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Patterns of Innovation in SaaS Networks: Trend Analysis of Node Centralities

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Abstract: As software vendors provide their software as a service (SaaS) and allow users to access the software functions via open interfaces, the innovation style has shifted from local innovation of a software user, to collective innovation of an entire system of users and software. This new innovation trend directs the innovation research to the structural and evolutionary patterns of SaaS networks, in which a node represents a software service and a link the combined use of two software services for provisioning a new service. However, prior research concentrates only on the static properties of network structure and the position of nodes in the network, but misses the dynamics in the evolution context. In this paper, we close this gap by investigating the trend of centralities of five representative software services in a SaaS network. The data has been obtained from www.programmableweb.com. Our results suggest that each software service of a SaaS network follows the typical life cycle from growth to decline. In addition to this, the innovation trend shifts from image services to social networking services, involving a transition of network structure. Our results also show the necessity of innovation studies that investigate the changing patterns of evolving innovation networks.

Keywords: Open Innovation, Centralities, Composite Services, Software-as-a-Service.

JEL Classification Numbers: D85, L86, O33.

1. Introduction

The IT technology advancement and the demand for new business models, which attract users to innovate, motivate software vendors to provide their software as a service (SaaS). SaaS is based on an old paradigm, in which users can run software installed on a remote computer via the Internet. SaaS is again spotlighted since the emergence of cloud computing in a variety of areas, ranging from office applications to computer resources (Campbell-Kelly, 2009). SaaS is provided to users not only as a final good but also as a resource, which users can reuse for creating new services under the service-oriented architecture (SOA). SOA defines the interface, through which users can utilize the functions of the service for their innovation (Haines and Rothenberger, 2010). For example, a user can develop a composite service by adding her value on an existing service or combining several existing services. This requires that all services are provided with open application programming interfaces (APIs).

This new trend of innovation, in which each service is reused by other services, invites researchers to analyse the structure and the evolution of the environment of SaaS as a platform for “open innovation” from the perspective of networks (Chesbrough, 2003). The existing innovation studies on SaaS networks (Hwang et al., 2009; Kim et al., 2011) follow two research designs of innovation studies from the networks perspective: one investigates the structure and evolutionary pattern of networks (Newman, 2001; Valverde and Solé, 2007; Wagner and Leydesdorff, 2005), and the other correlates the network characteristics with innovation performance (Granovetter, 1973; Grewal et al., 2006; Krackhardt and Stern, 1980). These studies regard the network characteristics static and the effect of networks on innovation invariant. They lack the consideration of positional change of a node in the evolving network. For example, in the model of Barabási and Albert (1999), a hub keeps its status in the static topology once it occupies the position in the evolution. However, the change of the innovation leader and the innovation trend is normal in real innovation systems.

To investigate this in the context of SaaS, we investigate the position of five representative software services in a SaaS network and discuss the patterns of changing positions of the five software services in the evolving SaaS network within this paper. A SaaS network is a network, in which a node represents a software service and a link the use of two combined software services. The SaaS network that we consider is formed based on the empirical data surveyed from the Web site www.programmableweb.com, a public board listing information on software services with open APIs and on composite services that are built on top of other software services. We choose the following five software services as representative software services, as they have been used the most during the study period: Google Maps, Flickr, Twitter, YouTube and Facebook. For this SaaS network, we measure the normalized degree centrality, normalized eigenvector centrality, and the normalized betweenness centrality of the representative software services for each month of the study period.

Our main results lead to three propositions. First, the degree centrality and the eigenvector centrality of the representative software services show the typical life cycle of goods (i.e., the growth after birth, the prosperity, and the following decline). Second, as the innovation trend shifts from image services to social networking services, the betweenness centrality together with the other two centralities shows that the network

structure includes hubs. Finally, the network structure transformation involves two types of competition between the major software services: competition for getting into a hub position in the network, and competition for getting into a core position in several clusters. Our findings redirect the focus of innovation network studies from analyzing the invariant network topology and position to analyzing the incessant change of network position in invariant topologies. This shift of focus is expected to help understanding the innovation trend and identifying the strategy of software vendors for their software services.

The remainder of this paper is organized as follows. In the next section, we introduce the conceptual background on SaaS innovation systems and innovation network studies. In section 3, we describe how to form the SaaS innovation network and how to measure the position of nodes. Section 4 illustrates our analysis results, and section 5 concludes our paper with a discussion of the implications of our findings.

