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INDIRECT CONNECTIONS IN A SUPPLY CHAIN: VISUALISATION AND ANALYSIS

Claudia M Eckert[1], Marc Zolghadri[2], Rene Keller[3], and P John Clarkson[3]

[1]DDEM, The Open University
[2] IMS, Dpt. Laps, Université Bordeaux 1
[3]Engineering Design Centre, University of Cambridge

Keywords: Supply Chain, Change prediction, Visualization

1 OBJECTIVES

Even the simplest product can have complex supply chains, if they were mapped down to the producers of raw materials. Most supply chains involve a combination of products made specifically for that particular supply chain and those that are bought from standard stock and catalogues, as well as enabling products (AINSI/EIA-632, 1998), that are required for the development, production, test and deployment of the product and its support, maintenance and later disposal of the product. This paper discusses the use DSMs and network displays to visualise and analyse supply chains to support designer in:

Understanding the supply chain: Companies don't have complete visibility over their entire supply chain. They understand a few tiers up and down the supply chain, their customers' customers and their suppliers' suppliers, but only have a partial understanding of interactions further removed. Within a company the understanding of individuals is even more limited to that of their own components. Different modes of purchasing for different components further add to a confusing picture of designers. Some components are sourced through a form of competitive tender, while others are co-developed with suppliers.

Designing the supply chain: Many companies work with constant core suppliers, however many aspects of the supply chain are coevolving with the product. Key decisions about the product influence the supply chain and the capabilities of the supply affect the characteristics of the product (see for instance Zolghadri, 2008). Companies need to understand these mutual effects when they select their suppliers and assess the suitability of their suppliers. Changes to product during the design process can affect the entire supply chain, in particular partner selection, and change in the supply chain can affect the product. Conventional modes of displaying supply chains typically depict tree like structures, showing he flow of resources and components up the supply chain. However, this does not show the indirect links that can arise through the changes to the supply chain.

2 METHODS

The CPM tool has been developed by the EDC at Cambridge to assist change prediction in engineering change (Clarkson et al, 2004) through the product life cycle (Keller et al. 2008). The tool provides multiple visualisation of product connectivity through graph and DSM structures. The particular nature of change link between components is captured through linkage types, which also provide an aid memoir for the collection of impact and likelihood values, which allow the CPM tool not only to display the direct risks of a change form one component reach an other, but also to calculate indirect change risk (Keller et al. in press). Also CPM has been used for component models of products, the same notion of change propagation can be used to model the effects of modifications to products, requirement or quality across a supply chain.
For this paper we generated a small model of the supply chain of the knitwear for high street stores based on a detailed past study of the knitwear design process (Eckert, 2006). The model comprises 22 elements

with different linkages. The lower triangle models the flow down the supply chain, with essentially four linkages types representing basic relationships between suppliers and customers: design for, supply for product for and supply from catalogue. The matrix is symmetrical with the backward link in the upper triangle indicating whether a satisfactory product has been delivered. Risk values were assigned to each of these links on a high, medium and low scale, assigned to values of {0.8, 0.5, 0.3} respectively. The interpretation of risk down the supply chain is the risk of changes being required, if the specification of the design changes and up the supply chain it is the risk of an unsatisfactory product causing delays or requiring rework. Those parts of the supply chain, which are beyond the control of the supply chain partners, are no detailed and marked as frozen. For example in knitwear design, the spinners have no influence over the way the big chemical companies produce the dye stuff.

