# Mapping Business Competitive Positions Using Web Co-link Analysis[1]

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## Abstract

Based on the findings from earlier studies which showed that links to business Websites contain useful business information, we examined the feasibility of using Web co-link data to map business competitive positions. We hypothesized that the number of co-links to a pair of business Websites is a measure of the similarity between the two companies. Since similar or related businesses are competing businesses, the co-link data can be used to map business competitive positions. We selected 32 telecommunication companies for the study and collected co-link data to these companies from Yahoo!. Multidimensional scaling (MDS) analysis on the co-link data correctly mapped these companies into telecommunication industry sectors. This proved our hypothesis and further confirmed the theory that links to business Websites can be objects for Web data mining. We collected data in a way that would reflect two markets, the global market and the Chinese market. Results from the two data sets revealed the competitive positions of the companies in the two markets. We propose that regular data collection and analysis based on this method can be used to monitor the business competitive environment and trigger early warnings on the change of the competitive landscape.

## Introduction

Competitive intelligence (CI), a key component of business intelligence**,** is the process of enhancing marketplace competitiveness through a greater – yet unequivocally ethical – understanding of a firm's competitors and the competitive environment (Society of Competitive Intelligence Professionals, 2004). The growing interest in competitive intelligence, not only in management science but also in library and information science, testifies to its value and importance. The Web provides a fertile ground for CI research and there is a growing body of literature on this topic.

Web hyperlinks, a network that connects businesses, customers, suppliers etc. are of particular interest to CI research. Earlier studies have found that Web hyperlinks contain useful business information (Reid, 2003; Tan, Foo, & Hui, 2002). The number of links to a company Website correlates with the company's business performance measures such as revenue and profit (Vaughan, 2004a; Vaughan & Wu, 2004). The correlation is significant even after accounting for the size of the business (Vaughan, 2004b). Based on the results of the previous studies, the current study examined if and how Web co-link data can be used for competitive intelligence purposes.

Earlier Webometrics studies made clear distinction between inlink and outlink (e.g Ingwersen, 1998; Thelwall, 2002a). Inlinks are links coming into (or pointing to) a Web page while outlinks are links going out from a Web page (i.e the hyperlinks embedded in the Web page). Björneborn & Ingwersen (2004) further distinguished between co-inlinks and co-outlinks. If page X and Y are both linked to by page Z (i.e. page X and Y both have inlinks from page Z), then X and Y are co-inlinked. Co-inlinks (also called co-links later in the paper) are analogous to the bibliometric concept of co-citation (Small, 1973). In parallel to co-citation analysis, this study analyzes co-inlinks to business Websites and attempts to find relationships among businesses as revealed through co-link data.

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Our hypothesis is that the number of co-links to the Websites of a pair of companies is a measure of the similarity between the two companies. The more co-links the two companies have, the more closely related they are in the views of the sites that link to them. We selected 32 companies in the telecommunication industry and analyzed their co-link data by multidimensional scaling (MDS), which generated a map showing the relative positions of the companies. Similar companies were positioned together and the map matches our knowledge of the relationships among the companies. This proves our hypothesis. As related businesses are competing businesses, this map of business relationship effectively shows business competitive positions. We collected co-link data that reflected the business relationships in two markets, the global market and the Chinese market. The comparison between the two sets of market positions allowed us to further test our hypothesis and the usefulness of the proposed method for competitive intelligence. We chose the Chinese market because the tremendous development of the Chinese economy, the increasing competitiveness of China's telecommunication companies in recent years, and the growing interest towards the Chinese market within the international business community.

Previous studies (e.g. Vaughan and Wu, 2004) chose information technology (IT) industry as these companies are likely to be leaders in the use of the Web for business purposes. However there are over 500 IT companies in U.S.A. and Canada alone (Vaughan, 2004b). This number of companies would be too large for a co-link study due to the huge size of the co-link matrix that it would need. We decided to focus on the telecommunication industry in this study because the second author has over a decade of experience working in the telecommunication industry and is very knowledgeable about the competitive environment of this industry. We selected 32 companies for the study based on the following criteria:

1. Top companies in terms of revenue in the telecommunication industry.
2. Top companies from different regions of the world: North America (e.g. Nortel, Lucent, and Cisco), Europe (e.g. Nokia, Marconi, and Ericsson), and Asia (e.g. NEC, Huawei, and Fujitsu).
3. Representation of companies from different sectors of the telecommunication industry including wireless, optical transport, IP routing, Ethernet switching, and access equipments.

