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Mapping London's innovation networks

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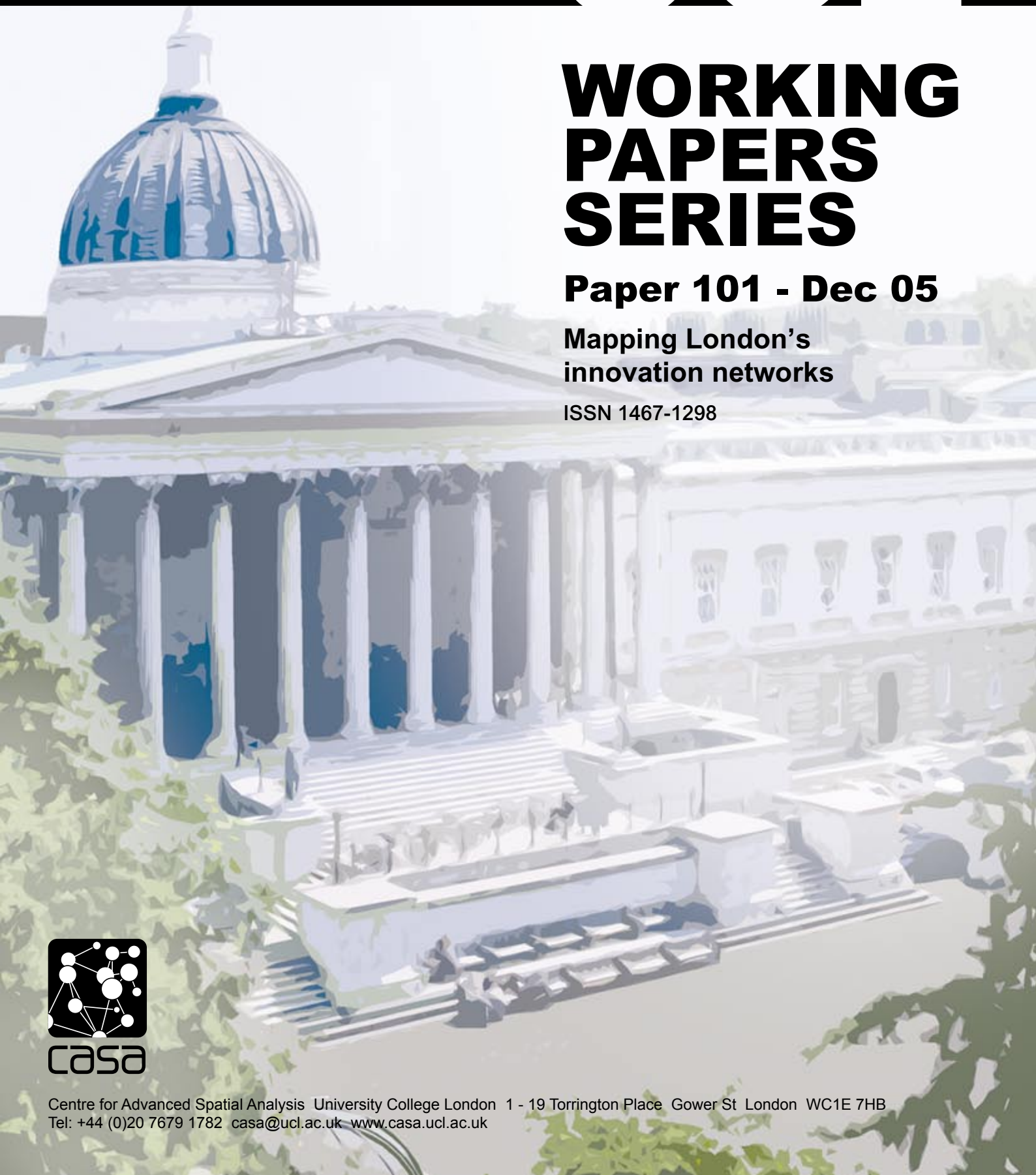

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MAPPING LONDON'S INNOVATION NETWORKS

Abstract

A wide range of authors have highlighted the potential benefits for entrepreneurial companies that engage in effective networking along and across the supply-chain. As many organisations have downsized or out-sourced basic research activities Universities have an increasingly important role within such networks. A number of UK initiatives have been established to encourage greater 'entanglement' between academia and commerce; the London Technology Network is one example which is intended to encourage interactions between London's leading research institutes and innovative businesses.

Using the detailed data acquired by this network this paper is intended to presents an exploratory analysis of such activities with the aim of establishing the extent to which company size, sector and/or location play a significant role in participation in the network's activities.

Keywords: Innovation networks, high-tech clusters

Introduction University/Business Networks and innovation economies

A common thread linking emerging innovation strategies (c.f. Chesbrough 2005, Miller & Morris 1999) is the importance of effective networks for the capture and sharing of explicit and tacit knowledge between companies, competitors, suppliers, universities, national laboratories, industrial consortia and start-up firms

As many organisations have downsized or out-sourced basic research activities Universities have an increasingly important role within 'open innovation' networks. Over the last five years a large number of UK initiatives have been established to encourage greater engagement between academia and commerce. In reviewing some of these early initiatives Lambert's Review of UK Business/University interactions (2003) confirmed that many of the most effective forms on knowledge transfer rely upon human-interactions between the two communities, and that sustained interactions generally favour local or regional scale activities. The value of such interactions is difficult to quantify - with many transactions remaining invisible to the organisations involved. However both formal and informal social networks appear to make important contributions to the formation of business clusters and thus have become the focus of much innovation related policy (e.g. Audretsch & Feldman 1996).

This paper presents early results from ongoing research at UCL that is focussed on exploring the web of formal and informal relationships between London's universities

and their industrial partners. Focussing on data gathered by the London Technology Network (LTN) over the last 5 years the paper presents the findings of a Social Network Analysis (Wasserman & Faust 1994) that maps the interactions between more than 1600 university and company researchers active within this innovation network. In doing so it seeks to determine the extent to which the networking role of companies in such events are influence by their industry sector, their size or their location. Thus the paper is intended to offer initial insights into the innovation behaviours of a diverse set of companies that are seeking to develop or maintain their relationships with London's leading research institutions.

