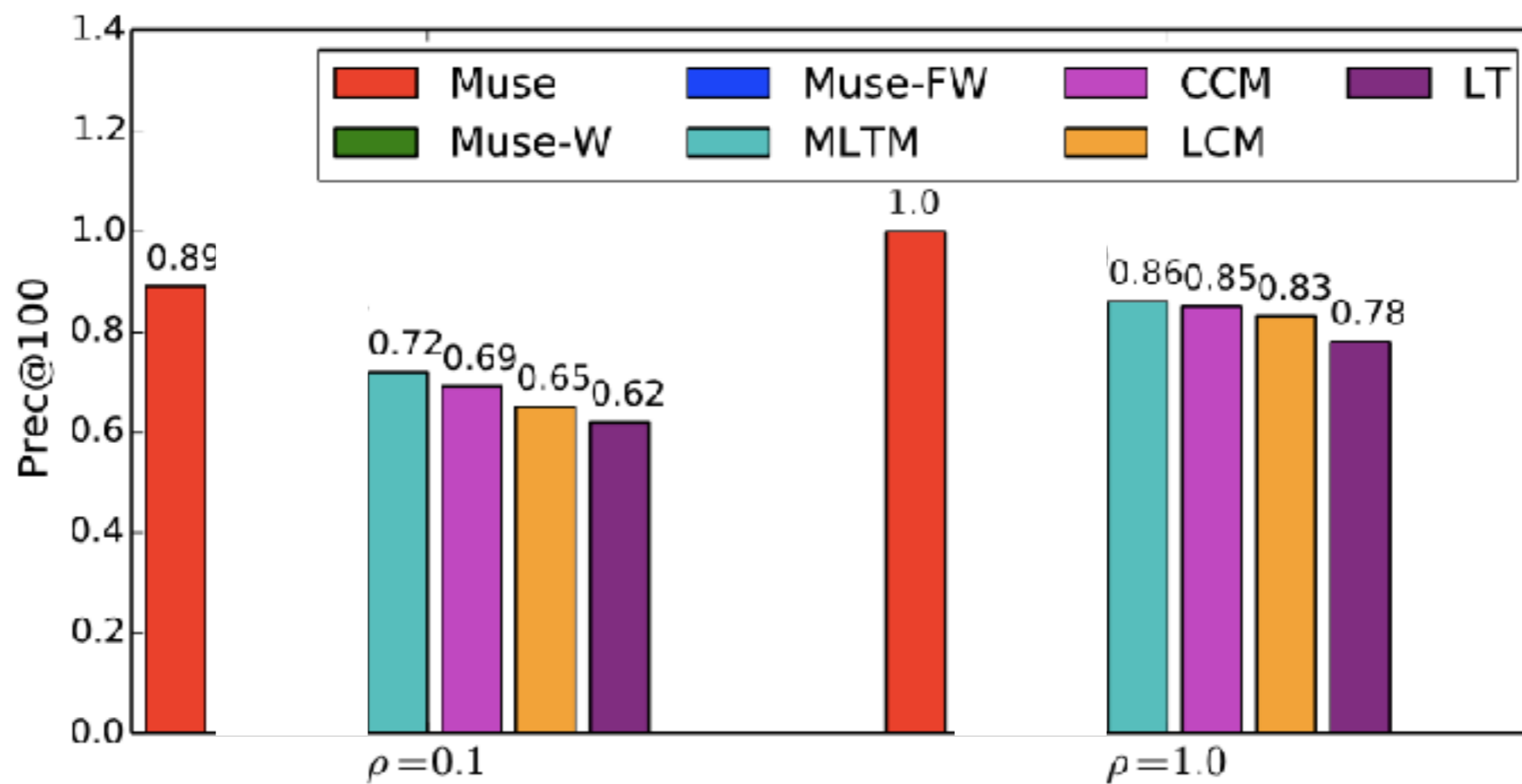