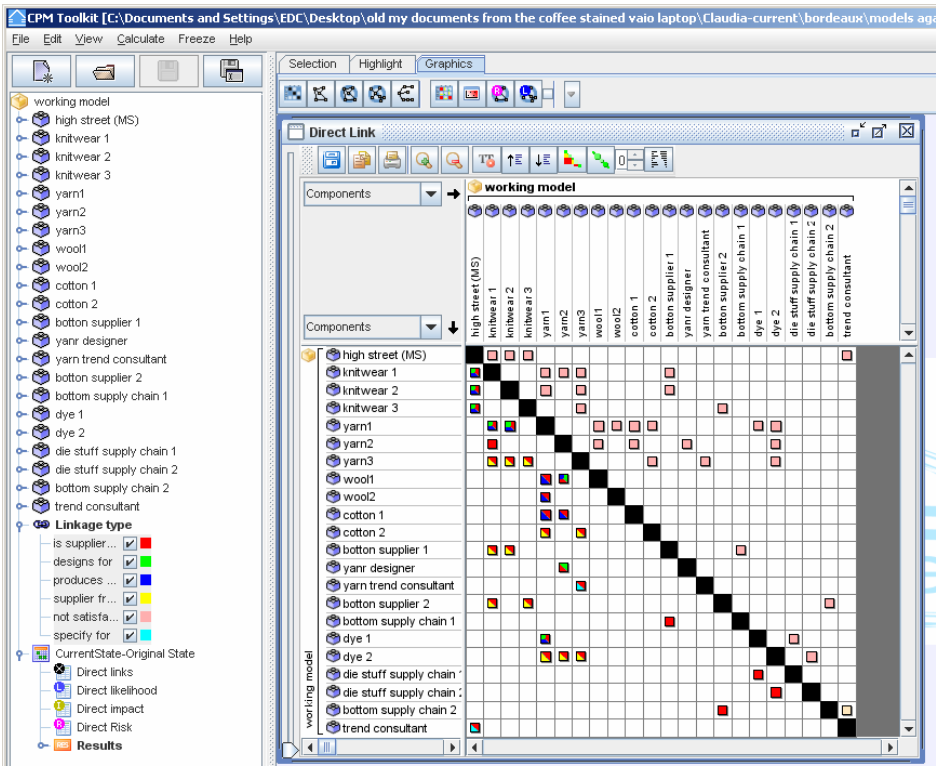


Figure 1 CPM model of a Supply Chain.

Different partners are mapped as elements of a DSM.

The colour coding indicates different linkage types which characterise the nature of the supply relationships.

The lower triangle models the flow down in a supply relationship.

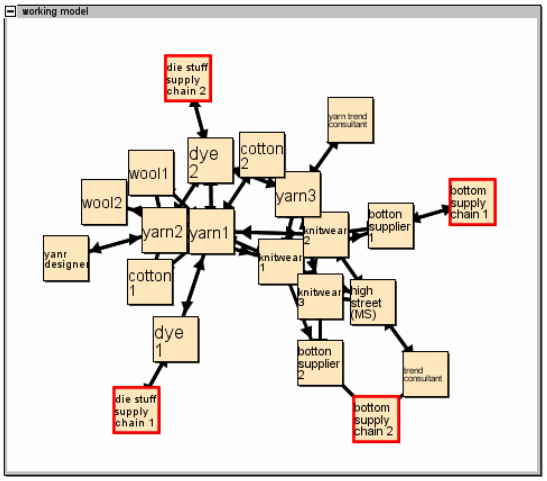
The symmetrical upper half shows the delivery of products or services.

3 RESULTS

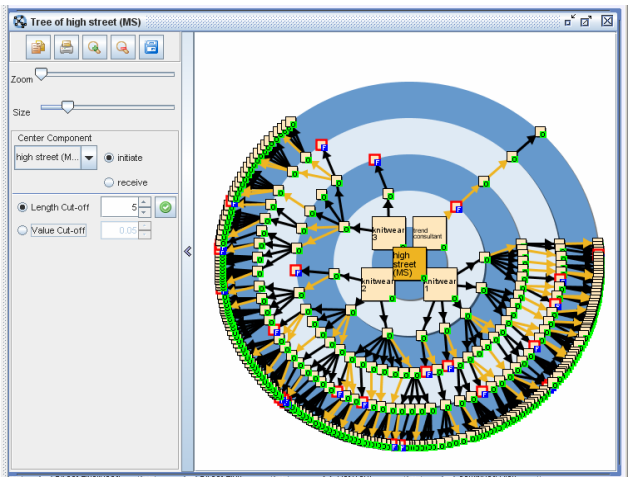
The tool offers different views of the connectivity between supply chain partner, as illustrated in Figure 2, which allow designers and procurement managers to visually navigate the network and identify bottleneck in the supply network. This information can be employed of part of activities to put a supply chain together and negotiate terms within the supply chain.

4 CONCLUSIONS

The CPM tool can be used, with suitable interpretations of the of various risk links, to show dependences between different partners in a supply chain and the change prediction algorithms can be used to support the design of supply chains. Unlike common ways to displaying a supply chain, the CPM can show and assess indirect relationships, so that designers can identify common bottle necks in selecting between different potential product offerings. Future work will address how other aspects of the CPM tools can be reinterpreted for modelling a supply chain and identify specific amendment for the tool for supply chains.



