Network Structure and Capability Leveraging: Lesson from China's TD-SCDMA Industry Alliance

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Abstract. After the acknowledgement of Time Division Synchronous Code Division Multiple Access (TD-SCDMA) international standard, China's TD-SCDMA industry alliance experiences high-speed development. As a network organization, the members and their relationships of China's TD-SCDMA industry alliance need *discussion*. This paper analyzes the network structure of China's TD-SCDMA industry alliance on the basis of social network analysis. By focusing on the network structure properties like network density, centrality and centralization, clique, structure and position, the paper discusses the structure of TD-SCDMA industry alliance in detail and gives proposals on capability leveraging of China's TD-SCDMA industry alliance. We indicate that under the situation of China, for the development of whole alliance, TD-SCDMA industry policy should facilitates isolated or peripheral members to build links with central members. Isolated and peripheral members should make efforts to get access to core area under the help of alliance mechanism or relationship with dominated members in the same clique. Central members should do more contribution to the whole network development by sharing their information, knowledge and technology.

Keywords: China's Telecom-Equipment Industry; TD-SCDMA Industry Alliance; Social Network Analysis; Network Structure

1. Introduction

Rapid changes in technology, the competitive environment, firm strategies and other pressures are prompting many firms to seek continuing cooperative relationships with other firms [1]. Under the globalization and network economic era, firms are embedded in its social relationships and innovation networks. Interorganizational relationships are seen as long-term oriented arrangements between organizations (firms, institutions, agencies, etc) [2]. As a type of cooperative relationship governance form, strategic alliance is paid more and more attention by researchers and industrialists. While different from strategy and organizational researches under dyadic level (relationships between two organizations) like resource dependence theory (Pfeffer & Salancik,1978) and transaction cost economics (e.g., Willianmson, 1991) or researching interorganizational contracts (e.g., Arino & Reuer, 2006), this paper analyzes strategic alliance on the basis of social network perspective, using social network analysis. Under the basis of analysis results, the network structure of China's TD-SCDMA industry alliance and proposals on capability leveraging of TD-SCDMA industry alliance are discussed.

2. Strategic alliance

Strategic alliances are voluntary arrangements between forms involving exchange, sharing, or codevelopment of products, technologies, or services [3]. They can occur as a result of a wide range of motives and goals, take a variety of forms, and occur across vertical and horizontal boundaries [3]. As a type

of network, various sector alliances are discussed under the network perspective, such as biotechnology sector [4], [5], textiles sector [6], chemicals sector [7], [8], steel sector [9], semiconductor sector [9], [10], pharmaceutical sector [8]. Different from a single industry research, Melissa A.Schilling (2007) researches the structure of 11 industry-level alliance networks and proposes that firms embedded in alliance networks that exhibit both high clustering and high reach will have greater innovation output than firms in networks that do not exhibit these characteristics [11]. As network structure analysis of alliance is popular in research, the research application in Chinese sector alliance is few. This paper focuses on TD-SCDMA industry alliance, one of typical sector alliances of China's telecom-equipment industry.

3. China's TD-SCDMA industry alliance

China, one of the most important late-industralized countries in the world, treats innovation as her national strategy in 2006. As one of the most R&D intensive-industries in China, Chinese ICT industry experiences high-speed development and becomes world's largest mobile cellular market [12]. Table 1 illustrates the outline of telecommunication industry development of China.

TABLE 1. OUTLINE OF CHINESE ICT INDUSTRY

	2000	Oct.2006	Average annual growth	Position in the world
Fixed phone users	145 million	371 million	21%	1/4 of the world
Internet users	33.70 million	131 million	31%	1/10 of the world
Wirless phe users	85.0 million	449 million	40%	NA
Sales of ICT industry	607 billion	3800 billion (2005)	31%	Number 3 in the world

Source: The Speech of Wu Bangguo in World Telecommunication Exhibition in Hong Kong, Dec.3, 2006. www.xinhua.net