2. Conceptual Background

2.1. Open Innovation of SaaS

As IT technology advances and new business models emerge that motivate consumers to participate in an innovation process (e.g., Web 2.0), software vendors provide their software as a service (SaaS). SaaS is a paradigm of software, which allows users to execute software that is installed remotely on a server in the Internet. The SaaS paradigm emerged with commercial computing in the 1980s but has been in the downturn with the raise of personal computers. Now, with the rise of cloud computing in the recent years, it moved again into the limelight in a variety of service areas ranging from office software (e.g., Google docs) to computing resources (e.g., Amazon S3) (Campbell-Kelly, 2009).

One implementation type of SaaS is Web services under the service-oriented architecture (SOA) concept. SOA defines how users can compose and reuse services through open interfaces (e.g., the open application programming interface (API)) (Papazoglou and Georgakopoulos, 2003; Haines and Rothenberger, 2010). A composite service is created by adding a unique value to an existing SaaS service or by combining several existing SaaS services. This composite service is also called “mashup” (Ogrinz, 2009). Figure 1 shows an example of a composite service, in which Weather Bonk provides weather information on a map. For example, besides further six services, Weather Bonk accesses map data of Google Maps and weather information of Weather Bug through open APIs.

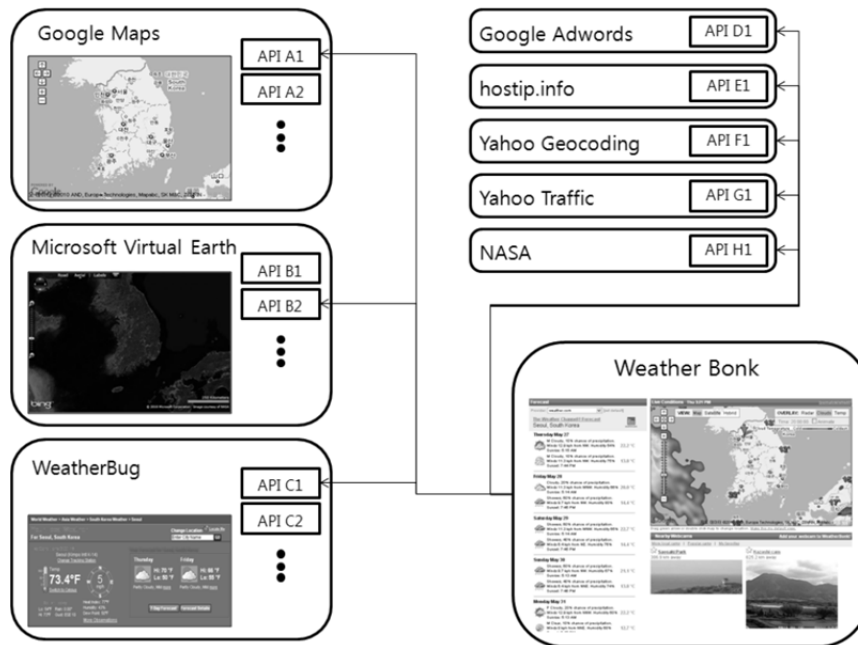


Figure 1. Example of a composite service mashed up with several SaaS services with open APIs.

According to the definition of the SaaS network introduced above, the Weather Bonk service links all eight software services used (shown in Figure 1) with each other. The resulting SaaS network is a fully connected graph. A SaaS network that is constructed of all mashups evolves into a scale-free network according to Hwang et al. (2009).

In this architecture, software vendors achieve a huge scale and scope of innovation through utilizing their service users (O'Reilly, 2007). This is open innovation (Chesbrough, 2003). SaaS providers achieve innovation by freely sharing their innovation resources with their service users and even with their competitors. Any SaaS provider can participate in the innovation by simply opening up the API of its services. As this allows users to reuse the functions for their own service development, users can participate in this innovation. In this setting, the innovation system grows with a specific structure (Hwang et al.; 2009).

2.2. Network Position and Innovation

In social network studies, a variety of measures exist to analyze the position of nodes (agents) in a network. The position of an agent in a network is important, as the position is related with the role of the agent in the society (Scott, 1991). The most popular measures are centralities based on the degree of a node and the geodesic between two nodes (Freeman, 1979). The degree centrality of a node measures the number of adjacent nodes, which indicates how deeply a node is embedded among its neighbours. The betweenness centrality of a node considers the number of geodesics paths through the node, in relation to all possible geodesics paths. It is used to determine how much the node connects other nodes. If a node has a high betweenness centrality but low degree centrality, it is supposed that the node might bridge several separated communities (Everard and Henry, 2002). Furthermore, it is also important to

understand to which node a node is connected, as the power of a node in a network is determined by its neighbors' power (Bonacich, 1987). For measuring this, the eigenvector centrality has been defined.

