Multivariate Time Series Association Analysis for Petroleum Big Data

Fan Min (闵帆)

Lab of Machine Learning, Southwest Petroleum University
www.fansmale.com

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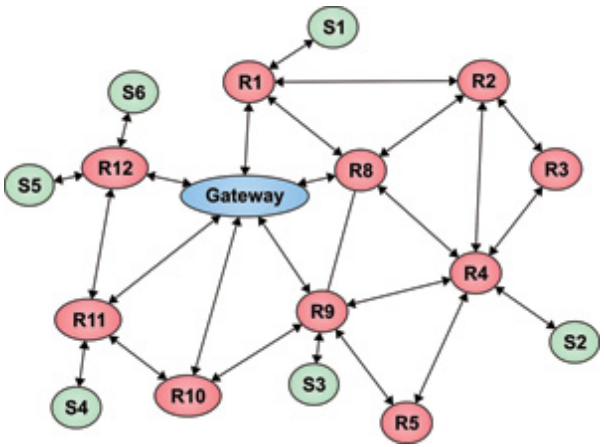
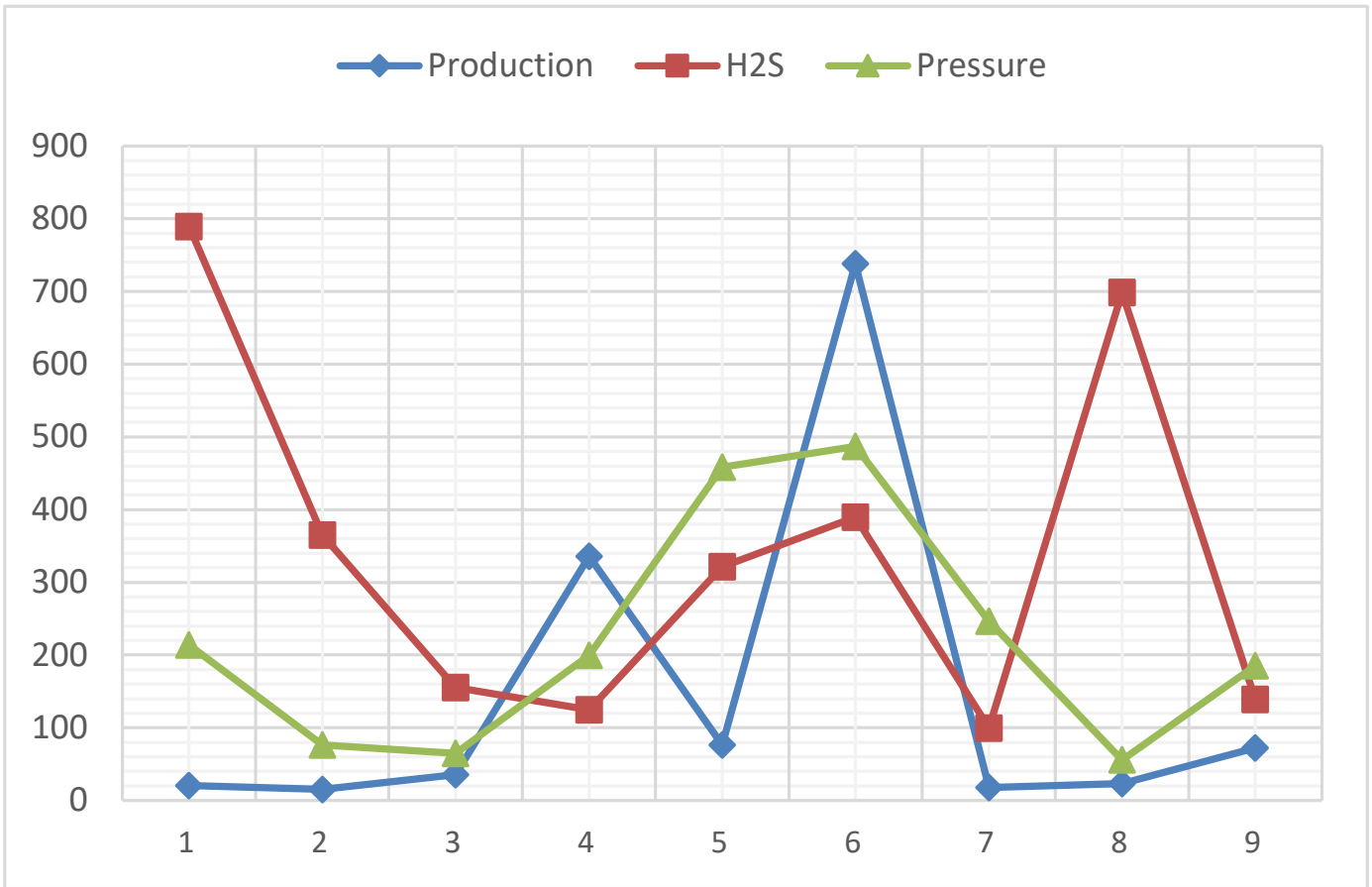
Contents

