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Metropolitan Telecommunication

Uneven Telegraphic Connectivity in 19th-Century London

Roland Wenzlhuemer
University of Heidelberg

Although the United Kingdom has long lost its position at the heart of a practically global empire, the British capital London still continues to stand at the very center of a global telecommunication and information network. Yet, global connectivity is not evenly distributed throughout the metropolis. As recent studies show, information-dependent businesses tend to concentrate in particular quarters in and around the City of London and the West End despite the spatial flexibility that modern telecommunication technology allows for. This study seeks to demonstrate how the modern ''digital divide'' that rips through London continuously evolved from similarly uneven connectivity patterns in the telegraphic network of late 19th-century London. With the help of historical Geographic Information Systems (GIS), these patterns will be visualized. This examination will show how important a role continuity played in the evolution of modern informational patterns and how this sheds new light on issues of technological dynamism and agency.

Keywords: *telegraph; telecommunication; London; information age; networks; social network analysis*

Within less than two decades after the Second World War, economic turmoil and rapid decolonization had relegated the remains of the formerly world-spanning British Empire to a position of only secondary importance in world politics and economy. Among other examples, the episode of the so-called Suez crisis stands testimony for the massive loss of power and influence that the British Empire had gone through in the decades before. In 1962, Dean Acheson summarized the UK geopolitical position in the early 1960s as having ''lost an Empire but not yet found a role.'' In addition, another phrase that has been used every so often to characterize British political and economic demeanor ever since is the catchy line ''punching above its weight.'' Both catchphrases refer to the fact that the United Kingdom no longer stood at the center of a global empire and has long lost superpower status. However accurate such a diagnosis might be, there remains little doubt that the United Kingdom has indeed lost much of its global centrality to competing players in North America and Asia since the end of the Second World War.

author's Note: Please address correspondence to Roland Wenzlhuemer, Cluster of Excellence ''Asia and Europe in a Global Context,'' University of Heidelberg; e-mail: wenzlhuemer@asia-europe.uni-heidelberg.de.

Interestingly, however, this loss of influence and centrality does not apply at all to the position of the country's capital in the global economic and informational structure. Quite the contrary: while the United Kingdom as a whole occupies an important but not a leading position in global politics and economy, London still finds itself at the very center of the world's financial and business networks. Several recent studies confirm this. A survey focusing on the number of available internet providers, for instance, shows that London was the best-connected of all evaluated European cities in the year 2004, followed closely only by Frankfurt am Main in Germany. The map that accompanies the survey data clearly illustrates that London occupies a pivotal place in the European communication network, while geographically it is located rather at the fringes of the surveyed territory (Telegeography, 2006). Another study, conducted by researchers from Loughborough University's Global and World Cities study group, goes even further than that and claims that London has been the world's best-connected place in both the years 2000 and 2004. Although a significant shift of positions in the lower ranks of the evaluated cities can be observed, the top six cities (London, followed by New York, Hong Kong, Paris, Tokyo, and Singapore) have been able to maintain their positions in the period of observation (Taylor & Aranya, 2006a). Although Taylor and Aranya also show that in both a global and a national context other cities feature higher connectivity growth rates than London (Taylor & Aranya, 2006b), the British metropolis still enjoys a comfortable lead in the competition for global connectivity. A recent study by the geographer and sociologist Lars Meier on the perceptions of German bankers living and working in London confirms these findings and shows that the British capital is—at least in the world of banking and finances—still seen as ''the navel of the world'' (Meier, 2007, p. 123).

However, this high rate of national and international connectivity is not evenly distributed throughout the British capital. Unsurprisingly, London features a large internal integration gap between the best and the worst connected parts of the city. Again, it has been the Global and World Cities study group who has tried to identify current clusters of connectivity in London (Cook, Pandit, Beaverstock, Taylor, & Pain, 2007). Connectivity here is represented by the clustering of financial and related services throughout the metropolis. Based on an impressive empirical survey, the authors found that the financial and related services in contemporary London feature extraordinarily pronounced concentrations in a number of small municipal locations. A look at the ''Atlas of Economic Clusters in London''—which among other publications sprang from the study—shows that banks, for instance, tend to concentrate in two specific spots, in parts of the West End and in the City of London. The latter is a preferred location for most other evaluated business branches as well and emerges as the unrivalled core of financial and related services in London (Walker & Taylor, 2003). Although the distribution of such business clusters is only a secondary indicator for the overall connectivity of a particular place, it is, at this time, the best measure that we have as it implicates that businesses that depend on fast and ready information access see all their requirements satisfied within these clusters.

Having established the existence of such a communicative integration gap within the British capital, it is the historian's obvious task to ask: How come? Or in more elaborate words: Is this particular aspect of the often-cited ''digital divide'' a product of the ''digital'' or ''information revolution'' starting somewhere in the 1960s or 1970s? Or does it build on an earlier uneven development in terms of global network connectivity? Can we identify similarities and differences when we compare modern communication and connectivity structures with their 19th-century forerunners and can we, thus, learn more about the respective roles of continuity and discontinuity in this context? If so, this might shed more light on the tender relationship between technology and society and fuel the still unresolved discussion on the historical agency of technologies.