Empirical research of networks has found that the position of nodes is heterogeneous in real networks in a variety of contexts. One of the most important and famous heterogeneity characteristics is the scale-free property of a network. "Scale-free networks" are networks whose frequency of degree decays by a power function. It means that the distribution is very inhomogeneous, or highly skewed, compared to the exponential distribution of random networks and regular networks (Albert et al, 1999). Another characteristic is clustering. In clusters, nodes are densely connected with each other, compared to the connectivity of nodes across clusters. For example, researchers of the Santa Fe institute can be clustered into communities based on the analysis techniques that they use (e.g., agent-based modeling, mathematical ecology and statistical physics) (Girvan and Newman, 2002). Besides, a node's position within a cluster of a network can also be heterogeneous. For example, a few nodes can be highly connected in its cluster while a majority of nodes are not (Newman, 2001).

The innovation performance of an agent is related to the position of the agent in a network. As the position of an agent can be quite different, an agent's performance can also vary widely. While innovation is a process of recombining fragmented existing knowledge (Hargadon 2002), knowledge in a discipline or industrial group advances in the context of the group. An agent (e.g., a firm or a researcher) creates new knowledge by recombining knowledge of the group. If an agent bridges two distant and separated clusters (or groups) through (even) relatively low intimate and infrequent connections with agents belonging to these clusters, it takes advantage of innovation. In this case, agents access a variety of knowledge repositories efficiently and effectively, so that new ideas can emerge from the whole system and not from a clustered group only (Granovetter, 1973; Burt, 1992).

The prior research of network analysis of innovation systems misses the dynamic context of network evolution, only focusing on the static mechanical properties and statistical relationship between factors. For example, in the empirical network analysis and the evolutionary model introduced by Albert et al. (1999), the characteristics of scale-free networks are invariant and the network is generated by a constant preferential attachment of a new-coming node to the existing nodes with higher degree. In their model, a hub locates at the central position forever, if it is chosen as a hub with some probabilistic reason at the early stage. The innovation studies investigating the effect of network position on innovation admits this hidden assumption of stable network structure even during the evolution of the network. Granovetter (1973) and Burt (1992) emphasized the importance of a node's position connecting separated, distant clusters for innovation but they omitted the time factor in their discussion of the relationship between network position and innovation. The analysis of how the network position affects innovation has been extended to a variety of conditions. For example, the relation between network position and innovation performance has been investigated. The more central node in a network is, the higher the innovation performance of a node, assuming that the node has a good absorptive capacity (Tsai, 2001), the node is in a central group (Sasidharan et al., 2011), or assuming that the

knowledge for innovation is complex (Hansen, 1999). These results are based on snapshots of network structure and innovation performance.

However, innovation systems are more dynamic than the network studies explain. On the one hand, innovation systems show life cycles from their emergence to their decline through prosperity on a variety of levels (i.e., from a single technology to the entire industry). Several dynamic models explain the driving force of the rise and fall of an innovation system. The application areas comprise the dispersion of a technology (Bass, 1969), the competition led by the opportunity due to new technology (Jovanovic and MacDonald, 1994), and the opportunity of strategic alliance with competitors and the challenge due to the redundant connection in a cluster (Lemmens, 2004). On the other hand, especially in case of innovation through collective intelligence, the trend of innovation varies as the interest of the crowd shifts according to a changing environment (Jin et al., 2009). The changing interest of a crowd is often revealed in information systems including Web sites, blogs and some special forums, and the analysis of interest change of crowd is used to predict the innovation trend (Gloor et al., 2009). The question is whether the network structure remains stable while the details of the system changes. Hwang et al. (2009) showed that hubs in a SaaS network change while the scale-free topology remains.

3. Dataset and Methodology

3.1. SaaS Network

Data has been gathered from www.programmableweb.com, which lists the information about SaaS services. If services are composed, these services are called mashups in the terminology of the Web site. The information includes also the name of a service that offers open APIs, the services that reuse existing services, and its launch date. We collected this information since the first composite service was added on September 14th, 2005 until September 30th, 2012. The SaaS network is defined as a set of nodes, representing software services that opened up their APIs, and a set of links between these nodes. A link indicates the existence of a composite service that uses the nodes being connected. In other words, the creation of a composite service yields a complete graph of those software services that are used for the development of the composite service. For example, as shown in Figure 1, Weather Bonk generates 28 links between the eight software services with open APIs (i.e., between Google Maps, Microsoft Virtual Earth, WeatherBug, Google Adwords, hostip.info, Yahoo Geocoding, Yahoo Traffic, NASA). The links of the SaaS network are non-directional and weighted. That is, a link does not show the information about the source and the destination of a relationship but its use frequency. For example, if another composite service is created using Google Maps and Microsoft Virtual Earth and is added to the Weather Bonk SaaS network, then the weight of the link between Google Maps and Microsoft Virtual Earth were 2 while the other links keep a link weight of 1.