1.1 Anomaly detection



- Various sensor networks.
- Monitoring data are collected automatically.
- Anomalies should be predicted.

1.2 Multivariate time series



1.3 Multivariate time series information system

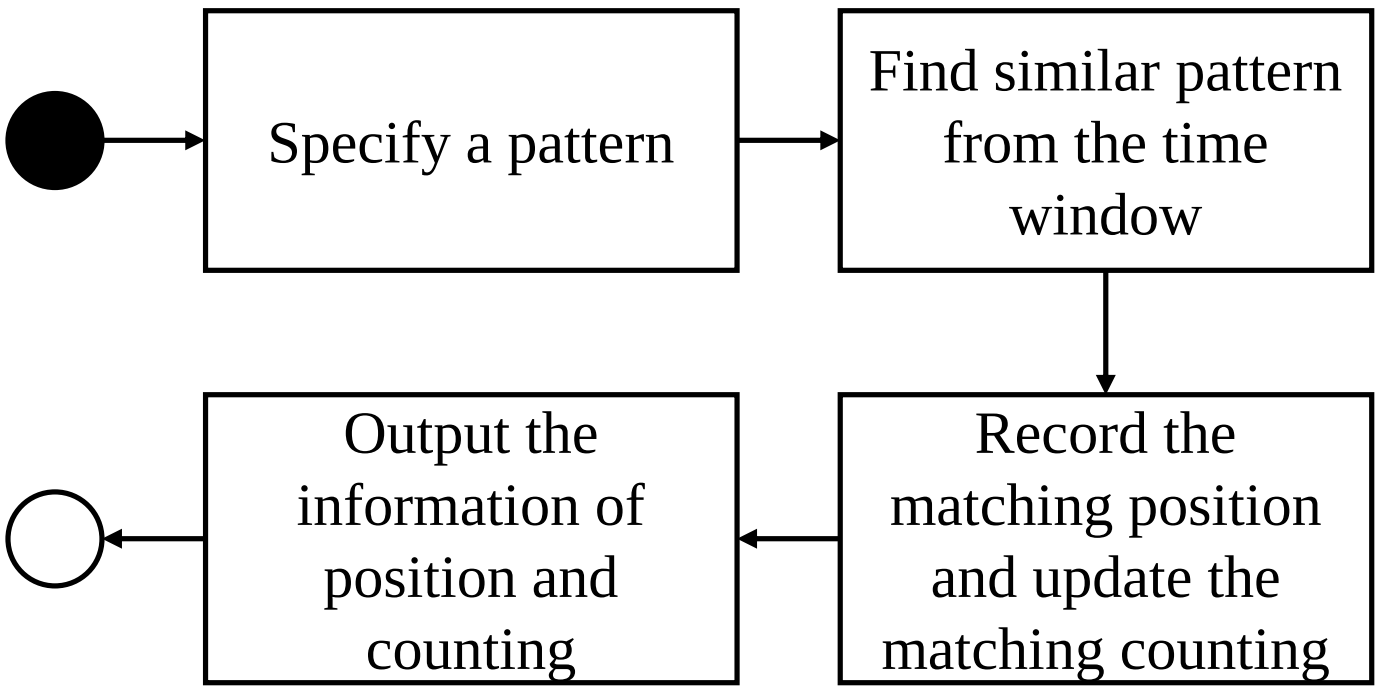
Time series	Production	H_2S	Pressure
20/4/2016	L	H	N
21/4/2016	L	N	L
22/4/2016	N	L	L
23/4/2016	N	L	N
24/4/2016	H	N	H
25/4/2016	H	N	H
26/4/2016	L	L	N
27/4/2016	N	H	L
28/4/2016	H	L	N

