Locate the Technological Position by Technology Redundancy and Centralities: Patent Citation Network Perspective

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Abstract--**Patent citation is important to analyse technological ability of a company, however, it only tells the relationship between a pair of technologies or companies. Patent citation network constructed by the concept of social network could explore the relationship of companies within a whole network. This study builds up a model to locate the technological position by technological redundancy and centralities of patent citation network. Technological redundancy includes two indicators of technological knowledge status and technological knowledge reliability. Centralities have four indicators of degree, eigenvector, closeness and betweenness centralities. After the model is built, the study tries to locate the companies' technological position of the sector of Intelligent Transportation System with this model. The result suggests that the model is effective to locate the companies' technological position before and after patents' transfer. From the positions' changes, the study finds out three kinds of acquisition strategies (1)enhance barriers to consolidate position, (2) milch cow for non-practicing entities, (3)shortcut for periphery and new entrants.**

I. INTRODUCTION

Prior researchers brought up many varied approaches with patent to evaluate technological ability including patent counts, citations, citaion network[1-18]. Chen[18] employed patent citation network to bring up technological knowledge status, TKS, and technological knowledge reliability, TKR. These two indicators could locate companies' technological position in the knowledge-relationship niche plot[19]. However, this approach ignored the functions of basic centralities including degree, eigenvector, closeness, betweenness in a patent citation network.

Patent citation analysis which employs bibliometrics to produce technological and knowledge indicators is an important approach[1, 8].Citations interpret patent's importance more than patent counts do[3, 11, 15, 16, 20]. Technologies protected by patents with more forward citations lead and attract more following developments[21]. Patent citations are also proper measurements of knowledge spillover. Patents cited more have more knowledge spillover and more value[22-25].

Although patent citation approach has its advantage, it has some disadvantage. Citation could show the relationship between a pair of patents but lack whole relationship among patents. Patent citation network constructed by the concept of social network could understand the whole relationship among patents and technological positions[14, 17, 26]. Podolny, Stuart, and Hanan [12] define technological position as "if we define a technological tie as a link between an antecedent and consequent invention, then an organization's niche is its position in technology space, as defined by the pattern of technological ties involving its inventions". Recently there have been many researches detect positions of a group by social network approach [17, 27-29].

Patent citation could be treated as the relationship between technological knowledges, thus a patent citation network also is a technological-knowledge-relation network which has two indicators of technological knowledge status, TKS, and technological knowledge reliability, TKR. TKS and TKR could figure out the positions and roles of companies and the movements of positions within the network due to patents acquisition. A company with high TKS having unique technology and high position in the technological network is often a pioneer owning advanced technology with fewer followers [17, 19, 30]. A company with high TKR having more common technological knowledge with others could be a leader or follower depending on the direction of connection. It with more forward citations might be a leader and a follower might have more backward citations. No matter leader or follower, they have more opportunities to cooperate with others, gain resource quickly and are hot in the technological network.

Although TKS and TKR could construct a knowledge-relationship network, however TKS uses the local company's self-citation counts to locate its status but lacks compairing to other companies, and TKR explores the cooperative possibility of the focal company with others by technological knowledge overlap but lacks its partners' properties in a network. In the other word, TKS and TKR only consider the focal company's situation but lack exploring its connected companies' properties. However, the connected companies' properties effect the focal company's position and role a lot. Therefore, this article employs centralities of network to make up for the shortcoming of knowledge-relationship network.

There are four centralities of a network. Degree centrality is the connection counts of a node. There are two kinds of degree. The count of one node receiving connections from others is inbound degree, on the contrary the count of one node sending connections to others is outbound degree. In the patent citation network, inbound degree means counts of forward citation and outbound degree represents counts of backward citation. Degree centrality is direct influence of a node. Inbound degree is a patent influencing others and outbound degree is a patent influenced by others [12, 17, 30, 31].

Eigenvector centrality is a measurement of the influence of a node based on the concept that connections to high-scoring nodes contribute more than equal connections to low-scoring nodes. In another word, people whose friend is a big brother is more influential than people whose friends are nobodies. The same, in the patent citation network, companies connect big and important companies, especially forward citations, are more important [12, 17, 30, 31].

Closeness centrality is defined as the reciprocal of the farness which is defined as the sum of its distances to all other nodes. Distance is the length of shortest path between two nodes. Closeness centrality could be regarded as how long it will take to spread information from one to all other nodes. It is a measurement to quantify the indirect influence for a node. A company with high closeness centrality influences all others more or in the reverse direction, and also conflicts with all others more easily [12, 17, 30, 31].

Betweenness centrality is the number of times a node acts as a bridge along the shortest path between two other nodes. It is the bridging power or blocking force between two nodes i.e. the influence of information movement. In the patent citation network, it is a measurement of quantifying direct influence between the particular pair of companies [12, 17, 30, 31]. These four centralities are introduced by social network and they could be regarded as measurements of leader and follower of patent citation network.

