Network Mechanisms and Network Structures

The Principle of Homophily

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[2]Soundcloud

MSc in Business Analytics, 2022/23

Outline

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Problem Set/Homework

Create the adjacency matrix behind the reporting network of a multi-unit organization with the following attributes

- Ten units
- One manager by unit
- Five middle managers by unit reporting to the unit manager
- Ten employees reporting to each middle manager

Then

- Visualize the adjacency matrix of the network
- Visualize the network
- Get the centralization index of the network

Submitted Solutions

- Artem
- Theodor
- Yuanheng
- $\rightarrow$?anyone else? check Slack

Outline

Network Theories across the Various Weeks of SMM638

Network theory	**2**	**3**	**4**	**5**	**6**	**7**	**9**	**10**
Value creation		•	•					
Coordination				•				
Network change					•	•	•	•
Contagion						•		•

Groups of Network Theories

Underlying model	**Social capital**	**Social homogeneity**
Network flow	Capitalization (value creation)	Contagion
Network architecture	Coordination	Adaptation (network change)

Source is [6, page 47]

Why do Network Mechanisms Matter?

1. Network mechanisms can explain why networks look how they look!
2. If we know the network mechanisms, we can predict the evolution of a network. E.g.,
   - Who will pay attention to which market offers
   - Who will date whom
   - Who will adopt or reject whom's opinion

What Are We Trying to Achieve in Sessions 6 and 7?

Network theory	**2**	**3**	**4**	**5**	**6**	**7**	**9**	**10**
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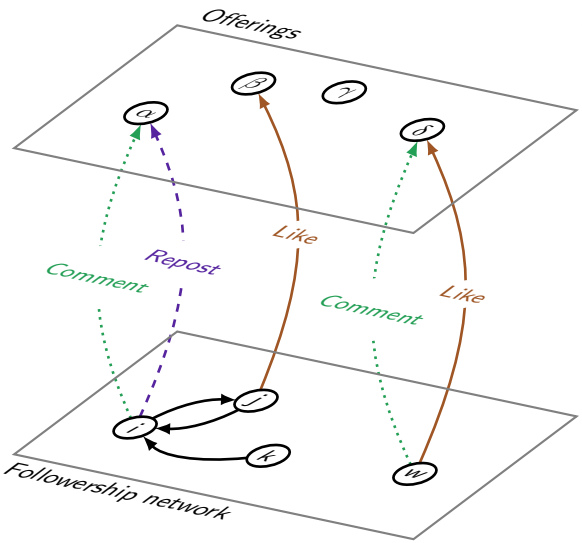
Contagion						•		•

- In session 6, we tried to discover the mixture of network mechanisms accounting for Soundcloud's network structure
- In today's session, we will learn how to quantify a key network mechanism and will connect it to the problem of contagion (critically important to explain offering popularity in markets)

A Real-World Example: The Soundcloud Networks



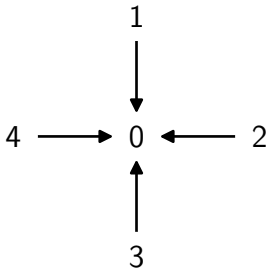
Some key general points emerging from the analysis of the Soundcloud example:

- The same pair of nodes can be connected because of multiple relationships (i.e., 'like,' 'repost,' 'comment')
- The nodes of a network may have the same type (e.g., 'following') or different types (e.g., 'like')
- Analytically separated networks may be correlated (e.g., one tends to like her/his followings' likes)

Network Mechanisms in the Followership Network

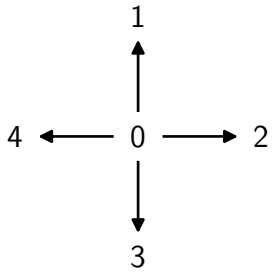
Popularity effects

Indegree popularity



Synopsis: certain nodes may develop a cumulative advantage — a so-called rich-get-richer effect

Outdegree popularity



Synopsis: certain nodes may develop a tendency to connect with many others

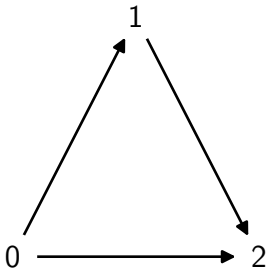
Network Mechanisms in the Followership Network

