

# intermediacy of publications

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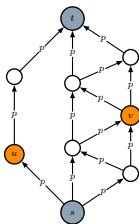
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# introduction & motivation

**algorithmic historiography** for evolution of field (**Garfield et al., 2003**)  
relying on **citations** between scientific **publications** from **WoS** & **Scopus**



existing approaches include **main paths** (**Hummon & Doreian, 1989**)  
(**longest/shortest paths**) many **irrelevant**/miss **relevant** publications  
(**intermediacy**) important publications should only be **well-connected**

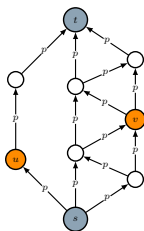
# intermediacy measure

(**input**) selected **source** & **target** publications **s** & **t**

(**method**) each citation is relevant/active with **probability p**

(**measure**) importance of **publication u** called **intermediacy**  $\phi_u$

$$\phi_u = \Pr(X_{st}^u) = \Pr(X_{su}) \Pr(X_{ut})$$

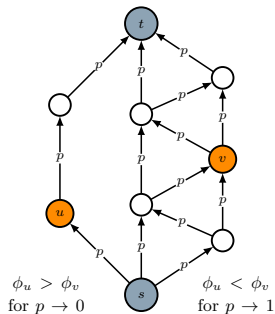


$X_{st}$  exists path **from s to t** &  $X_{st}^u$  exists path **through u**

# intermediacy for $p \rightarrow 0$

for  $p \rightarrow 0$  intermediacy  $\phi$  governed by  $\ell$  (**proof**)

for  $p \rightarrow 0$  if  $\ell_u < \ell_v$  then  $\phi_u > \phi_v$

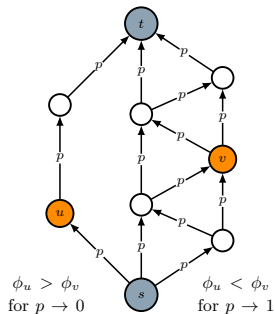


$\ell_u$  is **length** of **shortest paths** from  $s$  to  $t$  through  $u$

# intermediacy for $p \rightarrow 1$

for  $p \rightarrow 1$  intermediacy  $\phi$  governed by  $\sigma$  (proof)

for  $p \rightarrow 1$  if  $\sigma_u < \sigma_v$  then  $\phi_u < \phi_v$

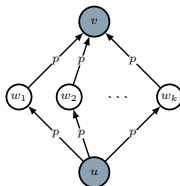


$\sigma_u$  is **number** of **independent paths** from  $s$  to  $t$  through  $u$

# intuition for $p$

for what  $p$  is **direct citation** equivalent to  **$k$  indirect citations**

$$\Pr(X_{uv}) = p = 1 - (1 - p^2)^k$$



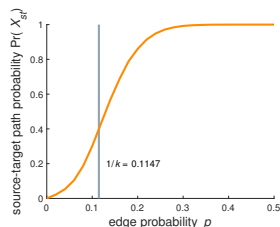
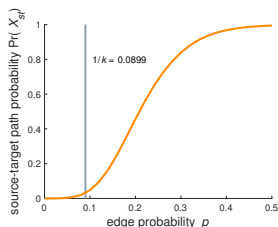
$k$	$p$
2	0.62
3	0.39
4	0.28
5	0.22
6	0.18
7	0.15
8	0.13
9	0.12
10	0.11

$k$  is **number** of **independent paths** from  $u$  to  $v$

# phase transition

for what  $p$  source-target path  $\Pr(\mathbf{X}_{st}) > \mathbf{0}$  & intermediacy  $\exists \mathbf{u} : \phi_{\mathbf{u}} > \mathbf{0}$

$$p \geq n/2m = 1/k$$

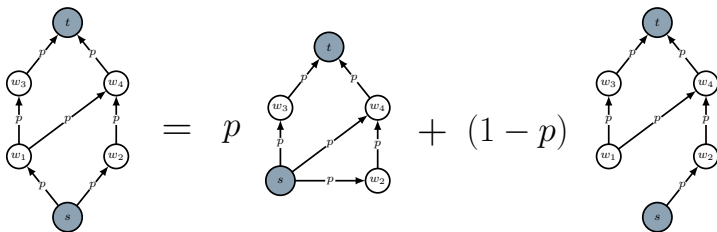


$k$  is **average** number of **citations/references**

# exact algorithm

decomposition algorithm by edge **contraction** & **removal** (Ball, 1979)