This study adds four centralities of patent citation network to make up for TKS and TKR in order to set up a model for technological evaluation and then verifies this model by Intelligent Transportation System , ITS. Companies could understand their technological position also their competitors' and set up operational strategies by the analysis results.

II. MODEL CONSTRUCTION

This study tries to construct a model to evaluate technological position of a company. There are three phases of constructing the model: (1) data collection and database construction, (2) data classification and (3) data analysis.

Phase 1: data collection and database construction

Step1: data collection and fundamental database construction

Find keywords through literature, news and websites review, then add or subtract keywords by interviewing experts. Retrieve patents by Boolean Operators(AND, OR, ANDNOT) from INPADOC or USPTO and search by field of title and abstract on application date, publication date and issue date then build up a patent fundamental database Ω.

Step 2: data sieving and verifing

Some patents in the database Ω may be out of research category. Delete those keywords out of research category after reviewing by manpower then retrieve again and build up a correct patent database Φ.

$$\Phi = \Omega - \{\text{patents out of research category}\}$$

Phase 2: data classification

Step 1: patent citation network

A network consists of nodes and ties. Patent citation network treats patents as nodes and citations as ties[12, 14]. Database Φ are classified into two types of patents. One is citing patent $[Q_i]$ having M patents, $1 \le i \le M$, the other one is cited patent $[P_j]$ having N patents, $1 \le j \le N$. The relation between $[Q_i]$ and $[P_j]$ of citation matrix $[\alpha_{ij}]_{M\times N}$ is shown as (1).

$$[\alpha_{ij}]_{M\times N},\ \ \alpha_{ij} = \begin{cases} 1 & Q_i\ citing\ P_j \\ 0 & otherwise \end{cases} \ \ 1 \le i \le M,\ 1 \le j \le N \qquad (1)$$

Define numerical number 'c' as the critical number for sieving patent. Any P_j cited less than 'c' times is deleted from $[P_j]$. The remainder of $[P_j]$ and $[Q_i]$ forms a new matrix $[\varepsilon_{ij}]_{m\times n}$, $m \le M$, $n \le N$ as (2). Because the cited patents are cited by citing patent repeatedly, n should be less or equal to than m i.e. $m \ge n$. Patent counts of $[\varepsilon_{ij}]_{m\times n}$ are effected by 'c' value. When 'c' is bigger, the cited patent counts n is smaller. The citing counts m will be smaller, too.

$$[\varepsilon_{ij}]_{m\times n},\ \ \varepsilon_{ij} = \begin{cases} 1 & Q_i\ citing\ P_j \\ 0 & otherwise \end{cases} \ 1 \le i \le m,\ 1 \le j \le n \qquad (2)$$

Step 2: patent co-citation approach, PCA

PCA which originates from co-citation in the literature [32] employs patent co-citation counts to measure similarity of patent to build up a patent classification approach [33]. The matrix, $[\omega_{jj'}]_{n\times n}$, is co-citation matrix of P_j and $P_{j'}$, (3).

$$\omega_{jj'} \begin{cases} \sum_{i=1}^{a} \varepsilon_{ij}\varepsilon_{ij'} & if\ \ j \ne j' \\ 0 & if\ \ j = j' \end{cases} \ 1 \le j \le n, 1 \le j' \le n \qquad (3)$$

Chen [18] modified PCA by Tabu search and scree test of R-square[34] in steading of the original factor analysis. Chen's modification calculates Pearson's correlation coefficient $[\gamma_{jj'}]_{n\times n}$ from $[\omega_{jj'}]_{n\times n}$ with setting its diagonal for '0'. Then patents are classified into presetting cluster counts through Tabu search and scree test of R-square. We label each cluster according to their technological properties.

Step 3: data completeness

If the target technological cluster has not enough patent counts, the cluster could be expanded by their citations and patent families. Patent citations gain relative patents from outside of company and patent families could gain patents from inside. INPADOC is a good source for searching patent family. Google Patent could retrieve the citing and cited patents for each patent of family. After the database is complete, Using UCNET could gain the relation matrix and then proceed the following analysis.

