Research Note

Mapping the Field of Virtual Work: A Cocitation Analysis

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Interest in the area of virtual work continues to increase with articles being written from different disciplinary perspectives—e.g., information systems (IS), management, psychology, and transportation. In this paper, we map research on virtual work to (a) understand the intellectual base from which this field has emerged, (b) explore how this field has evolved over time, and (c) identify clusters of research themes that have emerged over time and the relationships between them. Specifically, we use cocitation analysis of research published in all social science disciplines to map the field at three points in time—1995, 2000, and 2006. Our results show that the field has grown from 9 research clusters in 1995 to 16 in 2006. A comparison across these maps suggests that research in the cluster of “virtual teams” has gained significance even as research in some earlier clusters such as “urban planning and transportation” has lost ground. Our longitudinal analysis identifies relevant concepts, theories, and methodologies that have emerged in the field of virtual work. This analysis can help interested researchers identify how they may want to contribute to the field of virtual work—by adding to popular clusters, by enriching emerging smaller clusters, or by acting as bridges across clusters.

Key words: virtual work; virtual teams; bibliometric analysis

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With advances in information technology, “virtual work” in the form of global virtual teams, telecommuting, and distributed work is now being embraced by most organizations (The Telework Advisory Group 2007). Reasons for its growing popularity range from productivity gains that can be realized from such a work mode to an ability to harness talent that lies distributed across time and space (Gajendran and Harrison 2007, Raghuram et al. 2001). Consequently, it is not surprising that academicians from disciplines as diverse as information systems (IS), management, psychology, and transportation have become interested in researching this new work form.

How can we tap into the insights that these diverse literatures have to offer? Unfortunately, this is not a straightforward task. Given its multifaceted nature, there are several meanings associated with the term “virtual work.” For instance, terms such as computer-mediated work, telecommuting, and distributed work all have a bearing on our understanding of this new work mode. Given this proliferation of terms, it is difficult to identify the connections across the different contributions and to take full advantage of the accumulated knowledge.

To address these issues, we use IS tools to conduct a bibliometric study to map the field of virtual work. This approach allows us to uncover underlying connections between the contributions on virtual work from different disciplines. Scientific research is a social activity with researchers building on the efforts and
insights of many (Karuga et al. 2007, Oh et al. 2006). The mapping process that we apply in this paper to study the field of virtual work is premised on such an understanding. Specifically, we use cocitation analysis to (a) understand the intellectual base from which this field has emerged, (b) explore how this field has evolved over time, and (c) identify clusters of research themes that have emerged over time and the relationships between them.

The approach that we have used and the outcome of our analysis is of value to those directly engaged in the area of virtual work. By understanding the genesis of the field and where it has reached as of today, such a map helps us find fruitful avenues for future research. At the same time, the method that we use here can be applied to study other important areas in IS, complementing other methods that have been used to track a field.

1. Background

1.1. Virtual Work Reviews

With advances in information technologies, individuals are no longer constrained by time and space. It is therefore not surprising that virtual work has grown along with advances in technologies such as broadband communication (which allows for easy transmission of data) and groupware (which enables decision making and problem solving from distributed locations). Correspondingly, researchers from different disciplines have become interested in examining this new work mode and the body of literature in this area has grown significantly. This may be an opportune time for both academicians and practitioners to take stock of the developments in this growing field to determine future courses of action.

To conduct such a review, several methodologies such as meta-analysis, descriptive review, and bibliometric approaches can be used. Insights from science and technology studies suggest that the methods that we use critically shape our understanding of a field and our subsequent research (Latour and Woolgar 1979). Each method is “a way of seeing and a way of not seeing” (Poggie 1965, p. 284), and for this reason we briefly review meta-analysis and descriptive reviews as approaches that can be used to review a field before proceeding to offer greater details about cocitation analysis.

1.1.1. Meta-Analysis. Meta-analysis is an approach designed to statistically summarize the relationships found to be significant between variables across multiple studies so as to arrive at an overall estimate of the coefficients involved (Gajendran and Harrison 2007). To conduct a meta-analysis, researchers access both published and unpublished large sample studies (i.e., no case studies or theoretical articles are included). Typically, a meta-analysis requires that the researchers choose the articles to be included based on the specific relationships that they would like to explore.

Different studies may have used different participant samples, methodologies, and measures, and a meta-analysis aggregates all these findings into one overall finding (Cooper 2003). This is both its strength and its weakness. By bringing together various findings into one study, it provides researchers with a “bird’s eye view” of some of the more robust relationships between sets of predictors and outcomes that have been found in the literature. For instance, Gajendran and Harrison’s (2007) recent meta-analysis of 46 studies on virtual work identified perceived autonomy of individuals as an important variable that mediates the relationship between virtual work and beneficial outcomes such as job satisfaction, performance, and turnover. At the same time, however, such a macroperspective is often gained at the expense of the microprocesses constituting the phenomenon including the specific context of each study.