2. Pattern matching and discovery

2.1 Problem statement

- Assumption: The time series data is synchronous.
- Input: (1) $S = (T, A, V = \cup V_{a \in A}, f : T \times A \rightarrow V)$; (2) Pattern p; (3) Similarity threshold η; (4) Size of time window L.
- Output: (1) The counting of p occurring; (2) All occurrence position of p in S.

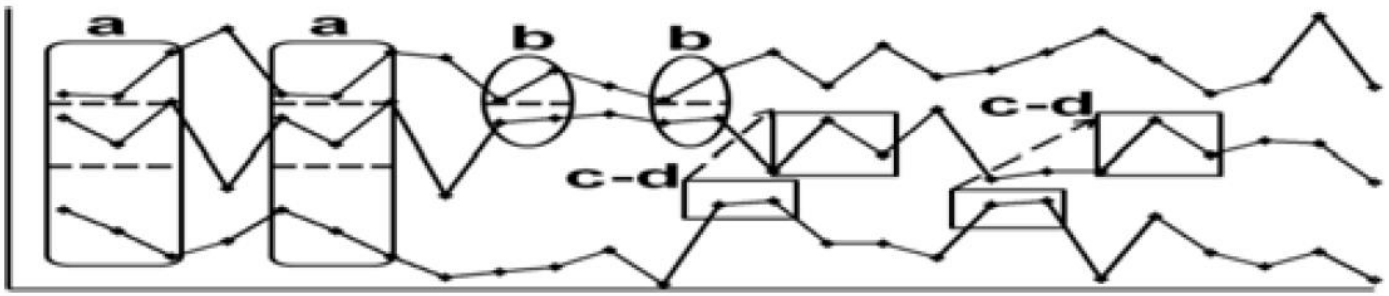
2.1 Pattern matching



2.1 Pattern matching

Time series	Production	H_2S	Pressure	
20/4/2016	L	H	N	
21/4/2016	L	N	L	
22/4/2016	N	L	L	p_3
23/4/2016	N	L	N	p_3
24/4/2016	H	N	H	p_2
25/4/2016	H	N	H	p_2
26/4/2016	L	L	N	
27/4/2016	N	H	L	p_1
28/4/2016	H	L	N	