As a method for participating global competition and catching-up strategy, China tries to play a role in the international game of standard setting. These attempts include Enhanced Versatile Disc (EVD), Intelligent Grouping and Resources Sharing (IGRS), Audio, Video Coding Standard (AVS), and Time Division Synchronous Code Division Multiple Access (TD-SCDMA) standards [14], [15]. TD-SCDMA, proposed by the China Wirless Technology Standard (CWTS) Group in 1998, was approved as one of the 3G standards by ITU in May 2000, and joined 3GPP in March 2001 [12]. Compared with the other two 3G standards, wideband CDMA (WCDMA) and CDMA2000, TD-SCDMA is based upon unpaired frequency band in TDD-mode with flexible downlink/uplink switching points to achieve a maximum utilization of the available frequency bands for each service and service mix [16]. By using Joint Detection Technical, TD-SCDMA minimizes multiple access interference (MAI) information and increases transmission capacity [12]. Under some technological advantages and large domestic market, Chinese government plays an important role of TD-SCDMA standard's formation, improvement, industrialization and commercialization. In 2002, China's TD-SCDMA industry alliance was established to support and promote the TD-SCDMA industrialization. After nearly a decade development, China's TD-SCDMA industry alliance absorbs 78 alliance members that cover the whole industry chain. Analyzing members and their relationships becomes meaningful to in-depth know the alliance's development and capability leveraging implications.

4. Social Network Analysis

In a very general way, a network is a set of nodes and the set of ties representing some relationship, or lack of relationship, between the nodes [17]. While nodes represents any actor among the network, ties can denote many types of connections such as supply-demand relationship, trade contracts, interlocking directorates and strategic alliances, and flows such as information, materials, financial resources, services and social support [18]. As a review from literatures of social network fields, the author of literature [18] discusses network structural issues from actor level and network level and summarizes major properties. This paper selects some important properties and illustrates them as follows to promote our research. (See table 2, all the formulation and measurement of properties can be seen in references [21-23])

5. study of China's TD-SCDMA industry alliance

We analyze the network structure of China's TD-SCDMA sector alliance. As a network, it's obvious that the nodes represent alliance members. When referring to links of nodes, as participating in alliance does not means two nodes have substantial ties, we define that two nodes have links if one of them publishes or notices the relationship on website or written materials. We search data from each member's (organization) website, China's TD-SCDMA industry alliance's website, two biggest search engines in China—baidu and google, TD-SCDMA industry monthly reports, during 2002 (the year that China's TD-SCDMA industry alliance established) to 2010, all the links refer to strategic cooperation agreement, technology transfer agreement, product tender agreement, project cooperation agreement, equipment supplier agreement, intellectual property sharing agreement, joint R&D activity (like R&D cooperation, joint laboratory), terminal application agreement, business merger contract, OEM agreement and company affiliated relationship. Due to the imperfection of industrial level database and updating lag of secondary data in China, the network we analyze eliminates members that join alliance in 2009 or 2010.

TABLE 2. IMPORTANT PROPERTIES FOR NETWORK STRUCTURE

Properties		Description	Theory background
Centrality and centralization	Degree centrality	The number of direct links maintained by an organization with other organizations [18].	Freeman(1997), Knoke and Burt (1983), Friedkin (1991), Faust and Wasserman (1992), Wasserman and Faust (1994) [20].
	Betweenness centrality	The number of paths between other nodes on which an actor lies [19].	
	Centralization	The extent one or a few organizations in the network considerably more centrally connected than others [18].	
Clique	k-plex	A maximal subgraph containing g_s nodes in which each node is adjacent to no fewer than $g_s - k$ nodes in the subgraph [22].	Seidman and Foster (1978), Faust and Wasserman (1992), Wasserman and Faust (1994); [23].
	n-clique	A subgraph in which the distance between every two nodes is less than or equal n [22].	Wasserman and Faust (1994), Scott (2000).
Network density		The ratio of existing links in the network to the number of possible pairwise combinations of firms [11].	Wasserman and Faust (1994).
Structure and position	core-periphery structure	Divide the network into two discrete blocks, that one refers to the relationship within subgroups and the other refers to the relationship between subgroups [23].	Alba (1973), Wasserman and Faust (1994), Scott (2000); [23].
	Broker relationship	To what extent does an organization span gaps, or structural holes in a network [18].	Granovetter (1973), Wasserman and Faust (1994); [23].
	Structural hole	The non-redundant links between two actors in the network [25].	Burt (1992), Borgatti, Everett & Freeman (2002);[23].