(a)



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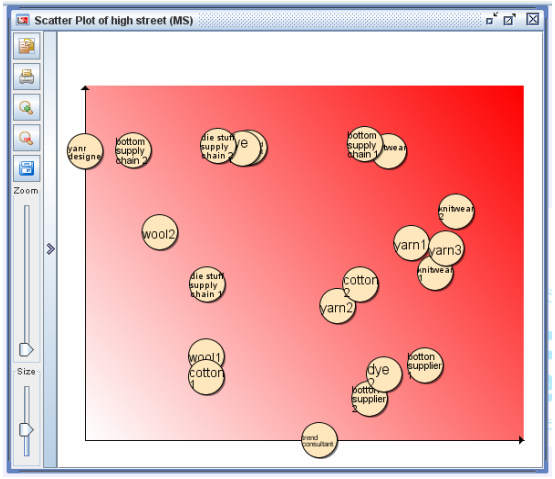

(c)

Figure 2 Analysis of the supply network
(a) shows the supply network, the red rimmed partners, that can not be influenced. (b) shows all the relations of a particular player, in this case the end customer. This shows multiple potential supply chains. The multiple occurrence of red rimmed partners, illustrates how multiple supply chains can end up involve the same players. (c) indicates the cumulative risk of changes propagating from an originating component (here the end customer) to other components. This summarises the effect of multiple paths. In the example the greatest risk is to the first tier suppliers and the common bottom of the supply chains.

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Contact: Claudia Eckert
DDEM, The Open University
Walton Hall, MK7 6AA, Milton Keynes, United Kingdom
Phone: +44 (0)1908 653555, Fax: +44 (0)1908 654052
e-mail: c.m.eckert@open.ac.uk

10TH INTERNATIONAL DSM CONFERENCE

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Claudia M Eckert[1], Marc Zolghadri[2], Rene Keller[3] and P John Clarkson[4]

[1]DDEM, The Open University
[2] IMS, Dpt. Laps, Université Bordeaux 1
[3] Concept Modelling and Development, BP
[4]Engineering Design Centre, University of Cambridge

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Overview

- The CPM tool for change prediction and visualisation in engineering products
- Change across products
- Change across the supply chain
- Visualising the supply chain
- Risk assessment in the supply chain
- Application areas

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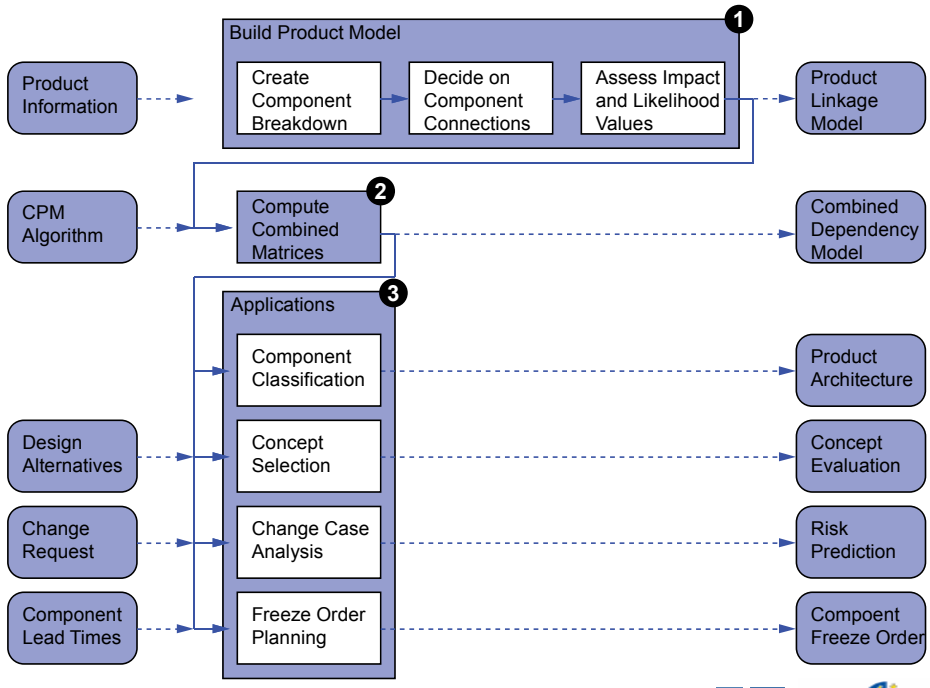
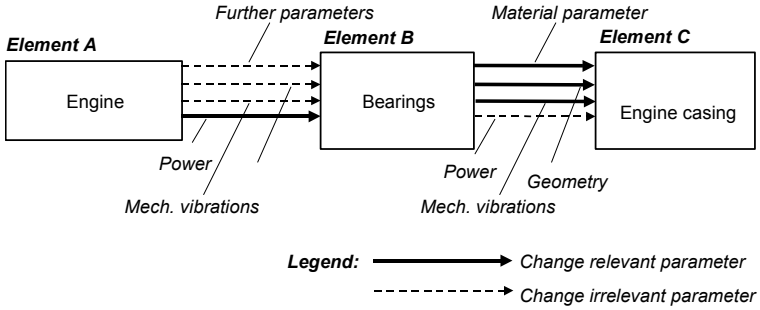
The CPM Tool