2.1 Pattern matching



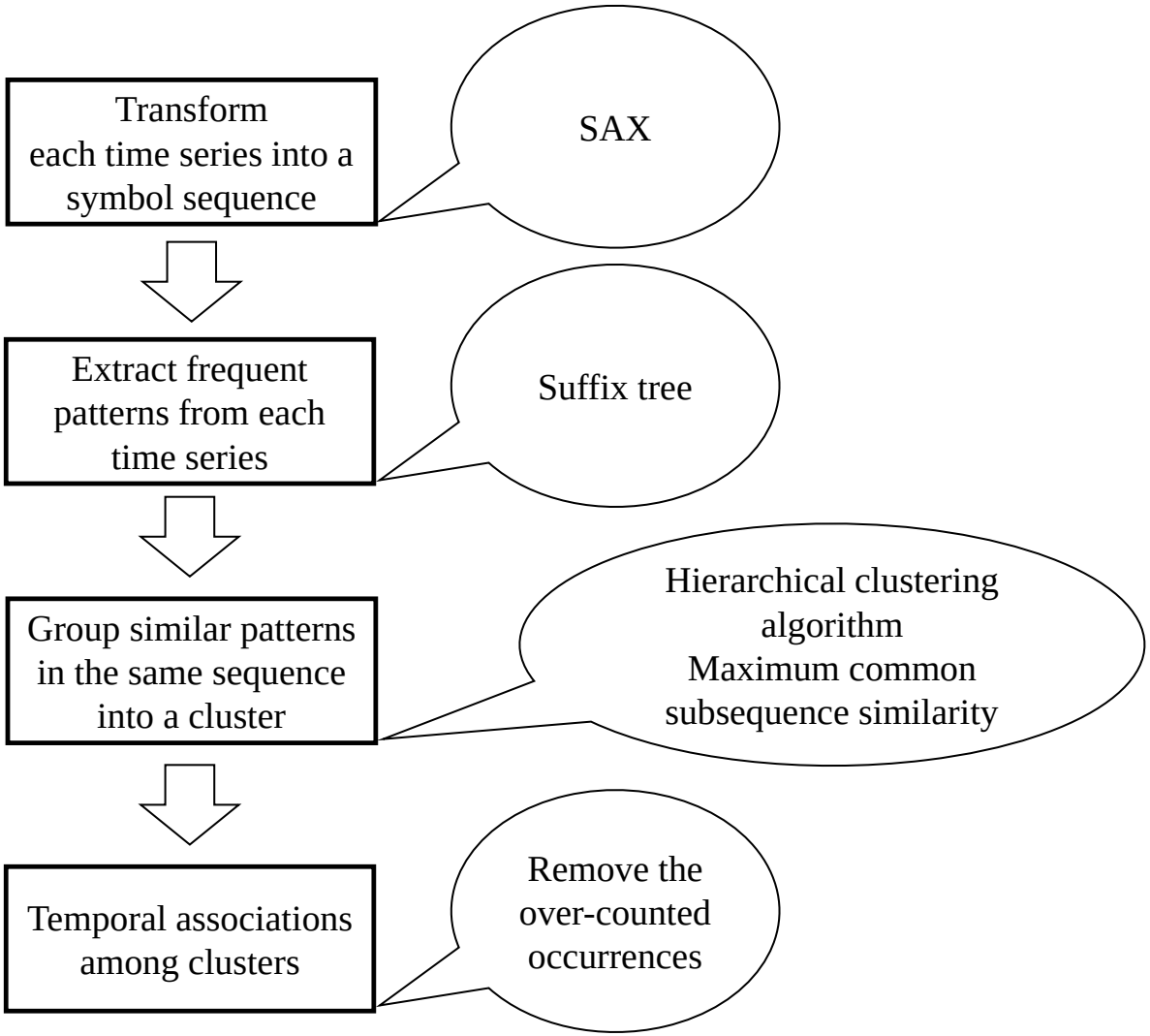
2.1 Pattern matching

- Question:
  What can we do when we cannot specify a pattern?
- Answer:
  Pattern discovery.