Interestingly, Meier's interviews with German bankers in the City of London hint at the importance of historical centrality in the interviewees' perception of London as the ''navel of the world,'' but the conclusions we can draw from this remain few and very tentative (Meier, 2007, p. 122). To offer a few more substantial answers to the above questions, I would like to reconstruct the network and connectivity structure of London in the middle of the 19th century. A thorough analysis of the evolving pattern will then allow us to find out whether the current inequalities do have historical predecessors. The exact time of observation lies in the year 1868 and has been determined entirely by the availability of sources. In the year 1870, all domestic telegraph companies in Great Britain were nationalized and came under the control of the General Post Office (GPO). In preparation of this gigantic merger, the GPO conducted a survey two years earlier to learn more about the telegraph traffic handled by the individual private companies. Only with accurate information in hand could the GPO later decide which offices to close, merge, or enlarge. To the historian, this is a rare stroke of luck and provides statistical data on most of the telegraph bureaus existing in Britain in the year 1868. Although some of the material on the smaller companies has been compiled and filed without much care by the surveyors and, thus, is often incomplete or full of mistakes and contradictions, at least the surveys on the two biggest companies in the field—the *Electric & International Telegraph Company* and the *British & Irish Magnetic Telegraph Company*—are of astonishing accuracy and exhaustiveness. Together these two companies handled about 77.8% of the total inland messages transacted in the year of observation (POST 82/173). Information collection on the third biggest competitor—the *United Kingdom Electric Telegraph Company*—seems to have been slightly less thorough, but nevertheless the available data is reasonably good. The three companies together handled more than 90% of the total inland traffic (POST 82/173), and therefore, their data allows me to reconstruct a fairly complete and accurate pattern of the 19th-century telegraph network in and around London.

The data available from the survey falls into two categories: ''usage'' data on the actual number of messages sent, received, or transmitted at a particular telegraph bureau as well as ''structural'' data on the position of a particular station in the domestic telegraph circuits of Britain. The former has been put into relation with census data on registration district sizes and inhabitants taken from the 1871 population census, while the latter has been prepared and processed with social network analysis software to provide us with different measures on the centrality of a particular node (or place) in the metropolitan communication network of the year 1868. The most important findings from both categories have then been visualized with the help of freeware Geographic Information Systems (GIS) software such as MapWindow GIS (MapWindow Team, 2007) and fGIS (Brown, 2005). Historical registration district border sets and census information for the year 1871 have been used in all figures courtesy of EDINA UKBORDERS.[1]

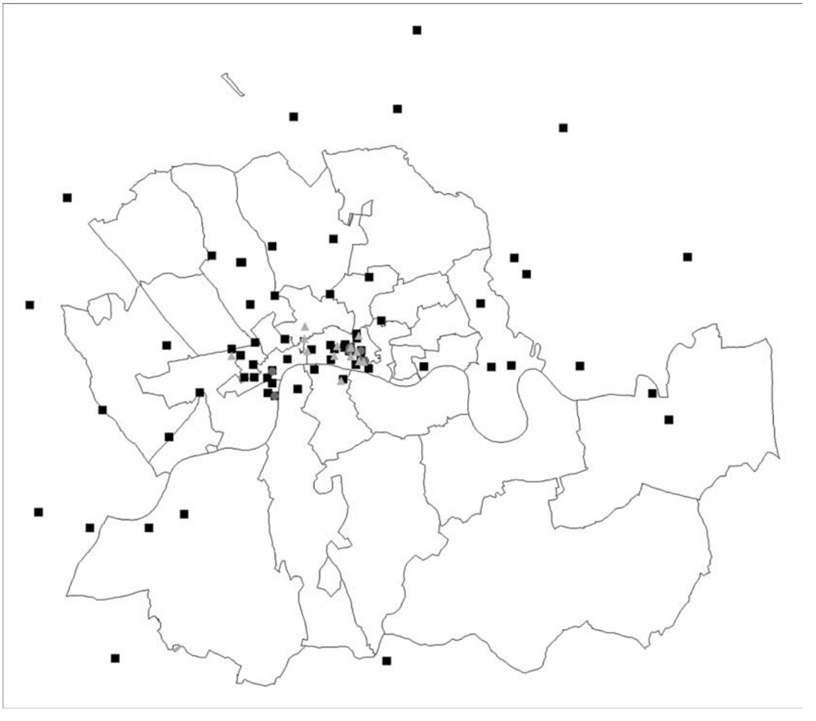
Use Patterns

The results of the domestic telegraph survey are currently held at the British Telecom Group archives at High Holborn in London. Information on the market leader *Electric* (and the railway companies associated with it) is the most comprehensive and fills five thick volumes of evaluation sheets alone (POST 81/51-81/55). The traffic of the *Magnetic* has also been collected in detail and has been bound in two volumes (POST 81/12-81/13). Information on the *UK* is less abundant and is stored in a single volume (POST 81/77). Unless otherwise stated, all traffic and circuit data used in this text has been taken from these files. All the so-called circuit returns cover the entire United Kingdom, but for this study, only the stations labeled as ''metropolitan'' have been taken into account. For the *Electric* company and its railway associates, this amounts to 70 bureaus. The *Magnetic* features nine and the *UK* 13 metropolitan stations, respectively, arriving at a grand total of 92 London telegraph bureaus covered. In addition, as we will see in the section on structural network patterns, nonmetropolitan stations in direct contact with a metropolitan station have been considered in the network analysis to allow for outside connectivity.