Changes across the the product

- Traditional application of CPM to assess changes to existing products in terms of the implication of a change on other components of the product

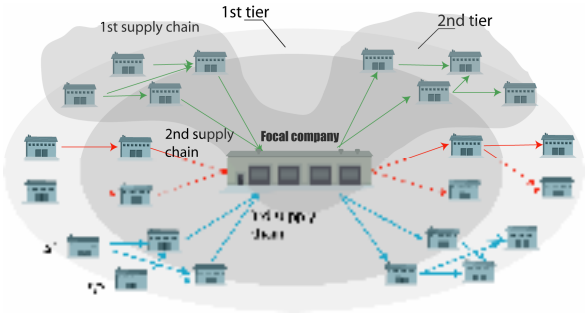


- Key assumption: a change can only propagate through a direct link between components, e.g.
  - Mechanical, thermal, electronic
- Excluded from the analysis: all product parameters, e.g. cost, weight, etc.

Changes across the supply chain

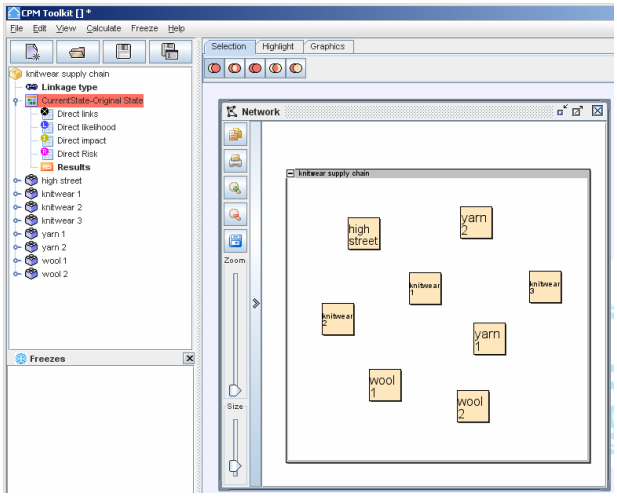
Supply Chains are networks

- Designing the supply chain
  - Capability
  - Availability
  - Cost
  - Quality
- Running the supply chain
  - Capability
  - Availability
  - Cost
  - Quality



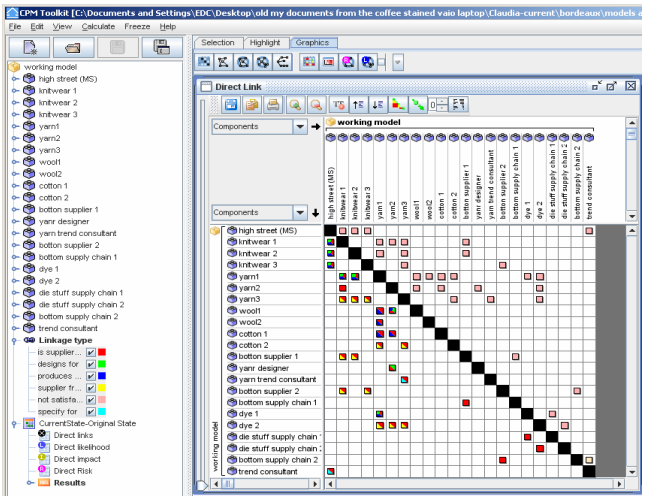
Changes to supply chain affect product and other partners in the chain

Building a Model



- Identify Supply Chain partner
- Decide on the limit of the modelling effort

Supply Chain DSM



- Mapping to analyse risk
- 22 supply chain partners
- Lower triangular matrix: commissioning:
  - Designs for
  - Supply for
  - Produce for
  - Supply from catalogue
- Upper triangular matrix: delivering:
  - Deliver satisfactory product