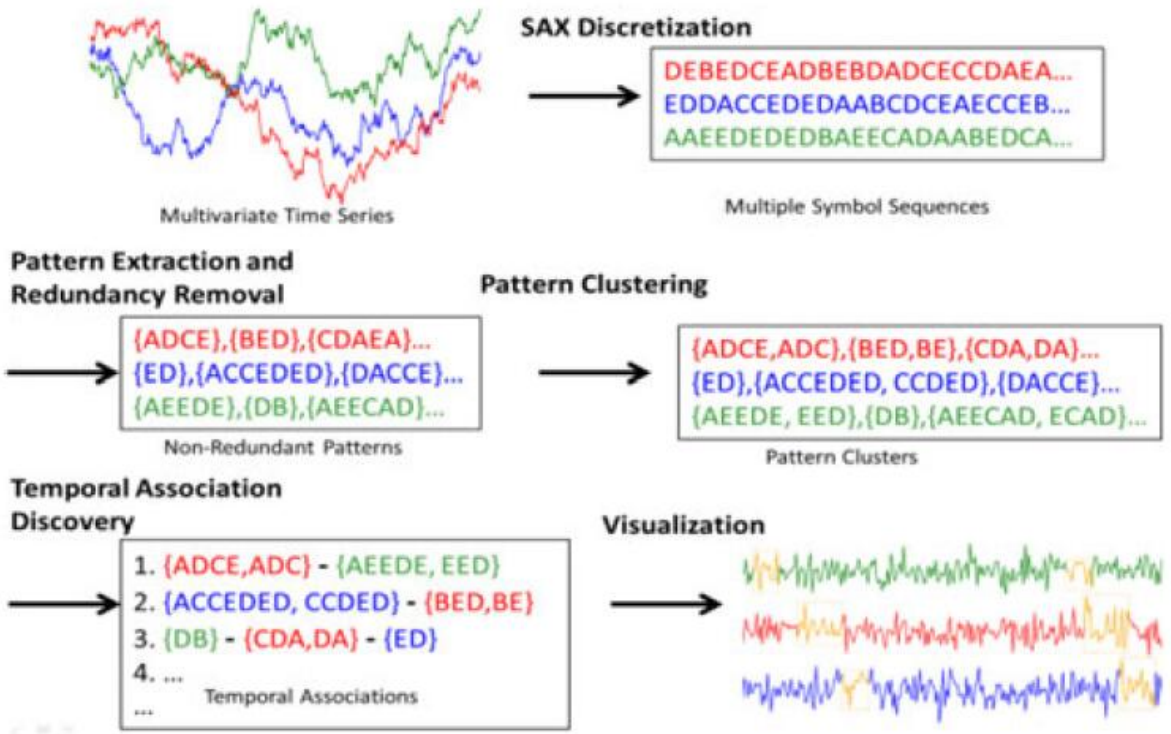
2.2 Pattern discovery

- Assumption: The time series data is synchronous.
- Input: (1) $S = (T, A, V = \cup V_{a \in A}, f : T \times A \rightarrow V)$; (2) Support threshold δ.
- Output: Temporal associations.
- Constraint: The supports of temporal associations are not less than δ.

