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Introduction to the special issue on multilayer networks

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During the last century, networks of several types have been used to model a wide range of physical, biological and social systems. For example, Moreno (1934) studied social networks with multiple types of ties, later called multiplex networks (Verbrugge, 1979; Minor, 1983; Lazega & Pattison, 1999) as well as networks with multiple types of actors. Networks with multiple types of actors and relational ties have often been used together: relevant examples are the extensions of two-mode networks studied by Wasserman & Iacobucci (1991), multi-level networks (Lazega & Snijders, 2016), and heterogeneous information networks (Sun et al., 2012). More recently, researchers in physics and computer science have developed models for different types of interconnected networks known as networks of networks (Buldyrev et al., 2010; D'Agostino & Scala, 2014), multilayer social networks (Magnani & Rossi, 2011), and interconnected networks (Dickison et al., 2012).

This special issue of Network Science focuses on recent attempts to unify all these approaches into a simple, but expressive, concept known as the multilayer network (Kivelä et al., 2014)—not to be confused with other models with the same name previously appearing in the literature. A multilayer network can be represented by a graph

1. whose nodes are partitioned into groups called layers,
2. where a node in one layer can relate to nodes in other layers.

Despite its simplicity, this extended graph model can subsume all the aforementioned approaches: different layers can represent different types of nodes, different types of relational ties, distinct networks connected through inter-layer edges, or a combination of these options. The possible linkages between nodes in different layers enable the representation of interdependent networks with common nodes; for example, different online social networks where the same individual may have accounts on multiple networks.

Multilayer networks have been introduced for two main reasons. First, to encourage the usage of a common terminology across disciplines and across application contexts. Second, to allow methods developed for one of the models mentioned above to be easily applicable to other types of data also representable as multilayer networks. The articles included in this special issue show that these objectives

have only been partially achieved so far. Long-standing disciplines still use their well-established terminologies—as an example, the term actor used in social network analysis is not popular and perhaps not even appropriate for other types of networks, and many methods developed for multilayer networks are in fact meaningful only for specific models, such as multiplex networks. At the same time, more and more researchers in different areas are adopting this common paradigm, which is helping to create bridges across sub-disciplines of network science.

This special issue gives a broad and up-to-date overview of current research efforts in the area of multilayer networks, with the objective of highlighting the variety of methods and problems studied. The articles included in this issue have been thoroughly selected to maximize diversity and quality. We received 22 abstracts and invited 16 of the authors to extend their contributions. Seven full manuscripts were sent to the reviewers and processed under the double-blind policy of the journal. At the end of the writing and review process, four articles from this set of seven plus a fifth article independently submitted to the journal, have been included in this issue.

The paper by Jeub, Mahoney, Mucha, and Porter analyzes the behavior of different random walk models for multilayer networks and how they can be used to identify communities. Sohn and Park introduce a multilayer stochastic blockmodel and address the problem of network changepoint detection. Longitudinal data are also used in the work by Hollway, Lomi, Pallotti, and Stadtfeld, where the authors redefine the concept of social space using a multilayer approach. The empirical part of the paper focuses on inter-organizational networks in the field of health care. Reiffers–Masson and Labatut deal with the classic topic of centrality, and propose a new centrality measure based on the propagation of opinions in multilayer networks. Finally, Omodei, De Domenico, and Arenas introduce a method to quantify the influence of interdisciplinary research based on the analysis of multilayer data.

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