Importance of University/Business networks to the economy

Many studies have demonstrated that successful universities are often a defining characteristic of successful places. The best deliver global impacts from high-technology clusters centred on well known institutions such as MIT (Shane, 2004), Stanford (Saxenian, 1994) and, more locally, Cambridge University (see Castells 2004 for an overview of the *'entrepreneurial university'*). Whilst world-cities such as London, New York etc. host HEI of similar stature their embedding in a larger, complex, metropolitan setting makes it more difficult to characterise the innovation 'footprint' of research and knowledge transfer activities at such intuitions.

University contributions to innovation are both direct and indirect. Direct contributions include actionable research findings that directly lead to new products and services or new businesses created to exploit technology. Indirect contributions include research training, knowledge transfer schemes and professional networks which contribute to business's ability to innovate within their own organisational structure. It has been argued that widely quoted, readily accessible, indicators of direct innovation contributions, such as numbers of patents, start-ups or licences do not fully reflect the outputs of university innovation activity (Meyer 2003). Complementary indicators of the indirect impacts of university innovation that have been widely analysed include citations of scientific publication (e.g. Bhattacharya & Meyer 2003) along with studies relating to the regional distributions of scientific citations (Batty 2004). However, further work is required to understand how to harness "open innovation" paradigms (Chesbrough, op.cit) that maximise the socio-economic benefits of formal and informal knowledge exchange between industrial and commerce researchers.

Attempts to characterise regional innovation networks

A number of researchers have sought to understand the impact of informal social networks in building innovation and entrepreneurial communities. However, even in the context of that most studied of entrepreneurial regions Castilla notes that:

"The most critical aspect of Silicon Valley is its networks" There is no proposition so universally agreed and so little studied (Castilla et.al. 2000:218).

In attempting to unpick the social networks that have contributed to that regions success the Silicon Valley Networks Analysis Project team have collected a wealth of data relating to the networks that link universities, financiers, entrepreneurs and established business within intersecting web of social networks (www.stanford.edu/group/esrg/siliconvalley)

In the UK the impacts of, and interactions between, participants in such networks has been most closely documented for universities which dominate the surrounding region - UK examples include Oxford (e.g. Lawton Smith et.al. 2003) and Cambridge (e.g. Myint et.al. 2004).

Understanding the interactions between such networks becomes more complex in the context of major metropolitan universities. This is a particular issue in the Greater London region where 42 higher education institutions strive to simultaneously compete and collaborate within their overlapping fields of expertise. This paper presents some initial findings of the effectiveness of one set of business/university linkages within this complex setting by leveraging existing relationships within the London Technology Network (LTN www.ltnetwork.org).

The London Technology Network – roles and functions

The London Technology Network (LTN - www.ltnetwork.org) supports London's innovation economy by *"catalysing and extending university-industry collaborations"*. In order to achieve its networking objectives LTN has recruited more than one hundred academic and senior research staff from London's leading university technology departments (those rated 4,5 or 5* in the last RAE) who act as LTN Business Fellows. Business Fellows are trained by LTN to optimise the interactions between their department and industry - acting as industry contact points for that research group and are providing regular feedback on their interactions with business. A central component of LTN's networking activities are evening lectures at which a panel of leading industrialists and academics seek to identify major challenges for a specific technology sector. Presentations are followed by an informal networking event and poster exhibition showcasing relevant research from leading London Universities. Between February 2003 and September 2005, the LTN organised 29 events attended by more than 2300 delegates from universities, industry sectors and government. Regular participants in the network fall into three main groups:

- LTN Business Fellows – over 100 faculty & senior research scientists from leading university technology departments who are trained to work as effective intermediaries between universities research groups.
- A London Knowledge Transfer Network (LKTN) of more than 75 university technology transfer professionals
- Representatives of more than 500 businesses who attend regular research networking events with to encourage greater interactions between industry and academia.

Characterising LTN networking activities

The LTN actively markets its events to both industrial and academic participants. Themes for such meetings are generally suggested by LTN fellows and initial guest lists are gathered from suggestions from the fellows and other staff within the member universities. LTN staff also proactively target potential industrial participants through previous guest lists and trade databases. The detailed attendee profiles arising from these events provide an informative data source regarding both thematic and geographic distribution of demand for such innovation-related networking events within the South East of England. These data offer the potential for the identification

of geographic regions and thematic sectors which are especially active in such activities. To date, participation data for 29 LTN events categorised by LTN staff into 3 distinct sectors is available for analysis:

- Biotechnology (803 delegates at 11 events)
- Engineering (930 delegates at 10 events)
- ICT (627 delegates at 8 events)

The LTN customer relationship management (CRM) system holds a wide of additional information on all attendees and invitees to the networking events. A useful attribute in the context of this study is company size which the LTN code into five size categories (Table 1).

Category	Description	Size
1:	Micro Organisations	< 10 Staff
2:	Small Organisations	10-50 Staff
3:	Medium sized organisations	50-250 Staff
4:	National Organisations	> 250 Staff
5:	Multi-National Organisations	

Table 1 Classification of business size

Business engagement in LTN activities – a sectoral analysis

Although each LTN network event had been assigned to one of the three categories detailed above we were anxious to confirm the integrity of these classifications before proceeding to analyse attendance patterns in more detail. Using Social Network Analysis (SNA) we derived sub-network representing a coherent sub-set of events attended by a common set of participants – thus offering the potential for repeated and sustained interactions between participants over several events.
The analyses were based upon adjacency matrix representation of a two-mode *affiliation network*. Here each column represents an individual event and each row a participant. The value of the row/column intersection is set to 1 if an individual attended a particular event and 0 if they did not.

The resultant network was extensively analysed using SNA techniques (Fruchterman & Reingold, 1991; Kamada & Kawai, 1989; Wasserman & Faust 1994) using UCINET (Borgatti et.al. 2002). These analyses indicated that the patterns of co-attendance at the events did not reflect their apriori categorisation so event themes and participants were re-classified based upon actual network attendance.

After extensive experimentation our segmentation based faction analysis derived from the bipartite graph of the affiliation network. It proved necessary to remove LTN staff members and attendees classified as 'Suppliers' from the analysis since their attendance did not exhibit sector or thematic characteristics. The most robust classifications were achieved by using faction based clustering into three sub-

networks using industrial attendees only – with attendees from the same company site (i.e. same home postcode) being grouped together to yield a weighted affiliation network. Through inspection of the event and company types represented in these classes the factions were felt to represent three key business sectors which we label: Engineering (faction 1) ICT (faction 2) and LifeScience (faction 3).