See Appendix 1 for a complete list of the companies.

## Methods

*Search Engine Used and the Queries*

Earlier studies of Web link analysis mainly used search engines AltaVista and AllTheWeb for data collection. Google was not used because it could not perform external inlink search (external inlinks are links coming from sites other than the site in question). Yahoo! acquired AltaVista and AllTheWeb in March 2004. Subsequent to this acquisition, AllTheWeb removed its link search options. At the time of the study (summer of 2004), AltaVista still provided link search. However, its database is a subset of that of Yahoo!. We explored and tested link search functions of Yahoo! and concluded that it is a better search engine than AltaVista for our study. The queries for external inlink search and co-link search are shown in Table 1. These queries can be submitted to Yahoo!' through its basic search mode (http://www.yahoo.com). It should be noted that in Table 1, we used partial domain name in the "site" portion of the query (i.e. we did not include "www"). The partial domain name search would do a more accurate capture of inlinks to the Website because it is conceivable that a related URL (e.g. mail.abc.com) is used by the company other than the standard www.abc.com. This is consistent with earlier studies that used AltaVista for data collection (e.g. Smith & Thelwall, 2002; Thelwall, 2001; Vaughan & Wu, 2004).

Table 1. Yahoo! Search Queries

| To search for | Query Used |
|---|---|
| External inlinks to www.abc.com | link:http://www.abc.com –site:abc.com |
| Co-links between www.abc.com and www.xyz.com | (link:http://www.abc.com –site:abc.com) AND (link:http://www.xyz.com –site:xyz.com) |

It should be noted that Yahoo!'s "link" command finds documents that link to a particular URL (in this study, links to a company homepage, not all pages of the company Website). Yahoo! has an undocumented (not documented in Yahoo! help menu) command "linkdomain" which will search for links to all pages of a Website. We experimented with both search commands and found that the majority of links point to the homepage of a company. We collected co-link data with both commands and compared the two sets of results. The result based on data collected with the "link" command provides more meaningful and more accurate descriptions of the competitive landscape of the telecommunication industry. We consider "link" command to be a better choice for this study and all results reported below are based on data collected through this command. However, the relative advantages of the two commands for co-link studies in general is unknown and need to be explored in future studies.

As stated earlier in the paper, we want to compare business positions of these companies in two markets, the global market and the Chinese market. We collected data from global Yahoo! (http://www.yahoo.com), as discussed above, to measure the company position in the global market. We then collected data from Yahoo China (http://cn.yahoo.com) as a measure of their positions in the Chinese market. We chose Yahoo! China as it was a top search engine in China at the time of the study and it had the same link search functions as that of the global Yahoo!. Search queries for data collection in Yahoo! China is the same as those in global Yahoo! as shown in Table 1. Yahoo! China is the result of the merger of the global Yahoo and a leading Chinese search engine (China Daily, 2003), so the search results in Yahoo! China and global Yahoo! will have many overlaps. We tested the two Yahoo! by entering the same link search queries. Yahoo! China consistently retrieved more hits. For the purpose of the study, we need to focus the Yahoo! China search to sites that reflect the market positions in China. There are two possible ways to do this: limiting the search to pages from China and limiting the search to pages in the Chinese language. We chose the latter option because language is a better indicator of the target market. Websites originating from China that are in English are more likely to target the global market rather than the Chinese market. Similarly, sites that originate outside China but are in the Chinese language are more likely to be aiming for the Chinese market. Data collection in global Yahoo! took place on July 21, 2004 while data collection in Yahoo! China took place on Aug. 20, 2004.