Reciprocity effect

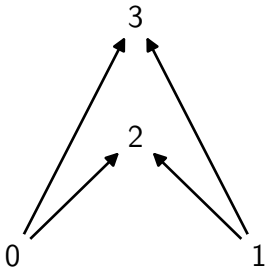
Synopsis: pairs of nodes may show a tendency to follow each other — that is, to reciprocate each other's following choice

Network Mechanisms in the Followership Network

Triadic closure



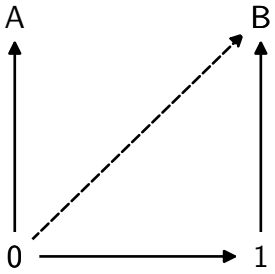
Synopsis: "My following's following is my following"



Synopsis: Pairs of (connected or disconnected) nodes may show the tendency to share 'followings'

Cross-Level Effects: From Following to Taste and Back

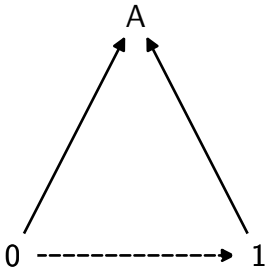
Membership closure



Synopsis: 1 introduces 0 to music style B; $\{A, B\}$ is the set of music styles; $\{0, 1\}$ is the set of users; 'vertical' ties can be intended as a bipartite graph linking users and music styles via 'likes,' 'comments,' or 'reposts' (mainly, user preferences); dashed arrows denote ties at risk to emerge based on membership closure

Cross-Level Effects: From Following to Preferences and Back

Focal closure



Synopsis: 0 follows 1 because of shared taste/preferences; $\{A, B\}$ is the set of music styles; $\{0, 1\}$ is the set of users; 'vertical' ties can be intended as a bipartite graph linking users and music styles via 'likes,' 'comments,' or 'reposts'; dashed arrows denote ties at risk to emerge based on focal closure

Outline

Let Us Get Back to the Fundamental Question

Why do networks look how they look?

A Possible Answer: Homophily

- According to the homophily principle, similarity breeds connection

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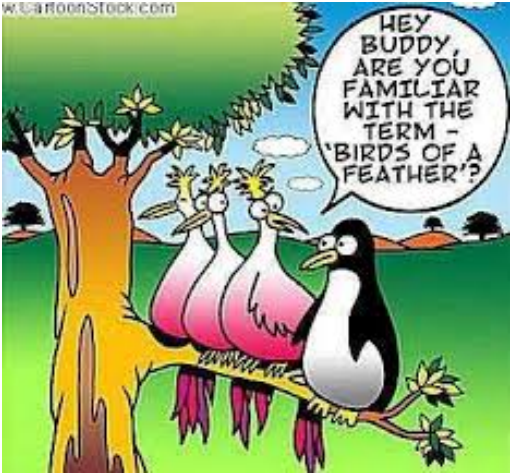
- According to the homophily principle, similarity breeds connection
- Hence, networks are homogeneous concerning:
  - Sociodemographic variables (e.g., age)
  - Reference social categories (e.g., being a knowledge worker)
  - Behaviors (e.g., purchasing choices)



Theoretical Background

BIRDS OF A FEATHER: Homophily in Social Networks

Miller McPherson[1], Lynn Smith-Lovin[1], and James M Cook[2]
[1]*Department of Sociology, University of Arizona, Tucson, Arizona 85721; e-mail: mcpherson@u.arizona.edu; smithlov@u.arizona.edu*
[2]*Department of Sociology, Duke University, Durham, North Carolina 27708; e-mail: jcook@soc.duke.edu*