1.1.2. Descriptive Literature Review. In contrast to meta-analysis, with a descriptive literature review, researchers can more readily include case studies, field studies, and theoretical articles. With such an approach, researchers access and read relevant articles to summarize findings, often guided by an overall framework. For instance, in a review of virtual work, Baruch (2001) summarized the definition, antecedents (such as information technology and employee and employer willingness), and outcomes (such as benefits and shortcomings) of virtual work. In a similar vein, Fjermestad and Hiltz (2000) reviewed 79 papers on group support systems and categorized the methodology and results into four factors—the context, intervention, adaptation, and outcomes. Through this review, the authors offer the group
support systems (GSS) researchers and managers an up-to-date descriptive evaluation of GSS research in organizations.

As may be apparent, conducting a descriptive literature review requires considerable attention on the part of those conducting the review. And herein lies this method’s strength and weakness. On the one hand, such reviews offer in-depth analyses of articles (the seminal ones, in particular) and provide a more nuanced understanding of the contextual issues involved as to how and why new work modalities such as virtual work may succeed. On the other hand, though, conducting a comprehensive and exhaustive review can be demanding. Such a review is constrained by the time and energy of the researchers involved who have to choose the articles that they can review, often based on their specific research interests. Consequently, there is a real possibility that several bodies of work can easily be excluded.

### 1.1.3. Bibliometric Analysis

A bibliometric approach uses IS tools to conduct a comprehensive search of relevant articles that appear in multiple databases. Such an analysis is different from a typical research review in that researchers’ priors do not limit the review. This is because software tools can help categorize research into clusters by extracting information from bibliographic records (Schneider 2006).

Citation analysis is a major bibliometric approach that can be used to identify underlying patterns of relationships between articles based on the references that they cite (Osareh 1996). Advances in information technologies for indexing and searching scholarly work have made this method all the more possible. For instance, with the availability of the database from the Institute for Science Information (ISI), citation analysis has become an important method for the study of developments in scientific communities (Garfield and Welljams 1992, Gmür 2003).

This approach is premised on citations being key indicators of past and present scientific activities (Braam et al. 1991, Garfield et al. 1983, Small and Griffith 1974) and the method allows for the inclusion of research articles from different disciplines. For example, Karuga et al. (2007) have used citation analysis to define the maturity of the IS discipline by examining the impact of 879 articles on IS and non-IS research (such as management, engineering, and organizational behavior). Manually reviewing this vast literature is a daunting task and is possible only because of the availability of software tools.

Cocitation analysis is a specific type of citation analysis used to identify clusters of references “cocited” by subsequent articles (Small 1973). This approach is particularly well-suited to gaining an understanding of a research trajectory by studying relationships that exist across prior work because it is based on the inputs of those who are the most knowledgeable in a research field, i.e., those contributing articles to the field. Specifically, by co-citing references in their bibliography, contributing authors establish connections between two or more references that have been published in the past. The assumption is that two cocited references are related, because they are part of the same research cluster or because their foci are similar (Garfield et al. 1983, Peters et al. 1995).

The presence of a sufficiently large number of citing articles in a field makes it possible to identify systematic cocitation patterns while ignoring random connections. These systematic patterns can be visualized in a cocitation network diagram (what we call a “map” in this paper) where the more frequently cocited references can be placed in close proximity in Euclidian space (Small and Griffith 1974). Clustering by cocitation is a self-generating, dynamic classification system because relationships between the different contributions (indicated by the contributors) are continually being updated by ongoing scholarly work.

A cocitation analysis of virtual work offers several advantages. It makes it possible for us to understand the structure of the intellectual base underpinning virtual work—one that is constituted through the contributions of scholars from different disciplines. Specifically, it enables the identification of connections across a large number of articles based on their references. Researchers can use cocitation analysis as a complement to other review methods. For example, researchers can choose to conduct a more in-depth review of cited references that the cocitation analysis demonstrates as being central in the network. They

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1 In other words, when two or more references (such as Nilles 1991, Mokhtarian 1991b) co-occur in the reference lists of articles, a link is established between these cocited references.
can also use cocitation analysis to see how seminal citations included in a traditional descriptive literature review connect with others.

2. Methodology

2.1. Data Source
We used the Social Sciences Citation Index (SSCI) of the ISI Web of Science to identify our sample of articles for this analysis. The SSCI is a multidisciplinary index covering multiple journals across social science discipline. It indexes individually selected, relevant articles from over 3,300 of the world’s leading scientific and technical journals. Each week, on average, 2,900 new records and 60,000 new cited references are added.