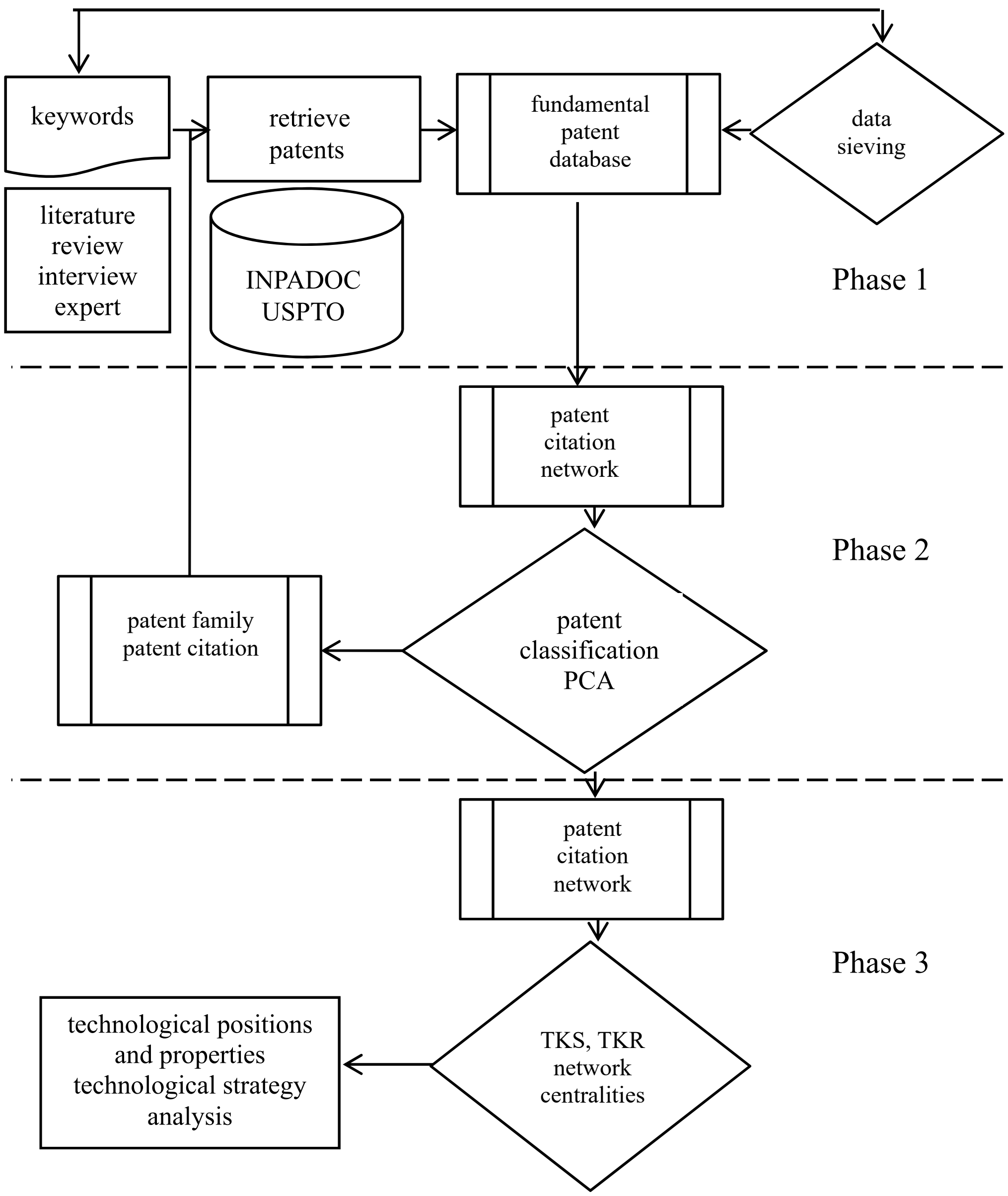


Fig. 3: Research Process

Phase 3: data analysis

Patent affiliate network is from social affiliate network which has some actors are affiliated with some events [35]. Patents affiliated with companies form a patent affiliate network, (4).

$$M = [\beta_{kr}]_{gxh},$$

$$\beta_{kr} = \begin{cases} 1 & if\ P_k\ affiliated\ with\ C_r \quad k = 1,2,\dots,g \\ 0 & otherwise \quad r = 1,2,\dots,h \end{cases} \quad g \geq h \qquad (4)$$

P_k: k^{th}patent, C_r: r^{th}company, g: patent counts, h: company counts

Step 1: technological knowledge redundancy analysis

Indicator 1: Technological Knowledge Status, TKS

$$[TKS_{ii}]_{hxh} = \mathrm{M^T M} \qquad (5)$$

$$TKS_{ii} = \sum_{k=1}^{g} \beta_{ik}\beta_{ki} \quad i = 1,2,\dots,h \qquad (6)$$

α_{kr}: k^{th}patent affiliated with r^{th}company, g: patent counts, h: company counts

TKS_{ii} represents the sum of self-patent redundancy of i^{th}company i.e. the diagonal of $[TKS_{ii}]$.

Indicator 2: Technological Knowledge Reliability, TKR

$$[TKR_{ij}]_{hxh} = \mathrm{M^T M}$$

$$TKR_{ij} = \sum_{k=1}^{g} \beta_{ik}\ \beta_{kj} \quad i = 1, 2, \dots, h \quad j = 1, 2, \dots h \quad i \neq j \qquad (7)$$

α_{ik} : k^{th} patent affiliated with i^{th} company, β_{kj} : k^{th}affiliated with j^{th}company

g: patent counts, h: company counts

$[TKR_{ij}]$ is the sum of patent redundancy between i^{th}company and j^{th}company. Patent counts of i^{th} company influence its TKR. $[TKR_{ij}]$ is divided by the sum of its self-patent redundancy i.e. its TKS,(8).

