A METHOD FOR CHARACTERIZING COMMUNITIES IN DYNAMIC ATTRIBUTED COMPLEX NETWORKS

Günce Keziban Orman, Vincent Labatut, Marc Plantevit,
& Jean-François Boulicaut

INSA de Lyon - LIRIS
Galatasaray University – Computer Engineering Department

Plan

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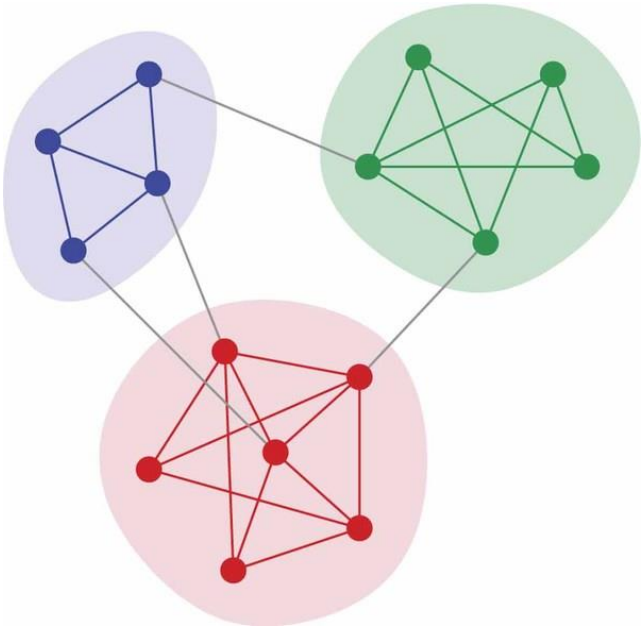
1.1. Community Detection



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**

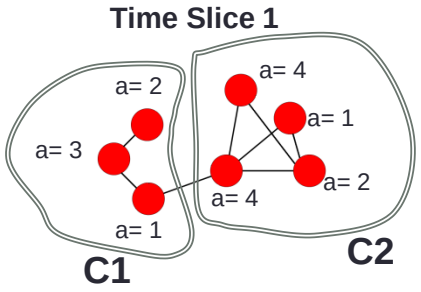
A *sequence database*

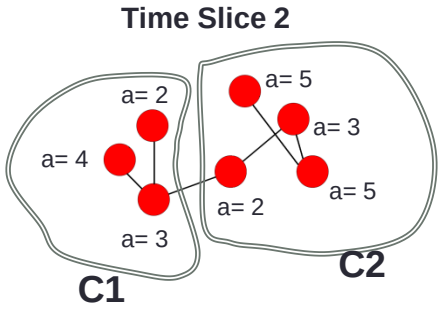
SID	Sequences
10	<a(**ab**c)(a**c**)d(cf)>
20	<(ad)c(bc)(ae)>
30	<(ef)(**ab**)(df)**c**b>
40	<eg(af)cbc>

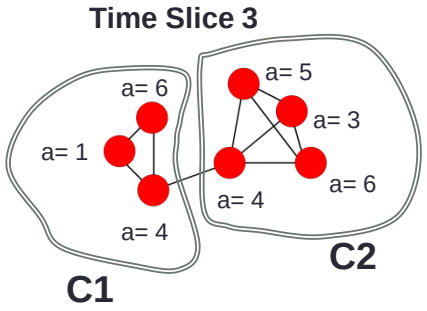
- A *sequence* <(ef)(ab)(df)cb> is an ordered set of itemsets.
- α = <(ab)c> is a *sub-sequence* of β= <a(**ab**c)(a**c**)d(cf)>

- Given *support threshold* $\min_{sup}$ = 2/4, <(ab)c> 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}

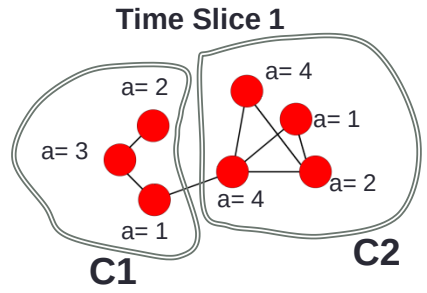
Node Sequence: *u(n1)=<(a=2)(a=2)(a=6)>*

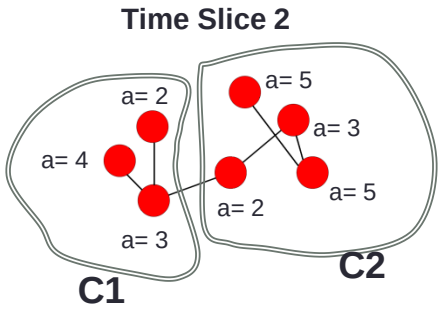
Node Sequence concatenation:
u(n1) ●C(n1) = <(a=2)(a=2)(a=6)(C1)>

