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Forecasting mobile broadband traffic: Application of scenario analysis and Delphi method

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A R T I C L E I N F O

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A B S T R A C T

Since the mobile boom has started to cause a traffic jam in mobile broadband networks, forecasts on future traffic needs are urgent information for the provision of high-quality mobile broadband services. Thus, this research aims to forecast mobile broadband traffic, focusing on the Korean case. With the emergence of diverse classes of services, where the available devices for the services and their patterns of use are changing rapidly, most of the existing forecasting methods may not be applicable. Therefore, this study designed a new methodology for traffic forecasts, a device-based forecasting that consider mobile traffic from various devices for mobile services. The proposed approach performs the three-round Delphi process to complement the experts' opinions in forecasting mobile traffic for 10 years. In particular, scenario analysis was applied to reflect uncertainty of future dynamic situations, investigating optimistic, neutral and pessimistic scenarios. In addition, the forecasting performance of the suggested approach was validated by comparing it with that of traditional forecasting tools. The research findings indicate that mobile traffic will increase rapidly, and the patterns of use for mobile devices will change to some extent, which will provide strategic implications for both companies and government.

1. Introduction

Smartphones have been changing the ways in which people communicate with others, collect information, and enjoy entertainment (Park, Kim, Shon, & Shim, 2013). In particular, the development of new operating systems and useful applications has facilitated a remarkable growth in the mobile business, increasing the number of users (Suh, Lee, & Park, 2012). Thus, although the dominant traffic in mobile broadband networks was voice, the introduction of smartphones affects the transformation of the industrial structure. Smartphone users are more interested in features other than voice services in smartphones, which allow them to access information in an instant, and connect quickly; and accordingly, the adoption of mobile broadband has grown exponentially, supported by the users of tablets and connected laptops. The mobile industry has been experiencing an intriguing revolution, where global mobile data traffic nearly tripled (2.6 times growth) for the third year in succession in 2010. In addition, mobile traffic shows more dramatic growth (in 2011, 33 times the traffic in 2009), and mobile traffic by smartphones accounts for 96.7%. The rapid and wide spread of mobile smart devices not only increases mobile data traffic drastically, but also integrates the PC-based internet market and even the TV-based home service market into a single ICT ecosystem (Chang, 2015). This global-scale market transition can be called 'multi-screen service' or 'ICT convergence' (Lin & Oranop, 2015). The vitalization of innovative services will continuously increase the mobile component, accelerating the change of mobile ecology toward contents and applications-oriented industry.

At the same time, the mobile boom has started to cause a traffic jam in mobile broadband networks, affecting the deterioration of mobile service quality (Alani, 2007). The quality in mobile service business can be determined by several main factors, such as connection quality, content quality, interaction quality, customer service quality, and device quality (Chae, Kim, Kim, & Ryu, 2002). Among others, the connection quality is one of the most critical factors, because it deals with a stable access to mobile services, without interruption of connection, providing a speedy response to requests of users. This quality can be enhanced, by reinforcing the performance of equipment: wireless telecommunication networks, and mobile devices. While mobile service providers continuously invest in the infrastructure of networks, mobile device manufacturers develop state-of-the art devices that have high performance. Thus, the forecasting of future traffic

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needs is in urgent need of providing high-quality mobile broadband services. In the perspectives of service providers, since the size of investment in network infrastructure is enormous, the timing of implementing such infrastructure should be planned, to optimize the strategy of investment. Well-forecasted mobile traffic data are also useful to mobile device manufacturers, because the specifications of mobile devices under new product development are influenced by the needs of hardware performance of mobile devices, which are dependent on mobile traffic. Therefore, a systematic approach should be implemented to reduce a forecasting error rather than just depending on intuitive judgment of experts. Relevant forecasting models need to be selected and sometimes combined to enhance the forecasting performance. In general, a dual-structured approach that synthesizes the results of two different forecasting methods (for example, the combination of a quantitative technique and a qualitative technique) can yield better forecasting error. In particular, a data issue may be the most important factor in all forecasting practices. Thus, a systematic process should include a method on how to decide time horizon and time bucket for forecasting, considering specific characteristics of target products or services.

Although several studies tackle the forecast of mobile services (Casey & Töyli, 2012; Hong, Dong, Chen, & Lai, 2010; Hwang, Cho, & Long, 2009; Lim et al., 2012), they have some limitations that should be overcome. First, most of the research has a tendency to make simple extrapolations from past data. However, the emergence of smartphones has restructured the landscape of mobile industry, rendering the past experience of feature phones obsolete. Thus, the trend extrapolation methodology is insufficient to anticipate the mobile traffic in a totally different mobile environment. Second, the existing literature focuses on providing the exact outputs of forecasting in the mobile industry, failing to consider various scenarios in the complex environment of mobile business. Since the mobile industry includes many stakeholders, such as service providers, device manufacturers, government, and customers, all of whom have diverse needs, strategies and policies, the situations of services and businesses can be rapidly changing from a historical event. Thus, potential scenarios that cover all thinkable situations need to be considered, in order to deliver valuable forecasting results. Third, since the mobile traffic occurs from many kinds of mobile devices, the future needs for the mobile traffic should be forecasted by reflecting the changing patterns of each device. However, traditional forecasting approaches have dealt with overall forecasts on total amount of aggregated mobile traffic. Finally, the forecasting of mobile traffic has not been performed in the transitional point from feature phones to smartphones. An approach and results to forecast this kind of future mobile traffic can offer useful tools and critical lessons to forecast the traffic, at a transitional point of services.