To reduce the possibility of drawing too narrow a search boundary (Chen 2006), we contacted seven researchers in the IS and management disciplines and identified the terms that they would most readily associate with virtual work. Our queries resulted in the following words: “telework,” “telecommute,” “virtual work/team,” “distance work/team,” “distributed work/team,” and “computer-mediated work/team.” To ensure that our search was comprehensive, we truncated search terms and used wild cards to include words that were different from the word stem. We considered all articles from the SSCI containing at least one of the search terms in their titles, abstracts, or keywords.

SSCI contains some data that have been entered manually or have been scanned from hard copies of articles. Consequently, there is a small possibility that errors may have crept in. Also, differences in the use of initials or mistakes in the spellings of authors can result in different names appearing for the same author. To rationalize such inconsistencies, we checked all the references in the sample for potential spelling errors. In some obvious cases (e.g., same journal, year, volume, and page but different spelling of author name), the record was corrected to its most frequently used form. In the less obvious cases, we used Google Scholar to verify whether references with similar names represented different publications.

Some articles included multiple citations to a reference (e.g., references to different pages of the same publication). These references were investigated to verify whether the record indeed cited two different references published in the same issue of a journal. If the records were merely referring to different pages of the same article, duplicate references were removed to avoid a distorted citation count and cocitation pattern.

2.2. Analyses
Our search yielded 490 articles on virtual work in the ISI Web of Science that had been published between the period 1976 and 2006, and we included the complete set of 490 articles in our study. These 490 articles cited 12,759 references. The inclusion of such a large number of references in the analyses would have resulted in a very fine-grained map. For this reason, we excluded references with low citation counts from a cocitation analysis (Mane and Börner 2004). Such exclusion did not significantly impact the structure of the resulting map.

We used the freely available Sitkis (Schildt 2005) software package to construct a cocitation network. From the 12,759 references cited by the articles on “virtual work” in our sample, we initially selected those that had been cited by at least 15 articles in our sample (Chen 2006). We then incrementally lowered this citation threshold until the map was at a level of granularity that was sufficient for us to visualize the evolution of major clusters in the field. Eventually, we arrived at a list of 140 references that had been cited by at least 10 articles, i.e., 2% of the 490 articles in our sample. These 140 references served as the basis for drawing the connections across the 490 articles.

In the next step, to identify research clusters from the overall cocitation network, we clustered the frequently cocited references (Small and Griffith 1974). Clustering is a process of rearranging references through the use of an iterative algorithm such that related references appear close to one another. Traditional clustering approaches such as hierarchical clustering, agglomerative clustering, and iterative partitioning (McCain 1990) appear to be suboptimal.

Google Scholar was used for convenience. It has information about books in addition to the articles that SSCI contains.

A similar approach has been used by Leydesdorff (2004), who progressively lowered thresholds to find “articulation points” between different network components that can be considered as subdisciplines.
for bibliometric research because these algorithms assign every cited reference to a cluster even if they are not relevant to any specific cluster (Schildt and Mattsson 2006).

To overcome this problem, we used the dense subnetwork grouping algorithm suggested by Schildt and Mattsson (2006). This algorithm forms a cluster of co-cited references; the formation of a cluster is initiated by first selecting two references from the sample that are most similar to one another. This similarity is determined by the Jaccard index4 (Small and Greenlee 1980). The Jaccard index is the ratio between the intersection of two sets and their union. The Jaccard value between two references can be calculated by dividing the number of articles that co-cite these references by all the articles citing any of the two references. The figure can range from zero (representing a situation where these two references were not co-cited even once by these articles) to one (representing a situation where these references were cocited by all these articles).

A cluster of references emerges as the algorithm seeds the process and iteratively adds additional references from the remaining pool that have the highest average similarity scores with the references already in the cluster. This process continues until the average similarity of the remaining references is below a preselected cutoff Jaccard value when a new cluster is formed. A low-cutoff Jaccard value results in few but relatively large-sized clusters with some overlaps between references. Conversely, a high-cutoff value generates more distinct but smaller-sized clusters and some references may not belong to any cluster at all.5 Selecting an appropriate cutoff value requires the judgment of researchers in evaluating the tradeoff between assigning maximum possible references to a cluster while generating several distinct clusters (Schildt et al. 2006).

Using an iterative process, we experimented with different cutoff values for generating the clusters. We used Jaccard index values of 0.05, 0.10, 0.15, 0.20, 0.25, and 0.30 for this exploration. Each time, after changing the index values, we evaluated the effect on the number and size of clusters that emerged. After testing different alternatives, we selected a cutoff value of 0.10. This parameter setting resulted in a sufficient number of distinct clusters for visualizing the evolution of research clusters on virtual work.