We use social network analysis software UCINET to promote analysis. Table 3 introduces alliance members that cover the whole TD-SCDMA industry chain. Figure 1 shows China's TD-SCDMA industry alliance network. Under the description of table 3, the whole TD-SCDMA industry chain includes 7 positions like equipment manufacture, chip, terminal, testing, antenna, operating system and repeater. After near ten years development, Chinese companies of alliance members have already covered all the industry chain. The low transaction costs and knowledge diffusion among alliance members promote the TD-SCDMA industry chain gradually towards a mature industry chain. Figure 1 describes the alliance network, under the defined links in the paper, though all the members establish direct or indirect ties on the basis of alliance mechanism, their roles in alliance presents heterogeneity. Nodes such as CHINA MOBILE, DTM (DangTang Mobile), ZTE, HW take the central position of network because of their relatively large number of links, while company CETC14, rdamico, BENQ, youke, FLEXTRONICS, CCIT, digimoc, NTS are isolated in the alliance. That may because they are late comers with single business structure or cooperative capabilities, and do not establish direct links with other members. Under the alliance mechanism or indirect links, they can still obtain the benefits like knowledge sharing or market opportunites in the alliance.

TABLE 3. NETWORK MEMBERS OF TD-SCDMA INDUSTRY ALLIANCE

Industry chain position of TD-SCDMA.	Company.
Equipment manufacture	Datang Mobile, ZTE, Potevio, TD Tech Ltd, Utstar, alcatel-sbell, fiberhome, postcom, CFC, GRENTECH, FINGU, JinPeng, EB, digimoc, NTS.
Chip.	Datang Mobile, COMMIT Incorporated, T3G, CYIT, spreadtrum, comlent, rdamicro, MediaTek, digimoc, NTS.
Terminal.	Datang Mobile, Holley Group, HuaWei(HW), Lenovo, ZTE, CECW, Hisense, COMMIT, T3G, Utstar, alcatel-sbell, Envada, dbtel, koretide, TCL, haier, postcom, BIRD, BOCO, yulong, SIM, LONGCHEER, BENQ, FLEXTRONICS, RME, CHINA MOBILE, PTAC, dopod, vtion, EB, WINGTEC, CCIT.
Testing.	Datang Mobile, ZY, ZCTT, StarPoint, CETC41, Rising Technology.
Antenna.	HTAT, tycc, andrew, comba, CETC14, MOBI.
Operating system.	Datang Mobile, koretide.
Repeater.	Datang Mobile, ZTE, comba, ACE, CFC, youke.

Source: summary from materials on website of China's TD-SCDMA alliance, http://www.tdscdma-alliance.org/english/index.asp

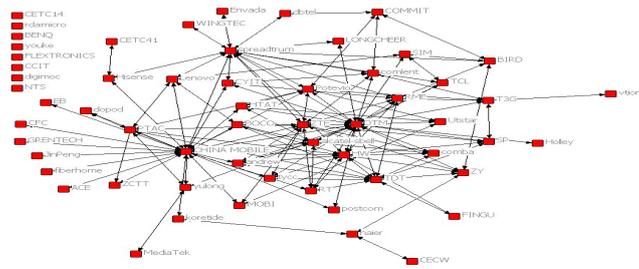Figure 1. TD-SCDMA industry alliance network

6. Results and discussions

6.1. Network density

The network density of TD-SCDMA alliance network is 0.0789, which means this network is relatively sparse. As a network composed of 59 nodes, the number of possible pairwise combinations of nodes in this network can reach 3422, but we find 270 ties in TD-SCDMA industry alliance network. We don't mean higher density is better because the establishment of each link may have transaction cost that refers to capital, human resource and time investment. But the density of real operating network of China's TD-SCDMA industry alliance must be higher as large number of links data cannot be obtained from official channels.