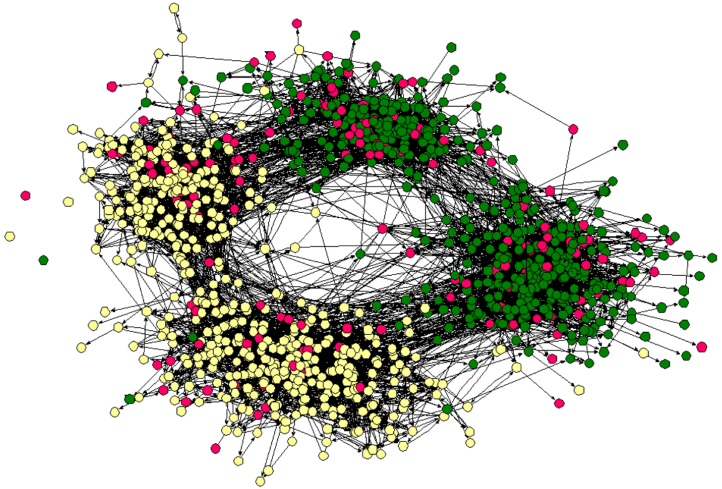
Key Words human ecology, voluntary associations, organizations

■ **Abstract** Similarity breeds connection. This principle—the homophily principle—structures network ties of every type, including marriage, friendship, work, advice, support, information transfer, exchange, comembership, and other types of relationship. The result is that people's personal networks are homogeneous with regard to many sociodemographic, behavioral, and intrapersonal characteristics. Homophily limits people's social worlds in a way that has powerful implications for the information they receive, the attitudes they form, and the interactions they experience. Homophily in race and ethnicity creates the strongest divides in our personal environments, with age, religion, education, occupation, and gender following in roughly that order. Geographic propinquity, families, organizations, and isomorphic positions in social systems all create contexts in which homophilous relations form. Ties between nonsimilar individuals also dissolve at a higher rate, which sets the stage for the formation of niches (localized positions) within social space. We argue for more research on: (*a*) the basic ecological processes that link organizations, associations, cultural communities, social movements, and many other social forms; (*b*) the impact of multiplex ties on the patterns of homophily; and (*c*) the dynamics of network change over time through which networks and other social entities co-evolve.

Source is [4]

Homophily in Practice: Example 1

Friendship and racial segregation in an American high-school



Source is [5]; nodes are color-coded to reflect student racial background; ties denote friendship between pairs of nodes

Homophily in Practice: Example 2

Discovering cultural similarity is key for tie formation in speed dating

Making the Connection: Social Bonding in Courtship Situations[1]

Daniel A. McFarland and Dan Jurafsky
Stanford University

Craig Rawlings
University of California, Santa Barbara

Sociologists have long argued that the force of a social bond resides in a sense of interpersonal connection. This is especially true for initial courtship encounters when pairs report a sense of interpersonal chemistry. The authors explore the process of romantic bonding by applying interaction ritual theory, extended and integrated with methods from computational linguistics, to the study of courtship encounters and, specifically, heterosexual speed dating. The authors find that the assortment of interpersonal moves associated with a sense of connection characterizes a conventionalized form of initial courtship activity. The game is successfully played when females are the point of focus and engaged in the conversation and males demonstrate alignment with and understanding of the female. In short, initial heterosexual courtship encounters are associated with a sense of bonding when they reflect a reciprocal asymmetrical performance in which differentiated roles are mutually coordinated.

INTRODUCTION

Social bonds are a central topic of sociology because they are the social glue of society. What renders social bonds distinct from other forms of inter-

[1] This article was prepared for presentation at the American Sociological Association meeting in Las Vegas, Nevada, August 21, 2011. Special thanks to Rajesh Ranganath, Sonal Nalkur, and Tanzeem Choudhury for assistance and advice on data collection and Sandy Pentland for a helpful discussion about feature extraction. This work received

0002-9602/2013/11806-0004$10.00

Source is [3]

Homophily in Practice: Example 3

Executives ask for advice from similar others in difficult times

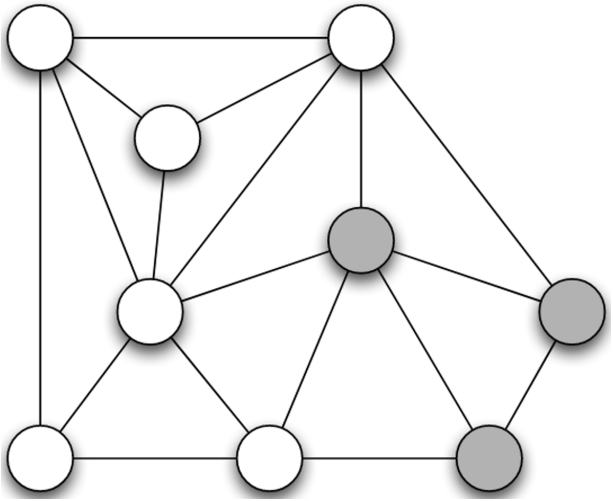
Getting by with the Advice of Their Friends: CEOs' Advice Networks and Firms' Strategic Responses to Poor Performance