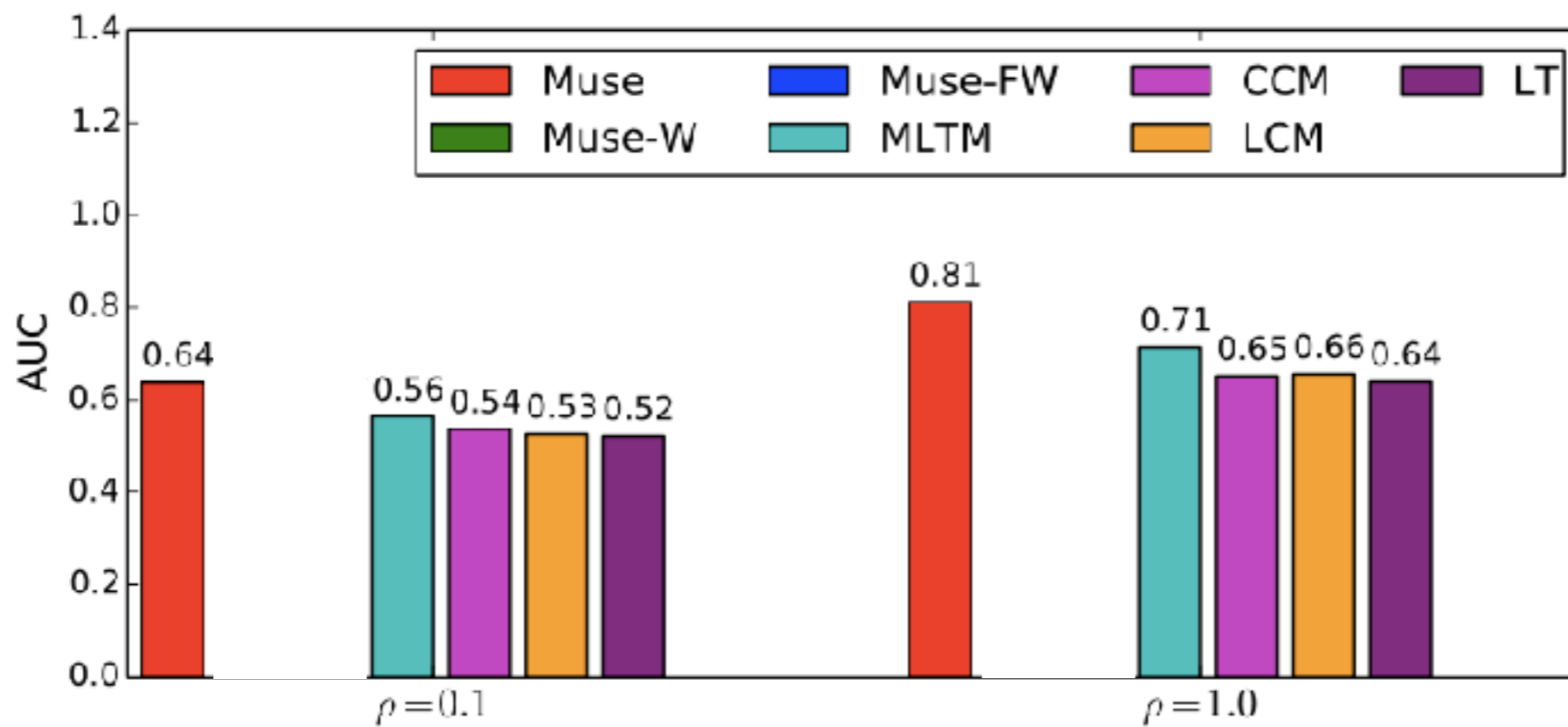
Experimental Results