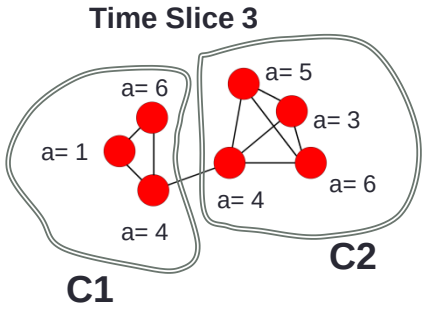
Node Sequence Database

N1 <(a=2)(a=2)(a=6)(C1)>
N2 <(a=3)(a=4)(a=1)(C1)>
N3 <(a=1)(a=3)(a=4)(C1)>
N4 <(a=4)(a=2)(a=4)(C2)>
N5 <(a=2)(a=5)(a=6)(C2)>
N6 <(a=1)(a=3)(a=3)(C2)>
N7 <(a=4)(a=5)(a=5)(C2)>

2.2. Representing Dynamic Attributed Networks







Choosing Criteria

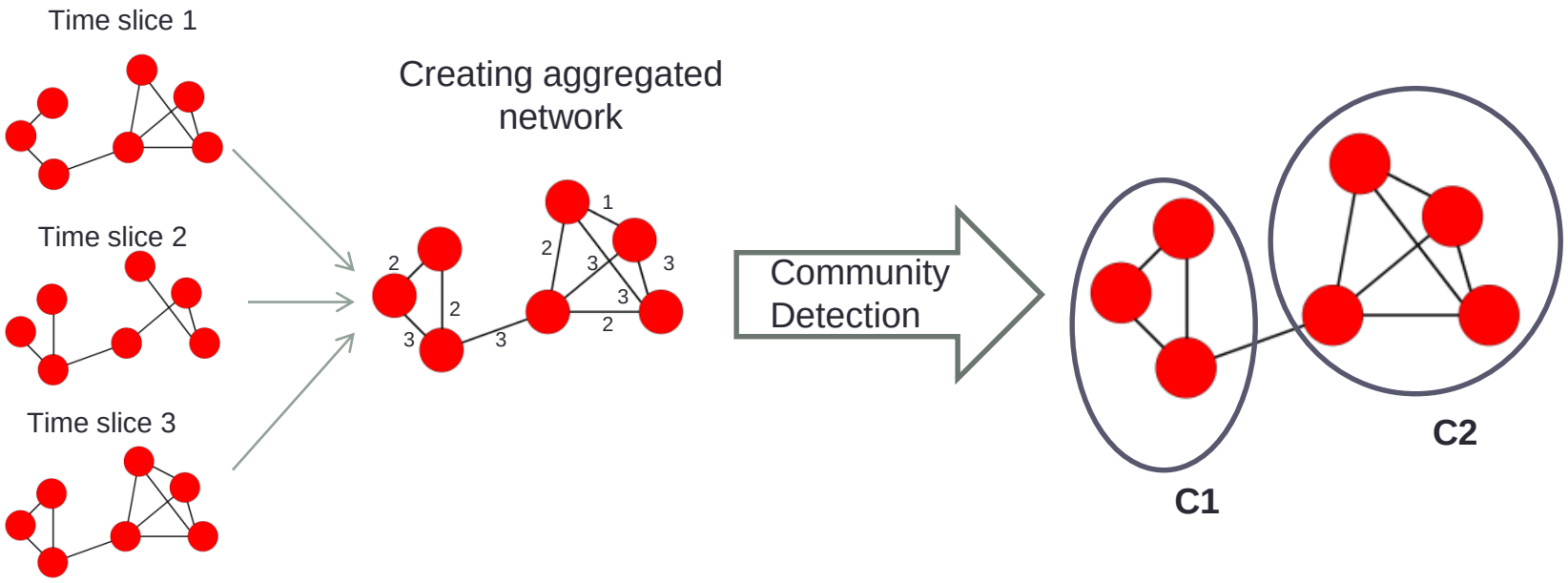
- **Prevalent:** Frequent sequences for min_{sup}
- **Informative:** Closed sequences
- What about **distinctiveness**?
  - Emerging Sequences
  - Growth rate of s relatively to a community C is
    - Gr(s,C) = sup(s,C)/(sup(s)-sup(s,C))
    - e.g., Gr(<(a=2)(a=2)>,C1)= ∞

