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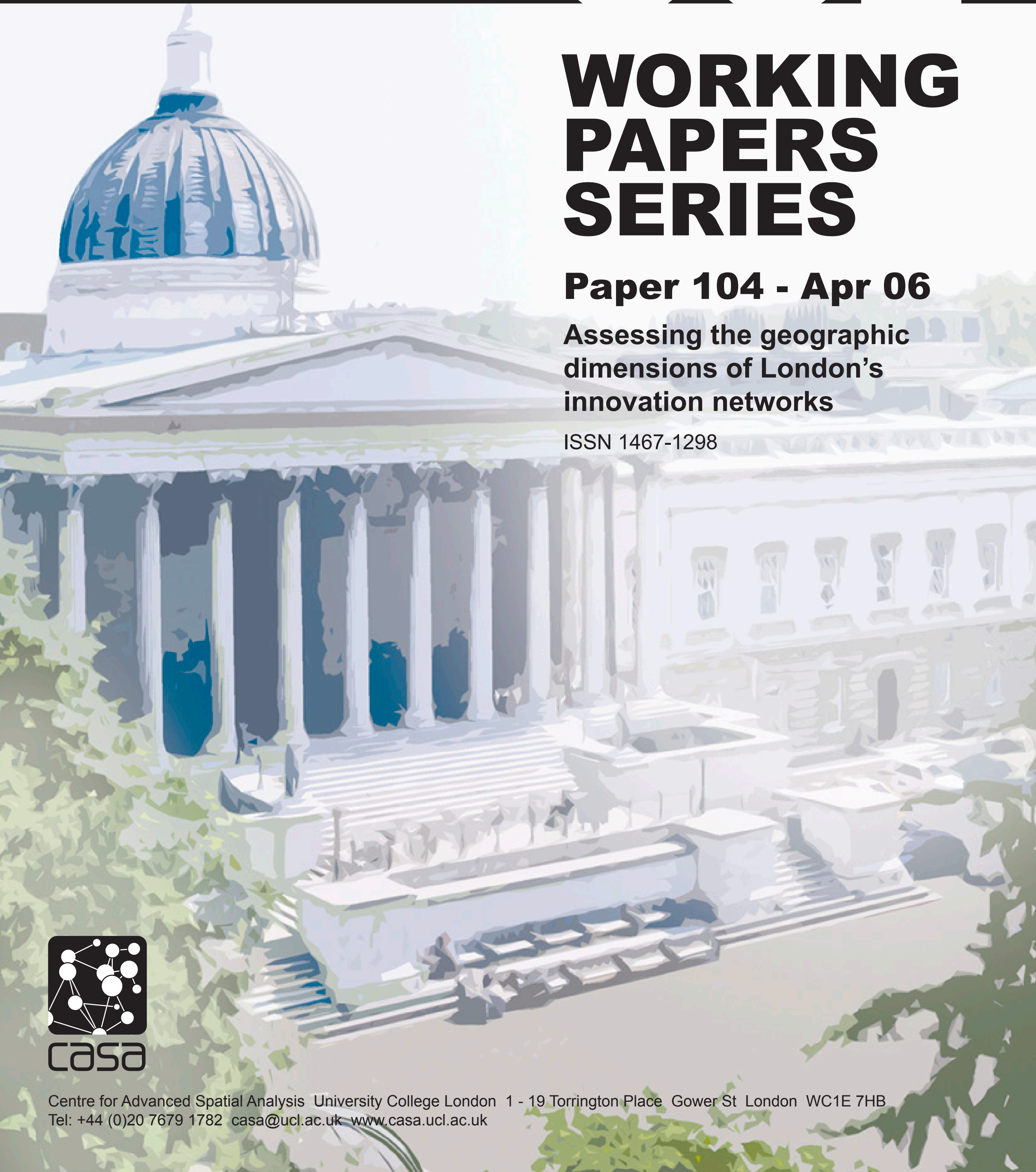

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Assessing the geographic dimensions of London's innovation networks

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Assessing the geographic dimensions of London's innovation networks

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Abstract

A wide range of authors have highlighted the potential benefits for innovation that may arise from effective networking between organisations 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 innovation organisations. Using the detailed data acquired by this network this development paper is intended to investigate the geographic distribution of these activities with the aim of establishing the extent to which location and/or distance play a significant role in participation in the network's activities.

Keywords: Innovation networks, high-tech clusters

1 INTRODUCTION

Today, successful universities are often a defining characteristic of successful places. A wide range of studies have demonstrated the global impact of high-technology clusters centred on well known institutions such as MIT (Shane, 2004), Stanford and, more locally, Cambridge University (see Castells, 2004 for an overview of the *'entrepreneurial university'*).

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 indicators of direct innovation contributions, such as numbers of patents, 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 (particularly those relating to joint university/Industry publications e.g. Bhattacharya & Meyer 2003) along with studies relating to the regional distributions of scientific citations (Batty 2004).

One conclusion of the Government's Lambert Review of UK Business/University interactions (Lambert 2003) was the confirmation that many of the most effective forms on knowledge transfer rely upon human-interactions between the two communities and that sustained interactions will generally favour local or regional scale activities. The value of such local, indirect, impacts is difficult to quantify and frequently remain invisible to the organisations involved. However both formal and informal social networks appear important drivers of business clusters and thus have become the focus of much innovation related policy (e.g. Audretsch & Feldman 1996).