Figure 1 shows the spatial distribution of all 92 evaluated telegraph stations within the metropolitan region. *Electric* stations are depicted as black rectangles, *Magnetic* stations as circles (in a dark grey shade), and *UK* stations as triangles (in a lighter shade of grey). The registration districts of the census year 1871 do not strictly correspond with the metropolitan selection criteria of the GPO survey, and therefore, some of the stations are outside the London district boundaries. Figure 1 clearly highlights the concentration of telegraph stations in and around the central and West End districts—especially in the City of London, the Strand, and Westminster. The distribution pattern is so dense here that symbols overlap and a more detailed perspective becomes necessary. Figure 2, therefore, presents a more detailed look at these central districts. More than a third of all metropolitan stations—31 of 92—are located in the City of London, but neighboring districts like the Strand or Westminster also feature a comparatively high density of bureaus. The intersecting outlines in Figure 2 indicate that in some instances bureaus from different companies can be found at the same place and, therefore, overlap in our representation. This is particularly true in the neighborhood of the key financial institutions in and around the City of London and especially near, for instance, the Stock Exchange or other goods exchanges and trading places.

However, Figure 2 does not merely indicate the evaluated stations' geographical position. It also depicts information on the telegraphic traffic handled by these stations. With the rare exception of government-run and strategically important stations—such as the Admiralty or the War Office—the GPO survey provides us with accurate information on telegraphic messages sent, received, or transmitted at each evaluated telegraph station. These figures refer to weekly averages. Therefore, very accurate station masters at very small and sparsely frequented bureaus might sometimes even give fractions below one message per week as the average number of messages handled. Within London, the *London & North Western Railway* station at Camden has been such a case. Other stations, however, handled messages in the thousands or—in the exceptional case of the *Electric* headquarter at Central—even more than 35,000 messages per week. Central is identified in Figure 2 by the large black rectangle dominating the City of London. The *Magnetic* headquarter at Threadneedle Street (handling more

Figure 1
Distribution of *Electric, Magnetic,* and *UK* Metropolitan Telegraph Stations in the Year 1868



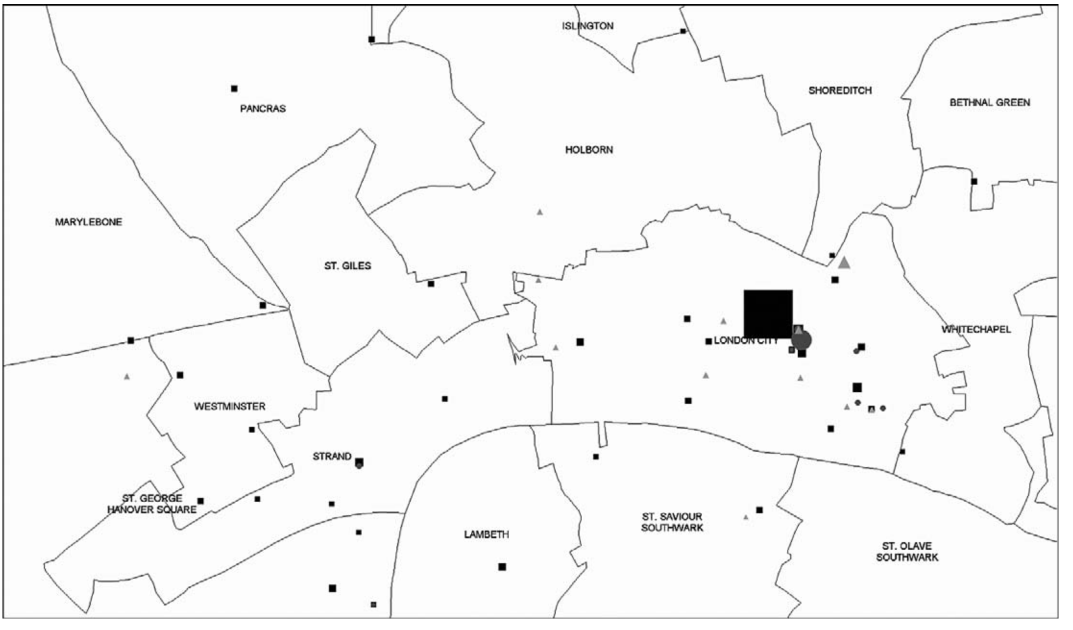
Sources: Data from General Post Office (GPO) survey; border sets from EDINA UKBORDERS.

than 12,000 messages per week) and the *UK* headquarter at Gresham House (more than 5,000) are represented by the big circle to the lower right of Central and the triangle near the border between the city and Shoreditch respectively. All stations have been arranged in a 10-step scale starting with 1 and ending with 40,000 handled messages. The size of the symbol accordingly refers to the amount of traffic handled.

Figure 2 clearly illustrates that the headquarters enjoy an exceptional lead in the amount of traffic handled. Central processed almost 10 times the traffic of the second busiest *Electric* station at Stock Exchange which still handled 3,790 messages per week. The same applies to a lesser extent to the headquarter stations at Threadneedle Street and Gresham House. This is our first indicator for the extremely pronounced centralization of the company networks in London (and, in fact, the entire United Kingdom) in the mid-19th and late 19th century. Central, for instance, processed more than half of the entire telegraph traffic of the *Electric* in London—and the same pattern can be seen in the *Magnetic* and *UK* networks. Several other stations in the financial and administrative districts of London handled a significant amount of telegrams as well—as can be seen in Figure 2—but none came close to the headquarters.