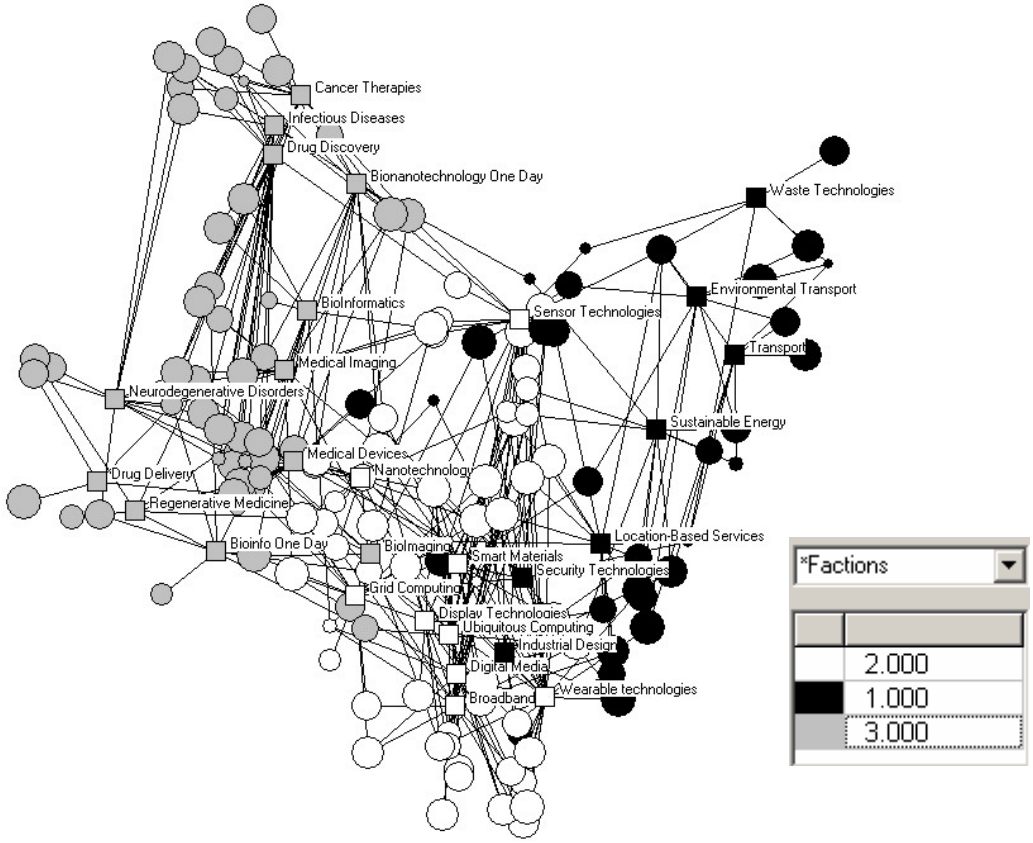


Figure 1 Faction analysis of companies participating in two or more LTN events

(symbol size represents company size)

Network roles of company and academic network participants

The analysis of patterns of participation and co-participation (Borgatti, 2005; Mizruchi & Potts, 1998; Marsden, 2002) provides us with a rich set of measures to reveal the structural properties of affiliation networks generated by the patterns of co-attendance to multiple events. This allows us to test the roles which various categories of LTN participants appear to be taking within the networks by quantifying the nature of relationships within the network. Essentially the more events LTN agents attend the more relations they may be able to build and hence the more successfully they can distribute information. Network analysis methods focus on the structural properties of a network and on the position of the individual actors within the network. The underlying rationale being that the actor's position can influence, or even determine, the behaviour other members and the performance of the network. In our case, we hypothesise that the “centrality” of some type of actors, such as small entrepreneurial business, may influence the “networking” behaviour of the other participants and therefore the overall success of the network. We would, for example, expect to find that LTN Business Fellows would take the most central 'brokering' roles within the network as this is the function they have been recruited and trained to perform. We

might also anticipate that given the very different sectors represented by the sub-graphs there should be some significant differences between the embedding of companies of differing sizes within the three networks.

There are several possibilities to measure actors' centrality in a network (Faust 1997:166, Freeman, 1978) based upon the actors 'degree' (the. number of connections of that actor to others in the network). Here we have used normalised eigenvector centrality defined by Borgatti & Everett (1997) as *" a weighted degree measure in which the centrality of a node is proportional to the sum of centralities of the node it is adjacent to"*. Using a normalised index of centralisation allows comparison of patterns of attendance at different classes of event enabling the investigation of the roles played by the various categories of participants.

To do this we extend our network to include both academic and industrial participants (Figure 2) with academics attendees being sub divided in five categories (Business. Fellows, Heads of Departments, Faculty, Industrial Liaison Offices, Management and Students) and companies into the five size bands detailed in Table 1.

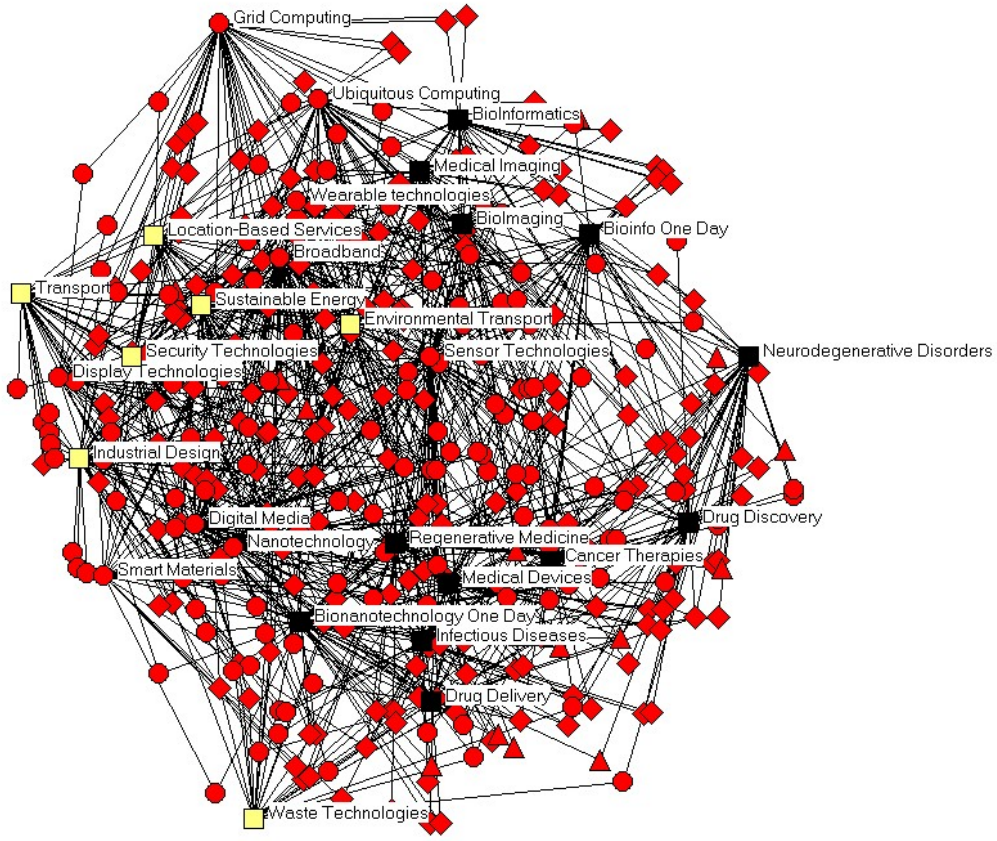
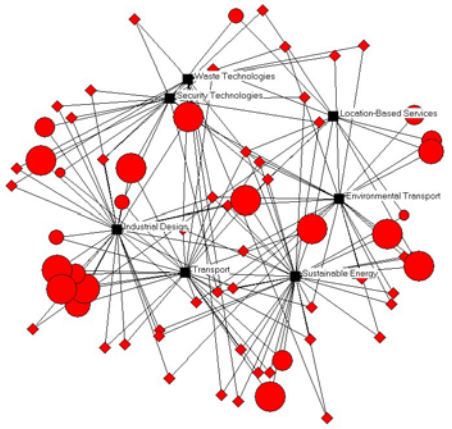