3. Method

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

3.1. Community Detection

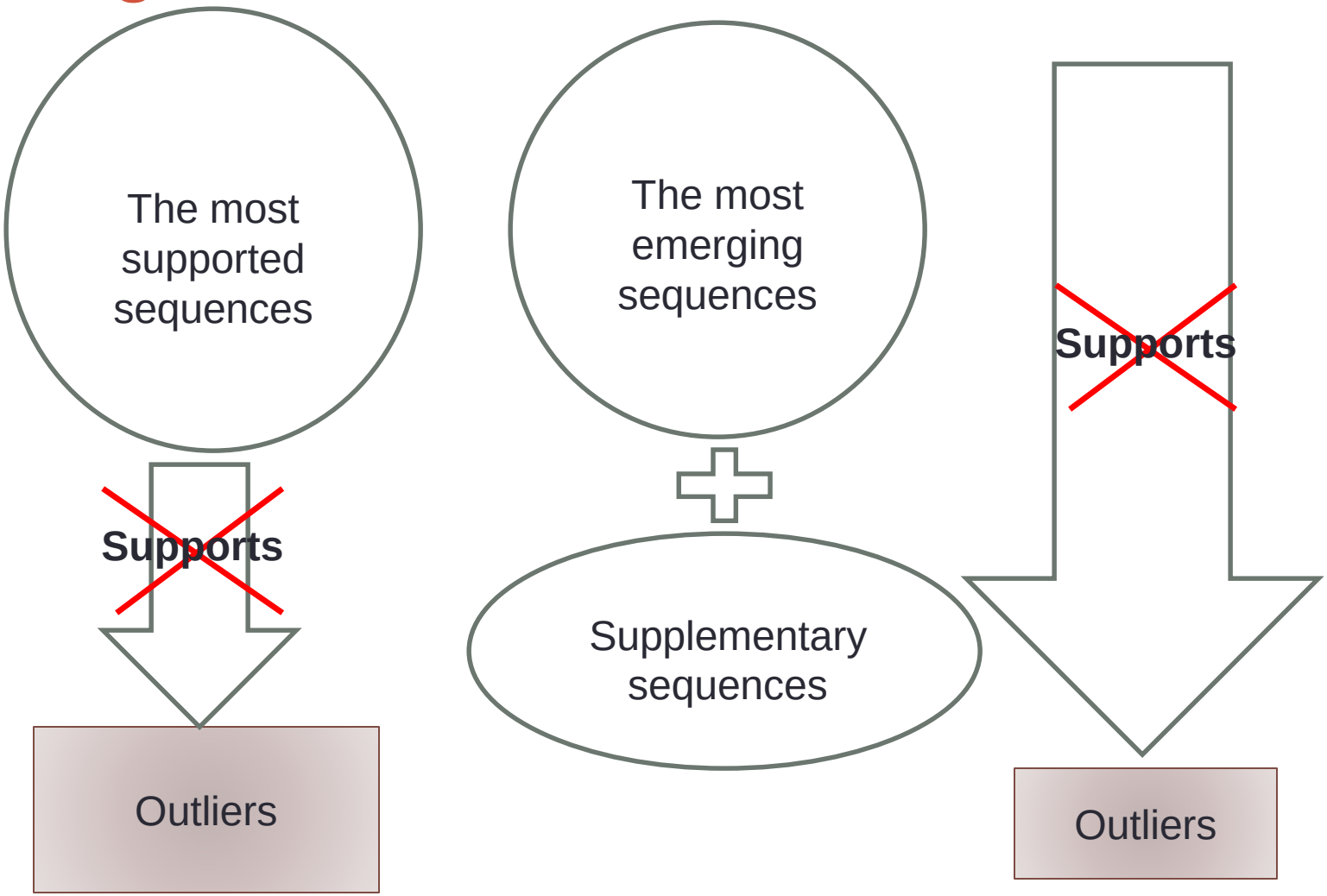
- Creating aggregated network
- Detecting communities by considering link weights
  - Louvain Method [Blondel *et al. 2008, JSTAT Mech*]



