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Identifying the Networks of Mobile Application Services

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Abstract

The mobile service industry has recently moved into a new epoch due to the explosive growth in mobile application services available at "App Stores". This research empirically analyzes the interrelationships among the mobile application services to characterize their structures and identify local positions. Particularly, this paper develops mobile application service network through a text-mining based network analysis using the descriptions posted in App Store to visualize inter-service relationships and gauge structural and positional properties. It can be helpful to understand the relationships and sectoral characteristics of mobile services in terms of contents and functionalities in App Store.

Keywords: Mobile application; mobile service; network analysis

1.0 INTRODUCTION

Today, it is indisputable that mobile services and mobile platforms have hit critical mass in information and communications technology (ICT) industry. New smart computing devices such as smartphone and tablet PC have recently taken a prominent place by replacing traditional PC. Especially, the key of their success has been based on the mobile application ('app') services, which include naive software or contents and primary channels to connect to Internet-based services with a good user experience in the smartphone. Since the launching of Apple App Store in 2008, there has been an explosive proliferation of mobile app services. Due to the open concept of App Store, any developers who have various levels of expertise could freely create the mobile app services.[1] Accordingly, full-scale innovation has discovered in various mobile service sectors such as contents services (e-book, news) or traditional offline services (banking, healthcare) etc.[2]

Although scanty, previous literature has discussed issues on App Store such as the market outlook and the strategies of App Store in the business level, [3-4] the changes of mobile ecosystem and business model driven by App Store in the industry level,[5-6] and the diffusion or adoption of mobile innovation in the user level.[7] However, there is a lack of the empirical investigation for the structures and contents of mobile app services especially by focusing on mobile apps themselves. Since mobile app services can be indiscriminately and instantaneously created by third party, [8] a vast amount of mobile app services are continuously emerged and quickly changed. Therefore, there is a need for identify the structures and contents of mobile app services. Although previous studies on App Store mainly utilize qualitative or simple statistical approaches for survey data,[9-10] they are not enough to analyze the contents and structures of mobile app services. Moreover, App Store's mobile app services per se are a significant data source for understanding the mobile service characteristics. Thus, more systematic techniques can be applied to lots of web documents describing app services in App Store in order to identify which significant services are developed in detail.

In response, this research investigates the relationships among mobile app services to identify overall structures and influential services. In order to gauge the relationships between services by similarities of their contents and functions, this paper applies text-mining based network analysis using the descriptions of mobile app services in App Store. Text mining, the process of automated discovery of knowledge from unstructured text, helps to transform the unstructured service documents into analyzable structured keyword vectors.[11] Network analysis, a quantitative technique derived from graph theory, facilitates the analysis of interactions (edges) between actors (nodes),[12] and shows the relationship among services as a visual network. In the studies on patent or literature related analysis, text-mining based network analysis have utilized to observe the technological structures and trends engaged in patents or literatures by identifying information such as the main clusters of technological fields, the affinities of them, the technological periphery, or the significant technological topics. [13-14] Particularly, this study compares network structures according to 'mobile service value' and explores the relationships between them, in order to understand mobile service characteristics more effectively. Mobile services can be divided into utilitarian and hedonic service according to value, which is the purpose, motivation, or result of consuming services perceived by user.[15]

The remainder of this study is organized as follows. First, Section 2 discusses the concepts of App Store and mobile app service as well as mobile app service value. Next, Section 3 outlines the methods of text-mining based network analysis and overall research process. Section 4 explains the results of mobile app service network. Finally, conclusions involve the contributions and limitations of our research in Section 5.

2.0 BACKGROUND

2.1 App Store and Mobile App Services

App Store is a logical extension of the mobile content market that has existed for more than a decade.[3] Apple App Store is a digital application distribution platform or open market for iOS developed and maintained by Apple. The service allows users to browse and download apps from the iTunes Store that were developed with the iOS SDK (Software Development Kit) or Mac SDK and published through Apple, Inc. It includes 'ecosystem' that attracted numerous developers and generated a great number of apps, based on the concept of open platform, open API (Application Program Interface), and open market.[1] Mobile apps are software programs that can interrogate a web server and present formatted information to the user. They make use of the technical functionality of smartphones such as touch sensitive screens, and web features such as information or functionality of html pages. The benefit of mobile app services is that they represent a major revenue source, and they tend to lock-in the user of the mobile phone to a particular set of apps.[4]