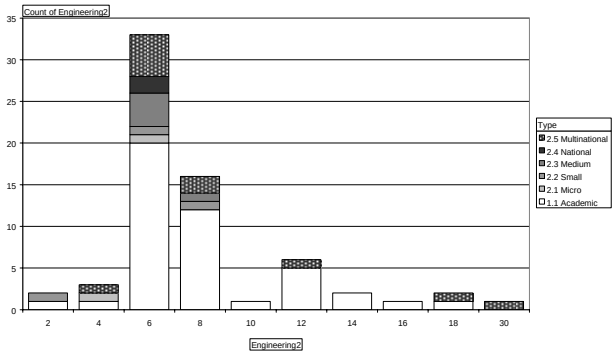
Figure 2 Sociogram of business and academic attendees. Circles represent businesses, Diamonds represent LTN Business Fellows, Triangles represent other academics.

The figures and graphs below (Figure 3 a..f) reflect our initial analyses of the centrality of the various players in each of the three networks. The diagrams (Figure 3,a,c,e) represent sociograms for each faction from which pendant actors (i.e. those who have only participated in a single event) have been removed. Commercial participants are represented as circles which are scaled to reflect the company size. Academic participants are represented by diamonds (Business Fellows) and triangles (other academics). The figures clearly show that the central portion of the graph is, as

we would expect, largely populated by Business Fellows. However the figures also appear to indicate that companies of various sizes participate in different ways in each sub-network with small and medium organisations playing a more central role in the ICT and Engineering networks than in the Life Science faction.

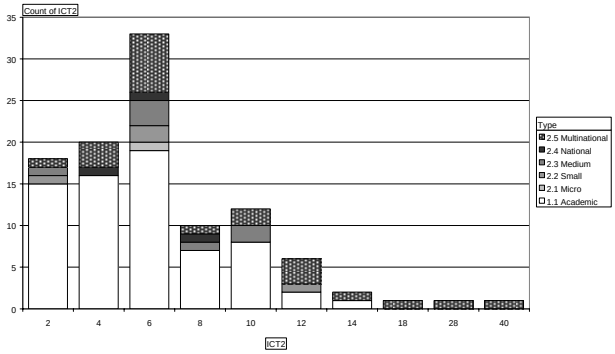


a. Sociogram of Engineering events

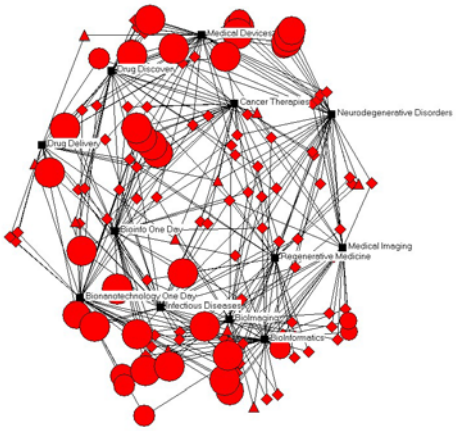


b. Centrality measures for Engineering events

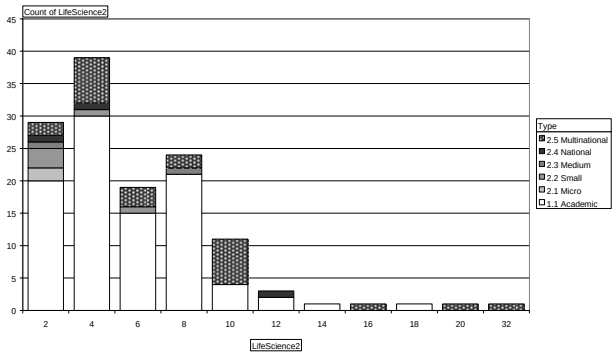
c. Sociogram of ICT events



d. Centrality measures for Engineering events



e. Sociogram of Life Science events



f. Centrality measures for Engineering events

Figure 3 Analyses of thematic sub-networks

Clearly, given the nature and structure of these industries this could simply reflect the company size structure for that industry. However as we can see from Figure 4 an analysis of network participation by company size indicates that a smaller proportion of SME's participated in Engineering and ICT events than those categorised as being in the Life Science sub-network. The graph for each faction (Figure 3,c,d,f) presents histograms for of the counts of participants in sub-categories of attendees against their

normalised eigenvector centrality computed from a bipartite graph for each two mode network. The surprisingly large values (centrality > 30) for some of the Multinational Companies can be explained by the fact that a number of companies sent a large number of delegates (c. 5) to some key events. However, focussing on the bulk of the participants the graphs confirm the more central roles played by SME's in these the Engineering and ICT sub-networks. This pattern of behaviour suggests that there may be differing dynamics at play within each of these sub-networks which merit further investigation through detailed interviews of the participants. We hope to undertake such a survey in the next phase of this research.