2.2 Pattern discovery



2.2 Pattern discovery

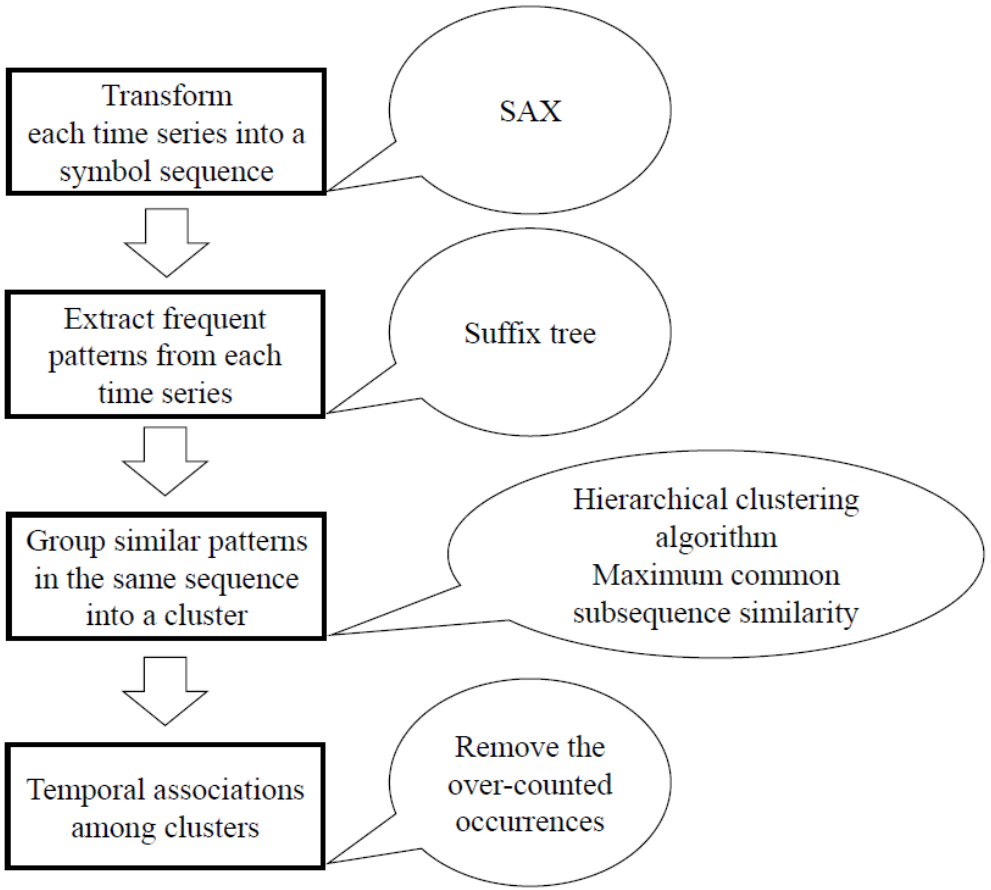


[Zhuang et al.(2014)Zhuang, Li, and Wong]

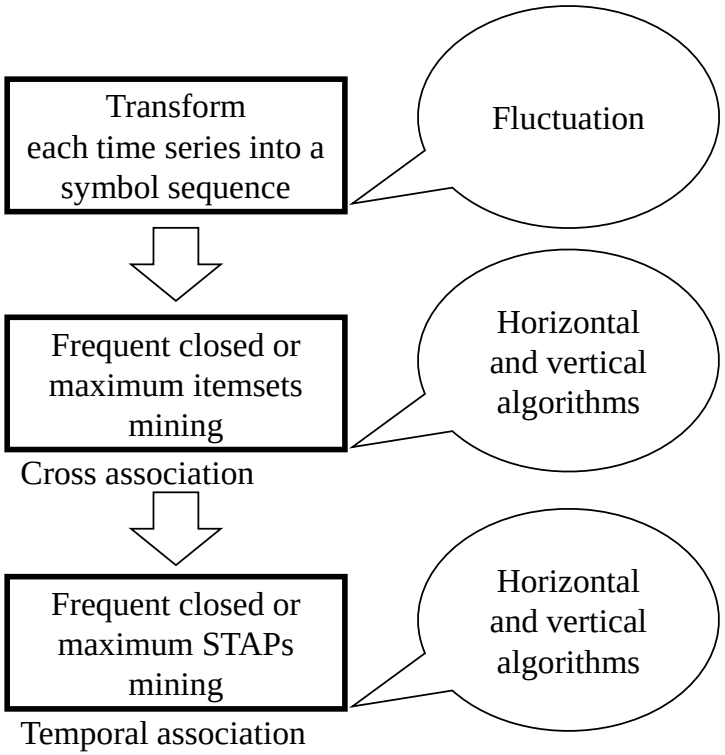
3.1 Problem statement

- Assumption: The time series data is synchronous.
- Input: (1) $S = (T, A, V = \cup V_{a \in A}, f : T \times A \rightarrow V)$; (2) Itemset support threshold δ_w; (3) Sequence support threshold δ_d.
- Output: Frequent STAPs.
- Constraint: (1) The supports of itemsets are not less than δ_w; (2) The supports of sequences are not less than δ_d.