Experimental Results



Experimental Results



Experimental Results: Rank of different diffusion channels

Table 3: Rank of different diffusion channels.

Rank	Channal Notation	Channal Physical Meaning
1	Ω_1	“Manager”
2	Φ_1	“Followee”
3	Ω_4	“2nd-Level Manager”
4	Ψ_6	“Peer-Followee”
5	Ψ_3	“Manager-Followee”
6	Ω_3	“Peer”
7	Φ_2	“Followee-Followee”
8	Ψ_1	“Followee-Manager”
9	Ψ_5	“Followee-Peer”
10	Ψ_4	“Subordinate-Followee”
11	Ψ_2	“Followee-Subordinate”
12	Ω_2	“Subordinate”
13	Ω_5	“2nd-Level Subordinate”
14	Φ_3	“Reply Post”
15	Φ_5	“Post Notification”
16	Φ_4	“Like Post”

Experimental Results: Rank of different diffusion channels

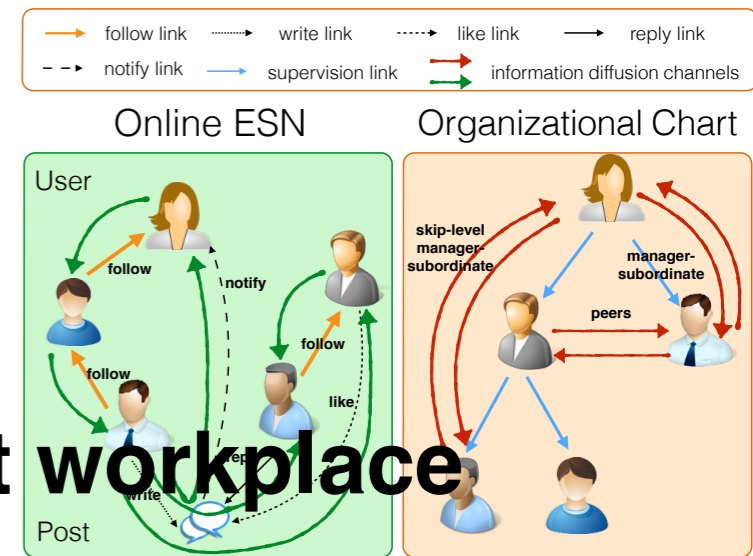
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3	Ω_4	“2nd-Level Manager”
4	Ψ_6	“Peer-Followee”
5	Ψ_3	“Manager-Followee”
6	Ω_3	“Peer”
7	Φ_2	“Followee-Followee”
8	Ψ_1	“Followee-Manager”
9	Ψ_5	“Followee-Peer”
10	Ψ_4	“Subordinate-Followee”
11	Ψ_2	“Followee-Subordinate”
12	Ω_2	“Subordinate”
13	Ω_5	“2nd-Level Subordinate”
14	Φ_3	“Reply Post”
15	Φ_5	“Post Notification”
16	Φ_4	“Like Post”

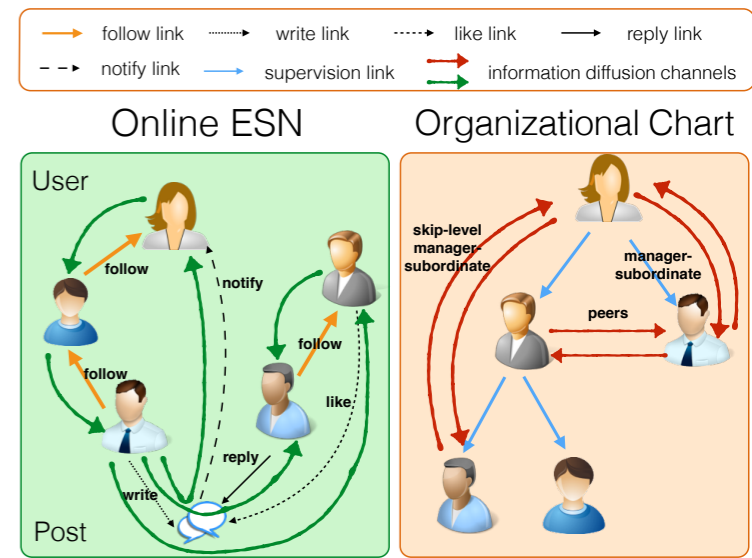
Observations:

- Influence: Manger > Peer >> Subordinate
- Hybrid channels are important
- Text content information is not important
- Short diffusion channels have higher weights

Summary



- Problem Studied: **information diffusion at workplace**
- Proposed Diffusion Channel: MUSE (**multi-source multi-channel and multi-topic** information diffusion model)
 - *Diffusion channel extraction*: online, offline hybrid channels
 - *Diffusion channel aggregation*: with logistic function
 - *Diffusion channel weighting and selection*
- Experiments on **Microsoft** internal datasets
 - *Yammer*: enterprise online social network about Microsoft employees
 - *Organization chart of Microsoft*



Information Diffusion at Workplace

Q&A

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