

A METHOD FOR CHARACTERIZING COMMUNITIES IN DYNAMIC ATTRIBUTED COMPLEX NETWORKS

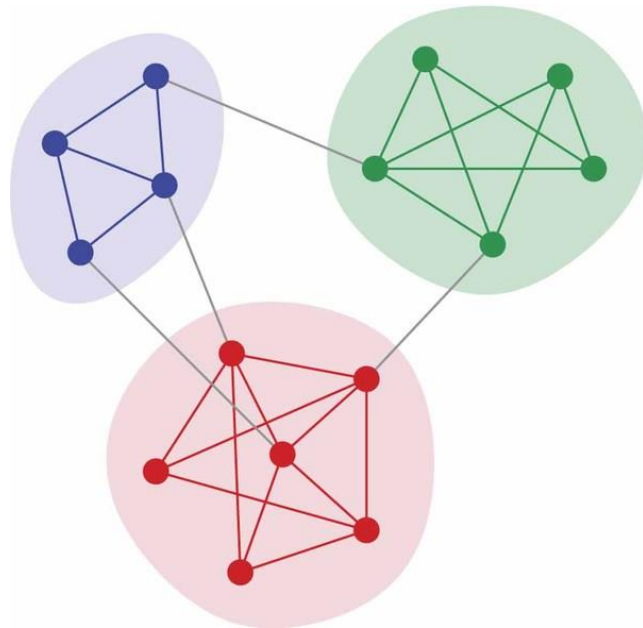
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Plan

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 2. Community Characterization (Novel Problem)
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 2. Representing Dynamic Attributed Networks
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 1. Community Detection
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 4. Selecting Characterizing Patterns and Finding Outliers
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1.1. Community Detection



A very active sector
concentrated on detection task

**What about community
interpretation?**

1.2. Community Characterization

Novel Problem

- Community = group of nodes with common properties
 - Node description
 - Topology (via network)
 - Relational Information
 - Attributes
 - Individual Information
- Community = group of nodes with common behaviors
 - Temporal evolution of the descriptions

Interpreting communities in a systematic way by considering common changes on the node descriptions over the time

2. Problem Definition

- Identifying the discriminant features of the nodes of each community
- **1. What are the features?**
 - Encoding all the information describing the evolution of each node from each community in a complete and compact way
- **2. How to measure their typicality?**
 - Choosing objective criteria to measure the power of representation of each sequence
 - Informative
 - Prevalent
 - Distinctive

2.1. Sequence Mining

- Finding correlated elements in an ordered set of elements
- Given a set of sequences, finding the complete set of **frequent sub-sequences**

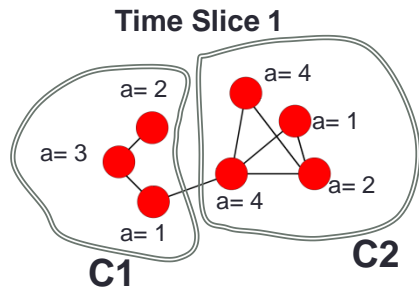
A *sequence database*

SID	Sequences
10	<a(ab c)(a c)d(cf)>
20	<(ad)c(bc)(ae)>
30	<(ef)(ab)(df) c b>
40	<eg(af)cbc>

- A *sequence* <(ef)(ab)(df)cb> is an ordered set of itemsets.
- $\alpha = \langle (ab)c \rangle$ is a *sub-sequence* of $\beta = \langle a(\underline{ab}c)(a\underline{c})d(cf) \rangle$

- Given *support threshold* $\min_{\text{sup}} = 2/4$, $\langle (ab)c \rangle$ is a *frequent sequence*
- A sequence is *closed* if there is no other super-sequence of it with the same support

2.2. Representing Dynamic Attributed Networks

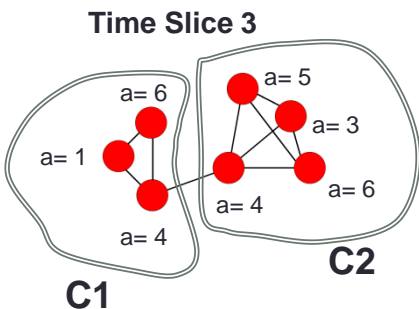
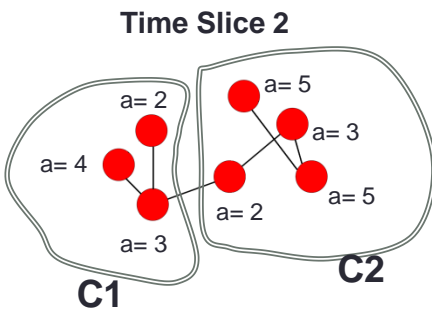


