An Activity-Centric Network Model of Engineering Design as a Social Process

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This study offers an approach to characterise engineering design projects through their network of design activities and social interactions. To do so introduces a procedure to model the social process of design and to gather, structure and analyse the required relational data. At least two aspects distinguish this approach from previous research: firstly its use of interconnected design activities as the shared spaces where the design object emerges out of a contingent network of communication episodes and secondly, it takes a project level perspective, where multiple development areas concurrently design the components and processes required to conceive and give form to the final product.

The industrial practice of Engineering Design (ED) is embedded in complex socio-technical systems. These systems are the place where designers, in the context of projects with concrete design activities, interact with others across functional and organisational boundaries to define the design object. Two parallel literature streams have contributed to the network analysis of the engineering design practice: the Design Structure Matrix (DSM) and Social Network Analysis (SNA). DSM focuses on dependencies between and within domains, including product's components, people and processes. The key aim is optimising their sequence through a more efficient modularisation and a better alignment between domains (Eppinger and Browning 2012). In turn, the use of SNA in ED has been mainly focused on the analysis of social interactions and communication in R&D teams, analysing brokerage roles and other boundary spanning issues (Collins, Yassine and Borgatti 2009). This paper brings together learning's from these two streams, combining the multi-domain DSM perspective with the communication emphasis and richness of SNA metrics.

The proposed approach uses a two-mode valued network that includes the project participants and the design activities. The edges are based on the weighted interactions between individuals, and between individuals and design activities via the level of responsibility and time investment reported by each participant. These descriptions are used to quantitatively describe the social process of design. The network analysis is carried out at two levels: at the design activity ego-network level where the alters are individuals (Figure 1a and 1b), and at the whole network level where design activities are connected by people co-occurrence (Figure 1c). At the ego-network level the aim is to identify the impact of the network structure on the design activity performance. At the whole network level the purpose is to create a system overview of the social connectivity between development areas and the evolution of the design process. This research, through an in-depth case study of a complex engineering design project, provides an example of the industrial application and relevance of this kind of network analysis.

Figure 1 shows three graphs with different representations of the network of activities. 1a and 1b display two design activity ego-networks allowing correlations between the network structure of each design activity and its efficiency and effectiveness to be tested. 1c is a one-mode network based on the deduced social connectivity between design activities. This whole network view allows to identify potential areas for knowledge transfer and idea diffusion, as well as cascading effects of performance across the network.

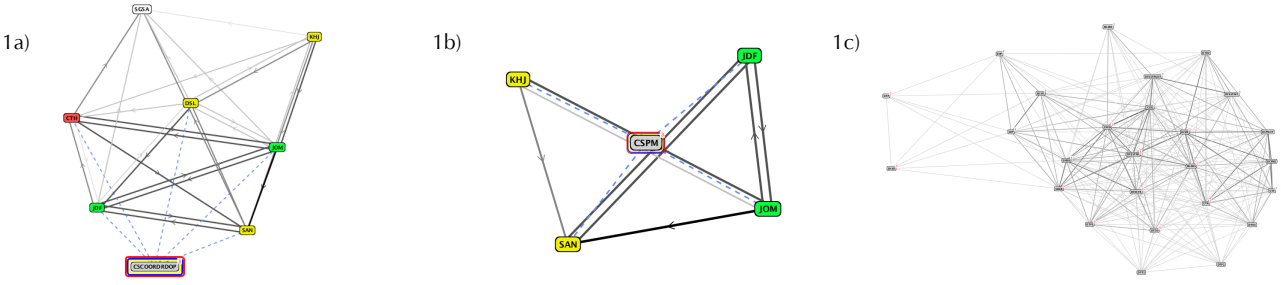

Figure 1: Three network representations of An Activity-Centric Model of Engineering Design as a Social Process (case study data). Design activities in grey. People coloured according to their department affiliation, yellow for sales, green for R&D, red for production and white for other stakeholders.