The impacts of, and interactions between, participants in such networks has been most closely documented for universities which dominate the surrounding region - well known UK examples include Oxford (Lawton Smith et.al. 2003) and Cambridge (Myint et.al. 2004). Understanding the interactions between such networks becomes much 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. In seeking to improve the effectiveness of business/university linkages within the uniquely complex London setting this study sets out to analyse the spatial dimension of a major networking initiative the London Technology Network (LTN), and hence give some insight to the determinants of effective network geographies that may inform subsequent innovation networking initiatives.

Access to detailed participation information relating to the LTN allows us to characterise the type and the spatial distribution of organisations seeking to engage with London's science base. This enables us to pose a number of questions relating to both the geographic and social aspects of this network. Whilst this research was originally intended to focuses on the geographical aspects of this activity it has also proved necessary to also consider some of the social aspects of practical operation of the network. Our evaluation focuses on two key aspects of the network operations:

- To what extent is distance important in determining *active participation* in the network?
- Does the geographical distribution of industrial participants support the hypothesis that innovative companies are likely to preferentially locate in geographic clusters?

2 BACKGROUND – INNOVATION ECONOMIES AND R&D STRATEGIES

The creation of business environments that encourage the development of innovative products and services is a key competitive advantage for organisations seeking to establish or maintain a leading position within the knowledge-based global economy.

Chesbrough (2005) bluntly states that 'Companies that don't innovate die'. Arguing that traditional 'closed' models for innovation within corporate laboratories are more suited to sustaining, incremental innovation than to the development of radical new products he sets out a framework for 'Open Innovation'. This model places great emphasis on connectivity between internal & external ideas and paths to market (Chesbrough op.cit. p. xxiv). Presenting a complementary framework Miller and Morris (1999) propose an emerging *4th Generation of R&D* practices that emphasise the benefits of the fusion of knowledge harvested across and along traditional value and supply chains.

A common thread linking these emerging innovation strategies is the importance of the establishment of effective networks that provide conduits for the sharing and capture of explicit and tacit knowledge. This acknowledges the situation that useful knowledge relating to discontinuous innovation is likely to be distributed across companies, competitors, suppliers, universities, national laboratories, industrial consortia and start-up firms. This implies the need for greater engagement and exchange between the research capacity of universities and the communities which they serve. Thus a key question for knowledge-based economies is the extent to which there is a healthy interchange of ideas between university researchers and the organisations that might be best placed to exploit new discoveries.

2.1 INNOVATION NETWORKS AND REGIONAL DEVELOPMENT

The increasing importance for companies to be well connected within appropriate networks has, in turn, lead to ongoing and sometimes heated debate about the importance of geographic location on innovation performance (see, for example, Simmie 2001 Ch 1 or Caniels & Romijn, 2003).

A leading advocate of locational factors as a driver of innovation behaviour is Michael Porter (1998) who sets out the ‘common’ national or regional characteristics that tend to favour innovation alongside ‘cluster-specific’ micro-economic factors that might influence the creation of clusters of co-located enterprises.

Porter has argued that clusters may be initiated either by market actions (e.g. Silicon Valley, Saxenian 1990) or by public intervention (e.g. Austin, Texas, Miller, J, no date). This raises the issues of the extent to which regional development agencies can provide appropriate support mechanisms that encourage the creation of dynamic innovation-led economies - which has led to a number of UK initiatives aimed at identifying, stimulating and supporting cluster-related innovation activity (e.g. Corporation of London 2003).

One of the key hypothesised benefits of local clustering is that the truly innovative, interconnected organisations envisaged by Chesbrough may have difficulty in effectively monopolising the new knowledge that they create or assemble. This may and perhaps should lead to 'knowledge spill-overs' which, given an appropriate innovation framework, may be tapped thorough the creation of small, innovative, risk taking ventures. A key question mark over cluster behaviour is the extent to which geographic proximity is important in facilitating the exchange of new knowledge between organisations and the extent to which *'local knowledge spill over'* favours the creation of local geographic clusters of interrelated business (as opposed to *'long-distance knowledge spill overs'* mediated through face-to-face communications or, increasingly, electronic exchange – see, for example, Simmie 1999 p.37.).

By careful analysis of the effectiveness of the London Technology Network we hope to be able to identify the extent to which geography matters within the context of such activities and the whether the organisations who actively participate show any pattern of collocation within geographic clusters.

3 INNOVATION, UNIVERSITIES, AND LONDON'S INNOVATION ECONOMY

Within the UK there is increased focus on the development of an economy that is capable of initiating and harnessing technology innovation and a range of policy initiatives have been implemented to enhance and extend HE innovation capacity[1] in this area. In addition to national initiatives Regional Development Agencies have been charged with stimulating 'knowledge-based' industries that are able to contribute to the

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[1] Including HEROBaC/HEIF; Science Enterprise Centres;University Challenge Seed funds etc.

formation of regional clusters that will further catalyse university-industry interactions (Porter& Ketels 2003).