3. Results

We present two kinds of maps based on the approach that we described. First, to provide the reader with a macrolevel understanding of the field, we present overview maps of the field depicting the various research clusters and their connections at three different points in time. Second, to provide the reader with microlevel details, we zoom into the major clusters comprising the most recent map of the field (as of 2006) and show the most influential scholarly works and how they are related. Both types of maps are important as it is difficult to understand the complete picture without understanding its nuances and vice versa. The possibility of going back and forth between macrolevel understanding and microlevel detail helps generate a holistic understanding of the field.

3.1. Longitudinal Cocitation Networks

To trace the evolution of research on virtual work, we generated three snapshots of the field as it appeared in 1995, 2000, and 2006 (Figure 1).

A visual comparison of the networks across panels (a), (b), and (c) in Figure 1 suggests that the field has emerged from a disparate set of nine clusters as of 1995 (Figure 1(a)) to one exhibiting small-world characteristics among 16 clusters as of 2006 (Figure 1(c)). By small world, we mean that the connections between two or more densely connected networks is established by relatively short paths (Watts and Strogatz 1998). In 2006, for instance, there appear to be two such networks (in dotted lines, representing two major research domains) connected by a cluster related to references on “work family/review” and a cluster related to “practitioner focus.”

A further examination of these maps shows that there were two major domains of research as of 1995 (Figure 1(a))—a larger, denser one focusing on “urban planning and transportation” and “early theory” (research domain A) and a smaller one focusing

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4 The Jaccard index is defined as the size of the intersection divided by the size of the union of two sample sets: $J(A, B) = \frac{|A \cap B|}{|A \cup B|}$.

5 The relationships between the different clusters are structurally similar across the different parameter settings. The results are therefore robust for different settings of this parameter.
Figure 1  Cocitation Networks Over Time

(a) Cocitation network across research clusters until 1995

(b) Cocitation network across research clusters until 2000

(c) Cocitation network across research clusters until 2006

Size and thickness

- Size of symbol = number of citations
- Line thickness = cocitation

Shape

- □ Cluster references
- ◇ Related references
- ● First cited in (or before) 1990
- ○ First cited in (or before) 1995
- ▲ First cited in (or before) 1996
- ◆ First cited in (or before) 2000
- ▼ First cited in (or before) 2006
on “virtual teams” and “computer-mediated communication” (research domain B). Research in domain A offered descriptions of the virtual work phenomenon, initial empirical evidence for its emergence, and early theoretical models to explain the changes in work modes that were occurring. This research served as a platform to spawn subsequent empirical explorations and conceptual developments (as the map of the field in 2000 shows). Research in domain B was very small and distinct. There were no crossovers between research topics in the two domains.

The map of the field as of 2000 shows that research domain B, drawing on a theory base that advanced understanding of virtual team processes, grew by encompassing research on virtual organizations and global virtual teams (Figure 1(b)). Two clusters, in particular, bridged research domain A with research domain B. One had a “practitioner focus” and another examined “organizational structures” such as network organizations. Although it connected the two research domains, the “work family” cluster was in the periphery.

The 2006 map (Figure 1(c)) shows reemergence of the partition between the two research domains that had almost come together in 2000. Domain B evolved to become larger and denser in comparison to domain A. The “work family” cluster moved from its status of a connector across the two research domains and established stronger ties with research domain A. Within research domain B, the “virtual teams” cluster grew denser and became more prominent. The “practitioner focus” cluster remained a major bridge across the two research domains. The “literature review” cluster was another bridge connecting the two research domains through its link with research in practitioner-oriented cluster.

### 3.2. Network Composition

We can examine the structure of knowledge generation within and across research clusters by probing deeper into the network composition. For simplicity, we focus only on the 2006 map and then allude to the networks in the other two maps as required. Rather than provide a cluster-by-cluster description of all the 16 clusters comprising the 2006 map (Figure 1(c)), we focus our description on the larger clusters that account for 73% of all citations. The clusters marked “early theory” and “urban planning and transportation” are the two largest clusters within research domain A. “Virtual teams” and “computer-mediated communication” are the two largest clusters within research domain B. To understand the composition of these four clusters, please see Figures 2(a)–2(d).

In these graphs, the size of the circles is proportional to the number of citations each reference has received. The thickness of the lines represents the extent to which these references were cocited by the 490 articles, as measured by the Jaccard index explained earlier. In our description, we provide a general sense of the clusters’ characteristics, common theories, and research methodologies used by the groups of researchers.