6.2. Centrality and Centralization

We choose two major indexes degree centrality and betweenness centrality to analyze the centrality property of China's TD-SCDMA industry alliance network but don't calculate the closeness centrality index as it does not apply to non-connected graph (including isolated nodes)[22]. In addition, we calculate the network centralization index to reflect the whole network centralization property. Results are in Table 4.

TABLE 4. CENTRALITY ANALYSIS RESULTS OF CHINA'S TD-SCDMA INDUSTRY ALLIANCE NETWORK

	Degree Centrality			Betweenness Centrality		
	rank	Absolute value	Relative value	rank	Absolute value	Relative value
1.	CHINA MOBILE	28.	47.458%.	CHINA MOBILE	522.597.	31.615%.
2.	DTM.	27.	45.763%.	DTM.	328.170.	19.853%.
3.	spreadtrum.	17.	28.814%.	spreadtrum.	220.761.	13.355%.
4.	ZTE.	16.	27.119%.	HW.	74.751.	4.522%.
5.	HW.	15.	25.424%.	ZTE.	67.437.	4.080%.
6.	TDT.	13.	22.034%.	ZY.	65.519.	3.964%.
7.	Potevio.	10.	16.949%.	Potevio.	57.790.	3.496%.
8.	PTAC.	9.	15.254%.	T3G.	50.927.	3.081%.
9.	RME.	9.	15.254%.	haier.	50.625.	3.063%.
10.	alcatel-sbell.	9.	15.254%.	yulong.	49.501.	2.995%.
Network Centralization.	40.02%.			30.35%.		

The network centralization of China's TD-SCDMA industry alliance is 40.02% under the degree centrality measurement and is 30.35% under the betweenness centrality measurement. The value is high which means China's TD-SCDMA industry alliance network exists large imbalance. Some members occupy core positions while others are relatively marginalized. As centrality rank of table 4 shows, large equipment manufacturers like DTM, TDT and Potevio, large terminal companies like CHINA MOBILE, HW, PTAC, alcatel-sbell have more links in alliance which means they are more active in cooperation and may make use of alliance network resources better. Also, the rank of betweenness centrality reflects members such as CHINA MOBILE, DTM, spreadtrum, HW, ZTE et.al take more important intermediary positions in the network, which means they have better information or resource control capability than other members. Table 5 presents the statistic results of degree centrality and betweenness centrality. From the results, the degree centrality is relatively stable, which means alliance mechanism creates opportunity for members' cooperation not only to large or dominated companies but also to small ones. But the statistic results implies that the distribution of betweenness centrality is unbalanced which means large numbers of business links are derived from core members' business activities, leading to core-periphery structure phenomenon of China's TD-SCDMA industry alliance network with imbalance of information and resouces flows in the network.

TABLE 5. CENTRALITY STATISTIC RESULTS OF CHINA'S TD-SCDMA INDUSTRY ALLIANCE NETWORK

.	Mean.	Std Dev.	Sum.	Variance.	Minimum.	Maximum.
Degree centrality.	5.576.	5.542.	329.000.	30.719.	1.000.	28.000.
Betweenness centrality.	29.458.	83.338.	1738.000.	6945.254.	0.000.	522.597.

6.3. Clique

We use two indexes k-plex, n-clique to analyze the clique or sub-organization properties of China's TD-SCDMA industry alliance network. The exitence of cliques reflects that factors such as regional characteristics, industrial characteristics and related business activities have effect on members' linkages in a network. Members within a clique interact more closely while members between cliques interact less. Large number of cliques in a network means the network structure presents serious small-groups phenomenon [26] which is not conducive to directly or widely information exchange among the whole network members. By setting the minimum set size equals 6 and value of k equals 2, there are 27 plex in China's TD-SCDMA industry alliance network. Among all the alliance members, DTM, who is the drafter and initiator of TD-SCDMA standard, belongs to all the 27 plexes. ZTE, who is one of the China's TD-SCDMA industry alliance founders and important equipment manufacturers, belongs to 17 plexes. CHINA MOBILE and HW, who are council members of China's TD-SCDMA industry alliance and important terminal companies, respectively belong to 21 and 26 plexes. By setting the minimum set size equals 6 and max distance (namely, the value of n) equals 2, there are 20 cliques in China's TD-SCDMA industry alliance network. The results are in table 6.