In emphasising the importance of regional development and clusters in the knowledge based economy there is an implicit assumption of an underlying geographic framework to such activity. Indeed a recent review of business/university interactions (Lambert 2003) suggests an increasingly territorial role for universities with greater engagement with the local and/or regional economies. However the independent reporting and auditing of Business/University interactions within London's 42 HE institutions means that it is rather difficult to assemble a clear pattern of the regional and subregional impacts of such activities.

4 THE LONDON TECHNOLOGY NETWORK – LINKING TOWN & GOWN?

The London Technology Network (LTN - www.ltnetwork.org) is intended to support 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 faculty members or senior research scientists 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. A central component of LTN’s networking activities are evening lectures and poster displays 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 December 2004, the LTN has organised more than 20 events attended by more than 1200 delegates from universities, industry sectors and government. The LTN has been very active in marketing 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 and offer the potential for the identification of regions which are especially active in such activities.

5 Analysis of participation in LTN events.

Participation data for 20 LTN events were available for analysis within this project (Table 3). These had been categorised by LTN staff into 5 distinct categories and had been marketed accordingly. The categories were:

1 Product Development (177 attendees at 2 events)

2 Information and Communications Technology (ICT, 689 attendees at 7 events)

3 Process Engineering (303 attendees at 3 events)

4 Medicine (554 attendees at 5 events)

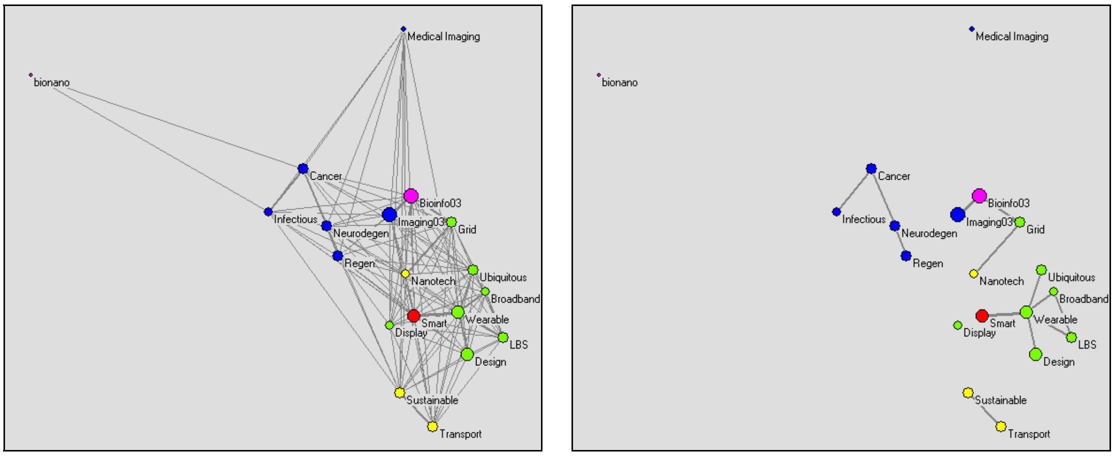
5 BioTechnology (108 attendees at 2 events)

5.1 Testing the categorisation of LTN events through patterns of participation

The overall structure of the LTN activities is arranged into sub-networks of events each representing different “markets” for R&D. In order to test the extent to which each sub-network represents a coherent sub-set of attendees we first examined whether events within sub-networks were attended by a common set of participants – thus offering the potential for repeated and sustained interactions between participants over several events.

To do this we first derive an adjacency matrix in which each cell represents a link between two events and the values represent the number common participants to the two events on both sides of the link. We have visually explored the network through the use of sociograms (Fruchterman & Reingold, 1991; Kamada & Kawai, 1989; Wasserman & Faust 1994), which plots the nodes (i.e. LTN events) closer if they share a high number of common participants.

The results (Figure 1) appear to show the emergence of mixed clusters. This is particularly evident in Figure.1b where links that represent less than 15 common participants are removed. Two mixed clusters are apparent: one with two industry sectors (Product Development and ICT) and one with three sectors (ICT, Process Engineering and Life Sciences). These indicators of cross-disciplinary groupings become significant in the context of subsequent analyses and call into question the classifications applied to the LTN in developing their typology of events and hence potential participants.



a *b*

Figure 1 – Sociograms of the network of LTN events: size = number of participants to each event that also participated to other events, colours = category of event (blue: Medical Technologies; green: ICT; yellow: Process Engineering; pink: Life sciences; red: Product Development). On the left: all links; on the right only links representing more that 15 common participants

5.2 EXAMINING THE NETWORKING ROLES OF ATTENDEES

Using the original sub-network classifications suggested by LTN it is possible to use the participation data to form hypotheses regarding the potential roles of various classes of participants in LTN events. Participant data is categorised into the classes and sub-classes shown in Table 1 with the participation in ICT events for each main group being shown in Figure 2.