Those served as the prime relay stations for traffic in the networks but did not produce much traffic themselves as a closer look at the usage statistics reveals. Total traffic numbers

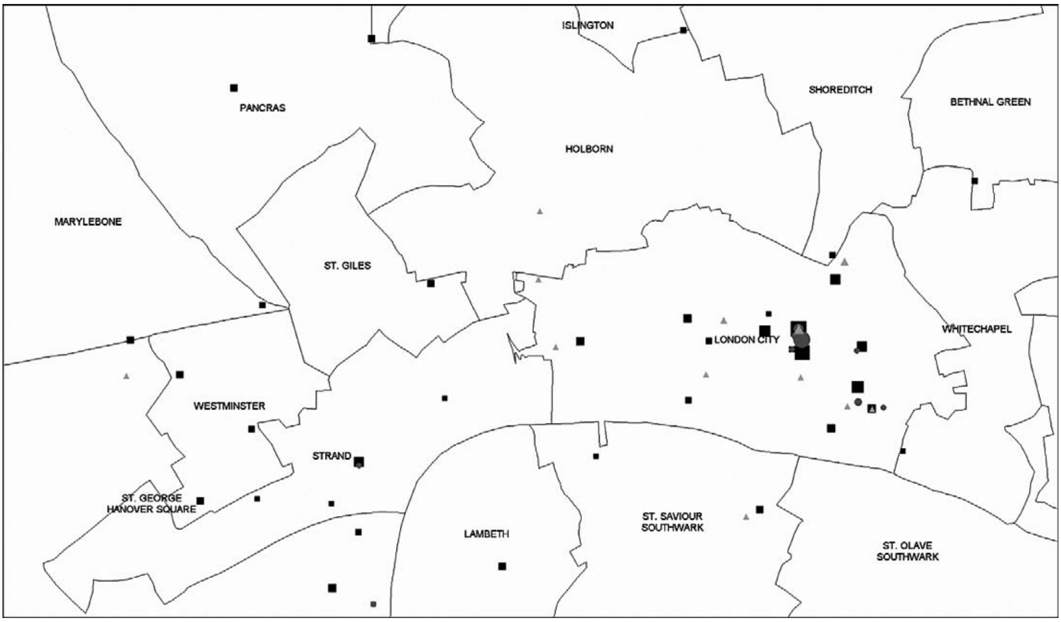
Figure 2
Traffic Handled at *Electric, Magnetic,* and *UK* Metropolitan Telegraph Stations in the Year 1868



Sources: Data from General Post Office (GPO) survey; border sets from EDINA UKBORDERS. Representation: 10-step scale; values from 1 to 40,000.

(Figures 3, 4, and 5) have been split into three different categories: messages forwarded, received, and transmitted. The size of the station symbols in Figure 3 refers to the number of messages forwarded, that is originating, at a particular station. Clearly Central does not generate much traffic at all. Most inner-city bureaus somehow contribute to the forward traffic, but a certain focus can be made out around the Stock Exchange and the key financial area. Figure 4 on messages received per week shows a completely different picture. Again, the main relay stations dominate the scene and serve as the principal terminal stations from which telegrams are dispatched to the addressee per messenger. The symbol sizes (Figures 3 and 4) can be directly compared as they are all arranged in a 10-step scale starting with 1 and ending with 10,000. Figure 5 employs a slightly different 10-step scale from 1 to 26,000 and depicts the number of messages transmitted, that is passed on to a different destination, at a station. Here, we see that only a handful of stations were in a position to transmit messages at all. Among those, the headquarters handled by far the biggest share of transmitted telegrams. If we want to directly compare Figures 3 and 4 with Figure 5, the symbols in the latter must be enlarged by the factor 2.6 to adjust for the difference in scale. A more accurate comparison can be drawn if we look at Table 1, which displays all metropolitan bureaus handling more than 1,000 weekly messages. The relative data in the table shows that Central, Threadneedle Street, and Gresham House were, indeed, mainly relay stations occupied with transmitting telegrams. In the case of Central, 73% of the traffic belonged to that

Figure 3
Messages Forwarded at *Electric, Magnetic,* and *UK* Metropolitan Telegraph Stations in the Year 1868