*Data Processing*

The co-link data collected are stored in the form of a symmetrical matrix with each row and column representing the URL of a company. The number in the cell row x and column y is the number of co-links between URL X and URL Y, i.e. number of pages with links that point to both URLs. The matrix (size 32 by 32, lower-triangle) is omitted here due to the space limitation. This is the raw co-link matrix which can be fed directly into the multidimensional scaling program for mapping. However, the raw co-link count may not be an accurate measure of the strength of the relationship between a pair of companies. For example, a co-link count of 5 is very high if the number of links pointing to each company is 6. It will be low if the number of links pointing to each company is 100.

To measure the relative strength of the relationship between companies, we normalized the co-link counts for each pair of companies by dividing by the sum of inlink counts for the two companies minus the number of raw co-link count. This is the Jaccard index method that Small (1973, 1981) used to normalize co-citation counts, the method that is also recommended by Egghe and Rousseau (1990, p. 240). Parallel to the definition by Small (1973, p. 269), we give a formal definition of co-link counts in terms of set theory notation.

$$NormalizedColinkCount = n(A \cap B) / n(A \cup B)$$

Where A is the set of the Web pages which links to URL X
B is the set of the Web pages which links to URL Y
$n(A \cap B)$ is the number of pages which link to both URL X and URL Y, i.e. the raw co-link count
$n(A \cup B)$ is the number of pages which link to either URL X or URL Y.

For example, if inlinks to company URL X and URL Y are 100 and 200 respectively and the raw co-link count to the two URLs is 50, then the normalized co-link count is 50/(100+200-50)=0.2.

We fed both the raw co-link matrix and the normalized co-link matrix into the multidimensional scaling (MDS) program of SPSS version 12 and compared the mapping results from the two matrices. Judging from our knowledge of the telecommunication industry, the map from the normalized co-link matrix depicts the company relationship better. So the maps shown in the following sections are all from the normalized matrices. A technical note on MDS in SPSS is warranted here. SPSS version 12 has two options for MDS: PROXSCAL and ALSCAL (some earlier versions of SPSS only have ALSCAL). PROXSCAL allows for input data to be either in the form of similarity matrix or dissimilarity matrix while ALSCAL allows input only to be in the form of dissimilarity matrix. Co-link counts, same as co-citation counts, are similarity measures (the larger the count, the more similar the two objects are), so we used the similarity matrix option of PROXCAL.

We defined the co-link data to be ordinal data parallel to Ahlgren, Jarneving & Rousseau (2003, p. 558) argument that co-citation should be considered as ordinal data. We used the "untie the tied observations" option of MDS according to recommendation by Borg and Groenen (1997, p. 170). All MDS results reported below have a normalized raw stress value of less than 0.05, which indicates very good fit between the input data and the out maps (Meulman & Heiser, 2001, p. 201). If the stress value were higher, then a higher dimension map would be used which would make the interpretation of the map more difficult.

**Results**

*Global Market Positions*

Fig. 1 is the MDS output map that shows the relative positions of the 32 companies based on the co-link data collected from global Yahoo!. The companies are clearly clustered into the sectors of the telecommunication industry as labeled in Fig. 1, namely "wireless" companies, "comprehensive" companies, "optical" transport companies, "routing/switching" companies, "access" companies and "Chinese comprehensive" companies. The map shown in Fig. 1 is consistent with the competition landscape of the telecommunication industry. For example, Canadian company RIM (Research in Motion) is not clustered with other companies. This shows the unique product and market position of RIM. RIM's main product BlackBerry is a handheld wireless access device which has its own niche market and is not really competing with products from other wireless companies in this study. The two other companies that are not grouped into clusters in Fig. 1 are Putian and Datang. These two Chinese companies are fairly new comers in the global telecommunication market. They are big telecommunication companies in the Chinese market. However, they have little exposure so far in the international market. Their revenues are mainly from the domestic market. In contrast, the other Chinese powerhouses, Huawei, ZTE and UT Starcom, are in a closer position to their international competitors. This reflects the fact that these three companies are far more successful than Putian and Datang in the international market. For example, Huawei's revenue from the international market is around US $2 billion in 2004 which is 40% of its total revenue in that year. ZTE had 30% of its revenue from the international market in 2003. These two companies also pose more competitive threats to Western telecommunication vendors.