$$TKR_{ii} = \frac{\sum_{j=1}^{h} TKR_{ij}}{TKS_{ii}} \quad i = 1,2,\dots,h \quad j = 1,2,\dots,h \quad i \neq j \tag{8}$$

Step2: network centrality analysis

Indicator 3: Degree centrality

$$C_D(n_i) = \sum_j x_{ij} \tag{9}$$

Indicator 4: Eigenvector centrality

$$C_E\,(n_i) = \lambda^{-1} \sum_j x_{ij} e_j \tag{10}$$

Indicator 5: Closeness centrality

$$C_c(n_i) = \left[\sum_j d(n_i, n_j)\right]^{-1} \tag{11}$$

Indicator 6: Betweenness centrality

$$C_B(n_i) = \frac{C_B(n_i)}{\frac{(g-1)(g-2)}{2}} \tag{12}$$

Each of six indicators is divided into two kinds of high and low. The indicator being higher than average mark as '+', contrary mark '-' represents the low one. The symbols of TKS, TKR, Degree centrality, Eigenvector centrality, Closeness centrality and Betweenness centrality are 's', 'R', 'D', 'E', 'C' and 'B'. For example, only TKS and Degree are higher than averages^{+} D^{+} R^{-} E^{-} C^{-} B^{-}. Implication of all indicators is shown in table 1.

III. CLOUD COMPUTING AND INTELLIGENT TRANSPORTATION SYSTEM

'Cloud' emerged from Google Search Appliance (RSA) Conference, 2008. Cloud computing develops fast along with technological growing of internet, electron, communication, control and detection industries. Intelligent Transportation System, ITS transmits instant imformatiom, increases safety and efficiency and improves traffic condition. Global positioning system,GPS, geographic information system, GIS, Google maps, navigation and big data computing push users interacting with ITS closer and closer. Companies provides more extra services such as personal travel suggestion, instant road rescue and public transportation control.

Phase 1: data collection and database construction

First, based on 'cloud' for retrieving, this study concludes keywords (SPEC/"Cloud" and ("compute$" or "brows$" or "service" or "system" or "web$" or "communicate$")) from science literatures, website and experts. Period of retrieving is from 2003 to 2014. The fundamental database Ω_{cloud} has 16285 patents.

Secondly, some patents are out of the research field such as 'cloud point', 'electron cloud', 'point cloud' and so on which usually apply to chemical or material technologies. Patents of forty five keywords unrelated to cloud technologies are deleted, table 2. Only 9760 patents left form a new database Φ_{cloud} from database Ω_{cloud}.

TABLE 1: IMPLICATION OF INDICATORS

indicator			property
TKS	H	S^{+}	technological uniqueness, status within the technological network
	L	S^{-}	
TKR	H	R^{+}	technological redundancy with others, opportunity of cooperation
	L	R^{-}	
Degree centrality	H	D^{+}	technological connection counts, resource counts
	L	D^{-}	
Eigenvector centrality	H	E^{+}	connection counts with important company, the spot is hot or not
	L	E^{-}	
Closeness centrality	H	C^{+}	distance among all others, speed of getting resource
	L	C^{-}	
Betweenness centrality	H	B^{+}	bridge of a pair of companies, cross section of technological path
	L	B^{-}	

TABLE 2: KEYWORDS UNRELATED TO CLOUD TECHNOLOGIES

sharpening	cloud point	ion cloud	cloud chamber	cleaning an ion source
point cloud	oligonucleotide	quadrupole ion	heart cavity	paraffinic
vaccinating	n-alkanes	segmented-ion	endocardium	quadrupole ion
pyridine	olefins	catheter	point cloud	hydrofluorocarbon
radiation	microalgae	polysaccharides	ion-ion reactions	solar insolation
atom	fatty acid	bimanual	glycol	heart cavity
cycloparaffin	electron cloud	dust cloud	silane	cloud point
toner	colorant	estolide	oligonucleotides	cleaning an ion source
benzoic	steam	detergent	polypeptides	oligonucleotide

Pase 2: data classification

The network matrix of Φ_{cloud} is $[\alpha_{ij}]_{9760\times9760,cloud}$. Patents with one forward citation or less are cut off from the matrix. Five hundred and thirty five patents left forms a matrix of $[\varepsilon_{ij}]_{535\times535,cloud}$. The row matrix is citing patents and the column matrix is cited patents. Due to the matrix size of 256 x256 limited by UCINET, patents of column matrix with one forward citation or less and patents of row matrix with zero backward citation cut off forms matrix of $[\varepsilon_{ij}]_{148\times89,cloud}$. After PCA and scree test of R-square, 11 clusters suit this study most, see table 3, Fig. 4 and Fig. 5.

