

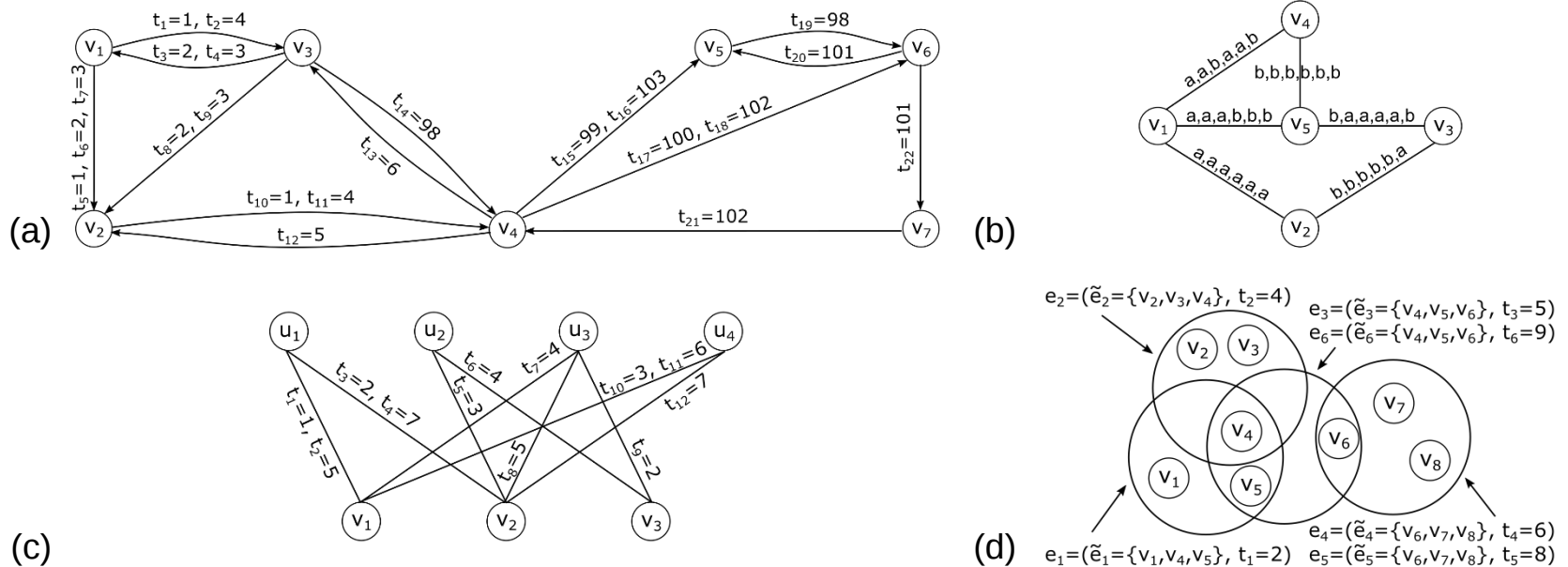
Temporal Network Motifs: Concepts, Algorithms, and Applications

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Motivation & Ideas

- Motivations:
 - Most surveys only provided an overview of static network motifs.
 - There have been a number of studies on temporal network motifs in recent years, but these advances are not covered in existing surveys.
- Ideas: We present a review of the most (if not all) temporal network motifs and their algorithms proposed in recent years.



Temporal network motifs are defined differently for various types of temporal networks. (a): Topology-varying temporal networks; (b): Attribute-varying temporal networks; (c): Temporal bipartite graphs; (d): Temporal hypergraphs.

Main Contributions

- Contributions:
 - We propose a classification based on how to reinterpret the recurrent and statistically significant nature of network motifs in temporal networks: (1) motifs based on topology repetition and (2) those based on attribute persistence.
 - We illustrate the concepts of temporal network motifs with detailed examples that clarify their specific constraints and applicability.
 - We discuss existing applications and future opportunities in this field.

Temporal network motifs with topology repetition			
Research	Year	Concept	Network Type
Borgwardt et al. [17]	2006	Frequent dynamic subgraphs	Topology-varying; General graphs
Zhao et al. [19]	2010	Communication motifs	Topology-varying; General graphs
Kovanen et al. [20]	2011	–	Topology-varying; General graphs
Song et al. [23]	2014	–	Topology-varying; General graphs
Gurukar et al. [24]	2015	Communication motifs	Topology-varying; General graphs
Hulovatyy et al. [25]	2015	Dynamic graphlets	Topology-varying; General graphs
Paranjape et al. [27]	2017	δ -temporal motifs	Topology-varying; General graphs
Kumar et al. [29,69]	2017 & 2018	Temporal cycles	Topology-varying; General graphs
Li et al. [28]	2018	HIN motifs	Topology-varying; General graphs
Kosyfaki et al. [30]	2019	Flow motifs	Topology-varying; General graphs
Pashanasangi et al. [31]	2021	Temporal triangle	Topology-varying; General graphs
Liu et al. [32]	2022	–	Topology-varying; General graphs
Lee et al. [33]	2023	TH motifs	Topology-varying; Hypergraphs
Cai et al. [34]	2023	Temporal butterflies	Topology-varying; Bipartite graphs
Temporal network motifs with attribute persistence			
Research	Year	Concept	Network Type
Jin et al. [18]	2007	Trend motifs	Topology-varying; General graphs
Ahmed et al. [21]	2012	Relational state patterns	Topology-varying; General graphs
Desmier et al. [22]	2013	Trend dynamic subgraphs	Topology-varying; General graphs
Ahmed et al. [26]	2015	Coevolving relational motifs	Topology-varying; General graphs
Chen et al. [35]	2025	–	Attribute-varying; General graphs