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

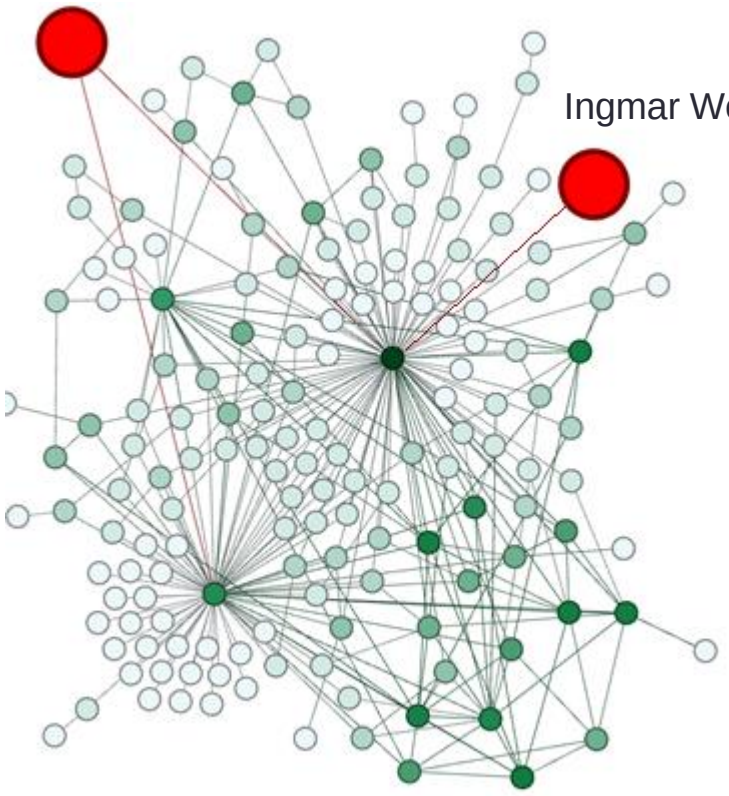
MOST SUPPORTED SEQUENCE SIZE FOR EACH COMMUNITY

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



Representation of Community 45

<(*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

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

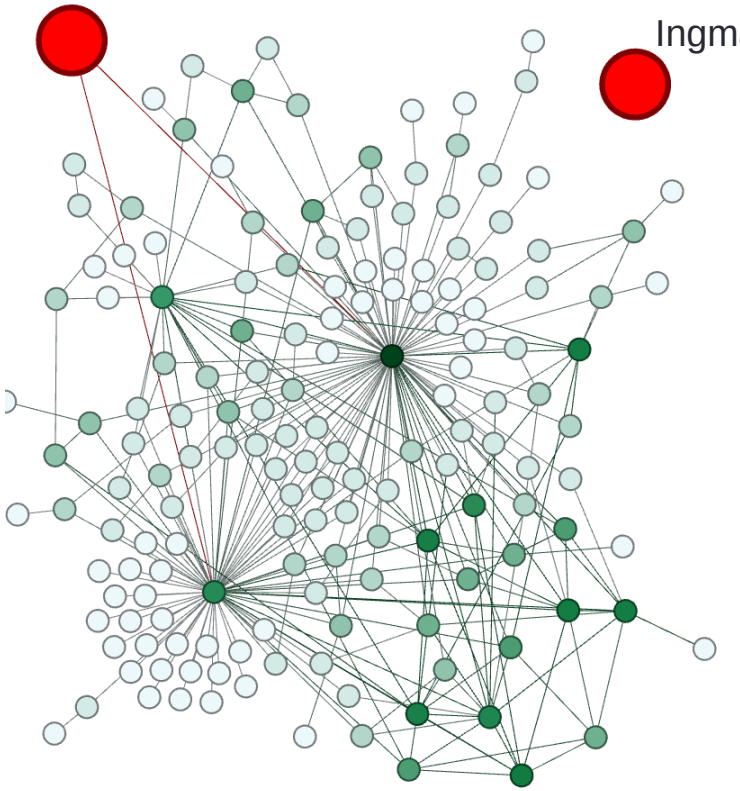
Descripteurs	**Ranges**				
Dégrée	[0;3] *Non populaire*	]3;10] *Peu populaire*	]10;30] *Populaire*	]30; ∞[*Très populaire*	
Transitivité	[0;0.35]	]0.35;0.5]	]0.5;0.7]	]0.7;1.0]	
Dégrée interne normalisé	]-∞;2.5] *non-hub communautaire*	]2.5, ∞[*Hub communautaire*			
Coefficient de Participation	[0;0.05] *Ultra Périphaire*	]0.05;0.6] *Périphaire*	]0.6;0.8] *Connecteur*	]0.8;1.0] *Kinless*	
Enchaissement	[0;0.3] *Peu appartenance*	]0.3;0.7] *Appartenance*	]0.7;1.0] *Très haute appartenance*		
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 emergents

Anastasia Ailamaki

Ingmar Weber



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

<(*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