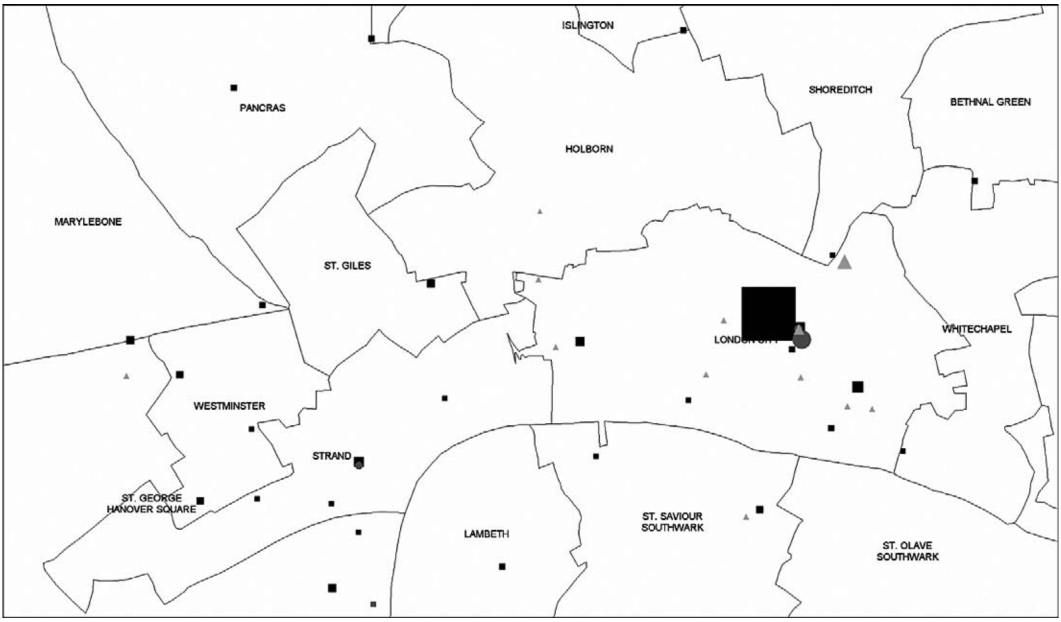


Sources: Data from General Post Office (GPO) survey; border sets from EDINA UKBORDERS. Representation: 10-step scale; values from 1 to 10,000.

category, while not a single telegram originated from the place. The picture is very different for the big bureaus at the exchanges or important markets. They rarely transmit at all (the *Electric* Stock Exchange being a slight exception) but forward and receive messages in roughly equal shares. This further supports the point that the 19th-century telegraph network in and around London was very strongly centralized and relied on only a handful (one for each company) primary switches that controlled and relayed the telegraphic traffic. We will come back to this point in the section on the structural pattern of the London telegraph network.

Before doing so, however, we should zoom out again and try to put the apparent concentration of information services in the city and the West End districts in a wider perspective. How does the traffic produced and handled in London relate to population figures? Does a per-head perspective cushion the inner-city bias of the telegraph traffic or will we end up with an even more pronounced integration gap? Figure 6 contains some answers to these questions. The number and corresponding color of the districts reflects the number of weekly messages handled per 10,000 inhabitants. Resembling our earlier results, most of the outer (and some of the East End) districts feature extremely low figures in the region of zero or slightly above, while the West End districts reach values in the hundreds. The Strand easily leads the table here with 359 weekly messages handled per 10,000 inhabitants. This further supports our earlier findings as to the existence of a massive ‘‘pre-digital’’

Figure 4
Messages Received at *Electric, Magnetic,* and *UK* Metropolitan Telegraph Stations in the Year 1868



Sources: Data from General Post Office (GPO) survey; border sets from EDINA UKBORDERS. Representation: 10-step scale; values from 1 to 10,000.

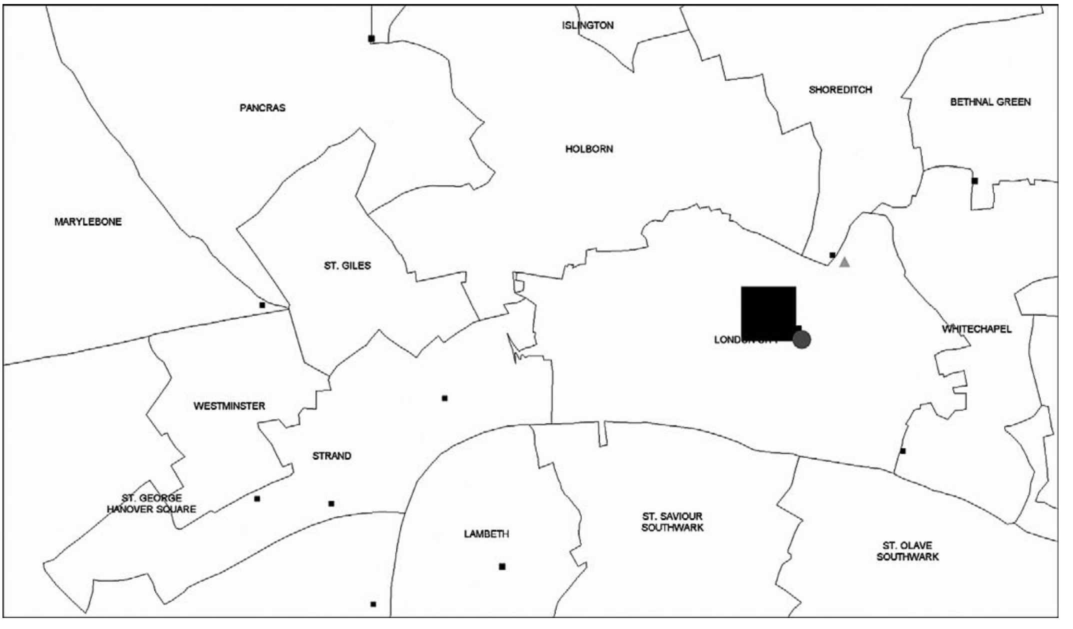
divide ripping through 19th-century London. But what about the City of London colored in black and not contained in the regular scale of the figure? The city has been excluded from the regular scale because its figures would have completely distorted the color scheme. It reaches a traffic density of 9,726 weekly messages per 10,000 heads and, therefore, bursts any reasonable scale as this is more than 25 times the value of the Strand.