TABLE 3: TECHNOLOGY CLUSTERS FOR PCA OF CLOUD TECHNOLOGIES

cluster	technology	cluster	technology
TF01	technology for environment detective	TF07	technology for customized service
TF02	technology for location-based service	TF08	technology for critical point detective
TF03	technology for data transmission and process	TF09	technology for dynamic traffic flow optimization
TF04	technology for safety monitoring	TF10	technology for speech recognition
TF05	technology for interaction of community website	TF11	technology for traffic monitoring
TF06	technology for data management system		

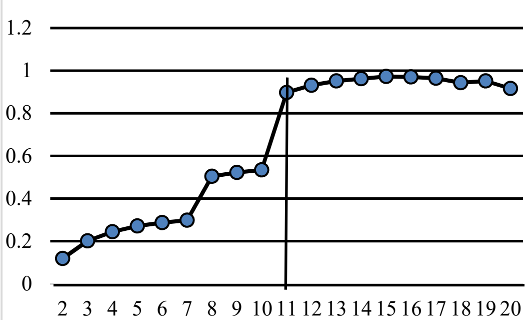


Fig 4: R-Square of PCA Analysis of Cloud Technologies

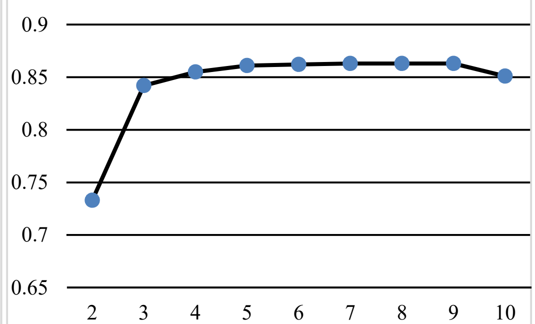


Fig 6 : R-Square of PCA Analysis of Intelligent Transportation System

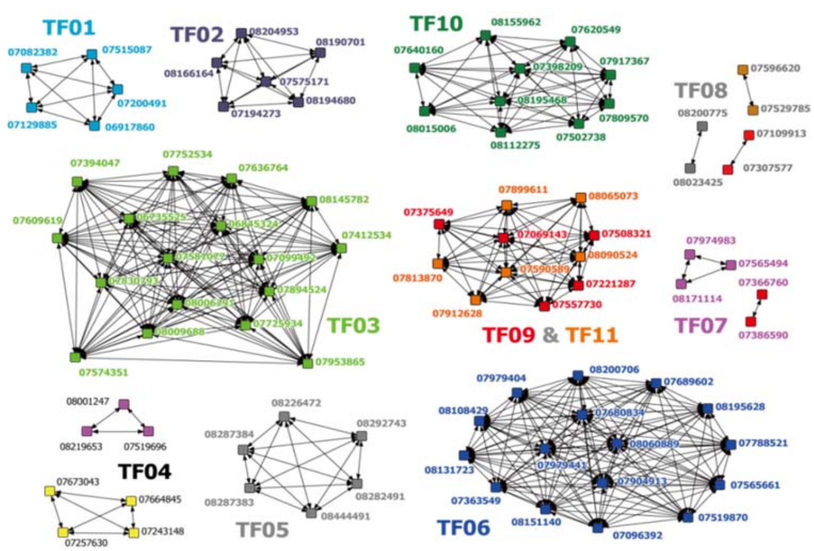


Fig 5: groups of clusters in the cloud technologies

TABLE 4: TECHNOLOGY CLUSTERS FOR PCA OF INTELLIGENT TRANSPORTATION SYSTEM

cluster	technology	cluster	technology
2-TF1	technology for information and communication system in motor vehicles	2-TF3	technology for dynamic traffic flow forecasting
2-TF2	technology for paging massage/broadcasting	2-TF4	technology for information retrieving in motor vehicles

Fig. 5 shows that TF09, technology for dynamic traffic flow optimization and TF11, technology for traffic monitoring are connetted together. TF09 relates to TF11strongly. Custer TF 09 contains application technologies of 'traffic imfomation' and TF11 centres on 'dynamic flow' forecasting. Both belong to ITS. These two are new developments having not many patents. The patent families and citations of these two clusters of patents construct a database, $[\alpha_{ij}]_{463\times463,ITS}$ of ITS. Patents with four forward citations or less are cut off to form a patent citation network matrix of $[\varepsilon_{ij}]_{278\times278,ITS}$. Because citation between patents is main concern of this research, 88 patents with two forward citations or less and 78 patents with zero backward citations are cut off to form a modified matrix of $[\varepsilon_{ij}]_{210\times190,ITS}$. Based on R-square, these patents divided into four groups are labeled as table 4.