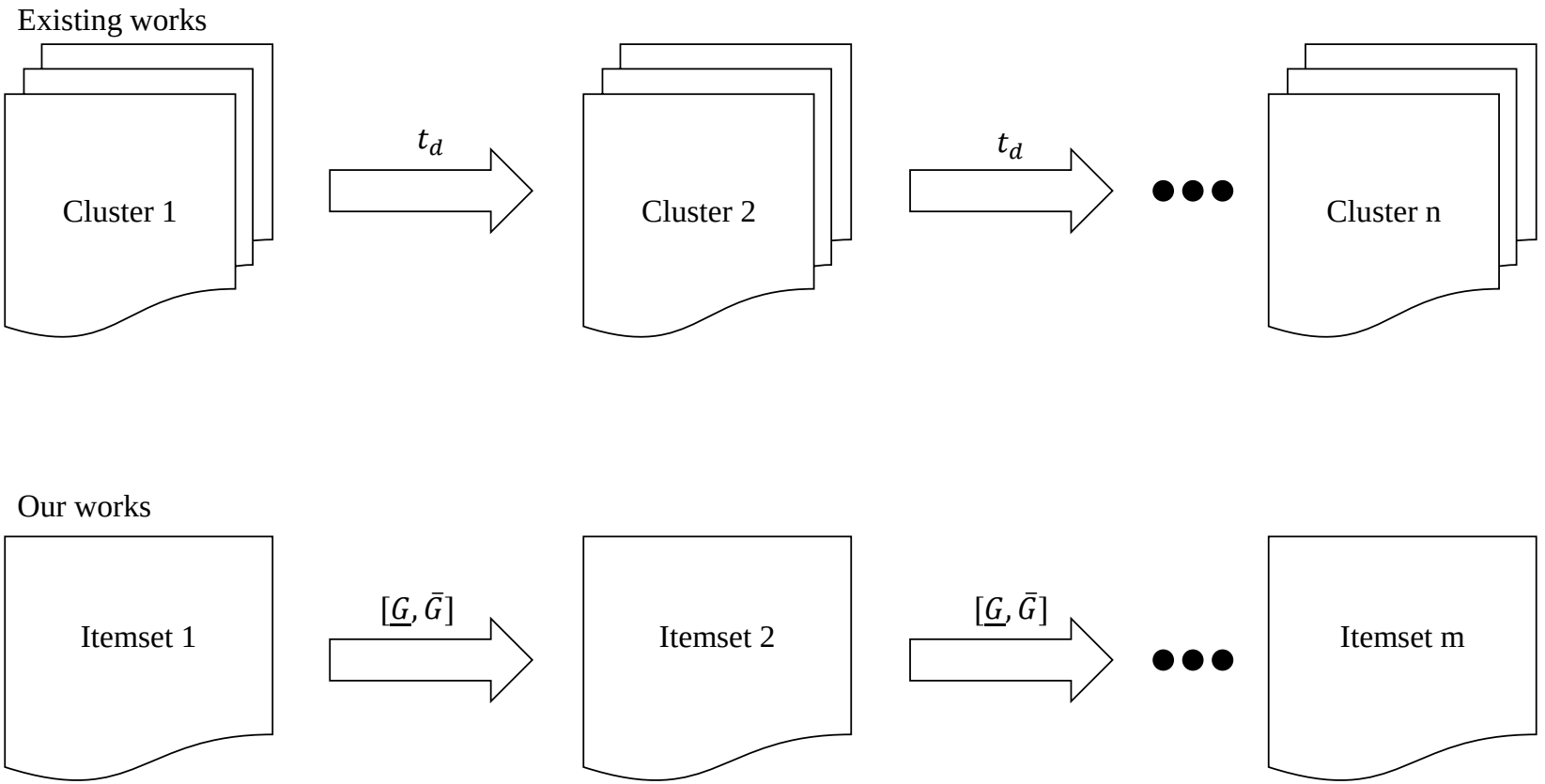
3.2 Framework of STAP



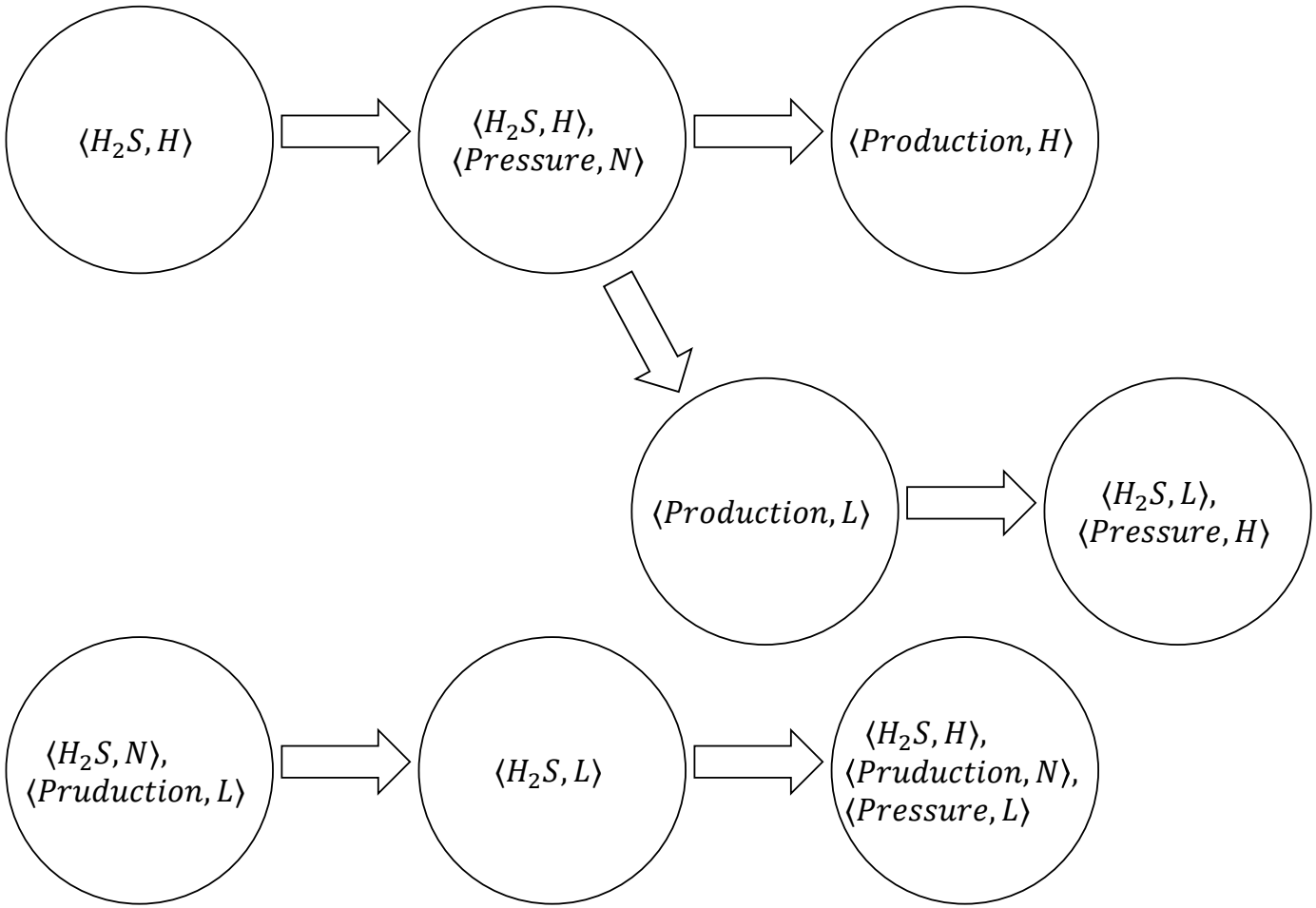
Cross and temporal association



Type of STAP


Existing works
Cluster 1
t_d
Cluster 2
t_d
Cluster n
Our works
Itemset 1
$[\underline{G}, \bar{G}]$
Itemset 2
$[\underline{G}, \bar{G}]$
Itemset m

Example of STAP



Discussions

- Semantics explanation of patterns
- Feature extracting, Occurrence counting

Any question?

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D. E. H. Zhuang, G. C. L. Li, A. K. C. Wong, Discovery of Temporal Associations in Multivariate Time Series, IEEE Transactions on Knowledge & Data Engineering 26 (12) (2014) 2969–2982.