This is a clear indicator for the fact that by far the biggest share of telegraph traffic in the 19th century was business-related or business-generated. Information-critical businesses such as banks, exchanges, merchant houses, or the media were located in and around the city and produced the lion's share of messages. The general population—as evaluated by the per-head measure—did not participate significantly in telegraphic communication and produced only a fraction of the total traffic. The disproportionate concentration of telecommunication flows on the inner-city districts appears to be even more pronounced when put into relation with population figures.

Structural Patterns

As already pointed out, the GPO survey of 1868 also contains information on the physical structure of the British telegraph network. Accordingly, we know which stations were

Figure 5
Messages Transmitted at *Electric, Magnetic,* and *UK* Metropolitan Telegraph Stations in the Year 1868



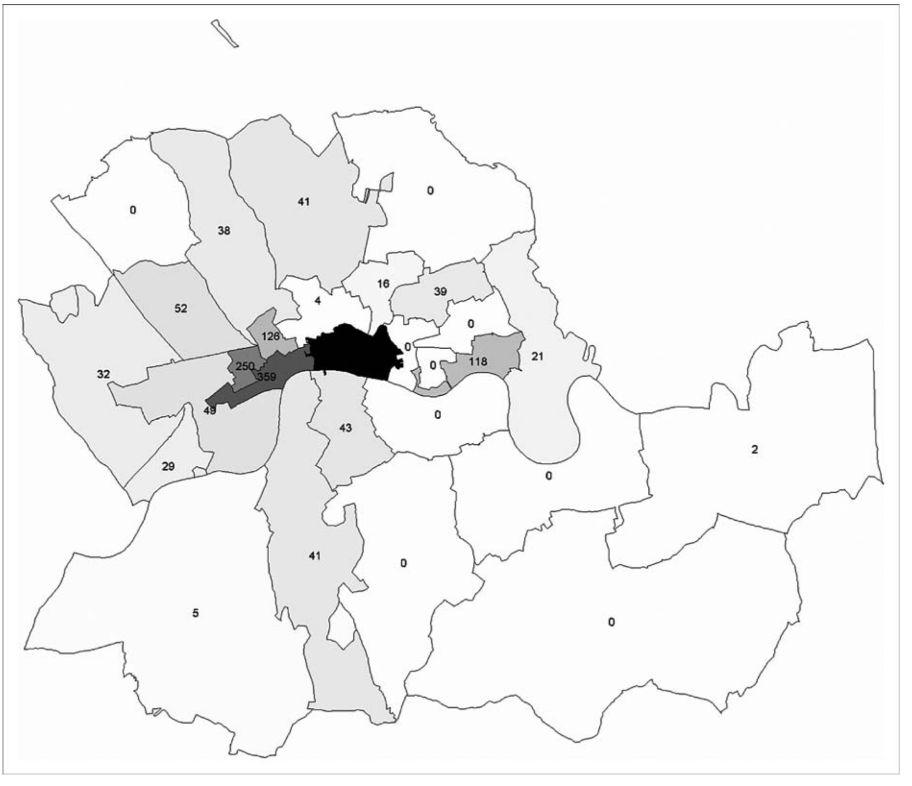
Sources: Data from General Post Office (GPO) survey; border sets from EDINA UKBORDERS. Representation: 10-step scale; values from 1 to 26,000.

Table 1
Messages Handled at *Electric, Magnetic*, and *UK* Metropolitan Telegraph Stations With More Than 1,000 Weekly Messages in the Year 1868

		Forwarded		Received		Transmitted		Total
Station	Company	Absolute	Relative (%)	Absolute	Relative (%)	Absolute	Relative (%)	Absolute
Central	*Electric*	0	0	9,598	27	25,599	73	35,197
Cornhill	*Electric*	1,749	100	0	0	0	0	1,749
Fleet Street	*Electric*	529	47	585	53	0	0	1,114
Lothbury	*Electric*	1,134	100	0	0	0	0	1,134
Mincing Lane	*Electric*	1,265	53	1,111	47	0	0	2,376
Stock Exchange	*Electric*	1,956	52	1,517	40	317	8	3,790
Strand	*Electric*	945	53	8,24	47	0	0	1,769
Stock Exchange	*Magnetic*	1,010	62	611	38	0	0	1,621
Threadneedle Street	*Magnetic*	2,417	20	2,780	23	7,066	58	12,263
Stock Exchange	*UK*	932	48	1,028	52	0	0	1,960
Gresham House	*UK*	579	11	1,876	35	2,855	54	5,330

Note: General Post Office (GPO) survey; border sets from EDINA UKBORDERS.

Figure 6
Messages per 10,000 Inhabitants in London Registration Districts in the Year 1868



Sources: Data from General Post Office (GPO) Survey; border sets from EDINA UKBORDERS. Representation: 10-step scale; values from 0 to 400; City of London excluded from regular scale.

on which circuits, how many direct connections existed between two network nodes, and what kind of telegraph apparatus was used on a particular line. This information allows us to reconstruct the actual paths and connections of the network and thus sheds more light on the varying functions of the individual network nodes. To this end, the circuit information from the survey has been torn apart and reassembled—the results of which can be seen in Figure 7. In addition, the connection data have been processed with the help of social network analysis software (Borgatti, Everett, and Freeman, 2002) to provide us with in-depth information on the centrality and functions of certain nodes.