Category	**Sub Category**	**Category**	**Sub Category**
Academic	Business. Fellow	Industry	Biotech
	Dept. Head		HiTech
	Faculty		Manufacturing
	Ind. Liaison Off.	Supplier	Consulting
	Management		Contract Research
	Student		Employment
Government	Assoc. or cha		I.T.
	Department		Legal - Finance
	Gov Agency		Marketing
Research Council			Trainer

Table 1 Categories of Participants at LTN events

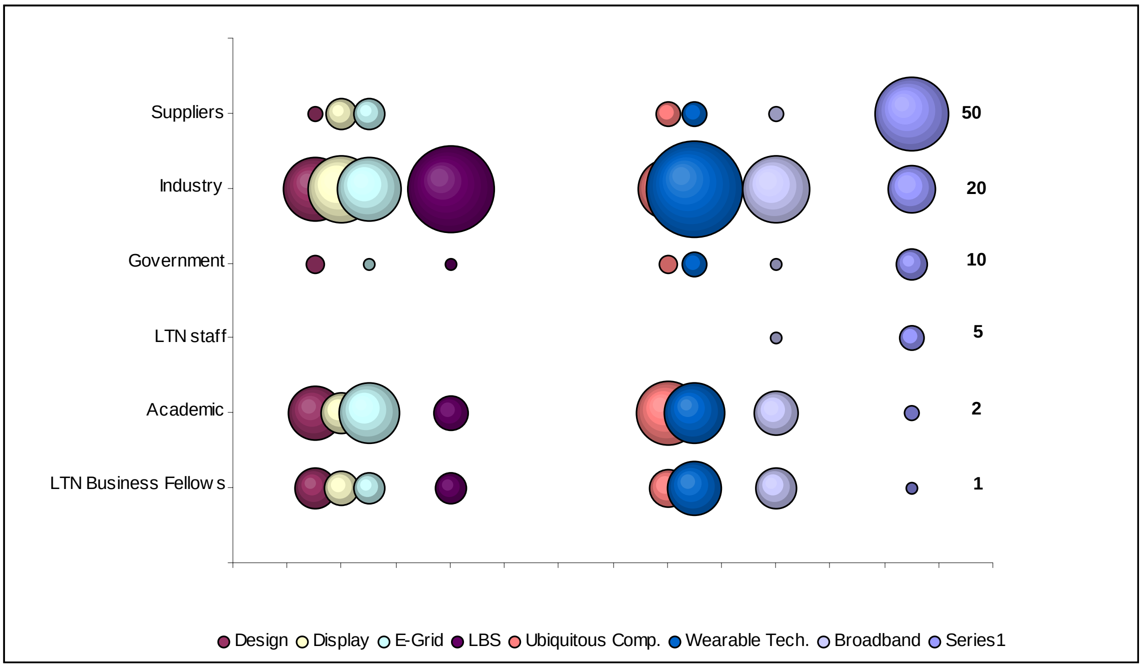


Figure 2 Number of participants in ICT related events

Analysis of patterns of participation and co-participation (Borgatti, 2005; Mizruchi & Potts, 1998; Marsden, 2002) provides us with a set of techniques to reveal the structural properties of the networks generated by the patterns of co-attendance to multiple events. This allows us to test the extent to which LTN business fellows appear to be taking on as broker or gateways roles within the networks by developing the 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 structure and the position influence, or even determine, the behaviour of the actors and the performance of the network. In our case, we hypothesise that the "centrality" of some type of actors, the LTN business fellows, may influence the "networking" behaviour of the other participants and therefore the overall success of the management of the LTN events.

There are several possibilities to measure actors' centrality in a network (Freeman, 1978). Here we have focussed on two: degree centrality[i], which measures the number of direct contacts each participant has with other participants (his/her popularity); and betweenness centrality, which captures the role of "Brokers" or "Bridges" measured as the extent that the participant stands on the path(s) between other pairs of participants in the network. That is, the more people depend on that participant to make connections with others, the more power he/she has.

By computing the aggregate indices of centralisation we can compare the patterns of attendance at different classes of event. For example Table 2 indicates that network of participants to Information and Communication Technologies (ICT) events is sensibly less centralised than the one for Medical Technologies (MT). This can be interpreted as a higher cohesiveness and solidity of the network whereby participants are more connected to each other and less dependent on a single or a few agents.

	Degree centralisation (Connectivity)	Betweenness Centralisation (Brokerage)
ME	0.70890	0.21699
ICT	0.60890	0.18491

Table 2 - Centralisation measures for the two networks

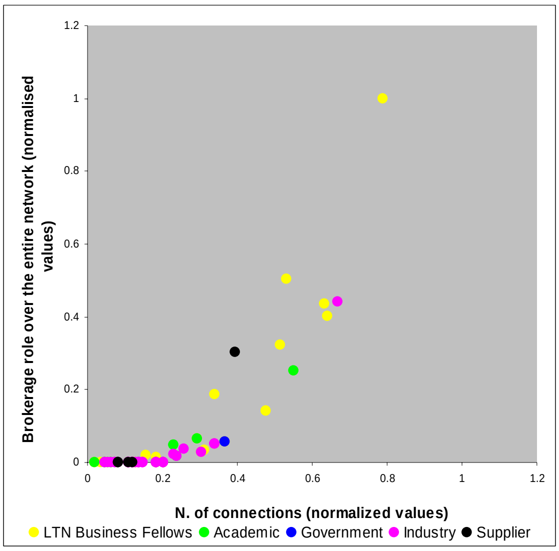
However, we are not only interested in the overall performance of the networks but also in the positions of the different categories of participants. In particular we have analysed the correlations between the two centrality measures implying that a high number of interpersonal exchanges would correspond to a higher brokerage position and that LTN Business Fellows should display high values of both measures.

