

Visualising Interactions in Complex Design

René Keller, Claudia M. Eckert, P. John Clarkson
Engineering Design Centre
University of Cambridge
Trumpington Street
Cambridge, CB2 1PZ
United Kingdom
{rk313, cme26, pjcl0}@cam.ac.uk

Designing a product is complex in many ways. Four layers, which can be sources of complexity in design, can be identified. First, the product itself can be complex as it might have many components that are highly interrelated and linked in various ways. Second, the process of designing the product can consist of many interlinked tasks with probabilistic outcomes that can cause costly iteration. Third, the organisation that designs the product can be considered complex, as it consists of a large number of multidisciplinary teams. Fourth, the relation of the product to its environment can be complex. In addition representations used to interact with the product can also be highly complex.

We concentrate on how to visualise the first two aspects of complexity, the complexity of the product architecture and the complexity of the corresponding design process. Both, products and processes can be modelled as networks, consisting of items (components and tasks) and interactions and dependencies between them. Networks that show an appropriate level of detail can easily become very huge, consisting of hundreds or thousands of items connected in various ways. The key for successful design is to have appropriate interfaces and visualisations of this information so that the designer can effectively make use of the models.

Two main representations for network data exist: Adjacency matrices and node edge diagrams. Both representations have advantages and disadvantages when showing such data. While matrices are very compact representations that let users easily extract information about direct linkages between items, networks proved superior behaviour when indirect interactions between items are to be visualised. However, for very large and complex models, further advanced information visualisation techniques such as filtering and fisheye techniques are necessary in order not to overwhelm the user with the amount of available information.

We will introduce network and matrix representations that make use of advanced information visualisation techniques and are used in two methods developed at the Engineering Design Centre Cambridge to support the design of complex products. The signposting methodology allows a dynamic approach to planning and analysing the design process used to design complex products. The basic idea is to dynamically update the state of the design and present the designer at each state of the design using a signpost of how to proceed with the design process. Simulations of such design processes allow further analyses in order to detect bottlenecks and to find optimal task execution orders. The other method that makes extensive use of network visualisations is the CPM (Change Prediction Method) to predict direct and indirect design changes. When a component of a complex product has to be changed (e.g. because of a customer request), this change can have knock-on effects on other components that then equally affect further components. Using the CPM method allows designers to predict the impacts of changes to directly and not directly connected components.

In both examples it is important for the designer to get detailed information about a particular case as well as a global overview over the entire information space. In this paper we will introduce displays that visualise complex process and product data taking advantage of enhanced information visualisation techniques and that have shown to be highly beneficial to the design process.