The “urban planning and transportation” cluster (Figure 2(a)) represents research examining the impact of virtual work on job-housing balance and travel patterns in urban and suburban areas. Research in this cluster predicts the spread of telecommuting by examining (a) individuals’ decision to telecommute based on their perception of constraints and their motivations (Mokhtarian 1998, Mokhtarian and Salomon 1994), (b) occupations conducive to telecommuting (Handy and Mokhtarian 1995), and (c) the impact of telecommuting on travel distances and travel times (Pendyala et al. 1991).

Most of the research in this cluster originated in the State of California, known for its heavy traffic patterns, rising cost of urban living, and disruption of transportation because of possible earthquakes (e.g., Mokhtarian 1991a). The region is also known for most of the innovations in communications technology. The research examines the impact of virtual work on decreasing automobile congestion, traffic diversions, energy consumption, and air pollution. Some of the research is directed toward developing public policy changes for mass transit and urban planning (e.g., Mahmassani et al. 1993). Interestingly, research in this cluster offers definitions and nuanced understandings.

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6 The entire network resulting from this analysis is available by request from the authors.

7 High resolution Figures 2(a)–2(d) and additional information are contained in an online appendix to this paper that is available on the Information Systems Research website (http://isr.pubs.informs.org/ecompanion.html).
Figure 2  Cocitation Network of the Four Largest Clusters

(a) Cocitation network of the research cluster on urban planning and transportation

(b) Cocitation network of the research cluster on early theory
Figure 2 (Continued)

(c) Cocitation network of the research cluster on computer-mediated communication

(d) Cocitation network of the research cluster on virtual teams

Size and thickness

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<th>Size of symbol</th>
<th>Number of citations</th>
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<tr>
<td>Line thickness</td>
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Shape

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<th>Cluster references</th>
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<td>Related references</td>
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Shade

| First cited in (or before) 1990 |
| First cited in (or before) 2006 |
of virtual work that can be found even today. For example, Nilles (1991, p. 413) defined telework and telecommuting as:

Telework is the substitution of telecommunication technology for work related travel. Telecommuting, a subset of teleworking, is the partial or total substitution of telecommunication and or computer technology for daily commute to work.

Furthermore, research from this cluster distinguished between home-based work and telecenter-based work (Mokhtarian 1991b, Stanek and Mokhtarian 1998). Telecommuting, according to this research, is not an all-or-nothing approach. Consequently, telecommuting should be viewed along a continuum, thus broadening the potential base of telecommuters (Mokhtarian 1991b). A notable difference between this cluster and the other clusters was the consistent use of the terms “telework” and “telecommute,” rather than “virtual work.”

Distinct from a public policy perspective, the “early theory” cluster (Figure 2(b)) adopts an employee-centric approach to focus primarily on home-based work. It draws on theories from sociology, psychology, and organizational behavior such as Hackman and Oldham’s (1976) task characteristic model and Maslow’s need hierarchy to explain the effects of reduced socialization and increased identity conflicts (Salomon and Salomon 1984, Shamir and Salomon 1985). The outcomes explored include work-family balance, organizational identification, employee productivity, stress, and job satisfaction. The determinants examined include an individual’s ability to manage social isolation, self-determination, the availability of information technology, and family structure (Kraut 1989, Venkatesh and Vitalari 1992).

This “early theory” cluster represents some of the initial empirical research using the theoretical bases described earlier. The prevalent research methodology in this cluster consists of interviews, case studies, and small sample surveys (DeSanctis 1984, Olson and Primps 1984) because of the difficulties in identifying large samples of home workers (Kraut 1989). The viability of virtual work is an undercurrent that runs through a number of articles in this cluster (e.g., Kraut 1989, Shamir and Salomon 1985). Overall, this cluster can be credited for identifying many constructs central to virtual work that have been examined in greater depth by researchers belonging to the other clusters.

The “computer-mediated communication” (CMC) (Figure 2(c)) cluster builds on social presence theory, social information processing theory, and media richness theory (e.g., Daft and Lengel 1986) to offer a sociotechnical lens in understanding the impact of communication technology (Sproull and Kiesler 1986). A critical evaluation of the theories and research on CMC by Walther (1992) provides insights into the core ideas of this cluster. A common understanding was that CMC, because it lacks nonverbal cues, would result in an exchange of messages that would be impersonal and task oriented. Walther (1992), however, suggested that this might be true for only certain situations. In many cases, CMC may facilitate those involved in developing deeper relationships, especially if communications are allowed to unfold within an expanded time frame. Specifically, given enough time, computer-supported groups will exchange enough information to form social and emotional bonds (Chidambaram 1996). Likewise, electronic mail can prove to be an effective communication medium if an organization encourages and supports its use (Markus 1994). Most empirical studies in this cluster compare computer-mediated groups with face-to-face groups in laboratory settings and evaluate participants on the use of technology in accomplishing specific tasks.