These hypotheses are confirmed in Figure 3a and 4a. However we can see that in the case of the ICT network other categories of participants, namely industry, supply and academic are positioned at high levels of both centrality measures. This can be interpreted as a positive outcome of the networking activities - with different categories of participants being “dragged” towards the centre of activities. In Figure 3b and 4b the layout of the sociograms puts participants that have shared many events, closer to one another.

In the case of the MT network, no industry participant appears to have significant values for the two measures. This could be due to the nature of the network, where industries play a minor role, or to the marketing activities of the LTN networking events, which fail to raise the attention of industry actors and hence bring them repeatedly to the centre of the networking activities (Figure. 4b).

The different roles of participants within these sub-networks offers much potential for further analyses as the networks mature – in particular it will be interesting to observe the extent to which industrial network partners in the various networks migrate to increasingly central roles.

Information and Communication Technologies



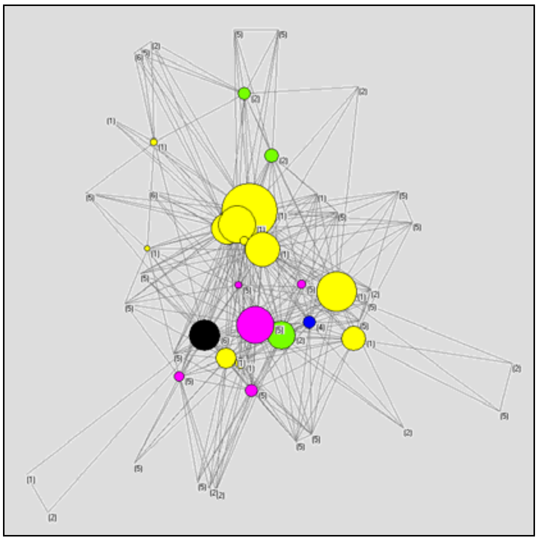
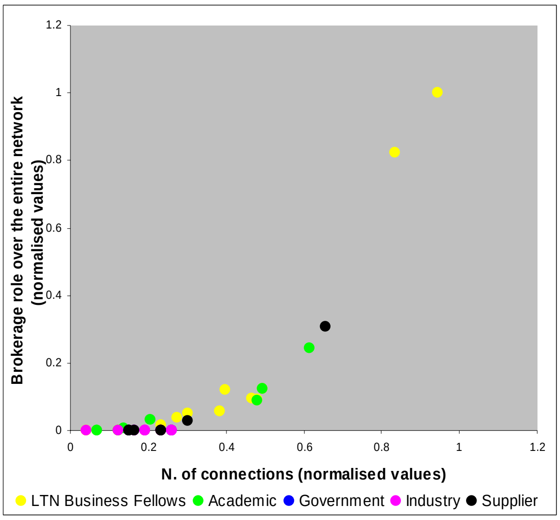


Figure 3a – Correlation between overall brokerage and number of relations (normalised values)

Figure 3b - Sociogram of ICT network (size = brokerage, colour = type of delegate*)*

Medical Technologies



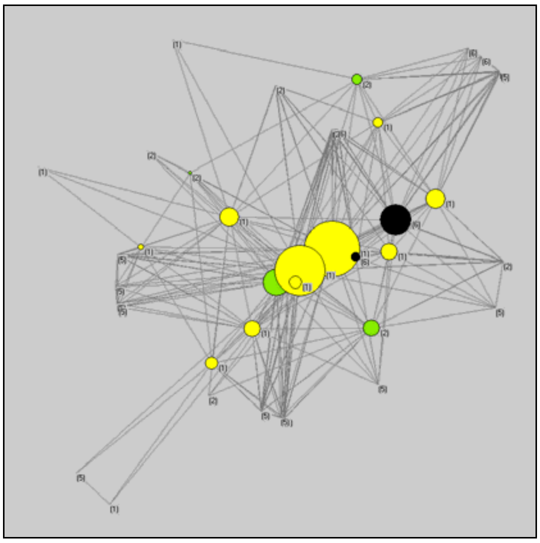


Figure 4a – Correlation between overall brokerage and number of relations (normalised values)

Figure 4b *– Sociogram of MT. Network (size = brokerage , colour = type of delegate)*

6 DOES DISTANCE INFLUENCE PARTICIPATION OF INDUSTRIAL PARTNERS?

The participation networks analysed to date assume that all attendees are equally able to participate in events. One key question is the distance over which networks such as the LTN can be effective in offering a forum for frequent and repeated interactions between its members. The gravitational attraction of high-class events which offer a backdrop for networking between academic and industrial peers may, to some extent, to be offset by the impedance in time and/or cost of travel to such events. 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 it highlighting abnormal patterns of attendance that may be indicators of geographic factors influencing company locations. In order to compare investigate these phenomena we have compared the network role of industrial attendees with factors relating to the relative location of company and event for the sub-group of ICT events.

It is important to note that al LTN events are 'by invitation only' and so before analysing the distribution of network partners we examine the pattern of invitations. LTN staff issue invitations based upon information gained from LTN Fellows, Trade directories and data gathered from publications such as the DTI R&D scorecard. Target organisations are generally medium to large firms active in the sector covered by the event. In order to compare the pattern of invitations with the general population of employees in the ICT sector we have examined their correlation with the total number of employees in the sector as derived from the Office of National Census Annual Business Inquiry[2] (ABI). Workplace employment estimates for each postcode sector have been assembled from these 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).