Example: Supply chain of high street retailer for knitwear

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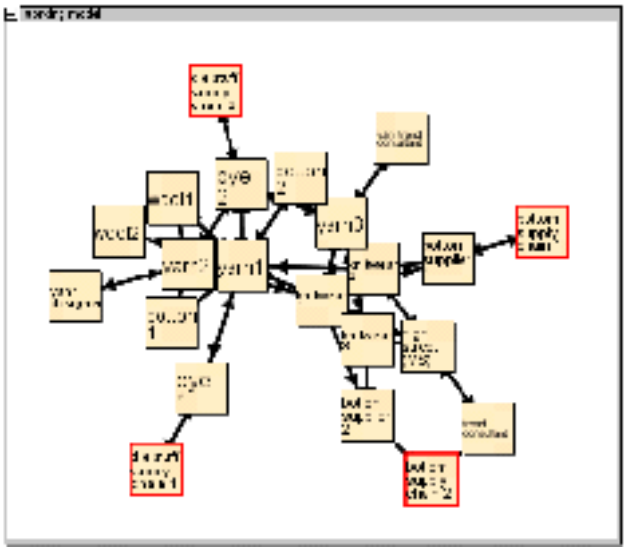
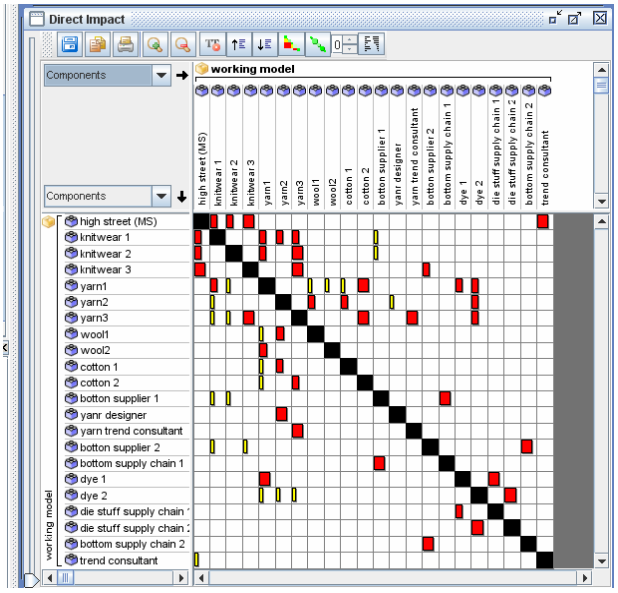
Network View



- Network of suppliers
- Strong interconnection of materials suppliers
- At the end of the supply chain stands another complex supply chain, which can not be influenced - Marked as frozen

Risk Values



Interpretation of risk –
Open research question

Selected interpretation for impact and likelihood

- Lower triangular matrix:
  - change to the specification affecting supplier
- Upper triangular matrix:
  - Not delivering a satisfactory product

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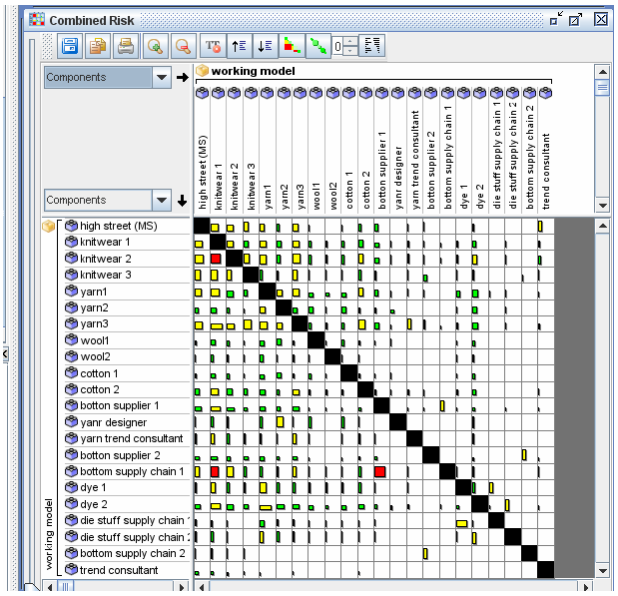
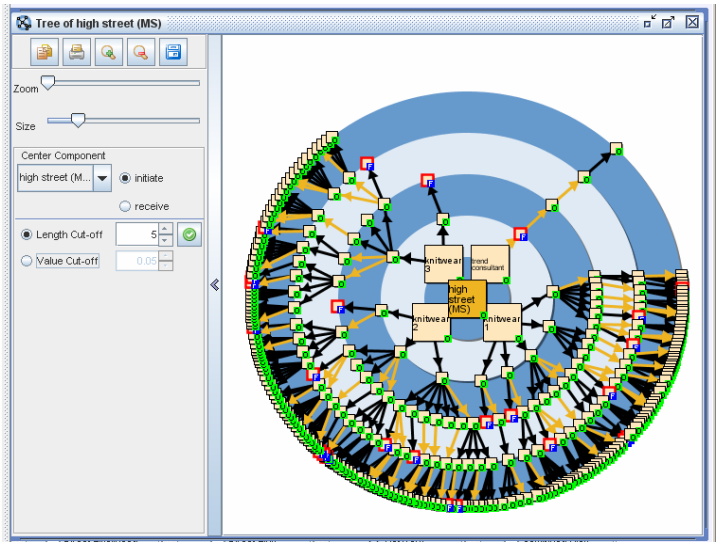
Indirect Risk