2.2 Mobile App Service Value

Mobile users obtain mobile value created through the use of mobile apps containing Internet contents and services. Due to the distinctive features of mobile services, several studies identified mobile service values such as ubiquity, time-criticality, spontaneity or immediacy, accessibility, convenience, localization, personalization, etc. [16]

However, the mobile service value can be understood in terms of the offering consumed and experienced by users in the context of motivations or purpose for consumption.[15] Utilitarian value refers to extrinsic motivation that exists in a goal directed service use. It is closely related to the effectiveness and efficiency that result from the use of a service. On the other hand, hedonic value means intrinsic motivation that exists in experiential, fun and enjoyable service use. It is primarily non-instrumental, experiential, and affective. This study investigated the utilitarian and hedonic values of the mobile service and the relationships between them. Since there are services that include both high utilitarian and hedonic aspects, they are classified as convergent segment. 20 categories in Apple App Store are divided into utilitarian, hedonic, and convergent segments as shown in Table 1.

Table 1 Segment of mobile app service value

Segment	Category
Utilitarian	Business, Education, Finance, Healthcare & Fitness, Medical, Navigation, News, Productivity, Reference, Utilities, Weather
Hedonic	Entertainment, Games, Music, Photography, Social Networking, Sports, Travel
Convergent	Books, Lifestyle

3.0 METHODOLOGIES

The objective of this paper is to gain a deeper understanding of the structure and complexity of relationships between mobile app services in App Store. The overall process of developing mobile service networks comprises several steps. For the database including the description on app by app, text-mining based network analysis,[17] was applied in five stages: collection of description data, construction of keyword vector, construction of association matrix, development of service network, and analysis of interrelationship.

3.1 Collection of Description Data

In this paper, data from Apple iTunes App Store were utilized. iPhone Apps Plus (http://www.iphoneappsplus.com), which is website tracking all apps in 70 iTunes App Stores around the world, is utilized to collect raw data. Since information of apps such as category, rating, price, size, launch and update date, detailed description, reviews, etc. are presented for each app in this website, we scraped each HTML webpage and 100,830 apps' data are gathered.

3.2 Constitution of Keyword Vector

Since detailed description of each app are expressed in natural language, text mining that extracts keywords from documents is used to transform the unstructured data into analyzable structured data. In text mining, a keyword vector is the general form of handling and structuring texts. This study utilized TextAnalyst 2.1 to extract 563 keywords from apps' data, eliminated some of documents with no occurrence, and set the frequency of keywords in each document. As a result, 1,919 apps' keyword vectors with 563 keywords are constituted.

3.3 Construction of Association Matrix

Based on the keyword vector, association matrix is constructed using the relationship between services which is quantified in terms of distance or similarity. This study utilized cosine similarity, which is one of representative measurements for similarity between two vectors of n dimensions, calculates the cosine of the angle between them.

3.4 Development of Service Network

By applying the association matrix as input, service network is generated with nodes and links visually. In order to generate network, the similarity values should be converted into the degree of connectivity in the association matrix. The degree of connectivity is decided based on the threshold value that the analyzer is supposed to determine. The connectivity between two keyword vectors is set to 1 in the association matrix if the cosine similarity is larger than the selected threshold value. Otherwise, the connectivity is set to 0 and is considered a weak relationship. Then, service networks are developed using visualization software. Networking software package Pajek is used to depict network and compute quantitative indexes.

3.5 Analysis of Interrelationship

The characteristics regarding structure or interrelationships are identified through the quantitative indexes drawn from network theory as a complementary to visualization for effective description. In this paper, two types of the characteristics of network are pursued: network structure property and node centrality. Also, they are measured by several metrics including density, centralization, degree centrality, closeness centrality, and betweenness centrality, which are one of the primary methods to understand networks and their participants. Table 2 summarized the indexes utilized in analyzing the interrelationships of networks.