Items: Node descriptors with their values
 $\{a=1, a=2, a=3, a=4, a=5, a=6\}$

Node Sequence: $u(n1) = \langle (a=2)(a=2)(a=6) \rangle$

Node Sequence concatenation:

$u(n1) \bullet C(n1) = \langle (a=2)(a=2)(a=6)(C1) \rangle$



Node Sequence Database

$N1 \langle (a=2)(a=2)(a=6)(C1) \rangle$

$N2 \langle (a=3)(a=4)(a=1)(C1) \rangle$

$N3 \langle (a=1)(a=3)(a=4)(C1) \rangle$

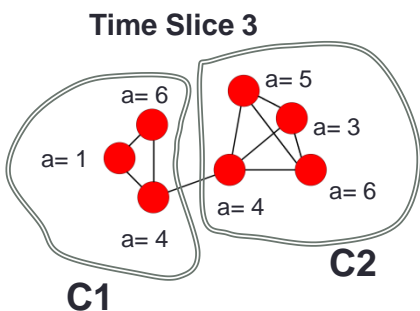
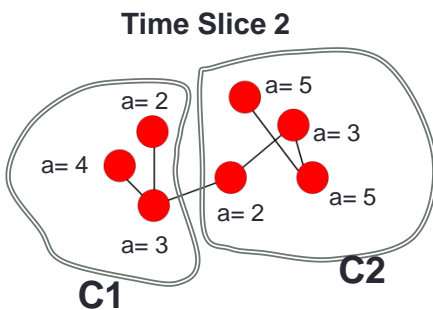
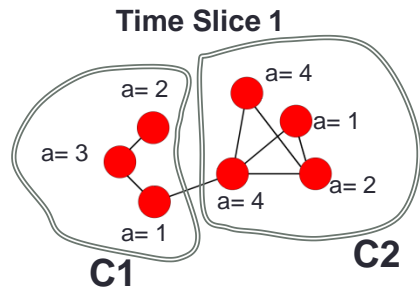
$N4 \langle (a=4)(a=2)(a=4)(C2) \rangle$

$N5 \langle (a=2)(a=5)(a=6)(C2) \rangle$

$N6 \langle (a=1)(a=3)(a=3)(C2) \rangle$

$N7 \langle (a=4)(a=5)(a=5)(C2) \rangle$

2.2. Representing Dynamic Attributed Networks



Choosing Criteria

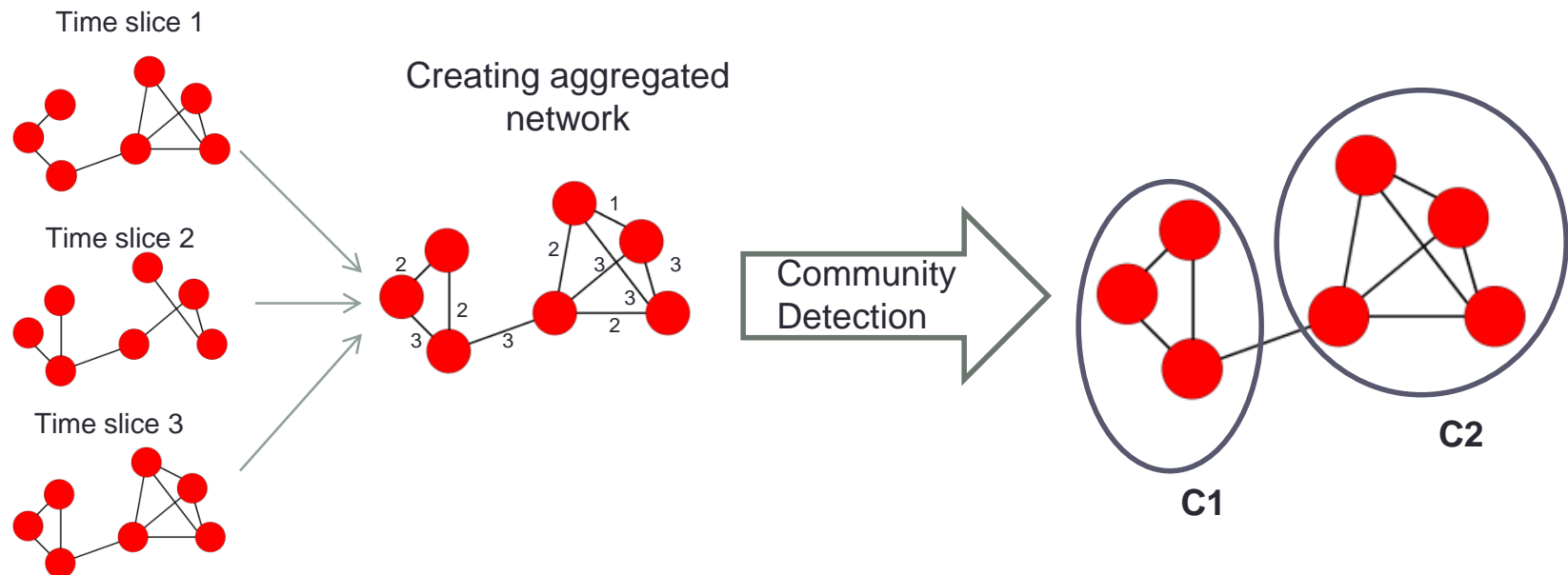
- **Prevalent:** Frequent sequences for \min_{sup}
- **Informative:** Closed sequences
- What about **distinctiveness**?
 - Emerging Sequences
 - **Growth rate** of s relatively to a community C is
 - $\text{Gr}(s,C) = \text{sup}(s,C)/(\text{sup}(s)-\text{sup}(s,C))$
 - e.g., $\text{Gr}(\langle(a=2)(a=2)\rangle, C1) = \infty$

