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School of Engineering
Department of Electrical and
Computer Engineering

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Title: «Distributed Cycle Detection and Removal»

Dr. Gabriele Oliva
Assistant Professor, Complex Systems & Security Laboratory,
University Campus Bio-Medico of Rome, Italy.

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Abstract:

Cycles in networks are either a blessing or a curse. On one hand, from a structural point of view, cycles imply the existence of redundant links and paths, that can be used to guarantee connectivity among the nodes in the event of signal fading, congestions or failures. On the other hand, the presence of a cycle might indicate a violation of the logical or relational structure that underlies the interaction among the nodes; this is well represented by Escher's paintings or by the well-known causal cycle paradox, where a future event is the cause of a past event, which in turn is the cause of the future event.

Consider, for instance, a network of agents, each with a task, and suppose that neighboring agents cannot execute their tasks at the same time (e.g., they share a common tool or resource). In this case, there is a need to define a priority for each pair of neighboring agents. The resulting directed graph must be acyclic to avoid deadlocks.

In several situations, there might be the need to provide a directed acyclic graph that preserves as much as possible the relations specified in the initial topology, where the cycles are present (e.g., when there are locally desirable leader/follower relations but the resulting graph is not acyclic).

In this cases, building an acyclic graph ex novo is not desirable; an alternative strategy might be to operate small changes in the orientation of some of the links, while leaving the remaining links unchanged.

It can be demonstrated, however, that swapping a minimum number of links to obtain an acyclic graph is an NP-hard and APX-complete problem.

Motivated by the above considerations, in this technical presentation novel distributed, yet suboptimal, algorithms are shown, which endow a set of agents with the capability to detect cycles in directed graphs and to remove them by swapping the direction of a limited number of links, attempting to preserve the original orientation of as many edges as possible.

In the proposed setting, the agents are interconnected at the communication level via an undirected graph, and at the relational level via an orientation of the links in the communication graph. The proposed algorithms let the agent exchange information at the communication level in order to detect cycles and to decide to swap the orientation of selected edges at the relational level, with the aim to obtain an acyclic relational graph.

Biography:

Gabriele Oliva took a "Laurea" degree and a PhD in Automation Engineering both at Roma Tre University, Italy, in 2008 and 2012, respectively. Since 2015 he serves as an assistant professor in Automatic Control at the University Campus Bio-Medico of Rome Italy. His main research interests include distributed systems, applications of graph theory in technological and biological systems, and Critical Infrastructure Protection.