TABLE 6. CLIQUE ANALYSIS RESULTS OF CHINA'S TD-SCDMA INDUSTRY ALLIANCE NETWORK

.		k-plex.		n-clique.
rank.	company.	Value of k-plex that belongs.	company.	Value of n-clique that belongs.
1.	DTM.	27.	DTM.	20.
2.	CHINA MOBILE.	26.	CHINA MOBILE.	19.
3.	HW.	21.	ZTE.	18.
4.	ZTE.	17.	Potevio.	17.
5.	andrew.	11.	spreadtrum.	17.
6.	BOCO.	11.	HW.	16.
7.	RT.	11.	CYIT.	16.
8.	spreadtrum.	9.	RME.	15.
Sum.		27 plexes.		20 cliques.

Company like DTM, CHINA MOBILE, et.al, who belongs to different plexes or cliques may establish the bridge between two or more plexes and cliques, they not only obatain the bridge benefits like information benefits and control benefits [22], but also play a role of coordinator, gatekeeper, representative, cosmopolitan or liaison [27]. Company like WINGTEC which just belongs to single clique (DTM, HW, Lenovo, ZTE, Potevio, Hisense, CYIT, spreadtrum, Envada, dbtel, TCL, comlent, BIRD, LONGCHEER, RME, CHINA MOBILE, WINGTEC) may have single business structure. But it has different strategic selection if it wants to seek resources from other clique members. For example, first, try to build direct links with a node belonging to another clique under the alliance mechanism; second, try to seek information or cooperation opportunity by the path that bridging node owns.

6.4. Structure and position

1) Core-periphery structure

By using discrete core-periphery analysis model that make the highest density among core members and lowest density among periphery members, and not consider the density of relationship between core and periphery region [26], we get the core-periphery structure of China's TD-SCDMA industry alliance network in Table 7. 21 members form the core area while 38 members form the periphery area. Compared with the whole network density 0.0789, the density of core area is up to 0.348 while the density of periphery area is just 0.013. It shows that China's TD-SCDMA industry alliance network has hierarchical structure. In addition, according to the industry chain position, table 8 divides core area members. The results of table 8 from model analysis are in line with the literature [28] which introduces the ten-year development of China's TD-SCDMA industry and important companies in industry chain.

TABLE 7. CORE-PERIPHERY STRUCTURE OF CHINA'S TD-SCDMA INDUSTRY ALLIANCE NETWORK

.	Members.	Number of members.	Density.
Core Area	DTM, Holley, HW, ZTE, Potevio, TDT, HTAT, T3G, spreadtrum, Utstar, alcatel-sbell, ZY, tycc, andrew, comlent, SP, comba, BOCO, RME, CHINA MOBILE, PTAC.	21.	0.348.
Periphery Area.	Lenovo, CBCW, Hisense, COMMIT, CYIT, Envada, ZCTT, dbtel, koretide, TCL, fiberhome, haier, postcom, CETC14, MOBI, rdamicro, ACE, BIRD, CETC41, CFC, yulong, SIM, LONGCHEER, BENQ, RT, GRENTECH, youke, FINGU, FLEXTRONICS, JinPeng, dopod, MediaTek, vtion, EB, WINGTEC, CCIT, digimoc, NTS.	38.	0.013.

TABLE 8. INDUSTRY CHAIN POSITION OF CORE AREA MEMBERS

Industry chain position of TD-SCDMA.	Members that belongs to core area of alliance.
Equipment manufacture.	Datang Mobile, ZTE, Potevio, TD Tech Ltd, Utstar, alcatel-sbell.
Chip.	Datang Mobile, T3G, CYIT, spreadtrum, comlent.
Terminal.	Datang Mobile, Holley Group, HuaWei(HW), ZTE, T3G, Utstar, alcatel-sbell, BOCO, RME, CHINA MOBILE, PTAC.
Testing.	Datang Mobile, ZY, StarPoint(SP).
Antenna.	HTAT, tycc, andrew, comba.
Operating system.	Datang Mobile.
Repeater .	Datang Mobile, ZTE, comba.