3. Method

- **Step1.** Community Detection
- **Step2.** Mining Closed Frequent Emerging sequences
- **Step3.** Selecting characteristic patterns and finding outliers

3.1. Community Detection

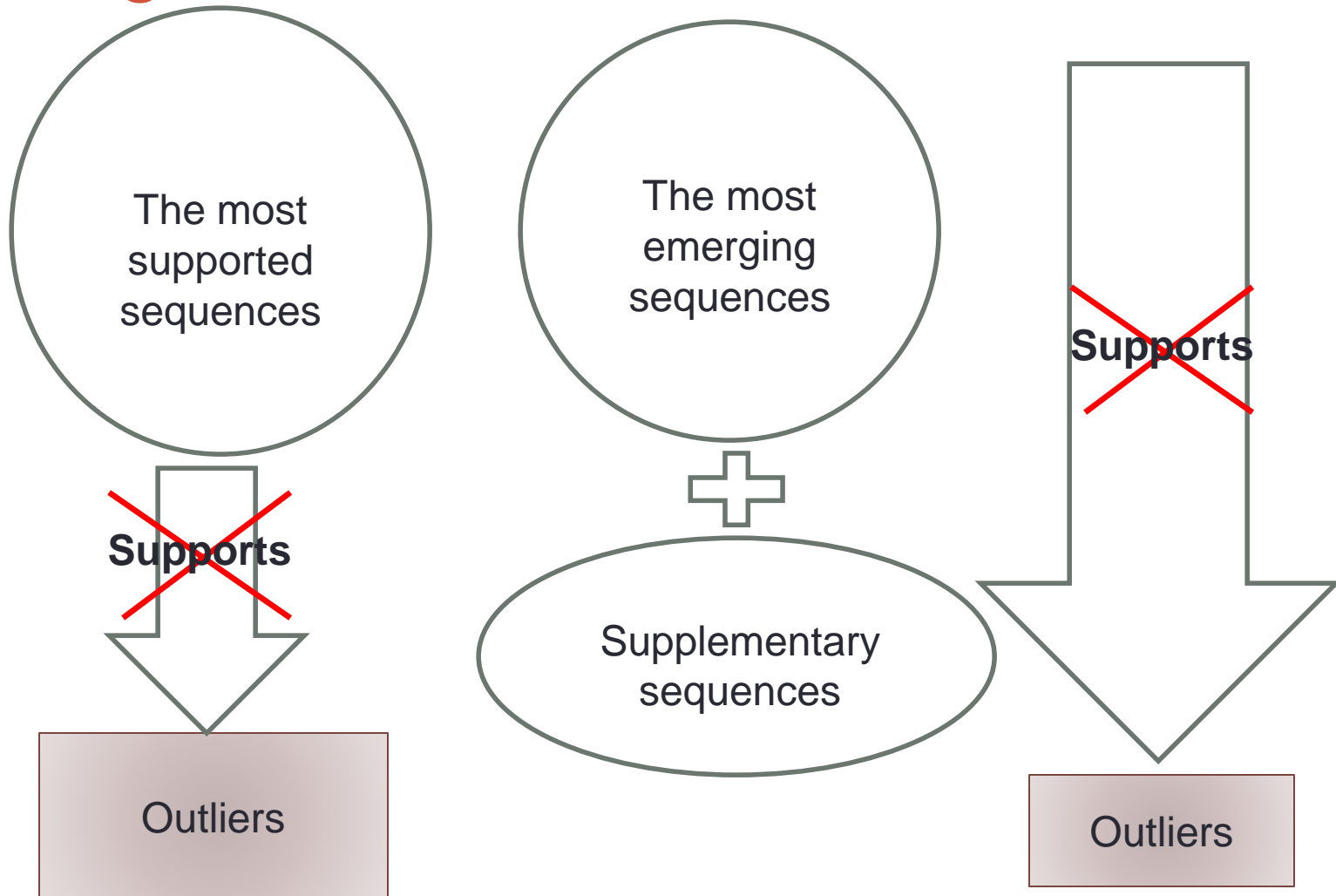
- Creating aggregated network
- Detecting communities by considering link weights
 - Louvain Method [Blondel *et al.* 2008, *JSTAT Mech*]