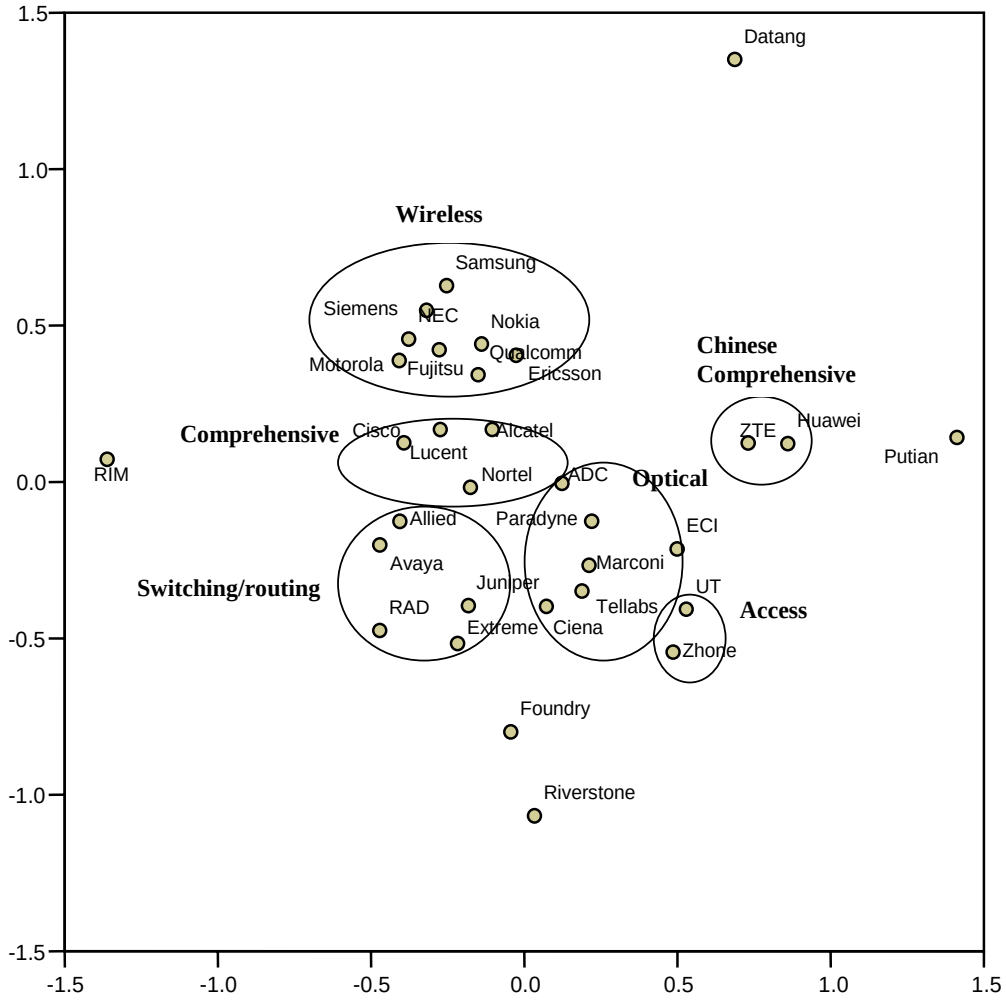


Fig. 1. MDS mapping result based on global Yahoo! data

The two Japanese companies that are not positioned according to the characteristics of their telecommunication products are NEC and Fujitsu. NEC should be treated as a comprehensive telecommunication company and Fujitsu's telecommunication market focus is optical transport. However, they are grouped by regional characteristics to be with other Asian companies in Fig. 1 for two reasons: 1. these two companies compete with each other and with other vendors in Asian market. They are still regional players in terms of competition; 2. These two companies have wider product portfolio in IT and have other electronic products which do not belong to the telecommunication category. Web links to those other products are included in the data we collected. In future studies, we will revise our data collection method by searching for the links related to the telecommunication division of the company rather than the whole company's Website.

The success of this mapping from co-link data suggests that co-link data do contain information about the relationship among companies. Highly co-linked companies are highly related in their products and the market. Since related companies are competitors (they serve the same market needs), it follows that co-link data can be used to map the competitive position of companies.