3.2. Definition of Indicators

While the SaaS network is a weighted graph, the centralities have usually been defined for binary graphs (Bonacich, 1987; Everard and Henry, 2002; Freeman, 1979). Therefore, we should modify the centralities for weighted graphs (Opsahl et al., 2010).

First, let w_{ij} be the weight of the link between nodes i and j belonging to the network G , which size is g . The weight of a link w_{ij} in a SaaS network represents the number of occurrences of collaboration between two nodes i and j . If w_{ij} is zero, there is no link between the two nodes.

The degree centrality in a weighted graph is defined as the sum of the weights of links of a node. That is, the degree centrality of node i in a weighted graph is the sum of weights w_{ij} that belong to links that node i has with other nodes j . The degree centrality of a node in a weighted graph is also called the strength of the node because it summarizes the strength of connectivity of the node (Opsahl et al., 2010). The degree centrality is likely to increase as the network size increases even in networks with identical density. In order to remove the effect of network size on the degree centrality, the degree centrality in a binary graph is normalized by the maximum possible number of links ($g - 1$) that a node can have. The normalized degree centrality in a binary graph varies between 0 and 1, and goes to 1, if each node is connected to all other nodes, and to 0, if no node is connected. Likewise, the degree centrality in a weighted graph is normalized by the maximum possible number of neighbours that a node can have, or ($g - 1$):

$$C_D(i) = \sum_{j \neq i} w_{ij} / (g-1). \quad (1)$$

However, the normalized degree centrality in a weighted graph is not a desirable index, since it can become larger than 1 if the weight is larger than 1 (as in our SaaS network). Nevertheless, the normalized degree centrality is sufficient for comparing nodes in networks of different sizes.

The eigenvector centrality is defined in a recursive manner. The eigenvector centrality of a node is the sum of the eigenvector centralities of its adjacent nodes. The adjacency of each node with other nodes in a binary graph of size g is represented with a g -by- g matrix A , whose elements a_{ij} are 1 if node i and j are directly connected, and 0 otherwise. The matrix A is symmetric, if the network is undirected. Let x be the vector of eigenvector centralities of all nodes in the graph. Then, the eigenvector centrality is the vector x , which satisfies the condition $A x = \lambda x$, where λ is an eigenvalue (Bonacich, 1987). The eigenvector is normalized by the vector length $\|x\|$. In a weighted graph such as our SaaS network, let W be the g -by- g matrix, which elements w_{ij} represent the weight between nodes i and j in graph G of size g . Then, the normalized eigenvector centrality of node i is defined as the i -th element of the normalized eigenvector x , satisfying the following condition:

$$W x = \lambda x . \quad (2)$$

There are g eigenvalues at most. We choose the eigenvector with the largest eigenvalue among the multiple eigenvalues, since it involves the nodes in the main component, which consists of the largest amount of nodes segregated from the other nodes. The eigenvector centralities of the nodes outside the largest component are all zero.

Finally, the shortest path length should also be re-defined in a weighted graph, since the betweenness centrality is defined on the basis of the shortest paths (geodesics). The shortest path between two nodes is the path that passes through the smallest number of

links between them. The shortest path length is the number of links of the shortest path. As a pair of nodes is more intimate as the weight of their link gets larger in the SaaS network, it is reasonable to assume that the path length between them is smaller than the path length without considering the weight. Therefore, the shortest path length $d^w(i,j)$ between two nodes i and j in a weighted graph G is defined as the minimum sum of inversed weights of the links on the path between the nodes (Opsahl et al., 2010):

$$d^w(i,j) = \min (1/w_{i_1} + \dots + 1/w_{i_j}) . \quad (3)$$

For defining betweenness, let σ_{ij}^w be the number of shortest paths between nodes i and j in a weighted graph G , and $\sigma_{ij}^w(v)$ be the number of shortest paths passing through node v between nodes i and j . Then, the betweenness centrality of node v in a weighted graph is defined as the sum of $\sigma_{ij}^w(v) / \sigma_{ij}^w$ for all nodes i and j , corresponding to the betweenness centrality in a binary graph. Since the number of pairs of nodes increases as the network size increases, the betweenness centrality is normalized by the maximum possible number of pairs of any two nodes except the node v in a weighted graph G of size g , or $(g-1)(g-2)/2$. Therefore, we define the normalized betweenness centrality in a weighted graph according to the normalization in a binary graph as (Freeman, 1979):

$$C_B^w(i) = \sum_{i,j:i} \sigma_{ij}^w(v) / \sigma_{ij}^w / ((g-1)(g-2)/2). \quad (4)$$

The normalized betweenness centrality both in a binary graph and a weighted graph varies between 0 and 1. The normalized betweenness centrality of a node goes to 0, if no shortest path passes through the node, and to 1, if all shortest paths pass through the node.