The “virtual teams” cluster (Figure 2(d)) focuses on geographically distributed teams and, in many cases, globally dispersed teams that transcend time, space, and culture (e.g., Jarvenpaa and Leidner 1999, Lipnack and Stamps 1997). The cluster identifies the benefits as well as the challenges related to trust, cohesion, and technology that virtual teams may confront (Townsend et al. 1998). Adaptive structuration (DeSanctis and Poole 1994) is a dominant theory within this cluster. This theory describes the interplay between advanced technologies, social structures, and human interactions that forms the basis for an understanding of processes associated with virtual teams (DeSanctis and Poole 1994, Maznevski and Chudoba 2000).

Within the “virtual teams” cluster, there is a sub-cluster focused on global virtual teams (Cramton 2001, Jarvenpaa et al. 1998, Jarvenpaa and Leidner 1999, Maznevski and Chudoba 2000) that is becoming important given the rise of multinational firms.
Global virtual teams consist of people who are distributed across international boundaries and who deal with issues that are global in nature (Maznevski and Chudoba 2000). In addition to the challenges that virtual teams confront, global teams have to deal with challenges related to working across international time zones, cultures, and geography. Research in this cluster frequently uses grounded theorizing from in-depth case studies (Glaser and Strauss 1967) because researchers have limited access to global virtual teams while requiring rich data to understand this relatively new work form. Some of the issues examined include: (a) the temporal pattern of interaction incidents (face-to-face versus online) as it relates to decision-making processes and relationship building (Maznevski and Chudoba 2000), (b) the development of trust (Jarvenpaa et al. 1998, Jarvenpaa and Leidner 1999), and (c) the failures in developing mutual knowledge and consequently collaboration (Cramton 2001).

Other research in this cluster focuses on answering questions central to virtual teams. These include questions such as: Do face-to-face teams have higher performance, information exchange, and relational links than virtual teams? (see, e.g., DeSanctis and Poole 1994, Jarvenpaa et al. 1998, and Walther 1995). The cluster, as a whole, makes significant contributions to our understanding of the critical issues that drive virtual team processes. Much of this work represents the theoretical and empirical foundations for current virtual team research.

In addition to these 4 major clusters, 12 smaller clusters define the virtual work domain. For the sake of brevity, we do not describe these clusters in detail here; instead, we provide a brief description of all 16 clusters in Table 1 along with examples of references cited by researchers.\(^8\)

These clusters show some overlaps in research topics, concepts, and problem sets. However, a closer look at each cluster reveals that the different research clusters build on different literature bases. For instance, they examine relatively distinct aspects of virtual teams such as technological facilitators, organizational outcomes, or cross-cultural issues (Figure 1(c)).

4. Discussion

Through our analysis, we have tracked the progress made in the field of virtual work over time and have offered our readers maps of the field over three different time frames (1995, 2000, and 2006). Tracking the development of a dynamic field can be useful to see how early ideas shape emerging discourses around the field and to draw implications for future research. Such an analysis has become all the more feasible because of developments in information systems. For example, the ISI Web of Science makes it possible to explore scholarly work produced over decades and to identify relevant articles with little effort. Clearly defined data structures and cross linkages between references that they cite make it possible for us to identify underlying connections between articles that could otherwise have remained obscured if we had been dealing with paper copies. From this perspective, the approach we have taken can be easily used to map and track other fields of interest to IS researchers.

Our analysis helps us understand developments in virtual work at several levels. At one level, the map shows a network of research topics and ideas in the field. Specifically, the map identifies key research themes as well as the themes that are most influential in connecting clusters. At another level, the maps provide a processual account of the emergence of new topics in scientific fields. For example, in the case of virtual work, the map of the field as of 2006 (Figure 1(c)) shows that the “virtual teams” cluster is not only highly cited but also densely connected with other clusters, a situation that results in the development of a platform to which researchers may preferentially attach themselves (Newman 2001). In comparison, the “urban planning” cluster seems to be growing slower than the “virtual teams” cluster and it is not as densely connected with other clusters (Figure 1(c)). Barring exogenous changes that may once again bring urban planning to the fore, this cluster appears to be losing in relative importance. The broader principle of preferential attachment (Bianconi and Barabasi 2001, Newman 2001) is that the growth of a cluster will be determined by a combination of two factors—the presence of a critical mass as well as the existence of critical connections with other clusters.