$$\Pr(X_{st} | G) = p \Pr(X_{st} | G/e) + (1 - p) \Pr(X_{st} | G - e)$$



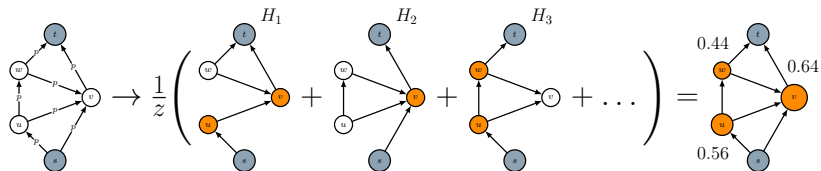
runs in **exponential time** since NP-hard even in DAG (Johnson, 1984)



# approximate algorithm

simple **Monte Carlo** simulation algorithm by edge **sampling**

$$\phi_u = \Pr(X_{st}^u \mid G) = \frac{1}{Z} \sum_{k=1}^Z \mathbb{I}(X_{st}^u \mid H_k)$$



runs in quasi **linear time** using  $p$ -DFS over say  **$10^6$  samples**

# intermediacy $\neq$ centrality

correlation coefficient between **intermediacies**  $\phi$  & **citations/references**

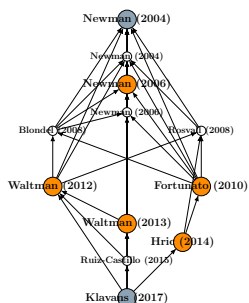


intermediacy  $\phi$  **uncorrelated** with standard **centrality** measures

# modularity example

(target) Newman & Girvan (2004), **Finding and evaluating community...**, *Phys. Rev. E* **69**(2), 026113.

(source) Klavans & Boyack (2017), **Which type of citation analysis generates...**, *JASIST* **68**(4), 984-998.

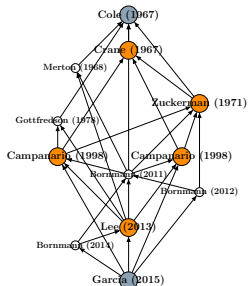


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- 2 Waltman & Van Eck (2012), A new methodology for constructing a publication-level classification system. . . , *JASIST* **63**(12), 2378-2392.
- 3 Hric et al. (2014), Community detection in networks: Structural communities versus ground truth, *Phys. Rev. E* **90**(6), 062805.
- 4 Fortunato (2010), Community detection in graphs, *Phys. Rep.* **486**(3-5), 75-174.
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- 6 Ruiz-Castillo & Waltman (2015), Field-normalized citation impact indicators using algorithmically. . . , *J. Informetr.* **9**(1), 102-117.
- 7 Blondel et al. (2008), Fast unfolding of communities in large networks, *J. Stat. Mech.*, P10008.
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# peer review example

(**target**) Cole & Cole (1967), **Scientific output and recognition**, *Am. Sociol. Rev.* **32**(3), 377-390.

(**source**) Garcia et al. (2015), **The author-editor game**, *Scientometrics* **104**(1), 361-380.



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- 8 Bornmann (2012), The Hawthorne effect in journal peer review, *Scientometrics* **91**(3), 857-862.
- 9 Bornmann (2014), Do we still need peer review? An argument for change, *JASIST* **65**(1), 209-213.
- 10 Merton (1968), The Matthew effect in science, *Science* **159**(3810), 56-63.

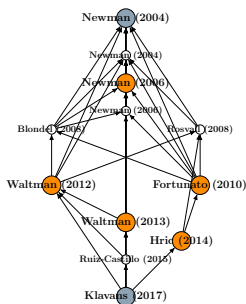
# conclusions & future work

(**proposal**) measure of importance of publications called **intermediacy**

(**theory**) conceptually clear & provable behavior in **extreme cases**

(**practice**) intermediacy shows promising results in **case studies**

(**future**) applicability on general (**un**)**directed networks**?



(**paper**) soon on **arXiv.org**  
(**code**) soon on **github.com**

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