Comparing aggregate counts of invitations have tabulated and correlated both data sets for sets of 10Km annular rings with corresponding data for ICT employment density sets we find a relatively weak correlation (R2 = 0.67) between these two data sets (Figure 5). In order better to visualise the relationship between invitees and the background ICT population Figure 6 shows the geographic distribution of these two data sets for the area around central London. This map captures the general distribution of both invitees and attendees against a surface representing the density of ICT employment derived from the ABI data. This map suggests some 'hot spots' that have not, to date, been targeted by the LTN but provides empirical confirmation that the general pattern of invitations does correspond to the general distribution of the target workforce.

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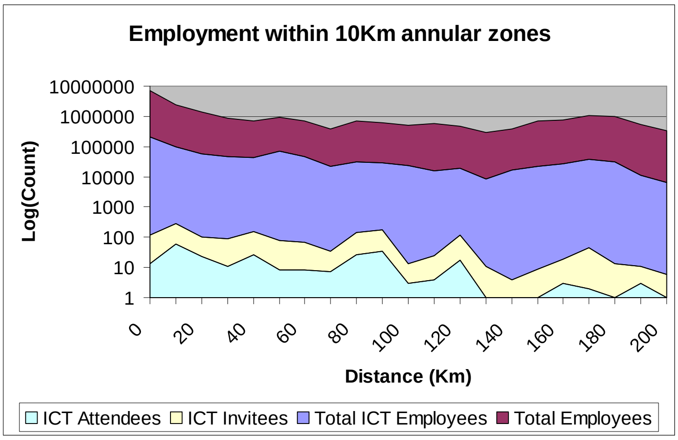
[2] http://www.statistics.gov.uk/abi/default.asp



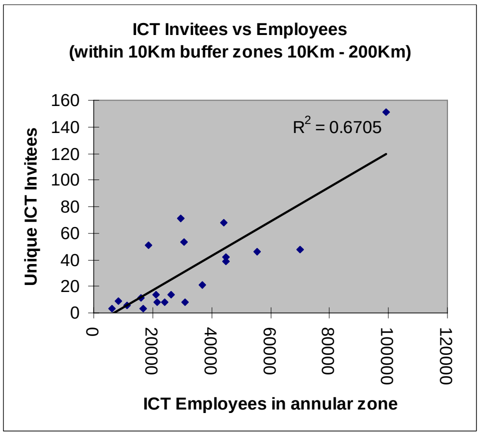


Figure 5 Correlation of invitations to LTN events with ICT employment

Since invitations seem to reflect the general business landscape we adopt the working hypothesis that the invitations sample the general population and focus on the analysis of the variation of acceptances with invitations. Grouping these data by Postcode district we are able to analyse the variation of attendance with invitation and of the ratio of invitees to attendees against a number of independent variables including Euclidean distance, density of ICT employees and derived parameters such as the ICT Location Quotient [3].

The only meaningful relationship that can be established in these analyses is between the number of invitations and the number of attendees – which appears to be relatively consistent over the region under study ($R^2 = 0.7$). The data analyses thus far shows no evidence of the expected relationships between attendance and either distance or the

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[3] There are several strategies available allow for to produce local surfaces that are re-weighted to allow comparisons between different areas. A commonly used method is the computation of a Location Quotient (LQ) which represents a ratio between the employment proportion locally and the national average of this proportion it can be derived from the following formula:

$$LQ_i = (e_i/e)/(E_i/E)$$

Were e_i represents the postcode sector employment in ICT, e the total employment at the postcode sector, E_i employment in ICT for England and E total employment in England.

Location Quotient (Figure 7). Furthermore, as is perhaps obvious from Figure 6, there appears to be no meaningful relationship between the degree of participation in the network (or indeed any other measures of participation) and any measure other than the number of invitations (Figure 8 a-d).

