Attribute-aware Community Events in Feature-rich Dynamic Networks

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Most real-world networks come as evolving topologies whose nodes and edges appear/disappear as time goes by [3, 5]. Accordingly, the meso-scale substructures hidden in such systems are subject to constant evolution as well. The task of Dynamic Community Detection represents the challenge of identifying evolving groups in dynamic networks and track group mutations over time [7]. Several categories of evolutionary events that characterize the life-cycle of a community have been proposed in the literature [6]. We can mention the most important ones: community *Birth* and *Death*, tracked by the first and last timestamps of the community evolution; *Growth* and *Contraction*, tracking changes in community size; *Merge* and *Split*, namely when two or more communities merge into a single community, and vice versa. However, all these mentioned events address topological changes only. Moreover, they never mention the importance of node metadata, widely used nowadays to identify both well-connected and homogeneous communities [2]. Since more and more algorithms begin to be applied to attributed dynamic networks [1, 4, 8], we aim to reason about a categorization of attribute-aware community events. In the following, we propose a preliminary taxonomy of such events that jointly describe temporal and attributive dynamics of groups.

We identify two distinct categories, *Attributive* and *Topological* events. On the one hand, Attributive events describe a change in a salient attributive trait representative of a whole community. For ease of use, we refer to this characteristic trait to as *Community Attribute* (CA). The CA can be, for instance, the most frequent value of a categorical attribute or the mean value of a continuous one, as well as a ground-truth value available a priori from the dataset. On the other hand, Topological events focus on CA variations after/guided by structural events, e.g., after a Split/Merge, Contraction/Growth. In other words, Topological events must have a structural event as a necessary condition, while Attributive ones are atomic semantic events that can be useful in the definition of more complex jointly events. Table 1 sums up the proposed taxonomy, and includes a set of events representative of the various categories. We mention *Switch* (categorical) and *Increase/Decrease* (continuous) events to describe a change in the Community Attribute behaviour, e.g., a different most frequent value between two timestamps (Switch). Conversely, Topological events rise from a joint variation in both node attributes distribution and topology, e.g., *Separate/Consolidate* events that occur together with a community Split/Merge. Fig. 1 displays an example of the Separate event; specifically, an Increase of the node attributes' maximum relative frequency (i.e., the community's CA) occurs simultaneously with a Split.

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At the present time, we are working on the extraction of such events from real-world networks. We also aim to test the statistical significance of the events obtained. As future works, we plan to propose some case studies to illustrate the relevance of semantic community events for the analysis of complex networks' meso-scale structure.

Table 1. Attribute-aware community events. The description assumes that C_t is a community identified at time t, and that l_{c_t} and a_{c_t} are a categorical and a continuous salient value, i.e., a Community Attribute, of C_t at time t, respectively.

Category	**Event**	**Description**	**Attribute Type**
Attributive	Switch	$l_{c_{t+1}} \neq l_{c_t}$	Categorical
	Stay	$l_{c_{t+1}} = l_{c_t}$	Categorical
	Increase	$a_{c_{t+1}} > a_{c_t}$	Continuous
	Decrease	$a_{c_{t+1}} < a_{c_t}$	Continuous
	Hold	$a_{c_{t+1}} = a_{c_t}$	Continuous
Topological	Separate	(i) Split	Both
		(ii) Switch/Increase	
	Consolidate	(i) Merge	Both
		(ii) Stay/Hold	

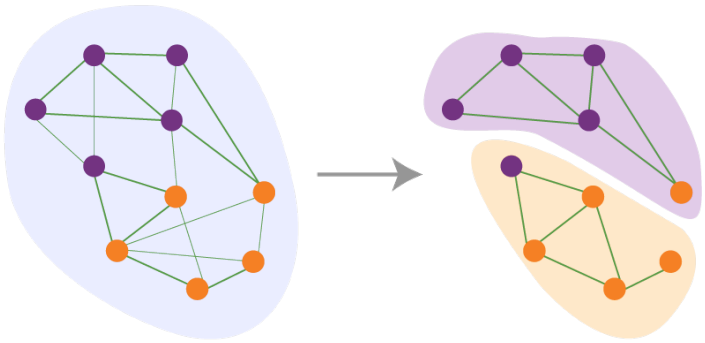

Fig. 1. Example of a *Separate* event. A unique community in t (left) splits into two communities in $t+1$ (right). Concurrently, the children communities show an Increase in attribute homogeneity w.r.t. the parent one.

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