We also note that the clusters that connect others in the map as of 2006 are not the ones from which...\(^8\) Additional information is contained in an online appendix.
## Table 1  Sixteen Most Cited Clusters of Virtual Work Research

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<th>Cluster</th>
<th>Description</th>
<th>First author* of the cited reference</th>
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the field emerged as captured by the map in 1995. The cocitation analysis demonstrates that few will attribute the origins of the field of virtual work to early contributions from literatures such as urban planning and information technologies. These maps show that the emergence of the field has been a far from linear process. The early map of the field (Figure 1(a)) makes these origins transparent and shows that early theoretical developments and definitional attempts are related to transportation rather than to the now-dominant topic of distributed and virtual teams. An understanding of the historical development of the field offers insight into the current continuing use of concepts and terminology such as “telecommuting,” the etymology of which would have remained obscured if we were to focus only on more recent research. It also shows why certain concepts may have been forgotten.

5. Implications for Research on Virtual Work

One of the most important contributions of an analysis of this kind is the comprehensiveness with which a search is conducted. In this regard, the method we have used allows us to analyze a broad range of literature bases, e.g., transportation, management, IS, and organization behavior. Consequently, we can identify multiple themes that are related to different facets of virtual work. Examples of these themes that cut across different facets of this work phenomenon include (a) conflict, isolation, communication ambiguities, and trust—drawing attention to the dynamics of behavior and attitudes; (b) family, team members, and co-workers—drawing attention to interpersonal relationships; and (c) performance and identity—drawing attention to outcomes. The very fact that these themes span different bodies of literature signals to researchers the broader impact of this work mode. In this way, our analysis generates options for researchers rather than prescriptions for specific relationships that they ought to explore.

Our longitudinal analysis suggests that some of the constructs that early theorists had identified have set the seeds for future research. For instance, in the early years, researchers were curious to learn how distance impacted the organizational identity of individuals who no longer came in contact with their peers or organizational symbols on a regular basis (Shamir and Salomon 1985). In later years, this question was fleshed out through empirical research as well as theoretical modeling (Fiol and O’Connor 2005, Thatcher and Zhu 2006, Wiesenfeld et al. 1999). Interest in identities continues as users adapt communication technologies to contemporary work patterns. Examples include research on self-presentation and online identities in virtual communities (Golden 2006, Shumate and Pike 2006). The underlying assumption of this research cluster is that some individuals shape their online identities to create desirable relationships with their virtual communities (such as customers or virtual team members). Likewise, examples can be found in the research examining the impact of media richness on collaboration in virtual teams (Banker et al. 2006, Majchrzak et al. 2005). A historical review of this kind highlights the resilience of issues such as organizational identity and conflict and collaboration. Thus, researchers interested in examining these issues in the virtual work context can use historical developments

Table 1 (Continued)

<table>
<thead>
<tr>
<th>Cluster</th>
<th>Description</th>
<th>First author* of the cited reference</th>
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<tbody>
<tr>
<td>16. Organizational structures</td>
<td>Theoretical base in organizational structures such as networked organizations. Role of communication within organizational structures.</td>
<td>Datt, Research in Organizational Behavior, 1984; Nohria, Networks and Organizations, 1992.</td>
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</tbody>
</table>

Note. This is a partial list representing references with high number of citations. *Names of only first authors are provided because of space constraints.
across clusters to deepen their research and expand the theoretical lenses available to them. Furthermore, a historical perspective allows them to better identify the significance of their own contributions in a far more nuanced fashion.

Another area from which research on virtual work may benefit is in defining virtual work. These maps show that researchers have grappled not only with the question of what is “virtual” (is it geographic distance, technology used for work, or frequency of face-to-face contact?) (Fiol and O’Connor 2005), but also with how such “virtualness” may be labeled. Accordingly, terms such as telework, telecommute, and distance work that refer to some of the same underlying dynamics of dispersion also reflect the fact that they have distinct origins. For instance, geographically distributed teams are referred to as “virtual teams” (Cluster 3, Figure 2(c)) rather than as “teleteams” or “telework teams,” which would be consistent with terminologies used in Clusters 1 or 2 (Figures 2(a) and 2(b)). Given that language and labels constitute how we theorize (Whorf 1956), it is useful for researchers and reviewers alike to be aware of the roots of this new work mode, a facet that can be easily forgotten.