4. Trend Analysis of Node Centralities

According to the data of software services surveyed from www.programmableweb.com, the first service was added to the database on September 14th, 2005. The last software service that we consider has been listed in September 30th, 2012. During this time period, 7427 software services have been registered. 6780 of those services are composite services, which only utilized 1153 different software services.

Consequently, our SaaS network that is based on this data set comprises 1153 nodes and 23573 links on September 30th, 2012. Among the software services in the SaaS network, we selected five representatives. Four of these software services (Google Maps, Twitter, YouTube, and Flickr) were used most frequently during the study period. Google Maps is a global map service developed by Google, which allows users to use its map data on Web pages. It was used by 2263 composite services since its introduction in September 2005. The second most frequently used (644 times) software service is Twitter, a microblogging service. The next two software services are YouTube and Flickr, which were used for composite services 598 times and 590 times, respectively. YouTube is a video sharing service provided by Google. It allows users to utilize the YouTube videos and related functions on their website. Flickr is a photo sharing service provided by Yahoo, and it supports the function for uploading, linking, tagging, and retrieving of photos on Flickr. The fifth software service is Facebook.

Facebook is a social service provided by Facebook, and it was used for composite services 352 times. Although Facebook is not at the fifth rank, we add Facebook to compare the trend in microblogging (social networking). Facebook belongs to the same service category as Twitter.

Table 1. Description of the selected software services.

| Software Service | Provider | Service category | Number of usage |
|-------------------------|-----------------|-------------------------|------------------------|
| Google Maps | Google | Mapping | 2263 |
| Twitter | Twitter | Social | 644 |
| YouTube | Google | Video | 598 |
| Flickr | Yahoo | Photos | 590 |
| Facebook | Facebook | Social | 352 |

The remainder of this section describes the trend analysis results of the position of these five software services in our SaaS network as well as the discussion of the analysis results. To measure the position of these software services in our SaaS network, we applied the normalized degree centrality, the eigenvector centrality, and the betweenness centrality. The SaaS network is undirected and weighted (as described in Section 3.1), and the weights between any two nodes represent the number of links between these two nodes. To examine the trend of the position of the selected software services, we measured the three centralities in the SaaS network for each month, starting always from September 2005. Note also that the SaaS network in January 2012 consists of all nodes and links that have been listed on the Web site between September 2005 and January 31st, 2012.

4.1. Degree Centrality

The normalized degree centrality was measured for each of the five software services (Google Maps, Twitter, Flickr, YouTube, and Facebook), in order to investigate how deeply each selected software services is embedded among its neighbouring nodes in the SaaS network and how the embeddedness changes over time. Figure 2 summarizes the trend of the normalized degree centralities during the study period and shows that these services stand out compared to the average normalized degree centrality of all software services in the SaaS network.