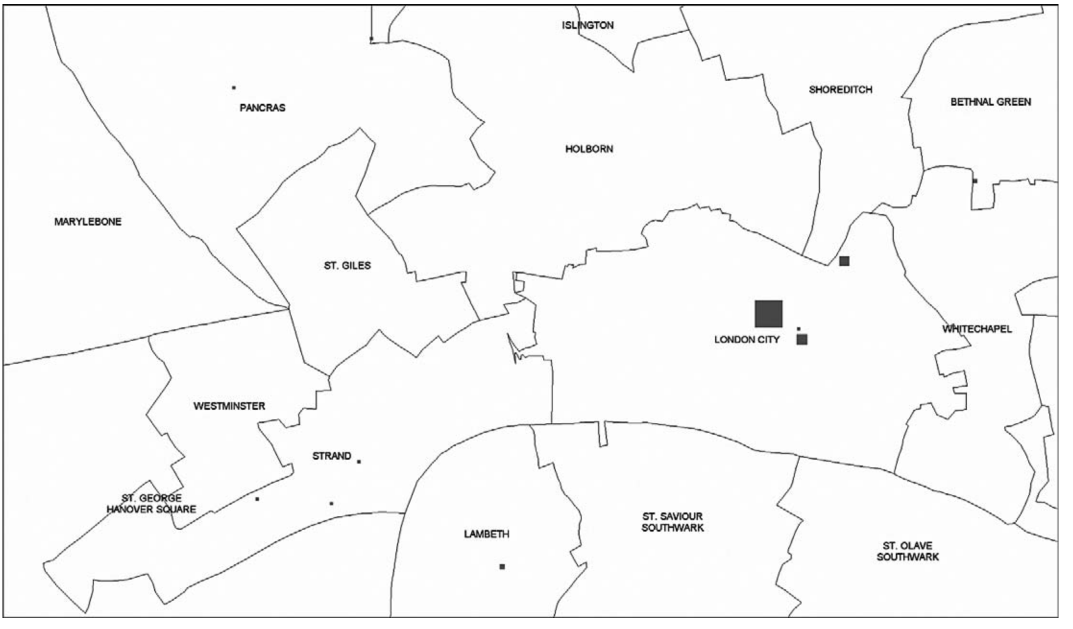
Figure 7 spatially focuses on central London and visualizes the pathways of telegraphic connections between individual bureaus. The *Electric* network is colored black, the *Magnetic* dark grey, and the *UK* light grey. The thickness of the lines refers to the number of telegraph wires existing between two nodes. As can clearly be seen, all three networks center on their respective headquarter that serves as the prime link between all other nodes. Cross-connections between such noncentral nodes are extremely rare and the headquarter occupies an absolutely crucial position as a switch and relay station. The network could not function without its center.

Figure 7
***Electric, Magnetic,* and *UK* Metropolitan Connections in the Year 1868**

Sources: Data from General Post Office (GPO) survey; border sets from EDINA UKBORDERS. Representation: 20-step scale; values from 0 to 20.

The results from the social network analysis confirm this. The connection data extracted from the GPO survey has been symmetrized and analyzed with the help of four different centrality measures: Freeman *degree, farness/closeness, betweenness*, and Bonacich *eigenvector*.[2] The most interesting results in our context were produced by the *closeness* and *betweenness* measures. The former is the reciprocal value of farness which, in turn, is the sum of all connections it takes for a node to reach each and every other node in the network. The *closeness* value, therefore, informs us about the reachability of a node. The higher the value, the easier a particular station can be contacted. Although important stations such as Central (63) or Threadneedle Street (46) do indeed feature higher *closeness* values, their lead against other stations is not very pronounced. Most metropolitan stations exhibit values between 30 and 40 in this category. This indicates that the metropolitan communication network was tightly woven in the 19th century and almost all telegraph stations were relatively easy to reach from all other places. The *betweenness* measure, however, can tell us more about the routes such contacts would have to take. It shows how often the shortest connection between two nodes passes through the evaluated node and, therefore, indicates where a certain node is positioned in terms of the actual flow of information in the network. As can be seen from Figure 8, the results differ significantly from the relatively evenly distributed *closeness* values. A normalized *betweenness* value has been used here that puts absolute values in relation to a maximum of 100%. All stations with normalized values over 0.1 have been included in the figure—and yet many inner-city stations would not pass that threshold

Figure 8
Normalized Betweenness of *Electric, Magnetic,* and *UK* Metropolitan Stations in the Year 1868



Sources: Data from General Post Office (GPO) survey; border sets from EDINA UKBORDERS. Representation: 10-step scale; values from 0.1 to 100.

as they were not located on a bigger circuit. The three headquarter stations almost exclusively serve as intermediaries and switches for the telegraphic flow as can be seen from their dominant size in Figure 8. This further emphasizes the structural reliance on single central stations in all three evaluated networks. Almost all traffic between two nodes passed through the main station once. Without this giant switch, effective communication within the network would have been impossible. Both the structural as well as the usage data support this point.