Earlier studies have shown that the number of inlinks to a company Website correlates with the company's business performance (Vaughan, 2004a; Vaughan, 2004b; Vaughan and Wu, 2004). When combining the inlink data (external inlink counts as defined in Table 1) with the co-link mapping result of Fig. 1, we can get a better understanding of the competitive positions of these companies. For example:

- Cisco is the most competitive company in the "comprehensive" group as it has the highest inlink counts. Its main competitors are Lucent and Nortel which are positioned very close to it.

Nortel, Alcatel and Lucent are also located in the "comprehensive" group since they have wider product portfolios ranging from wireless infrastructure equipments and optical transport equipments to switching equipments and access equipments.

- Nokia, having the largest number of inlinks in Wireless sector, is the most competitive player in this group. Compared with the companies in the comprehensive group, companies in the wireless group have product lines heavily focused in the wireless sector. Their competitive product portfolios are not only in the wireless infrastructure equipment market but also in the wireless handset market.
- Routing/Switching group includes companies like Juniper, Extreme, Avaya, and Allied Telesyn. These vendors are mainly competing with each other in routing and switching equipment market. Extreme is very competitive in this group. It is the number one competitor for Juniper as shown by their close position in Fig. 1. Although Cisco competes heavily with Juniper in the router market, Extreme is positioned closest to Juniper in Fig. 1. Cisco is positioned in the comprehensive group in Fig. 1, which correctly reflects the fact that the overall competition between Juniper and Extreme in routing/switching is more significant than that between Juniper and Cisco.
- Huawei has not yet been a Cisco's close competitor in the global market. It competes more with the optical transport companies in the global market rather than in the router market. The co-link mapping result of Fig. 1 correctly puts Huawei in closer position to the optical access group. The finding from Fig. 1, which is in line with the analysts' view, is that in the global market, the Chinese telecommunication vendors will be competitive initially in the low margin optical access equipment market rather than in the high margin switching/routing equipment market.

*Chinese Market Positions*

As expected, inlink search in Yahoo! China found different link counts compared to those found in global Yahoo!. The general pattern is that Chinese companies had more inlinks indexed by Yahoo! China than that by global Yahoo!. For example, the total number of inlinks to the five Chinese companies in Yahoo China is ten times more than that in the global Yahoo! (57103 vs. 5097). Meanwhile, the total number of inlinks to all companies in the study in Yahoo! China is ten times fewer than that in global Yahoo!. This validates to some extent our strategy of using Yahoo! China as a measure of the market positions in China.

Fig. 2 is the MDS mapping result for co-link data collected in Yahoo! China. Two companies, Zhong and Riverstone, had to be omitted from the MDS analysis as they had no co-link with other companies. This reflects the fact that these two companies had little exposure to the Chinese markets. Compared with Fig. 1, RIM is even more of an outlier in the Chinese market. It should be noted that some companies have different products in different markets. For example, Nortel and Alcatel have broad market share of various products in the global market so they are positioned in the "comprehensive" group in Fig. 1. In the Chinese market, however, Nortel is more competitive in high end optical products while Alcatel is more competitive in wireless products. Their positions in Fig. 2 reflect this.