3.2. Mining Closed Frequent Emerging Sequences

- Creating sequence database
 - Attributes
 - 5 topological measures
 - *internal degree, local transitivity, within module degree, participation coefficient and embeddedness*
- Mining Closed Frequent Sequences
 - CloSpan [Yan *et al.* 2003,SDM] with \min_{sup}
- Calculating emergence
 - PostProcessing [Plantevit and Cremilleux 2009, IDA]

3.3. Selecting characteristic patterns and finding outliers



4. Empirical Results

- DBLP Dynamic Attributed Network
 - Nodes=researchers
 - Links=co-authorship
 - 10 time slice from 1990 to 2012
 - Attributes :
 - Publication number in 43 journal/conferences
 - Total conference publication number
 - Total journal publication number
- Focus : Communities containing >40 nodes

4. Empirical Results

I- The most supported

- The majority of the nodes of each community has a non-hub community role

MOST SUPPORTED SEQUENCE SIZE FOR EACH COMMUNITY

Community ID	Community Size	Sequence Size	Support Value
38	335	2	0.99
40	43	8	0.97
77	41	7	1.00
115	125	1	1.00

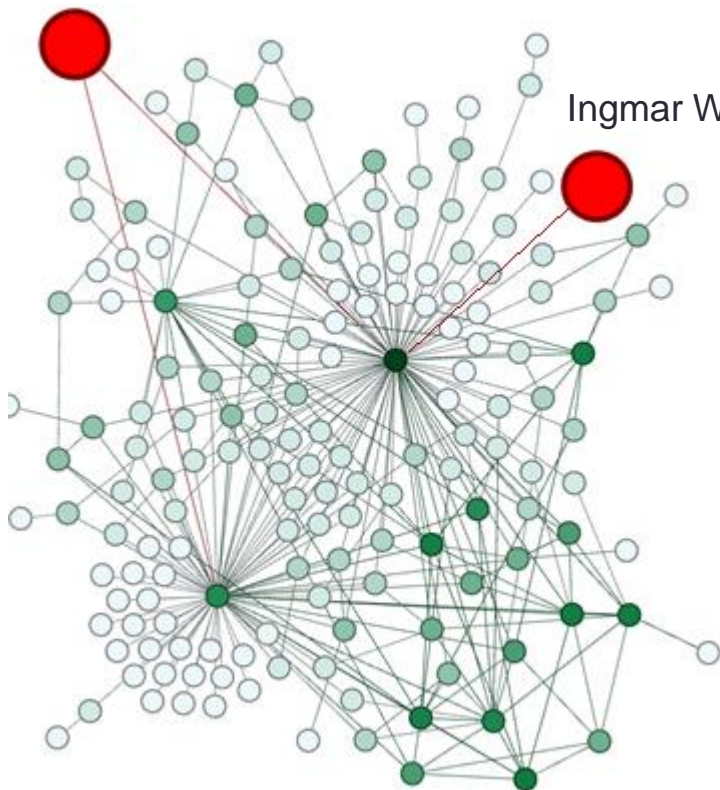
Philip S. Yu, Jiawei Han, Beng C. Ooi

Hans-Peter Kriegel

4. Empirical Results

II- The most emerging

Anastasia Ailamaki



Ingmar Weber

*<(VLDB publication number=3)
(having few connections **and** community non-hub)>*

