Time Centrality

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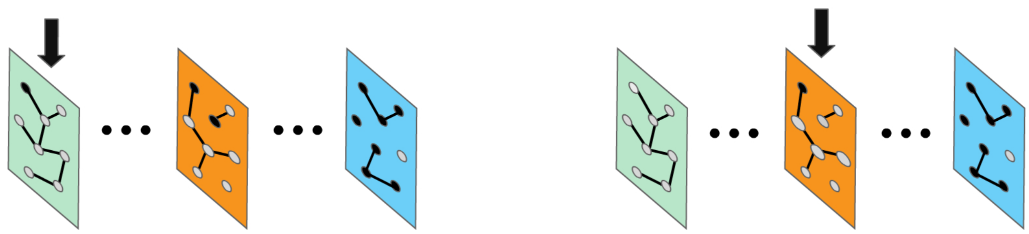
The concept of centrality in graph theory and network analysis usually refers to metrics that assess the relative importance of vertices (nodes) within a graph (network). Different ways of measuring node centrality have been proposed for decades, each of them suited to assess node centrality from a different point of view. Examples include using node centrality to evaluate network robustness to fragmentation or to identify the most important nodes for efficient information spreading in diffusion networks. More recently, there is an ever-increasing interest in investigating the dynamics of networks, i.e. when the network structure (nodes and edges) may vary over time, leading to time-varying graphs (TVGs). As a consequence, a number of recent efforts also investigate new centrality definitions to capture the relative node importance in a the context of TVGs. For instance, in information diffusion scenarios, one can target the identification of the most strategic nodes for information spreading in TVGs.

We argue that, for some applications modelled in TVG scenarios, more important than identifying the central nodes under a given definition, identifying the key time instants for taking certain actions can be of upmost importance for a more efective outcome. For instance, it can be interesting to determine the best time period at which a vaccine should be applied in a population to achieve better responses to an epidemic spreading or the best time period to start a faster information diffusion at lower costs.

In this work, we thus propose to investigate *time centrality*. Similarly to node centrality, the goal of time centrality is to assess the relative importance of a given time period compared with other time periods of the same TVG. Of course, again likewise node centrality, different time centrality definitions can emerge to assess to reflect different notions of importance for the time periods given the target application. For instance, in an information diffusion network, it could be more strategic to identify the best moment (i.e., the most central time instant) to start spreading information for a faster or more efficient diffusion than identifying the best node to start the diffusion (i.e., the most central node).

One simple way to represent a TVG is to use a sequence of snapshots that represent the graph structure at a given time instant. In order to illustrate the concept of time centrality, consider Figures 1(a) and 1(b) that represent the same snapshot sequence of a arbitrary TVG. In each snapshot, black nodes represent nodes that received information and grey nodes those that did not. In Figure 1(a), diffusion starts in the earliest time instant (green snapshot), reaches two nodes in the intermediate time instant (orange snapshot) and reaches almost all nodes in the last time instant (blue snapshot). In Figure 1(b), diffusion starts only in the intermediate time instant (orange snapshot) and reaches the same number of nodes in the last time period (blue snapshot). It can be seen that the diffusion was more efficient in the latter case, since the number of infected nodes is the same as in the former case, whereas the diffusion lasted just one time period, from the second to the last time instant.



(a) Diffusion starts in the green snapshot

(b) Diffusion starts in the orange snapshot

Figure 1: Illustrative example of time centrality where diffusion starting in different time instants change the efficiency of the diffusion.