Michael L. McDonald
James D. Westphal
University of Texas at Austin

This paper theorizes that relatively poor firm performance can prompt chief executive officers (CEOs) to seek more advice from executives of other firms who are their friends or similar to them and less advice from acquaintances or dissimilar others and suggests how and why this pattern of advice seeking could reduce firms' propensity to change corporate strategy in response to poor performance. We test our hypotheses with large-sample survey data on the identities of CEOs' advice contacts and archival data on firm performance and corporate strategy. The results confirm our hypotheses and show that executives' social network ties can influence firms' responses to economic adversity, in particular by inhibiting strategic change in response to relatively poor firm performance. Additional findings indicate that CEOs' advice seeking in response to low performance may ultimately have negative consequences for subsequent performance, suggesting how CEOs' social network ties could play an indirect role in organizational decline and downward spirals in firm performance.●

Source is [**mcdonald2013**]

When Does a Network Exhibit Homophily?



Notes: — Nodes are color-coded concerning a key relevant attribute (e.g., gender)

A Simple Homophily Measure Based on Frequencies

Intuition

Let us consider 'gender' as the key feature of nodes: what would it mean for a network not to exhibit homophily?

- The proportion of male and female friends that a person has resembles the underlying male/female distribution in the full population

A Simple Homophily Measure Based on Frequencies

Intuition

Let us consider 'gender' as the key feature of nodes: what would it mean for a network not to exhibit homophily?

- The proportion of male and female friends that a person has resembles the underlying male/female distribution in the full population
- In other words, "if we were to randomly assign each node a gender according to the gender balance in the real network, then the number of cross-gender edges should not change significantly relatively to what is seen in the real network"

Source is

A Simple Homophily Measure Based on Frequencies

The formal representation

Let's consider a network containing a fraction p of male nodes (m) and a fraction q of female nodes (f), and denote the link between nodes i and j as $e_{i,j}$.

The no-homophily hypothesis implies what follows:

1. $pr(e_{ij} \mid i = m,\ j = m) = p * p$
2. $pr(e_{ij} \mid i = f,\ j = f) = q * q$
3. $pr(e_{ij} \mid i = m,\ j = f) = p * q$
4. $pr(e_{ij} \mid i = f,\ j = m) = q * p$

If the proportion of male-female ties deviates from $2 * (p * q)$, then there is evidence of homophily in the network.

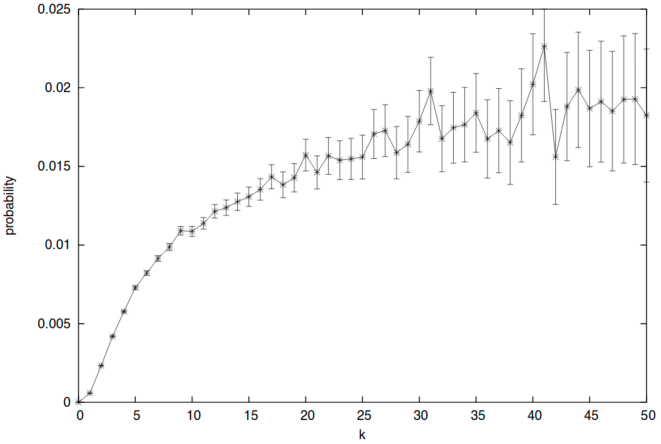
Mechanisms Underlying the Homophily Principle

There are two mechanisms through which homophily affects tie formation:

- **Selection:** individual bond with others they perceive 'similar' on salient dimensions
- **Socialization:** individuals that directly, closely, frequently interact with each other become more and more 'similar'