Table 2 Definition of network metrics

Index		Definition
Network structure property	Density	The degree of the overall level of network cohesion and interaction
	Centralization	The degree to which an entire network is focused around a few central nodes
Node centrality	Degree	The number of direct edges nodes has
	Closeness	The nearness of an node to all other nodes
	Betweenness	The extent to which node lies on the path between the various other nodes

4.0 MOBILE APP SERVICE NETWORK

This section involves the results of the visualization and analysis of mobile app service networks. In a micro view, the specific apps are represented as a single vertex for app-level analysis. Also, apps from every category can represent the specific relationships between categories. Although there are 1,919 nodes in whole app-level network, it is appropriate to break down a large network into a representative subset to facilitate effective visualization and analysis.[18] As a result, the data set was reduced to the 79 apps which have more than 20 of degree centrality and their energized drawing is shown in Fig 1. In order to visually differentiate the segments the category belongs to, node colors were used. Utilitarian segments were depicted with red spheres, hedonic segments were depicted by white spheres, and convergent segments were described as grey spheres. There are several central categories appear from utilitarian and hedonic segments in the whole structure of App Store.

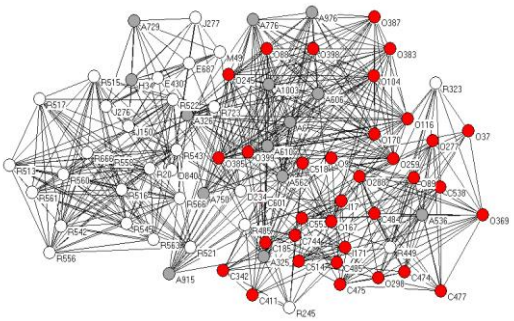

Figure 1 Mobile app service network (cutoff value = 0.8)

To complement the visual evaluation and gain further insight into the structure of mobile apps, network metrics were computed. The first measures are network density and centralization regarding the overall App Store network structure. Network density represents the degree of existing interaction and cohesion, thus higher density indicates a greater degree of interaction between services. On the other hands, network centralization refers to the degree to which an App Store network is dominated by a few services. In the network of Fig 1, the density is 0.1563 and the centralization is 0.1696. Accordingly, overall App Store network structure is somewhat loosely netted and hardly centralized.

The second measures related to node centrality are shown in Table 3. As noted visually, several apps, such as D234 (*There she is - step3*), A606 (*Northanger Abbey by Jane Austen*), I17 (*TextTV*), A1003 (*King Solomon's Mines*), and E687 (*Solitaire City*), seems to be identified as central players in the mobile App Store. These apps tend to assume catalysts role in the App Store system and connect services from different segments and categories. If these apps are removed, the App Store network can fragment into unconnected sub-networks. The visualization also underscores the dense structure of companies in convergent and utilitarian segments and the relatively sparse structure between companies in utilitarian and hedonic segments. Intuitively, it can be expected that apps in hedonic segments have formed more established relationships among others over time, thus formed extinct clusters. The most apps of convergent segments have relationships mainly with utilitarian segments.

Table 3 Centrality of top five services in network

Rank	Degree		Closeness		Betweenness	
1	A606	0.4223	D234	0.5495	A1003	0.0051
2	D234	0.4108	I17	0.5467	D234	0.0050
3	I17	0.3952	C185	0.5450	E687	0.0046
4	A610	0.3858	A606	0.5448	E430	0.0045
5	A6	0.3848	A610	0.5428	J150	0.0040

5.0 CONCLUSION

This research identified the relational characteristics of the mobile app services in the overall App Store mobile app service network. In order to visualize the similarity between the descriptions of mobile app services, text-mining based network analysis is applied. The several network indexes identified the structural cohesion and central services in network.

This paper is an important first step to understand the patterns and structures of mobile apps. Thus it provides implications for the participants of mobile ecosystem to learn to adapt to a network-centric mindset in order to compete and survive in today's highly competitive mobile market.[12] Information on what services are similar and related can help to identify adjacent services, which can be potential competitive service that competes in similar market segment, or complementary service that can be grouped as bundling services. Particularly, the text-mining network analysis that tracks the topics and keywords which contribute the relationship can be economical in terms of search time and cost. [17] However, this study has a number of limitations and future research themes. The accuracy of the visualization depends largely on the quality of the underlying data and data processing. Also, the network analysis can be elaborated through visualization techniques and quantitative indexes to provide further insight.

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