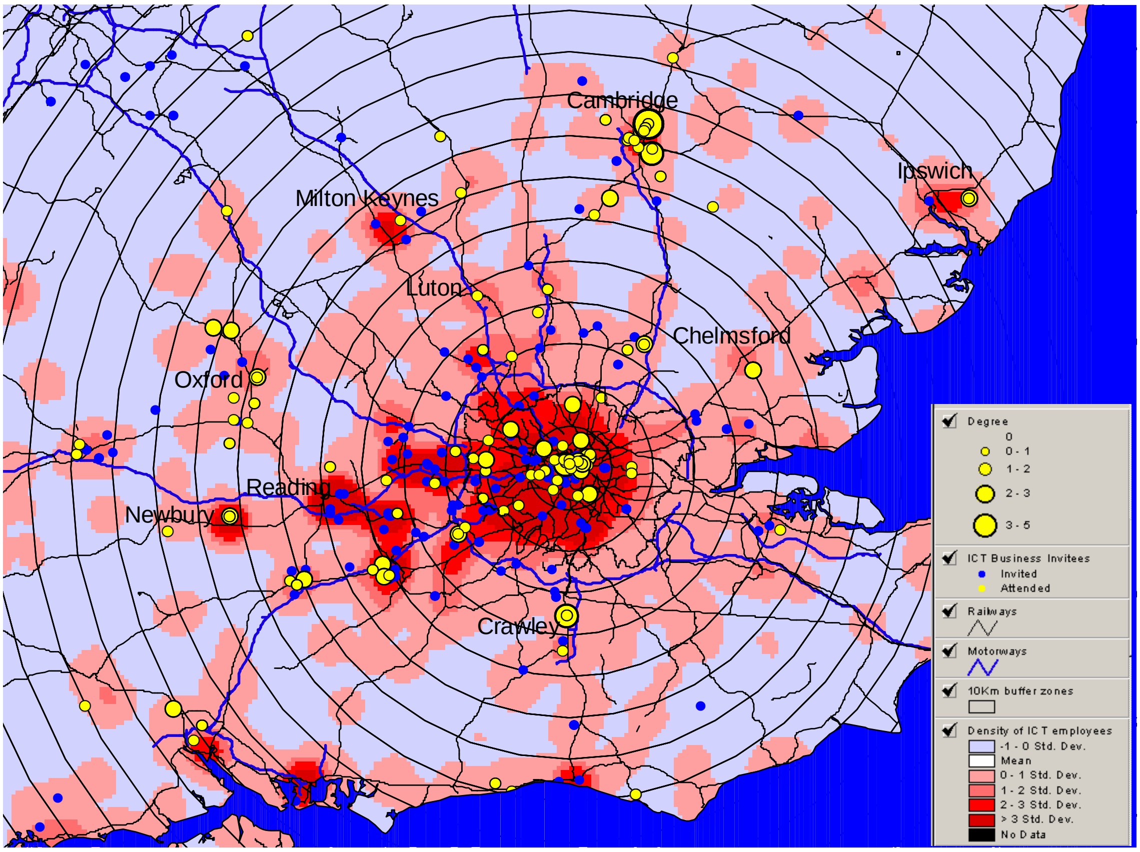
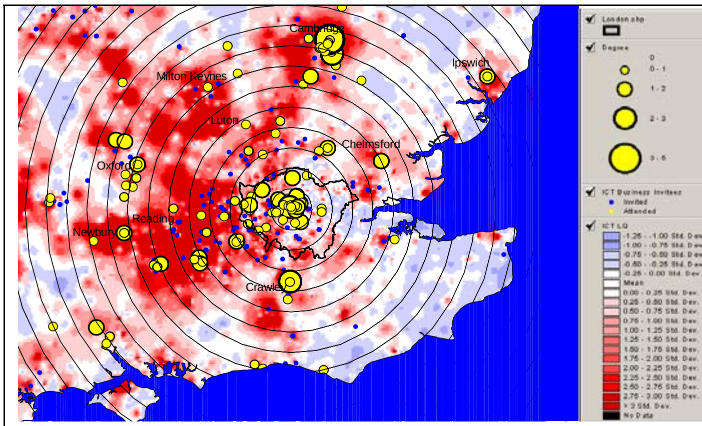


Figure 6 –distribution of LTN invitees and attendees over density surface of ICT employment



The location quotient was calculated for each postcode sector, with the value being assigned to each postcode sector centroid and surface from these centroids interpolated using inverse-distance weighting.

	The resulting surfaces highlight areas which have an industry concentration more suited for serving local needs, versus areas with a proportionally larger base which may be more suited to serving wider national and/or international demand.

Figure 7 – distribution of invitees and attendees over surface representing local ICT Location Quotient

7 CONCLUSIONS

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. However, to date, our spatial analyses of such relationships has added little to our understanding of any geographical factors that influence repeated and sustained network participation. Clearly a more detailed analysis of the impact on travel times (rather than distance) is likely to be required before it is possible characterise relationships in terms of possible spatial clustering. We also anticipate that further analysis of attendee profiles will yield more information of the characteristics of the organisations that are served by the network and we are confident that we may be already be able to use the techniques outlined above to more accurately target and sample potential partners for LTN activities.

However as Porter (1998) has noted:

'Clusters 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.'

Thus we are less confident that further analyses of readily accessible national statistics classified such as the ABI and easily derived measures such as the Location Quotient will, on their own, offer a sufficiently detailed data to fully characterise the geographic distribution of demand for LTN networking activities. Nevertheless, by merging commercial business geodemographic data and by comparing local and global analyses of workplace statistics with detailed attendance profiles at LTN events details we believe that these data may yet starting to reveal interesting aspect of the geographic dimensions of this evolving network.

Acknowledgements

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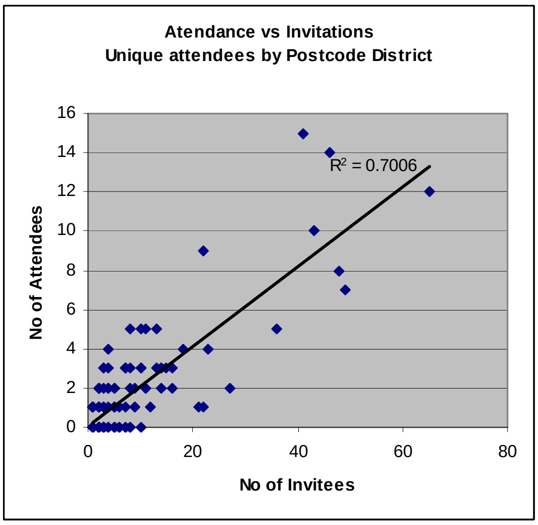