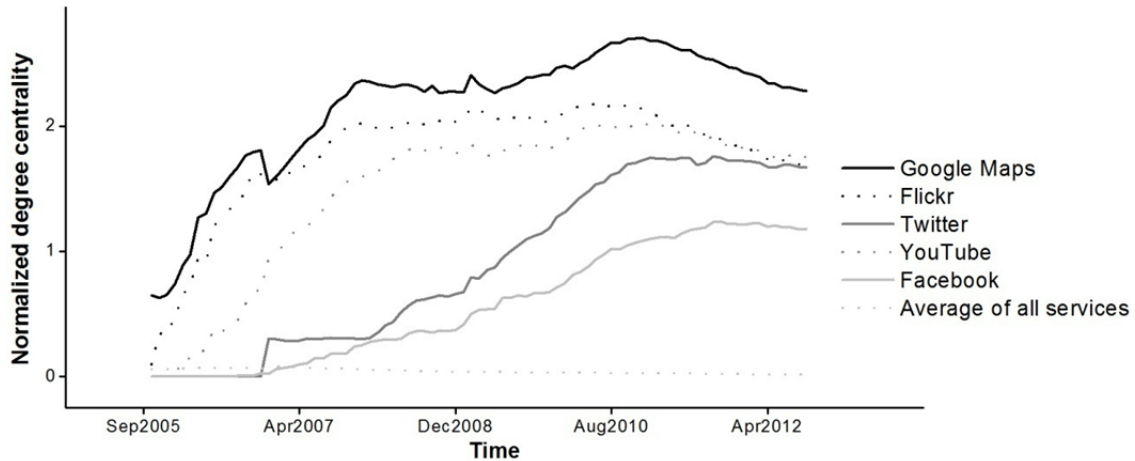


Figure 2. Trend of normalized degree centrality in the SaaS network.

The normalized degree centralities of Google Maps, Flickr and YouTube show a similar trend. They follow a life cycle. At the early periods, they increase fast and decline after some prosperity periods. In particular, the normalized degree centrality of Google Maps roughly increases from 0.65 in September 2005 to 2.37 in December 2007. Then, the increase rate is lighter than before. After that, from December 2010 onwards, the normalized degree centrality slightly decreases from 2.70 to 2.28 at the end of the study period. Likewise, the normalized degree centralities of Flickr and YouTube soar from 0.10 in September 2005 to 2.01 in December 2007 and from 0.14 in January 2006 to 1.85 in September 2008, respectively. After a short period of light increase, the normalized degree centralities of Flickr and YouTube decline from 2.18 in May 2010 to 1.68 at the end of study period and from 2.02 in January 2011 to 1.75 at the end of study period, respectively. Twitter and Facebook were introduced later than the other three software services (i.e., in December 2006 and in August 2006, respectively). They have similar trends that show steady growth and their prosperity period at the end of the study period. The only difference is twitter starts to grow with a delay. In detail, the normalized degree centrality of Twitter remains stable at about 0.30 until January 2008, and increases fast to 1.75 in May 2011. Then, it stays stable again with a slight decrease until the end of study period. The normalized degree centrality of Facebook continuously increases to 1.24 until October 2011, and then stays stable with a slight decrease similar to Twitter.

The trend of normalized degree centralities of the selected software services looks like a life cycle of technology. Prior research on diffusion of technology or on users' adoption of technology suggests that a new technology is adopted in full scale after an inactive early period and then declines, so that the cumulated adoption rate of the technology shows an S-like curve (Bass, 1969). For the SaaS network, it means that a software service, which emerges and is frequently reused for composite service development, goes to the central position. It goes out to the periphery of the network if it is not reused anymore that frequently. From this perspective, Google Maps, Flickr and YouTube have grown to their prosperity during the study period, and now face their saturation period. Twitter and Facebook are in their prosperity phase at the end of study period as they emerged late in the SaaS network.

Furthermore, Google Maps, Flickr and YouTube do not show the early, inactive period. This might be related to the fact that the first three services entered the network at the beginning of the evolution of SaaS network. At that point, Google Maps, Flickr and YouTube have already been the most popular services in the world, and users already knew how to utilize these services. Therefore, these services did not have to wait for being diffused to imitators (Bass, 1969).

4.2. Eigenvector Centrality

We calculate the eigenvalues and eigenvectors of the five software services as described in Section 3.2 and select the eigenvector with the largest eigenvalue among all eigenvalues. The results highlight three types of trends: shock, fast growth, and late growth. The normalized eigenvector centralities of Google Maps and Flickr start with high values (shock). The normalized eigenvector centrality of Google Maps is about 0.44 in average during the study period except for the fluctuation during the first 5 months. The one of Flickr is about 0.42 in average. The normalized eigenvector centrality of YouTube grows fast during the early period (fast growth). It increases from 0.08 in January 2006 to 0.42 in October 2008, and remains at 0.41 in average until the end of the study period. The normalized eigenvector centrality of Facebook grows slower compared to the other services. It reaches 0.27 in September 2012 from an initial value of 0.006 in August 2006. The normalized eigenvector centrality of Twitter grows slow similar to Facebook. It reaches 0.34 in September 2012 from an initial value of 0.06 in December 2006. It is also to note that the average normalized eigenvector centrality of all nodes is significantly lower than the five software services considered.