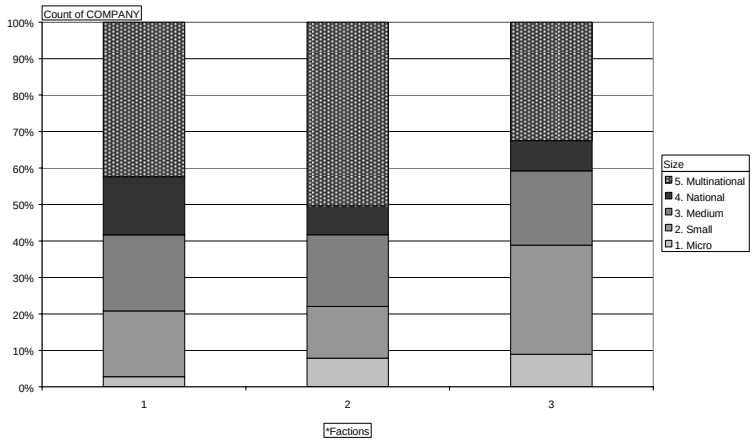


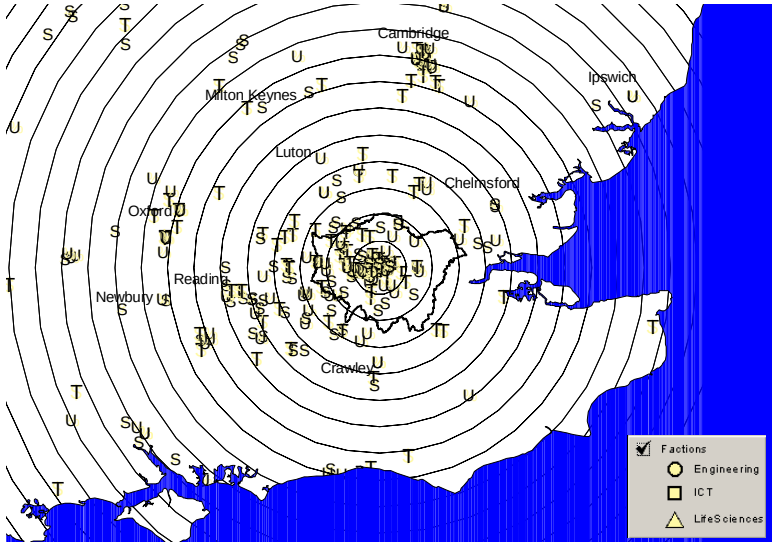
Figure 4 Breakdown of company participants by faction

(1=Engineering; 2=ICT; 3=Life Sciences)

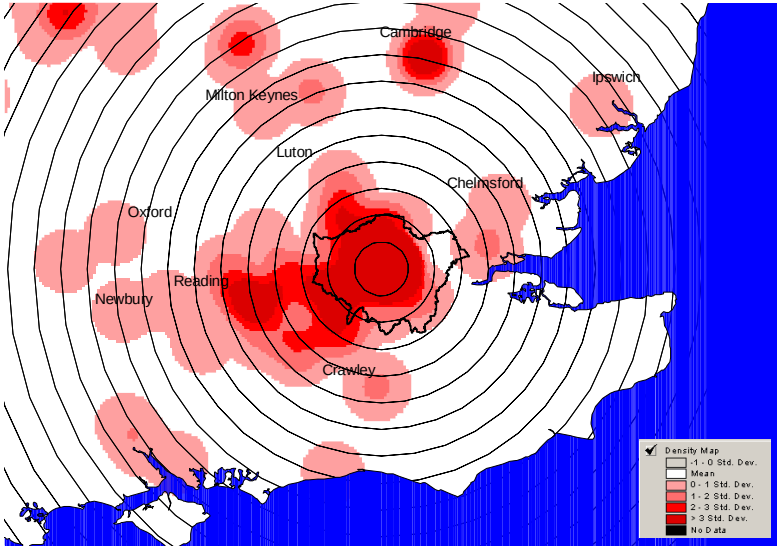
Geographical distribution of network participants

The participation networks analysed above assume that all attendees are equally able to participate in events. However, in seeking to decipher the patterns of company participation it is necessary to consider the extent to which the gravitational attraction of high-class events is offset by the impedance in time and/or cost of travel to the meetings.

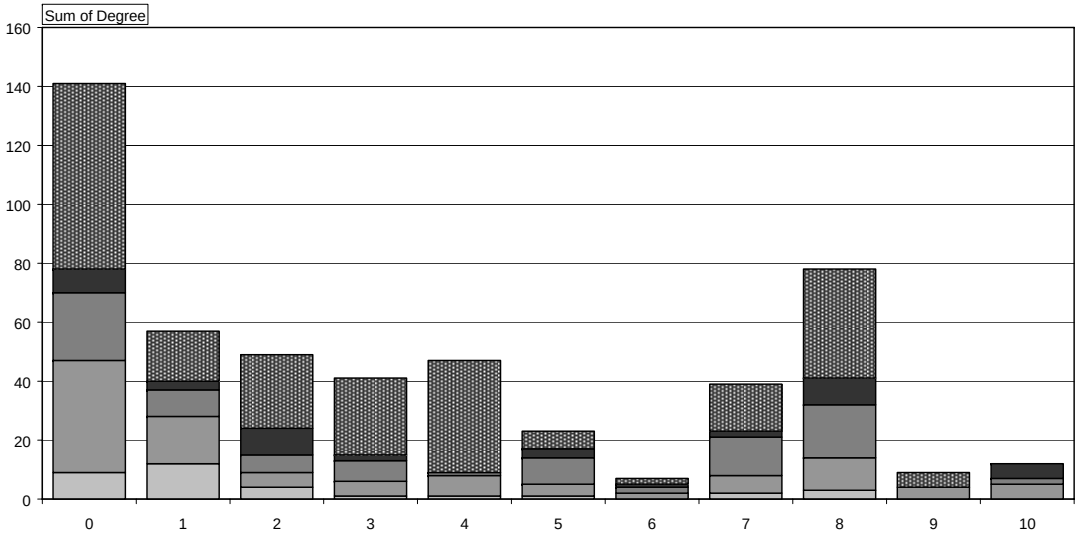
Thus, whilst a central London location may be convenient for the Business Fellows the extent of the catchment area for such events is not clear. Furthermore the effects of journey times on regular attendance, and hence increasing centrality within the network, is of interest both in terms of ensuring maximum attendance and in highlighting abnormal patterns of attendance that may be indicators of geographic factors influencing company locations.