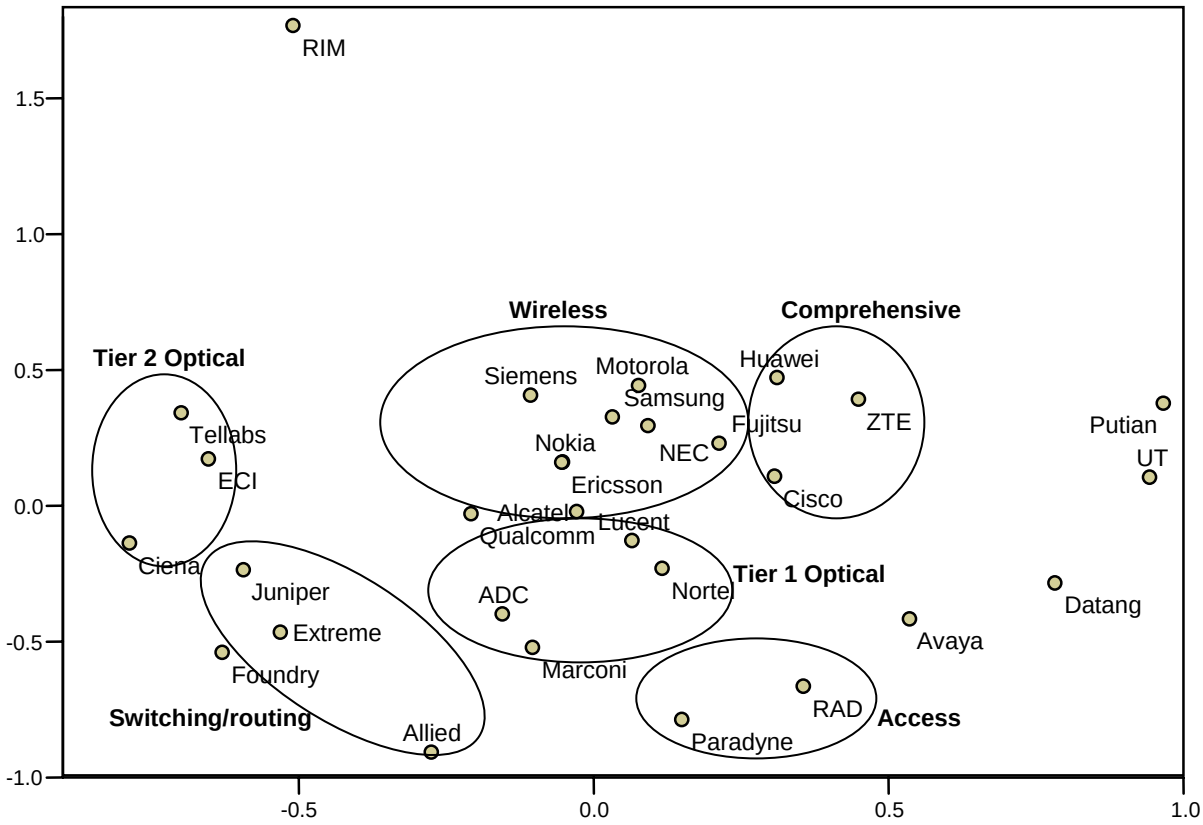


Fig. 2. MDS mapping result based on Yahoo! China data

Fig. 2 shows the competition landscape in the Chinese market.

- The two Chinese companies, Huawei and ZTE, are more competitive in the Chinese market than they are in the global market. They are positioned closer to the center of the competition landscape. Both compete heavily with Cisco in the comprehensive data communication category and Fig. 2 puts them in the same group with Cisco. Huawei ranks number one in the inlink count in Yahoo! China search result while Cisco ranked top in the global Yahoo! search result. These two companies are also position close to the wireless group, which means that they are competing with major wireless companies as well.
- UT Starcom, the only Chinese company whose stock is traded in US NASDAQ stock exchange, is positioned in the outskirt of Fig. 2, which shows its unique competitive position in the Chinese market. This is mainly due to the fact that UT Starcom focuses on the Chinese PAS (or Little Smart) wireless market which is very different from the mainstream wireless market (GSM and CDMA). The inlink count to this company reflects its relative position in the two markets too. Its inlink count in Yahoo! China is 497, only a third of that in global Yahoo! (1530) while other Chinese companies all have many more inlinks in Yahoo! China than in global Yahoo!.
- Nortel and Lucent are positioned in Tier 1 (larger market share and broader product portfolio) Optical group in the Chinese market where they mainly compete with Marconi and ADC. In addition, they are also more competitive in the Chinese wireless market than they are in the global wireless market as shown by their closer positions to the wireless group in Fig. 2.
- The Chinese market favors bigger companies over smaller specialized market players. Companies such as Ciena, Tellabs and ECI are clustered together as tier 2 (smaller market share and with focused product lines) optical players that have less market presence and market share. They are moved away from the center spot where all major companies are positioned. The same applies to the Access group (RAD and Paradyne). These two companies are more competitive in the global market than in the Chinese market. Their inlink counts

ranked relatively lower in China Yahoo! Their products in the Chinese market are different from those in the global market.