Gr. rate = 6.40 et sup=0.30

*<(community non-hub **and** total conference publication number between 1 and 5) (community non-hub, embedded to its community **and** ICDE publication number =3)>*

Gr. rate = 2.30 et sup=0.30

Representation of Community 45

4. Empirical Results

- Both topology and attributes support the interpretation process
 - Main theme of communities
 - Relations of nodes
- Three types of outliers
 - Different theme
 - Changing theme
 - Rising actors

5. Conclusion & Perspectives

- Novel problem : community characterization
- Considering dynamic community detection
- Considering constraints on sequential patterns
 - Patterns including information both on topology and on attributes
- Application on different networks from different domains

Questions

Discrétisation

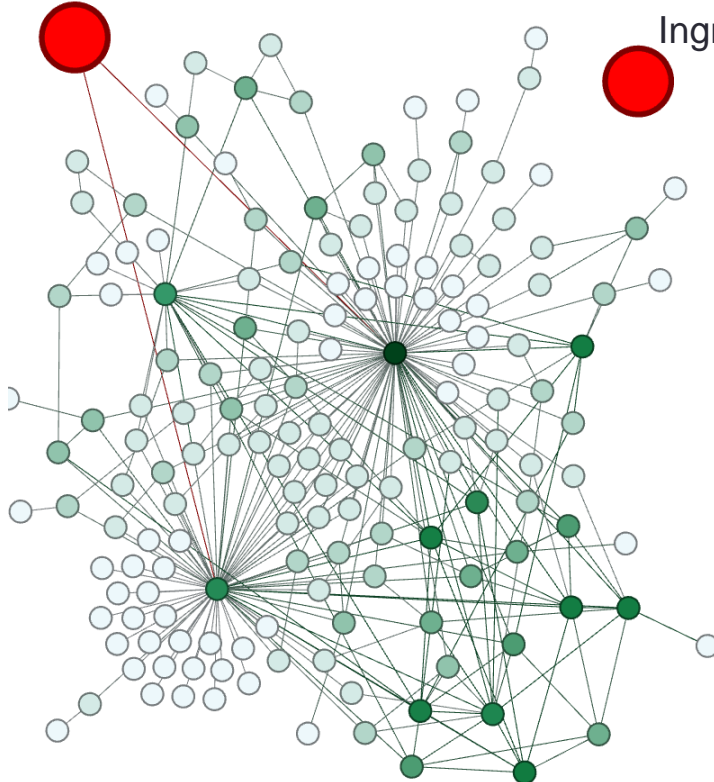
Descripteurs	Ranges				
Dégréé	[0;3] <i>Non populaire</i>	]3;10] <i>Peu populaire</i>	]10;30] <i>Populaire</i>	]30; ∞[<i>Très populaire</i>	
Transitivité	[0;0.35]	]0.35;0.5]	]0.5;0.7]	]0.7;1.0]	
Dégréé interne normalisé	] -∞;2.5] <i>non-hub communautaire</i>	]2.5, ∞[<i>Hub communautaire</i>			
Coefficient de Participation	[0;0.05] <i>Ultra Périphaire</i>	]0.05;0.6] <i>Périphaire</i>	]0.6;0.8] <i>Connecteur</i>	]0.8;1.0] <i>Kinless</i>	
Enchaissement	[0;0.3] <i>Peu appartenance</i>	]0.3;0.7] <i>Appartenance</i>	]0.7;1.0] <i>Très haute appartenance</i>		
Conf./Journal Pub.	1	2	3	4	]5; ∞[
Total Conf./Journal Pub.	[0;5[	]5;10[	]10;20[	]20;50[	]50; ∞[

3. Résultats

II- Les plus émergents

Anastasia Ailamaki

Ingmar Weber



<(nombre de publication VLDB=3)
(avoir peu de voisins **et** être non-hub communautaire)>

Gr. rate = 6.40 et sup=0.30

<(être non-hub communautaire **et** nombre de
publication conférence total entre 1 et 5) (être non-hub
communautaire, bien appartenir a sa communauté **et**
nombre de publication ICDE =3)>

Gr. rate = 2.30 et sup=0.30

Représentation de la communauté 45 p.r.a graph global
pondère