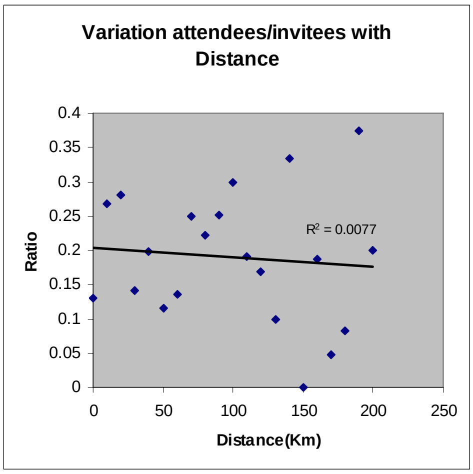

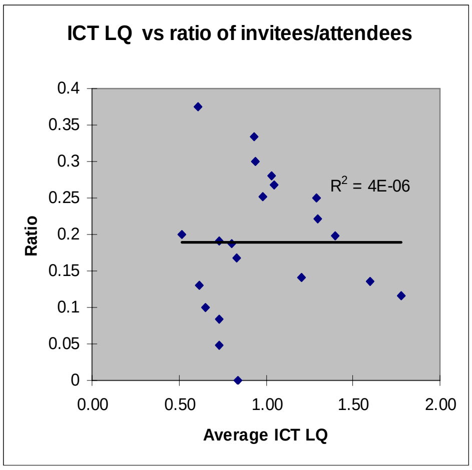

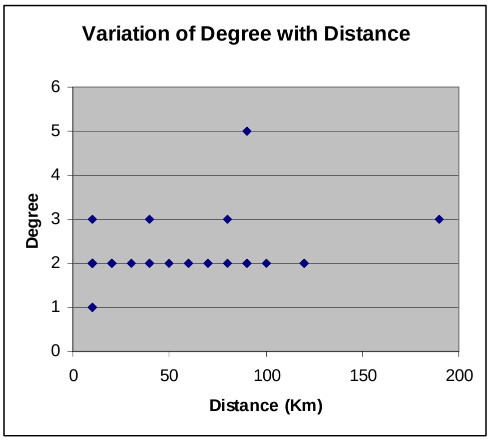

Figure 8 Correlations for various measures of network participation. 7a (top left) Attendance with numbre of invitations, 7b (top right) Ratio of attendees to invitees with distance, 7c (bottom left) Ration of attendees to invites with Location Quotient, 7d (bottom right) Degree of participation with distance.

Date	Code	Event Name	Type	Keyword
19-Feb-03	102	BioInfo	5//Bio	BioInfo
19-Mar-03	103	Imaging (Medical)	4//Medicine	Imaging03
23-Apr-03	104	Tissue Engineering & Regenerative Medicine	4//Medicine	Tissue
21-May-03	105	E-Grid	2//ICT	Grid
25-Jun-03	106	Nanotechnology	3//Process Engineering	Nano
17-Sep-03	107	Electronic Display Technology	2//ICT	Display
15-Oct-03	108	Ubiquitous Computing	2//ICT	Ubiquitous
12-Nov-03	109	Smart Materials	1//Product Development	Smart
10-Dec-03	110	Transport Infrastructure	3//Process Engineering	Transport
21-Jan-04	111	Neurodegenerative therapies	4//Medicine	Neurodegen
18-Feb-04	112	Sustainable energy technologies	3//Process Engineering	Sustainable
17-Mar-04	113	Wearable Technologies	2//ICT	Wearable
21-Apr-04	114	Technologies for security & defence	1//Product Development	Security
19-May-04	115	Onocology	4//Medicine	Cancer

16-Jun-04	116	Integration of design and technology	2//ICT	Design
14-Jul-04	117	Infectious diseases	4//Medicine	Infectious
22-Sep-04	118	Positioning tech & location-based services	2//ICT	LBS
20-Oct-04	119	Medical Imaging & Diagnotics	4//Medicine	Medical Imaging
	120	BioNano	5//Bio	BioNano
1-Dec-04	121	Challenges for Broadband - Enabling the next Killer Application?	2//ICT	Broadband

Table 3 LTN events analysed in this study

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[i] Attendance at events can be described as undirected valued Graph G = (V ;E), where V is the set of nodes (vertices) representing participants, and E is a set of undirected valued edges, where the value of the edge represents the number of direct encounters between participants, the degree centrality of a node *v* corresponds to the cardinality of the vertex set:

$$N(v) = \{ i \in V(G) : (i,v) \in E(G) \} \tag{1}$$

Betweenness centrality can be written as:

$C_B(v) = \sum_{i,j:i\neq j, i\neq v, j\neq v} \frac{g_{ivj}}{g_{ij}}$ where g_{ivj} is the number of paths from *i* to *j* through *v*.

We have also computed network centralisation indices which is the sum of the differences between the most central vertex and all other vertices, normalised by dividing by the maximum possible, which is the value attained by a star network with the same number of vertices. This is summarized by the formula:

$C_G = \frac{\sum [C(p^*) - C(p_i)]}{max \sum [C(p^*) - C(p_i)]}$ where C_G is the centralisation of the network *G* and *C* is any centrality measure. Values of C_G range from 0 to 1.