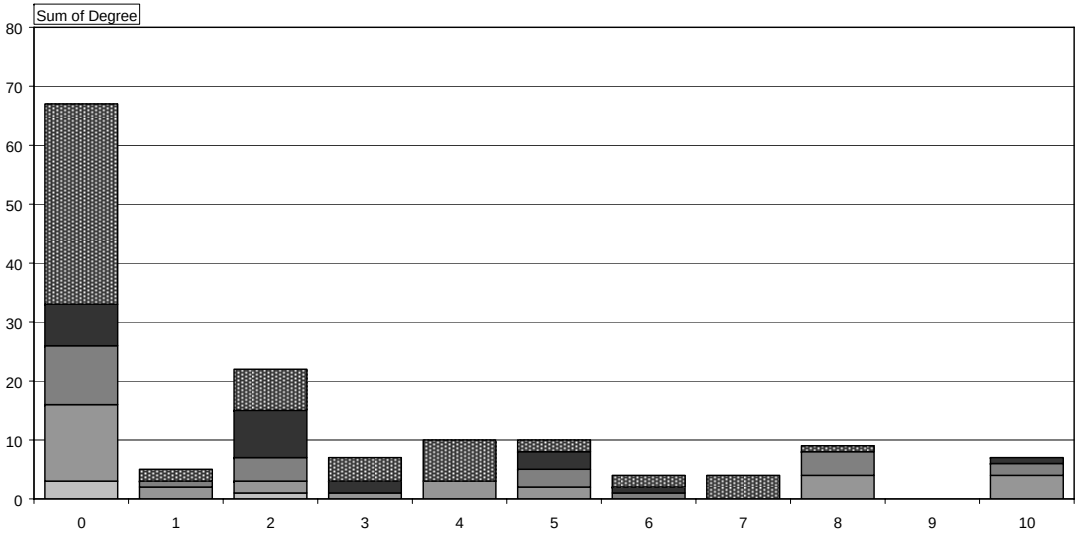
a. Geographic base for all company attendees at LTN events



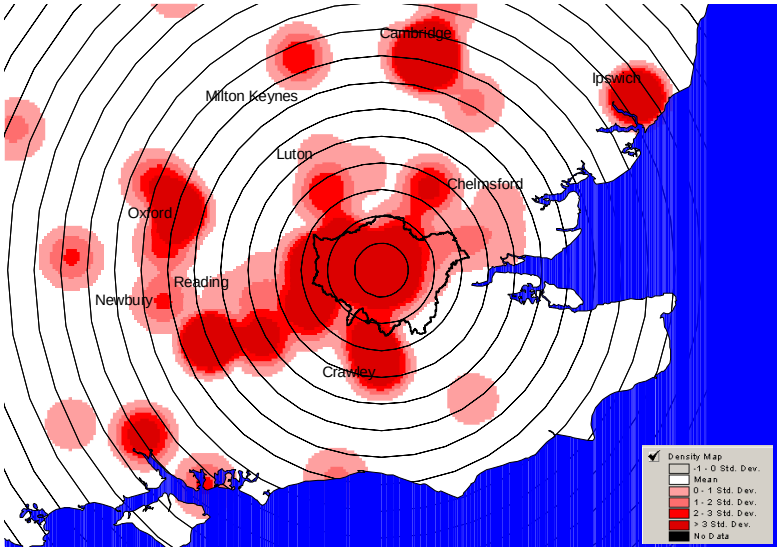
b. Density of Engineering attendees



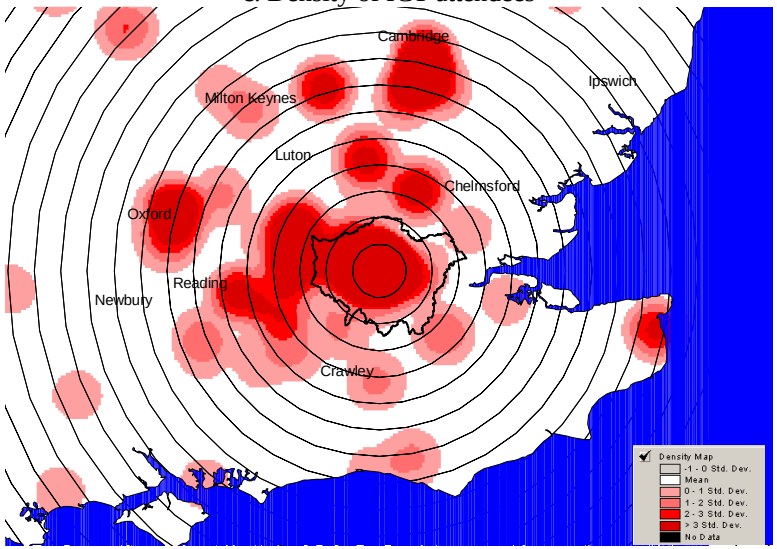
e. Number and category of all attendees (vertical axis) in 10km bands (horizontal axis)



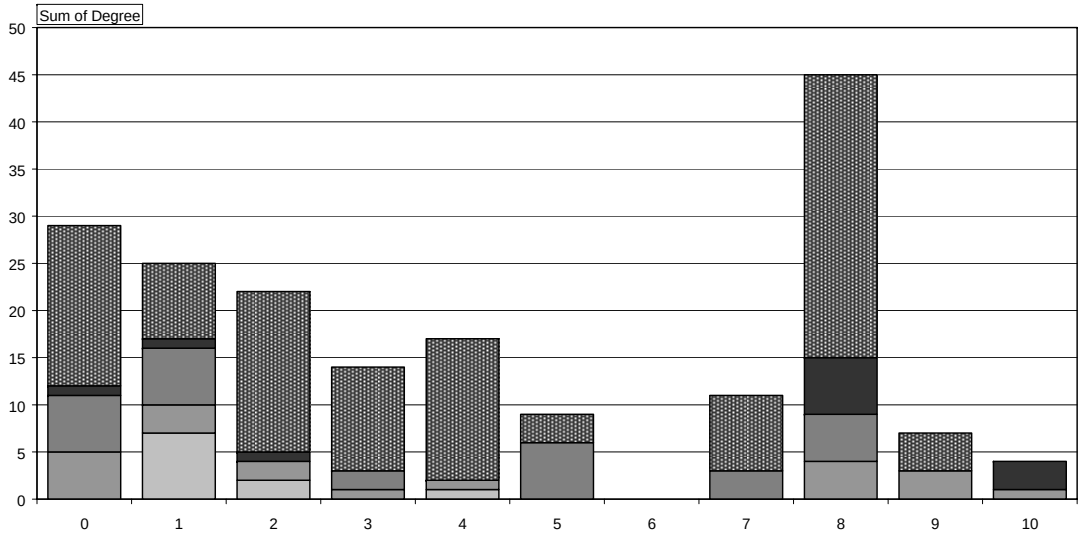
f. Number and category of Engineering attendees (vertical axis) in 10km bands (horizontal axis)