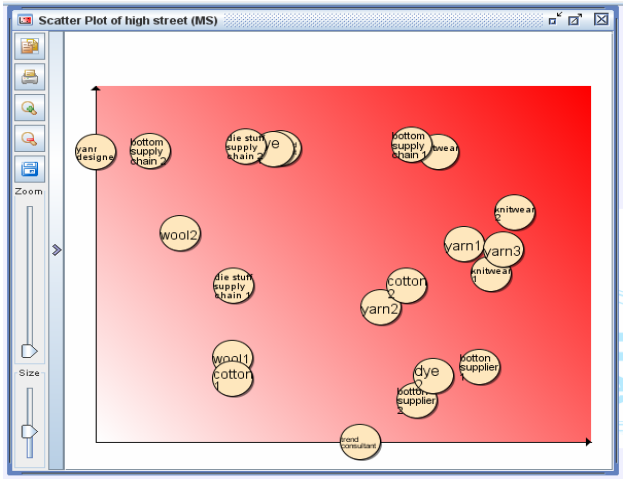
- Application of CPM change prediction algorithms to show how the changes could affect players in the supply chain indirectly

Supply Tree View



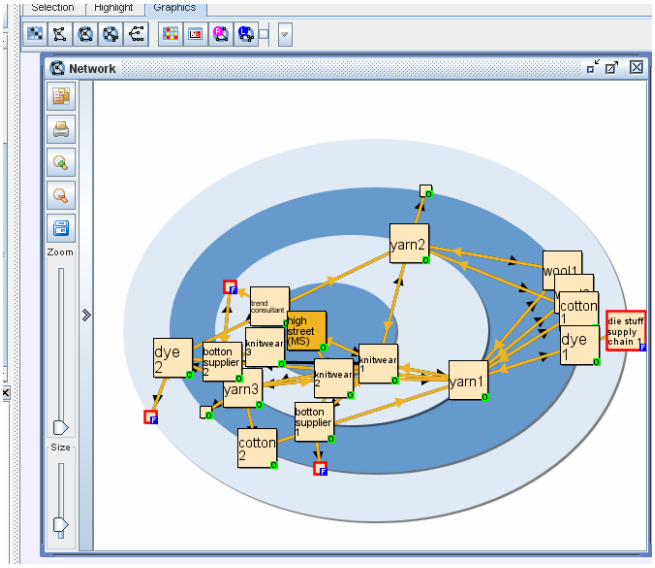
- Focus Company in the Centre
- All supply tree to a given lengths
- Shows multiple occurrence of the same players
  - E.g. red rimmed company at the end of the chain
  - Change to suppliers higher up might not solve problem

Cumulative Risk View



- Shows cumulative risk of a change to originating component affecting other components
- Summary of different risk paths

Investigation of particular paths in a network



- This shows paths through the network while displaying the context

Change Prediction for Supply Chains

Supply chain management is a type of change problem

- Designing the supply chain
  - Assessing the risks when the supply chain is running
  - Avoiding bottle necks through multiple supplier further down
  - Alternative first tier suppliers might carry very similar risks, if they depend on same supplier lower down
  - Ordering standard parts might be cheaper, but high risk of interdependence with other supply chains
  - Assessing the effect of low quality deliveries requiring changes to orders
- Running the supply chain
  - Assessing potential changes to supply chain, if product is changed
  - Assessing interdependencies when supplier needs to be replaced