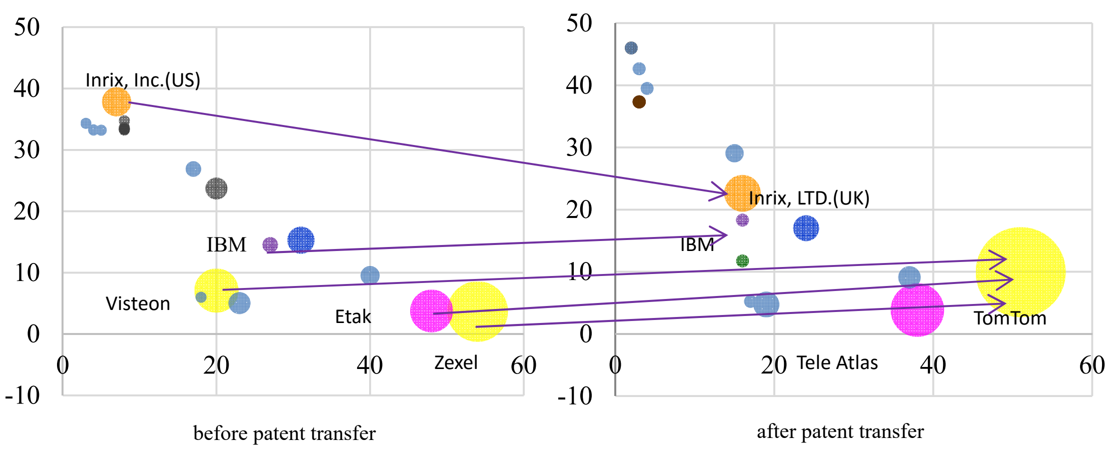
Phase 3: data analysis

Step 1: technological knowledge redundancy analysis

In the knowledge-relationship niche plot, some companies' positions move after patents transfer. Visteon and IBM with low TKS withdraw from the technology field after strategical ajustment.TomTom raises its technological positions through patent acquistion from Visteon, Etak and Zexel to compete in the technology field in fig. 7.

Step2: network centrality analysis

The numerical value is higher than average of the each indicator of TKS and TKR, degree, eigenvector, closeness and betweenness centrality marking as '+' and otherwise marking as '-'. The characteristics with high and low change of six indicators are shown in table 5 and 6.



X axis: TKS Y axis: TKR Size of Bubbles: patent counts

Fig. 7: knowledge-relationship niche plot before/after patent transfer

TABLE 5：HIGH AND LOW CHARACTERISTICS OF SIX INDICATORS BEFORE TRANSFER

Transfer Docket No.	Company	TKS		TKR		D		E		C		B	
		H	L	H	L	H	L	H	L	H	L	H	L
M01A	IBM Corporation(US)	S^+			R^-	D^+		E^+		C^+		B^+	
M01A	Applied Generics Limited(GB)	S^+		R^+		D^+		E^+		C^+			B^-
M01A	Visteon Technologies, Inc.(US)	S^+			R^-		D^-		E^-		C^-		B^-
M01A	Zexel Corporation Daihatsu-Nissan Ikebukuro(JP)	S^+			R^-	D^+			E^-		C^-		B^-
M01B	Sony Corporation(JP) | Etak, Inc.(US)		S^-		R^-	D^+			E^-		C^-	B^+	
M01B	Poppen; Richard F.(US)| Smartt; Brian E.(US)| Dunn; Linnea A.(US)| Derose; Frank J.(US)		S^-	R^+			D^-		E^-		C^-		B^-
M01B	Etak, Inc.(US)	S^+			R^-		D^-		E^-	C^+			B^-
M02	DeKock; Bruce W.(US)	S^+		R^+		D^+		E^+		C^+		B^+	
M03	Luciani; Sergio(US)		S^-	R^+		D^+		E^+		C^+			B^-
M03	Wenking Corp.(CA)		S^-	R^+		D^+		E^+		C^+		B^+	
M04	Inrix, Inc.(US)		S^-	R^+		D^+		E^+		C^+			B^-
M04	Infomove.COM, Inc.(US)	S^+			R^-	D^+			E^-	C^+		B^+	
M05	Mytrafficnews.com, Inc.(US)		S^-		R^-		D^-		E^-	C^+	C^-		B^-
M05	Navteq North America, LLC(US)		S^-	R^+		D^+		E^+		C^+			B^-
M05	Traffic.com, Inc.(US)	S^+			R^-		D^-		E^-		C^-	B^+	
M06	Trimble Navigation Limited(US)		S^-		R^-		D^-		E^-	C^+		B^+	
M06	At Road, Inc.(US)	S^+			R^-	D^+		E^+		C^+		B^+	
M07A	Mannesmann AG(DE)	S^+		R^+		D^+		E^+		C^+		B^+	
M07B	Motorola Inc.(US)	S^+			R^-	D^+		E^+		C^+		B^+	
M08	Daimler-Benz AG(DE)		S^-	R^+			D^-		E^-		C^-		B^-
M08	Decell, Inc.(US)	S^+		R^+		D^+		E^+		C^+			B^-
M10	Traffic Gauge, Inc.(US)	S^+		R^+		D^+		E^+		C^+		B^+	
M11	Triangle Software LLC(US)	S^+		R^+		D^+		E^+		C^+		B^+	
M12	Ran; Bin(US)	S^+		R^+		D^+		E^+		C^+		B^+	
M13	AT/COMM Incorporated(US)	S^+			R^-	D^+		E^+		C^+			B^-
M14	Case Corporation(US)		S^-		R^-		D^-		E^-		C^-		B^-
M15	Carine; Dean A.(US)		S^-	R^+		D^+		E^+		C^+			B^-
M16	E-Systems, Inc.(US)	S^+		R^+		D^+		E^+		C^+			B^-
M17	Gurmu; Hailemichael(US)| Gebre; Adamsu(NL)	S^+			R^-		D^-		E^-		C^-		B^-
M18	Hollenberg; Dennis D.(US)		S^-		R^-		D^-		E^-		C^-		B^-
M19	InfoSpace, Inc.(US)		S^-		R^-	D^+			E^-	C^+		B^+	
M20	KSI, Inc.(US)		S^-	R^+		D^+		E^+		C^+			B^-
M21	Lucent Technologies Inc.(US)		S^-		R^-		D^-		E^-		C^-		B^-
M22	Madnick; Peter A.(US)| Sherwood; Russell W.(US)	S^+			R^-	D^+			E^-	C^+			B^-
M23	Openwave Systems Inc.(US)		S^-	R^+			D^-		E^-		C^-		B^-
M24	Pietzsch AG(DE)		S^-	R^+			D^-		E^-	C^+			B^-
M25	Rockwell International Corporation(US)		S^-	R^+			D^-		E^-		C^-		B^-
M26	Santa Barbara Research Center(US)		S^-	R^+			D^-		E^-		C^-		B^-
M27	Sterling Software, Inc.(US)		S^-		R^-		D^-		E^-		C^-		B^-
M28	Xerox Corporation(US)		S^-	R^+			D^-		E^-		C^-		B^-