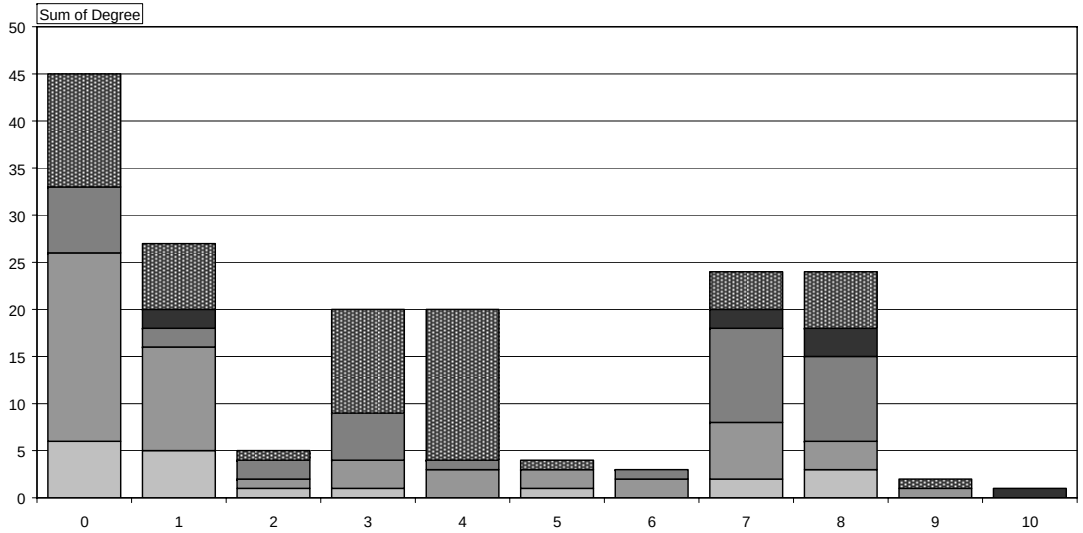
c. Density of ICT attendees



d. Density of Life Science attendees



g. Number and category of ICT attendees (vertical axis) in 10km bands (horizontal axis)



h. Number and category of Engineering (vertical axis) in 10km bands (horizontal axis)

Figure 5 Geography of LTN attendance

In order to investigate these phenomena we have combined the network roles of industrial attendees with their geographic location. This analysis is based upon the full network of business attendees for each faction (including pendants) which have been geocoded through the attendee postcode. Figure 5a. shows the distribution of all factions plotted on a map of the south-east of England centred on London. The circular zones represent buffers centred on London which have been used to count the number of companies located in each 10km annular zone and displayed in Figure 5. a..d show density maps derived by kernel density estimation that present an image of the varying density of business for each faction which have been classified into regions at 1,2 and 3 times the standard deviation of the density surface.

From the histograms of attendance by distance (Figure 5e..h) it is readily apparent that the ICT and Life Science sub-networks draw significantly more business participants for the Oxford and Cambridge region (at a distance of 70-90Km) than the Engineering event and that the majority of the Engineering delegates are drawn from the immediate surroundings of London. A more detailed inspection of participants shows that the proportion of SME attendees (compared with those from national and multinational scale companies) is greater for Life Science than the other factions. When we contrast this with the greater centrality of larger Life Science companies it would seem that these smaller companies are participating less frequently in network events than their counterparts in the other business sectors.

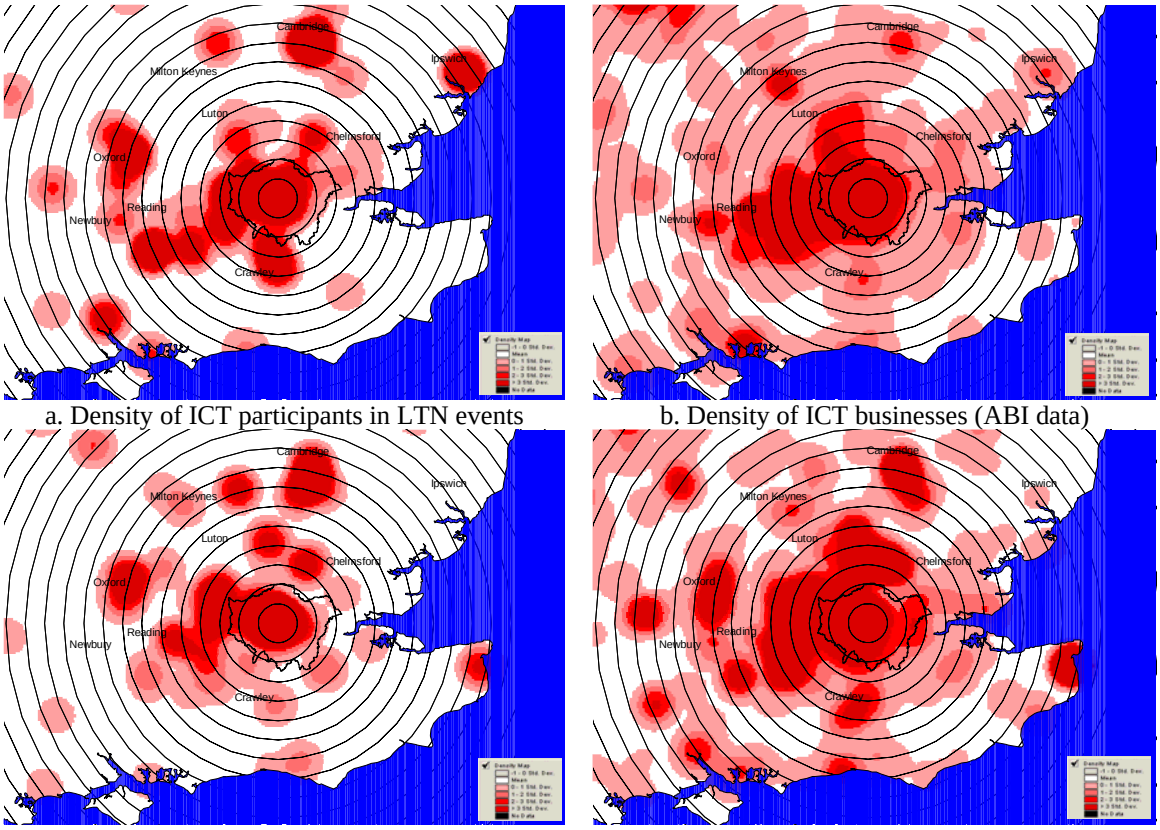
This may be indicative of the greater specialisation of these smaller life science companies - and thus a greater selectivity in attendance at events when compared with larger organisations in the sector or similar sized organisations from other sub-networks. This may indicate that SMEs in the different sectors are using the LTN networks activities for different purposes with Life Science firms focussing on more specific themes whilst ICT and Engineering SME's participate more widely across a broader range of events.