To meet the needs, this research aims to forecast mobile broadband traffic, focusing on the Korean case. When voice traffic was dominant, traffic patterns were generally static and predictable. In contrast, with the emergence of diverse classes of services, where the available devices for the services and their patterns of use are changing rapidly, most of the existing forecasting methods may not be applicable. Therefore, we designed a new methodology for traffic forecasts, a device-based forecasting that considers the number of users, and the patterns of use on each mobile device. The methodology was based on the three-round Delphi process, but also used relevant data, to complement the experts' opinion. In addition, this research tried to forecast traffic by devices, where different forecasting approaches were adopted, according to the characteristics of devices, and the patterns of use for each device were considered. In particular, a hybrid approach of Delphi process and scenario analysis can improve the forecasting power by examining the risks of dynamic future situations. In terms of practical contributions, the research attempting to consider the future of mobile devices can provide useful managerial implications for service providers, device manufacturers and policy-makers of telecommunication policy.

2. Previous studies

2.1. Demand forecasting on the mobile communication service market

The forecasting of innovation diffusion has been a topic of practical and academic interest, since the pioneering works of Fourt and Woodlock (1960), Mansfield (1961), and Bass (1969). Fourt and Woodlock (1960) proposed an exponential function for diffusion, with the assumption that the diffusion process is driven by mass-media communication. The model proposed by Mansfield (1961) assumes that adoption only occurs through world-of-mouth. Subsuming both, the Bass (1969) model incorporates both types of communication channels: mass media (external influence), and word-of-mouth (internal influence). These main models of innovation diffusion were well established by the 1970s. The best known models include the Bass model (1969), the logistic family models (Bewley & Fiebig, 1988; Mansfield, 1961) and the Gompertz model (Gompertz, 1825; Rai, 1999). These models provide S-shaped curves that describe technology diffusion among specific populations, and are commonly used to analyze the demand and diffusion processes in the fields of management, policy, economics, and marketing (Kim, Lee, Cho, & Kim, 2011; Mestekemper, Kauermann, & Smith, 2013). Most of the previous models rely greatly on time-series data on adopters to forecast the future demands. The most widely utilized methods in investigating the times series data include time series regression, exponential smoothing, decomposition methods and so on (Li, Gai, Kang, Wu, & Wang, 2014). Recently, new approaches such as Fourier transforms and wavelet transforms have been proposed to increase the accuracy of times series predictions with data on number of adopters (Di, Yang, & Wang, 2014; Joo & Kim, 2015). Therefore, they provide demand forecasting at the aggregate (population) level, rather than at the individual customer level. However, considering that innovation diffusion is the process of new product or service adoption by customers, more attention should be devoted to models that can deal with customer behavior at the micro level. Particularly for service, the diffusion processes are different from those for consumer goods. Many services are purchased by subscription, and customers can change service providers easily, when they are not satisfied with the service, or when other competing providers offer more valuable services, with lower prices. For these services, potential decisions of when and whether to adopt them will affect their diffusion processes.

A Delphi survey is developed as a systematic, interactive forecasting method, which relies on a panel of experts. It usually consists of several rounds, to build a consensus on unclear things, through feedback processes (Winkler, Kuklinski, & Moser, 2015). Thus, it has been used to derive backup data in emerging industries, which do not have enough data for quantitative forecasting (Bengisu & Nekhili, 2006; Gerdsri, 2003; Meesapawong, Rezgui, & Li, 2014); or to forecast the future of industries that need experts' opinion to support quantitative forecasting results, such as the tourism industry (Yong, Keng, & Leng, 1989), and aerospace industry (English & Kernan, 1976). In addition, the Delphi approach can be combined with scenario planning because it is an effective tool to gain foresights for an unpredictable future (Wright, Cairns, & Bradfield, 2013). Scenario planning is not forecasting of the most probable future but it creates a set of the plausible futures (Amer, Dain, & Jetter, 2013). Many studies have tackled to bridge the gap between scenario-based foresight and traditional quantitative market research/technological forecasting. Most of them utilize quantitative/systemic aids in the stages of key factors and environmental forces to analyze the dynamic causal relationships among the environment variables (Chang, 2015). For example, patent analysis, simulations and fuzzy cognitive map can support