By examining the clusters in Figure 1, we not only discover unique interests that researchers may like to pursue, but also the possibilities for bridging research clusters in the future. For instance, there may be an opportunity to bridge the more recent research on virtual teams with ideas developed in earlier work on urban planning and transportation. Transportation research has focused on the ways in which objectives such as reducing commute times and increasing cost efficiency may be achieved. Virtual teams and CMC have focused on objectives related to balancing technological and relational facets of communication. Research targeted at accomplishing objectives that are relevant to both clusters (i.e., achieving efficiency of work while enhancing effectiveness through relational and technological facets of communications) is one such possibility. In this regard, both the “practitioner focus” and the “literature review” clusters may have some interesting perspectives to offer as they act as bridges. The “practitioner focus” cluster provides research on (a) the benefits that businesses can derive from virtual work, (b) the conditions under which such work will be appropriate (Cascio 2000), (c) the role of managerial trust (Handy 1995), and (d) design and task delegation to virtual teams (Bell and Kozlowski 2002). The “literature review” cluster, on the other hand, draws on “initial empirical research” as well as “European research” to identify relevant issues. This cluster proposes a link with existing organizational theories to better understand the impact of telework (Bailey and Kurland 2002, Kurland and Egan 1999).

However, it is possible that authors who are “transdisciplinary” (Stokols et al. 2005) may find that their contributions are not readily embraced by others who squarely belong to any one discipline. It is here that an appreciation of the network structure and the specific issues constituting each cluster become useful. Specifically, the map of the field in 2006 suggests how researchers might position their research to address productive tensions and complementarities between clusters. In this sense, the map of virtual work from our analysis serves as a boundary object for researchers from the different clusters so that they might connect their research with ideas from other research clusters. A boundary object is a “flexible epistemic artifact that inhabits several intersecting social worlds and satisfies the information requirement of each of them” (Star and Griesemer 1989). The map of the field in 2006 and our understanding of the various clusters offer a perspective as to where the gaps exist in literature. It also suggests which clusters can be more productively integrated to yield new insights in the field of virtual work. Additionally, these maps can be invaluable to journal editors and reviewers in identifying referees and possible literature that can help authors.

6. Implications for Research Methodology

Cocitation analysis as a method leverages the availability of IS tools and databases to explore the emerging structures of a scientific field. It helps to capture conceptual and methodological changes that have taken place over time by adopting a historical approach (Cooper 2003). Compared to alternative approaches such as descriptive literature reviews or meta-analysis, this method has its own advantages but, at the same time, certain limitations as well. The
primary limitation stems from the very vantage point of such an approach—it offers an overview perspective of the literature. By itself, it cannot offer readers an in-depth understanding of the field that traditional reviews can generate. Thus, cocitation analysis is not an alternative to a careful reading of the articles of potential interest. Instead, the goal of cocitation analysis is to generate an understanding of the underlying structure of a field and its dynamics (Braam et al. 1991) that can then motivate a more nuanced reading of articles considered to be important. Such facility becomes all the more useful in a field such as virtual work, which is increasing rapidly over time.

Indeed, cocitation analysis lets us interact with the results. As we mentioned earlier, the map is a boundary object that makes it possible for different researchers to draw relevant inferences for themselves. The degrees of freedom that this mapping process affords renders this technique all the more powerful. Specifically, it is in a researcher’s control to generate a representation of the field at the level of granularity that is most informative. At the macrolevel, for instance, it is possible to plot the data longitudinally or represent the state of a scientific domain as it has evolved up to a specific point in time. At the microlevel, it is possible to zoom into any cluster to explore the dynamics and identify individual actors and groups that form invisible colleges (Crane 1969) as well as the specific topics they are pursuing. The availability of common IS data sources such as the ISI Web of Sciences or CiteSeer makes it possible to zoom out of a map and to look at the connections between a particular field of interest and other disciplines. This possibility may be particularly useful for IS researchers, because one of the strengths of this discipline is its ability to cross boundaries and connect and contribute to research from other disciplines such as psychology, management, and operations research (e.g., Briggs et al. 2006, Karuga et al. 2007).

7. Conclusion
The advent of information technologies has resulted in a world that is rapidly changing and is being driven by the convergence of boundaries. These dynamics are manifest in the emergence of organizational forms and work modes such as virtual work, which we have explored in this paper. Given the fluidity of boundaries and dynamics of change, researchers need a way to tap into emerging insights offered by existing literature as well as tap into what may have been forgotten over time. Mapping a field using cocitation analysis is one such way. It is an easy-to-use tool for tracking developments in a field and also provides researchers with a way to understand its underlying structure so that they can more mindfully locate themselves and their contributions.

When we applied this mapping process, we found that the field of virtual work is robust and dynamic, as new strands of research on this phenomenon are being realized in different ways and with different terminologies. We found that topics such as virtual teams are gaining in strength at the expense of some of the earlier framings around the need to transcend physical distance. However, insights from the sociology of science (Mane and Börner 2004) suggest that researchers often revisit earlier insights as a field matures to develop more robust and holistic understandings. We believe that this may be true of virtual work, as researchers become once again interested in concepts related to physical distance given current concerns about the environment. The mapping process that we have explored will certainly be useful.

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