**Conclusions and Future Research**

Previous studies used co-link analysis to study scholarly Websites (Larson, 1996) and university Websites (Katz, 2004; Thelwall, 2002b). The study reported in this paper is the first that applied co-link analysis to business Websites and specifically for competitive intelligence purposes. The study shows that co-link data can be used to map market segments to which the companies belong. Since companies in the same segments are competitors, the map can be used for competitive intelligence purposes. Incorporating inlink data, which were proven to correlate with business performance measures in earlier studies (Vaughan & Wu, 2004; Vaughan, 2004b), into the co-link analysis gives a more complete depiction of the competitive positions. Information from this kind of analyses can be used by industry analysts and decision makers who need objective and global view of the competition landscape. The information can also complement the knowledge of business people who have direct experience in these sectors but would need information from a different angle to verify or expand their views. For example, the competitive position of the Chinese company Huawei in both the global and the Chinese market is clearly illustrated in this study. However, Canadian companies are not keenly aware of this competitor as they should be until Nortel CEO pointed out recently (Maistre, 2004).

Although the study demonstrated the success of using co-link data for mapping competitive positions, it is limited to only one industry. Further research is needed to test and verify the method in other sectors. The mapping technique used in the study can also be improved. Currently, only co-link data are used to generate a two dimensional map and the inlink data are used to aid the interpretation and understanding of the competitive positions. In future, we intend to use the inlink data to add a third dimension to the two-dimensional map, i.e. add inlink data as the height of the companies in the map to indicate the relative strength of the companies. This will parallel to the three-dimensional co-citation mapping technique used by Chen, Paul, & O'Keefe (2001).

An even more important research direction to pursue is to monitor the changes of the competition landscape by collecting and analyzing data on a regular basis. The dynamic nature of the Web provides an excellent opportunity for this kind of monitoring. Monitoring the changes in the competitive positions could potentially trigger early warnings of the competitors' movement (competitors that are in the list of the companies being monitored). We have started this regular monitoring. The data collected in the fall 2004 show some interesting differences from that collected in the summer 2004 which are reported in this paper. We will continue to collect data and meanwhile follow closely the market developments in the telecommunication industry. If the mapping results match the changes in the industry, then the technique would be proven more useful.

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**Appendix 1. Telecommunication Companies in the Study**

| Company | Main URL | Country |
|---|---|---|
| Cisco | http://www.cisco.com | US |
| Nortel | http://www.nortelnetworks.com | Canada |
| Lucent | http://www.lucent.com | US |
| Ciena | http://www.ciena.com | US |
| Tellabs | http://www.tellabs.com | US |
| Juniper | http://www.juniper.net | US |
| Motorola | http://www.motorola.com | US |
| Qualcomm | http://www.qualcomm.com | US |
| ADC | http://www.adc.com | US |
| Avaya | http://www.avaya.com | US |
| Extreme | http://www.extremenetworks.com | US |
| Foundry | http://www.foundrynetworks.com | US |
| Allied Telesyn | http://www.alliedtelesyn.com | US |
| Riverstone | http://www.riverstonenetworks.com | US |
| Paradyne | http://www.paradyne.com | US |
| Zhone Technologies | http://www.zhone.com | US |
| RIM | http://www.rim.com | Canada |
| Siemens | http://www.siemens.com | Germany |
| Alcatel | http://www.alcatel.com | France |
| Nokia | http://www.nokia.com | Finland |
| ECI Telecom | http://www.ecitele.com | Israel |
| RAD | http://www.rad.com | Israel |
| Marconi | http://www.marconi.com | UK |
| Fujitsu | http://www.fujitsu.com | Japan |
| NEC | http://www.nec.com | Japan |
| Samsung | http://www.samsung.com | Korea |
| Huawei | http://www.huawei.com.cn | China |
| UT Starcom | http://www.utstar.com | China |
| ZTE | http://www.zte.com.cn | China |
| Datang | http://www.datang.com | China |
| Putian | http://www.china-putian.com.cn | China |
| Ericsson | http://www.ericsson.com/ | Sweden |