2) Structural hole

The measurement of structural hole refers to four indexes— 1.Effective size, which reflects the extent of nonredundancy of network; 2.Efficiency, which is the ratio of effective size to the actual size of a node; 3.Constraint, which refers to the node capability of utilizing structural hole in its ego-network and it maybe the most important index of structural hole measurement [23]; 4.Hierarchy, which reflects the extent of constraint that concentrated on a single node. Table 9 shows the result and we list 9 important nodes' structural holes indexes according to the rank of constraint index. Take ZTE as an example, the rank of effective size is 4 which means the extent of nonredundancy among network members of ZTE take the fourth place; the efficiency rank is also 4, which means the node ZTE presents good structural hole performance and utilizes high nonredundancy efficiency; the constraint index is 0.131 and rank is 4, which means the extent that whole network members push constraint on it is 0.131 and ZTE has good capability to make good use of structural hole opportunity.

TABLE 9. STRUCTURAL HOLES INDEXES' RESULTS OF CHINA'S TD-SCDMA INDUSTRY ALLIANCE NETWORK

Rank.	Member.	Effective Size.	Efficiency.	Constraint.	Hierarchy.
1.	CHINA MOBILE.	23.963.	0.888.	0.082.	0.091.
2.	DTM.	21.077.	0.811.	0.117.	0.076.
3.	spreadtrum.	13.250.	0.828.	0.117.	0.075.
4.	ZTE.	11.800.	0.787.	0.131.	0.112.
5.	HW.	10.000.	0.714.	0.172.	0.129.
6.	Potevio.	6.111.	0.679.	0.184.	0.031.
7.	TDT.	8.833.	0.736.	0.190.	0.161.
8.	RME.	5.250.	0.656.	0.195.	0.033.
9.	ZY.	4.667.	0.778.	0.196.	0.006.

In addition, we find 14 nodes (Holley, CECW, Envada, ZCTT, fiberhome, ACE, CETC41, CFC, GRENTECH, JinPeng, MediaTek, vtion, EB, WINGTEC) with the effective size, efficiency and constraint indexes equal 1. This implies they are constrained absolutely by one member that connects them. Take the node fiberhome as an example, the Dyadic Constraint Matrix (It does not list here) shows the node CHINA MOBILE has the absolute constraint on it.

7. Conclusions and Implications

Under the social network analysis, we get some conclusions and implications from China's TD-SCDMA alliance network. First, as a network composed of 59 members, its density is relatively sparse. Though alliance mechanism promotes the establishment of links between members, its effect still under development; Second, China's TD-SCDMA alliance network includes some central nodes that hold large number of links and different types of relationships, and isolated nodes whose relationships still need expand. Also, central nodes possess information benefits, resource benefits and control benefits while isolated and peripheral nodes possess few; Third, there are several plexes or cliques in the whole network, some central nodes are included in multiple cliques which implies their business capabilities are more comprehensive and integrated, while other nodes have single business structure and narrow range of links; Fourth, the whole network has significant core--periphery structure leading to polarization of information flows, resource distribution and development of members' competence; Finally, the structural hole properties reflect members' capabilities to utilizing the network nonredundancy, dominating nodes perform well while some other nodes are under large constraints. Under these results, to better achieve the capability leveraging of alliance mechanism on China's TD-SCDMA industry, policy guidance should creat opportunities for isolated and peripheral members to build links with central members. That may improve the balance of network resources division. Then, isolated and peripheral members of network should make efforts to get access to core area, which may help them to obtain benefits and develop company capabilities. A good strategy for them is building direct and strong links with dominated nodes in the same clique. Central members should make contribution to the whole network and

take more responsibility of alliance's development by kinds of ways like sharing information, knowledge and resources, transferring technology in low transaction costs, outsourcing business in low costs and so on.

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9. References

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