TABLE 6：HIGH AND LOW CHARACTERISTICS OF SIX INDICATORS AFTER TRANSFER

Transfer Docket No.	Company	TKS		TKR		D		E		C		B	
		H	L	H	L	H	L	H	L	H	L	H	L
M01A	IBM Corporation(US)	S^+			R^-	D^+		E^+		C^+		B^+	
M01A	TomTom Global Assets B.V.	S^+			R^-	D^+		E^+		C^+		B^+	
M01B	Tele Atlas North America CA	S^+			R^-	D^+			E^-		C^-		B^-
M01B	Sony Corporation(US)	S^+			R^-		D^-		E^-	C^+		B^+	
M02	Traffic Information, LLC	S^+			R^-	D^+		E^+		C^+		B^+	
M03	Strategical Design Federation W, INC.	S^+			R^-	D^+		E^+		C^+		B^+	
M04	Inrix UK LTD.	S^+			R^-	D^+		E^+		C^+		B^+	
M05	NAVTEQ B.V.	S^+		R^+		D^+		E^+		C^+		B^+	
M06	Trimble Navigation Limited	S^+		R^+		D^+		E^+		C^+		B^+	
M07A/B	Continental Automotive GMBH	S^+		R^+		D^+		E^+		C^+		B^+	
M07B	CDC Propriete Intellectuelle		S^-		R^-		D^-		E^-		C^-		B^-
M07A	Motorola Inc.(US)	S^+			R^-	D^+		E^+		C^+		B^+	
M07A	Agero Connected Service, INC.	S^+		R^+		D^+		E^+		C^+			B^-
M08	Ramsle Technology Group GMBH, LLC	S^+		R^+		D^+		E^+		C^+		B^+	
M10	Telecommunication Systems, INC.	S^+		R^+		D^+		E^+		C^+		B^+	
M11	Pelmorex Canada INC.	S^+		R^+		D^+		E^+		C^+		B^+	
M12	Trafficcast International, INC.	S^+		R^+		D^+		E^+		C^+		B^+	
M13	Transcore ITS, LLC	S^+			R^-	D^+		E^+		C^+			B^-
M14	CNH America LLC		S^-		R^-		D^-		E^-		C^-		B^-
M15	DAC Remote Investments LLC		S^-	R^+		D^+		E^+		C^+			B^-
M16	Allen Telecom LLC	S^+			R^-	D^+		E^+		C^+			B^-
M17	Thales Navigation, INC.				R^-		D^-		E^-		C^-		B^-
M18	LBS Innovations, LLC		S^-		R^-		D^-		E^-		C^-		B^-
M19	Switchboard LLC	S^+			R^-		D^-		E^-	C^+		B^+	
M20	Trueposition, INC.	S^+		R^+		D^+		E^+		C^+			B^-
M21	Vringo Infrastructure, INC.		S^-		R^-		D^-		E^-		C^-		B^-
M21	Electric Road Corporation	S^+			R^-		D^-		E^-	C^+		B^+	
M23	Unwired Planet, LLC		S^-	R^+			D^-		E^-		C^-		B^-
M24	International Road Dynamics INC.		S^-	R^+		D^+			E^-	C^+			B^-
M25	Mix Telematics North America, INC.		S^-	R^+			D^-		E^-		C^-		B^-
M26	Raytheon Company		S^-	R^+			D^-		E^-		C^-		B^-
M27	CA INC		S^-		R^-		D^-		E^-		C^-		B^-
M28	Tevhnology Licensing Corporation		S^-	R^+			D^-		E^-		C^-		B^-

IV. CASE DISCUSSION FOR TECHNOLOGICAL PROPERTIES MOVEMENT

According to induction, we choose three particular types of strategy of patent acquisition, enhance barriers to consolidate position, milch cow of NPEs, shortcut for periphery and new entrants, to discuss.