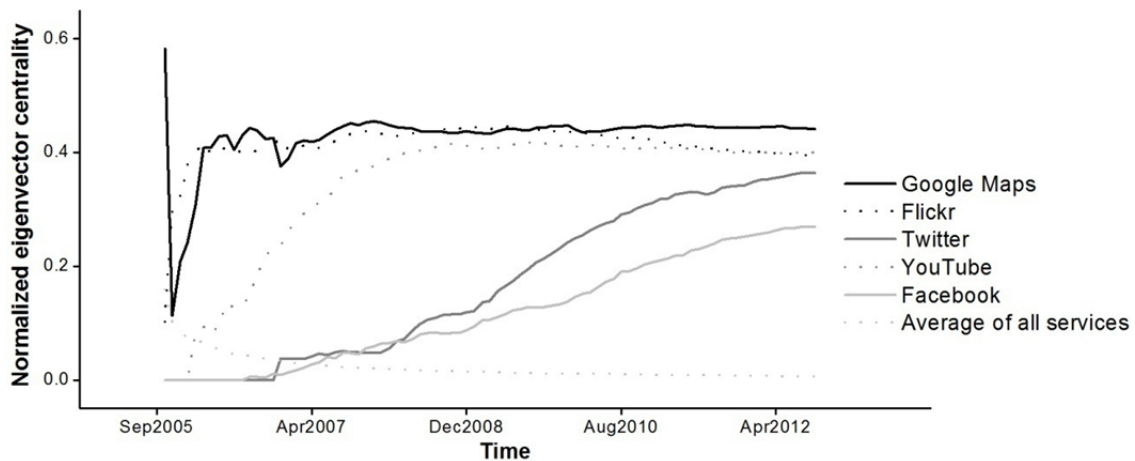


Figure 3. Trend of normalized eigenvector centrality in the SaaS network.

The trend of normalized eigenvector centralities of the selected software services indicates that the innovation in the SaaS network evolves in a more complicate manner than we could see in the previous centrality graph. As the eigenvector centrality of a node considers the strength of the neighbouring nodes, we can state that Google Maps, Flickr, and YouTube are stably connected to many powerful nodes. Furthermore, considering this result together with their normalized degree centrality, the position of Google Map, Flickr, and YouTube are stable despite the slight decline of their reuse

frequency as seen in Figure 2. As Twitter and Facebook entered the market late, they did not have the strong start as the other three software services. However, Twitter and Facebook managed to increase their normalized eigenvector centrality over time. Twitter almost reaches the same level as Google Maps, Flickr, and YouTube, and Facebook is growing consistently until the end of study period. They strengthened their position in the SaaS network continuously.

4.3. Betweenness Centrality

We calculate the normalized betweenness centralities to diagnose whether the selected software services are bridges for other software services in the SaaS network. The analysis results, as illustrated in Figure 3, show that the trend is idiosyncratic for each of the five software service. The normalized betweenness centrality of Google Maps is considerably higher than those of the other three services for the entire study period. It remains at about 0.22 in average with a slight decrease. The normalized betweenness centrality of Flickr declines gradually after the peak in the initial period. It rose sharply from 0.00 in November 2005 to 0.18 in June 2006 and, then, decreased to 0.07 at the end of study period with some fluctuation. The normalized betweenness centrality of YouTube increases gradually during the first half of the study period and stayed at the same level during the last half. In detail, it increased from 0.00 in April 2006 to 0.09 in October 2009, and remained at this level after that. The normalized betweenness centrality of Facebook increases to 0.05 until October 2011 and remains at about 0.04 in average with a slight decrease. The normalized betweenness centrality of Twitter shows another interesting trend. It stayed at 0.00 between December 2006 and January 2008, and then jumped from 0.01 in February 2008 to 0.03 in July 2008. It jumped again from 0.03 in March 2009 to 0.08 in June 2009 and, then, gradually increases to 0.12 by the end of study period. The average of the normalized betweenness centrality of all services is again way lower than the five services considered.