The maps of participation density also suggest some differing patterns of geographic association, between the sectors illustrated in Figure 5 a..d. This is particularly apparent in the regions to the West and North of the Greater London Boundary.

Interestingly, whilst these distributions broadly mirror those derived from more conventional analyses of company distributions based upon annual business inquiry[1] (ABI) data the differences between these data suggest strategies that may help identify clusters of more (or less) entrepreneurial, research active companies. Such analyses may offer addition perspectives possible business clusters which, as Porter (1998) has noted:

> *"… rarely conform to standard industrial classification systems, which fail to capture many important actors and relationships in competition. Thus significant clusters may be obscured or even go unrecognized.'*

[1] http://www.statistics.gov.uk/abi/default.asp Workplace employment estimates for each postcode sector assembled from ABI data based upon a sub-set of 4 digit Standard Industrial Classifications (SIC codes) using a classification scheme developed for a recent LDA business survey (London Development Agency 2003).



a. Density of ICT participants in LTN events

b. Density of ICT businesses (ABI data)

c. Density of Life Science participants in LTN events

d. Density of Life Science businesses (ABI data)

Figure 6 Comparison of LTN networking intensity (a,c) with company density derived from SIC classification of Annual Business Inquiry (b,d)

Conclusions and further research

Access to data from the LTN has given some insight to the appetite for networking activities between academia and industry. Between July and December 2004 outputs from these activities generated over £7 million from network businesses partners. As the data set continues to grow distinctive patterns of network relationships are starting to be revealed.

We hope to continue these initial analyses by combining them with surveys data captured from LTN network members. We also plan to compare and contrast these data other network data relating to university/business interactions including data relating to contract, consultancy and licensing relationships which may, to some extent, derive from such networking activities (see, for example, Figure 7).

Combining detailed attendance profiles at LTN events details and Business Fellow reports on outcomes with such data alongside detailed workplace statistics we believe that this paper shows the potential of these data to reveal further interesting behaviours within the London's complex and rapidly changing innovation networks.

Acknowledgements

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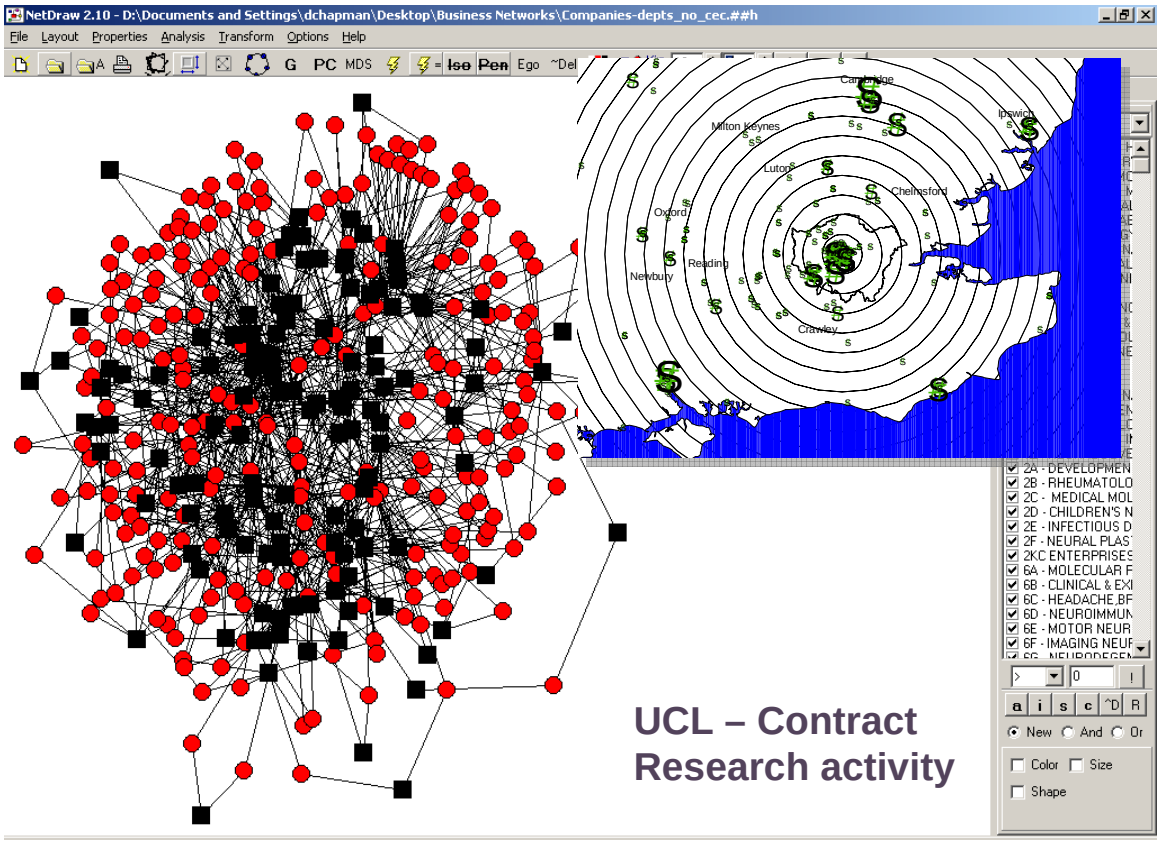

Figure 7 Sociogram of UCL's contract research activity with (inset) corresponding geographic distribution of contracts by value

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