Conclusion

For once, it seems that the historical data available are more sophisticated than the indicators we have as to the current connectivity pattern of London. Although we can work with a number of secondary indicators for the informational centrality of certain quarters in the metropolis, the 19th-century domestic telegraph survey that informs much of this study provides us with a wealth of details to which we have no current equivalent—at least at the time being. The results of both the indirect indicators of, for instance, the Atlas of Economic Clusters (Walker & Taylor, 2003) as well as the historical analysis show a very similar picture. The metropolis is and has for a long time been informationally divided. Although we see a concentration of information-critical businesses and trades in and around the city and the West End today, the same communicational inequality is repeated by both the usage and the structural data from the 19th-century survey. With some assistance from the West End, the City of London stands at the absolute center of the British telegraph network and acts as the prime switch and relay of the communication flow. Districts outside this core hardly participated at all in telegraphic communication.

The example discussed in this text provides at least four worthwhile clues to historians interested in the relation and interplay between technology and society. First, it emphasizes the influence of continuity and persistence in the history of telecommunication. Second, it adds fuel to the suggestion that even vibrant information technology can unfold as a conserving rather than a dynamizing social force. Third, it puts the still widespread notion into perspective that certain technologies have agency of their own and have a shaping impact on their carrier societies. Eventually, the example of the ''digitally divided'' metropolis also serves as a reminder to current initiatives that informational or knowledge gaps will not be successfully closed by simply installing information technology.

The uneven distribution of local and global connectivity established in the 19th century has clearly perpetuated itself in the current informational divide that rips through London and, thus, exhibits a remarkable influence of historical continuity and technological path-dependence (David, 1985; 2007) in an area which is usually viewed as highly dynamic and largely without history. When the domestic telegraph system started to catch on and expand in the mid-19th century, the City of London and its neighboring districts provided the best (and for some time the only) customers of the new service. The telegraph companies' attention accordingly focused on these areas and technological as well as financial incentives reinforced the effect. London's inner districts developed into the first telecommunication center and, thereby, attracted more information-dependent businesses. Instead of making alternative locations informationally accessible and attractive, the established informational structure perpetuated itself due to several independent factors—one of which is a certain in-built trajectory of infrastructure-based technologies. As most technological change is, indeed, incremental, technological advances are usually implemented in a step-by-step fashion. This means that a new technology often uses parts of the same infrastructure, the acknowledged rights-of-way, the trained personnel, and the existing technological subsystems of the preceding system. Therefore, sudden changes in network patterns occur only rarely. Accordingly, economic or sociological studies of modern information technologies should not ignore the historical roots behind current informational patterns. If we treat the information society as having no history prior to the so-called information revolution of the 1960s and 1970s, we deprive ourselves of the opportunity to fully understand the forces that shape information networks and flow patterns.

In this context, the example discussed also suggests that information technology can develop a preserving instead of a dynamizing character. Although the UK position in world politics and economy underwent dramatic changes during the 20th century, London and its financial districts managed to remain at the center of global financial flows until today. Strong connections and established structures that had for a long time been in place in and around the City of London unfolded a considerable conserving potential in this regard. The availability of a working and strongly centralized telecommunication network must be counted among such preserving factors.

This leads us to our third observation and supports the point that technology in general and information technology in particular has no historical agency of its own—as is still often propagated by advocates of what is usually called ''technological determinism.'' Technological systems are governed by a certain logic or a specific rationale which can be different from technology to technology. To offer only one example, infrastructure-dependent technologies—as pointed out above—often have a strong in-built continuity and can, therefore, become preserving factors in a changing world. Yet, this is by no means a sign of independent agency, but rather a specific way of reacting to socioeconomic or cultural cues. Technologies, thus, have a number of qualities but usually no agency. They only react and do not create. This explains, among other things, how global and local informational connectivity patterns have changed only marginally during the last century, despite the fact that information technology has become cheap, widely available, and easy to use. Fourth and finally, this responding character of (information) technology places serious constraints on all those initiatives that seek to bridge the global digital divide mainly by shipping laptops to developing countries. They ascribe a transformative power to telecommunication technology, which it surely does not have. Although the installation of an informational infrastructure can at a later stage provide valuable tools and opportunities, development initiatives must first and foremost tackle social and economic issues—as agency rests within people whereas technology can only serve as an instrument.

Notes

1. This work is based on data provided through EDINA UKBORDERS with the support of the ESRC and JISC and uses boundary material which is copyright of the Great Britain Historic GIS Project, Portsmouth University.

2. Due to the sheer amount of information contained in the GPO survey and the time it will take to compile, clean, and reassemble all this data, this social network analysis worked only with the metropolitan stations and stations in direct telegraphic contact with those. This means that links beyond these stations have been artificially truncated for reasons of manageability. In the worst case, this can distort the results of the analysis as important gatekeeper functions or other structural characteristics might not be fully weighted. This study's exclusive interest in metropolitan connectivity, however, will cushion much of this effect and keep the potential distortion to a minimum.

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Roland Wenzlhuemer has studied modern history and communication studies and earned a doctoral degree in history at Salzburg University in 2002. In 2003, he joined the Centre for Modern Oriental Studies in Berlin and then moved on to the Centre for British Studies, Humboldt-Universitaet zu Berlin, where he worked as lecturer and researcher in British History from 2005 to 2008. Roland recently joined the Cluster of Excellence ''Asia and Europe in a Global Context'' at the University of Heidelberg, where he currently leads a research group on ''Asymmetries in Cultural Information Flows.'' His research interests lie mainly within colonial history, telecommunications history, and especially wherever there are touching points between the two. He can be contacted at wenzlhuemer@asia-europe.uni-heidelberg.de.