A. Enhance barriers to consolidate position

TOMTOM is a leader of satellite navigation system. In order to consolidate the position, it strategically acquired Applied Generics 2006 to develop the technology of real-time traffic. TOMTOM, 2007, bought Horizon Navigation Inc. with 18-year experience of satellite navigation system to gain 16 patents belonging to Visteon and 30 patents belonging Zexel originally, and acquired Tele Atlas to gain one patent from SONY and 15 patents from Etak Inc. initially. TOMTOM continuously acquired companies and patents in order to enhance its leading position making it face antitrust charges filed by European Union. Its position became high SDECB and low R in the technological network after buying one patent from IBM in 2010.

INRIX Inc. founded in 2004 is a company providing smartphone and auto manufactures real-time traffic and path forecasting. Its code in technological network is high RDEC and low SB showing that its technological status is low and it is not an important bridge among other companies. Therefore, NRIX Inc. acquired Integrated Transport Information Services Ltd. to gain one patent which originally belonged to Infomove.COM, Inc. whose code in technological network is high SDCB and low RE. INRIX Inc. became an overlord with high SDECB and low R in technological network of real-time traffic and path forecasting.

B. milch cow of non-practicing entities (NPEs)

Traffic Information LLC in Texas, USA is a patent holding company whose main operating income is licensing fee. It gained three patents in 2004 from Bruce Dekock, Kevin Russell, Richard Qian, three certain individuals, about technology of transmitting real-time traffic to smartphone users from multi-monitors and web transmission. Because these patents' claim cover a lot of fields of real-time traffic, Traffic Information LLC used them to suit Volvo, Honda, HTC, Samsung, RIM, Yahoo, Google, Sony and HP. Only these three patents have code AH with all high SRDECB in technological network showing they are powerful and influential. Due to less maintain fee only for three patents, they are big milch cows for a NPE.

Companies avoid facing patent litigation, thus patent pool such as Strategic Design Federation W, Inc. emerges. Sergio Luciani had a patent with high RDEC and low SB, and Wenking Corp. had a patent with high RDECB and low S. Strategic Design Federation W, Inc. has position with high SDECB and low R after buying these two patents. Like Traffic Information LLC, Strategic Design Federation W, Inc. pays less and gains more. These two patents are good choices for a NPE.

C. shortcut for periphery and new entrants

Navteq was a new starter of Geographic Information System (GIS). Its technological status is low at first due to low SB and high RDEC. Navteq 2006 announced acquiring two important patents from Traffic.com , Inc. which provided real-time traffic to internet, smartphone and broadcasting. After acquisition, its position with all high SRDECB became much higher in technological network of Intelligent Transportation System , ITS.

Trimble Navigation Limited made GPS (Global Positioning Systems) receivers, laser rangefinders, UAVs (Unmanned Aerial Vehicles) and inertial navigation systems. Its position was high CB, low SRDE. Trimble Navigation Limited increased its position with all high SRDECB and became competitive after acquiring At Road, Inc. 2007.

V. CONCLUSION

A. Locate the position in the six-dimensional network

Understanding the position in the technological network is crucial for a company to set up its strategy of operation and technological development. This study sets up a model to make up for technological knowledge status(TKS) and technological knowledge reliability(TKR) with four centralities of degree (D), eigenvector (E), closeness (C), betweenness (B) to figure out the position of a company. TKS suggests the technological uniqueness and status in the network. TKR suggests the overlap of knowledge and opportunity of cooperation between a company and others. Degree centrality infers connections with others. Eigenvector centrality infers the partnership with important companies. Closeness centrality implies that its technology might close to all players. Betweenness centrality implies the bridging power between a pair of companies. These figures are useful to locate the position in the six-dimensional network.

B. Implications and further research

This evaluation model also suggests three types of acquisition strategies. First, companies enhance barriers to consolidate position. Their TKR become lower. TKS and centralities become very high. These companies could integrate patents with uniqueness (S+), more resources(D+) in network, hot spots(E+), core technological knowledge(C+), bridging power (B+), and blocking cooperative chances from other competitors (R-) in order to become an overlord. Secondly, another type of acquisition strategy is milch cow of non-practicing entities (NPEs). No matter whether patent troll or its rival, patent pool, they both try to reduce cost and undertake broad litigation and licensing. They purchase a few patents with high TKS and centralities, but TKR which is not concerned. The last type is shortcut for periphery and new entrants. The companies with periphery position or new comer in the technological network of Intelligent Transportation System both need to purchase patents with high centralities in order to gain cooperative opportunity and rise their status.

Each company has to know its position in order to decide the patent and technological acquisition strategy and technological development strategy. This model of six-dimensional network could help a company to locate the technological position and to find more different types of acquisition.

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