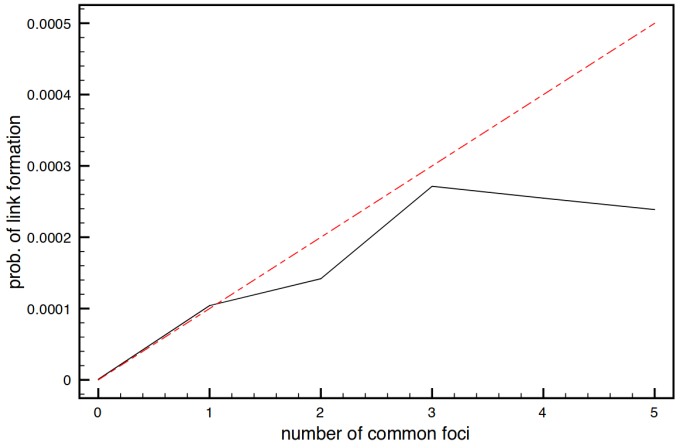
Note: The relative strength of 'selection' and 'socialization' largely depends on the attributes individuals use to assess interpersonal similarity. Socialization does not operate for fixed demographic factors, whereas it plays a central role when attitudes or behavior are used as a basis for similarity

Probability to become a member of a community i when k friends are already part



Source is [2]

Probability of inter-personal link formation when two members share k classes

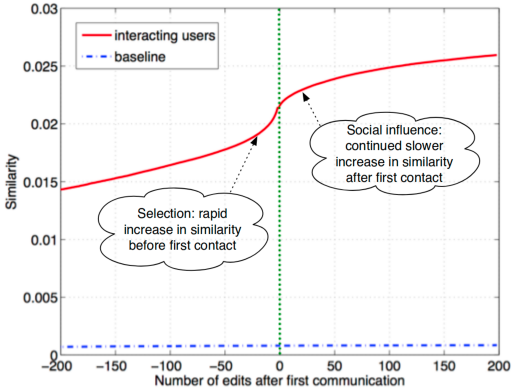


Source is [2]

Mechanisms Underlying the Homophily Principle

The interaction between selection and socialization

Similarity of two Wikipedia contributors' edits before and after the formation of an inter-personal link



Source is [1]

A Thought Experiment

How does a network with homophily look like?

A Thought Experiment

How does a network with homophily look like?

A small-world network you say?!

A Thought Experiment

How does a network with homophily look like?

A small-world network you say?!

Cool! Let's see how homophily relates to diffusion then!!

Modeling Diffusion through Networks

The adoption of new ideas, styles, technologies, products, or, in general behaviors, is subject to direct-benefit effects

- The benefits to 'ego' of adopting a new behavior increase as more and more 'neighbors' adopt it
- The implication is that an individual adopts a certain behavior once a sufficient proportion of her/his neighbors have done so
  - For example, you may find it easier to collaborate with co-workers, if you are using compatible technologies

Modeling Diffusion through Networks

A networked coordination game

- We will study a situation in which each node has a choice between two possible behaviors, labeled A and B
- If nodes v and w are linked by an edge, then there is an incentive for them to have their behaviors match
- If v and w both adopt behavior A, they each get a payoff of $a > 0$
- If they both adopt B, they each get a payoff of $b > 0$
- If they adopt opposite behaviors, they each get a payoff of 0
- Each node v is playing a copy of this game with each of its neighbors, and its payoff is the sum of its payoffs in the games played on each edge

Source is [1]

Modeling Diffusion through Networks

Solution to the game

- The basic question faced by v will be the following: suppose that some of its neighbors adopt A, and some adopt B; what should v do in order to maximize its payoff?
- Suppose that a p fraction of v's neighbors have behavior A, and a $(1-p)$ fraction have behavior B
  - If v has d neighbors, then pd adopt A and $(1p)d$ adopt B
  - If v chooses A, it gets a payoff of pda, and if it chooses B, it gets a payoff of $(1p)db$
- A is the better choice if:

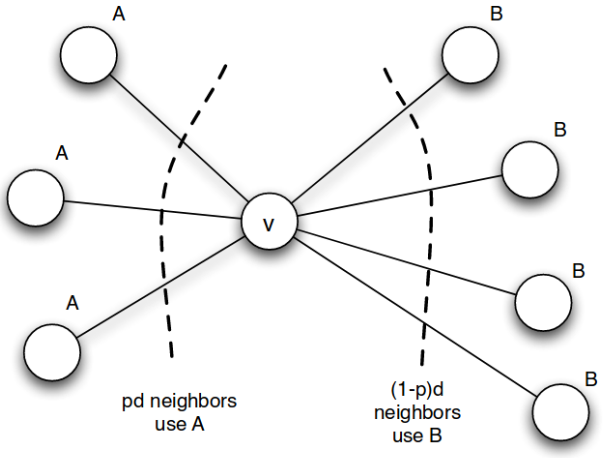
$$pda \geq (1-p)db \tag{1}$$

that is,

$$p \geq \frac{b}{a+b} \tag{2}$$

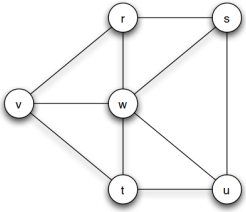
Modeling Diffusion through Networks

Solution to the game

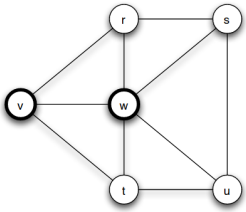


Modeling Diffusion through Networks

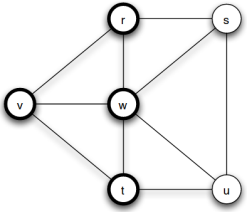
Cascades of adoption



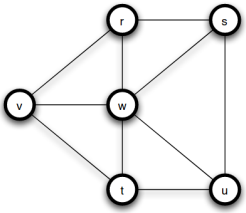
(a) *The underlying network*



(b) *Two nodes are the initial adopters*



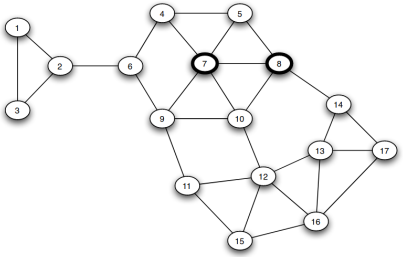
(c) *After one step, two more nodes have adopted*



(d) *After a second step, everyone has adopted*

Modeling Diffusion through Networks

Intermediate equilibrium



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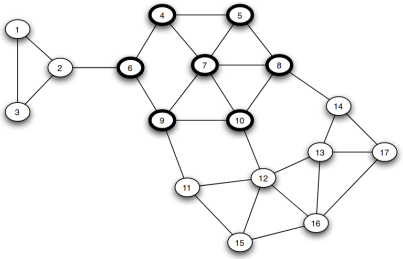
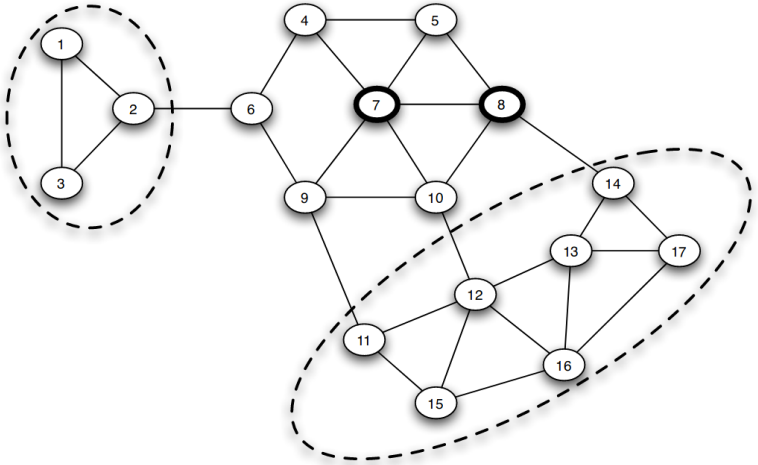


(b) *The process ends after three steps*

Modeling Diffusion through Networks

The role of homophily and communities



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[4] Miller McPherson, Lynn Smith-Lovin, and James M Cook. "Birds of a feather: Homophily in social networks". In: *Annual review of sociology* (2001), pp. 415–444.

[5] James Moody. "Race, school integration, and friendship segregation in America". In: *American Journal of Sociology* 107.3 (2001), pp. 679–716.

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