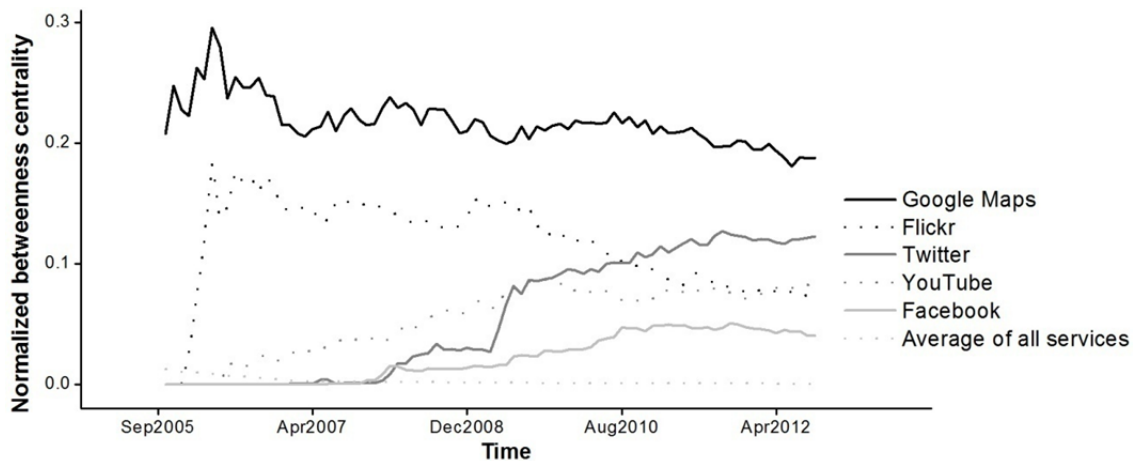


Figure 4. Trend of normalized betweenness centrality in the SaaS network.

Despite the idiosyncratic trends of normalized betweenness centralities of the 5 services, the trends depict a shift in the innovation trend. (Note, a node with high betweenness centrality and low degree centrality implies that the node bridges multiple separated and distant clusters, while a node with high betweenness centrality and high

degree centralities plays the role of a hub (Everard and Henry, 2002)). In our SaaS network, Google Maps and Flickr are the hubs in the SaaS network initially. That is, they are linked to many nodes and connect many clusters. However, while Google Maps keeps the same position, Flickr's declines over time. As Twitter and Facebook show growth in degree centrality and betweenness centrality, they emerge as hubs. Especially, Twitter becomes even a more important hub than Flickr from August 2010 onwards. Flickr loses its importance as a hub position and is at the same level as YouTube in September 2012.

It is also notable that the normalized betweenness centrality of YouTube grows late, while its normalized degree centrality is high in the early periods already. This means that YouTube is linked to many nodes but does not connect many clusters. From a graph theoretical perspective, such a pattern occurs, if the node is not a hub in the global network but a core node in some clusters.

Considering the results of all centrality measures, we can state that Google Maps is expected to maintain its structural position for a substantial period of time. Innovations will happen through the use of Google Maps together with other major services (e.g., Flickr, YouTube, Facebook and Twitter). However, it is expected that not all services can keep their position. As the normalized betweenness centrality of Flickr indicates, it is likely that Flickr will be substituted as a major player in the near future. That is, Flickr lost its attraction as the major innovation trend moved towards social networking. The place that Flickr left will be occupied by Twitter and Facebook, which steadily grew their normalized degree centrality, their betweenness centrality, and their eigenvector centrality. It attracts the creation of new composite services. Finally, we can state that the innovation trend shifts from image services (e.g., Flickr) to social network services (e.g., Twitter and Facebook).

5. Discussion and Conclusion

Within this paper, we analyzed the trend of the position of five representative software services (i.e., Google Maps, Flickr, YouTube, Twitter, and Facebook) in a SaaS network with respect to their normalized degree centrality, their normalized eigenvector centrality, and their normalized betweenness centrality. Our results suggest that the focus of innovation shifts from composing image services to composing social networking services. This shift is not only a quantitative change but also a structural and qualitative change. In our trend analysis, it is expected that Google maintains its central position in the SaaS network and that Flickr goes to the periphery of the SaaS network. Twitter and Facebook, however, improve their position. Moreover, we found a couple of patterns of position competition between these software services. Twitter and Facebook emerge as a hub in the SaaS network while Flickr lost its importance as a hub position. YouTube competes with the other services for the position of core services in clusters.

Our findings cast important implications both to academia and industry. On the one hand, academic research on innovation (e.g., Grewal et al. (2006) and Kim et al. (2011)) should also consider the evolving patterns of a network and the position of nodes in those evolving networks. The static network characteristics that influence innovation are not the only factors, if the position of a node in the network can change as we demonstrated with our research. From the entrepreneurial perspective, on the other

hand, our analysis results show that each software service emerges and declines as suggested in prior research on diffusion (Bass, 1969). These changes over time have been missed in prior research on networks of information systems. Prior research of network analysis described only the network structure and the evolutionary rule of a network (Hwang et al., 2009; Valverde and Solé, 2007). Therefore, our results suggest that our analysis method can be applied to the analysis of innovation trends of information systems.

However, our network analysis of information systems on the evolving patterns of networks opens up the need for further studies. As we chose only five representative software services in this paper, we need to analyze the trend of a larger number of software services. Furthermore, we should validate our propositions on the trend of positions with a rigorous statistics test for all the nodes in the SaaS network. Then, our current research can support the development of hypotheses for statistical analyses.

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