

Chapter 16

Utility Theory Based Approach for Converged Telecommunications Applications

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Abstract Convergence of heterogeneous products and services is now a leading phenomenon of telecommunications industry. These new and innovative converged applications are able to meet the diversified but pooled demands of the subscribers, so their demand is rapidly increasing. In this paper researchers have done both qualitative and quantitative analysis to find out subscriber satisfaction levels for these services. This analysis is based on utility theory, probability theory and Bayes theorem. The aim of this analysis is to find out subscribers' satisfaction levels and their willingness to pay for converged applications for decision making by manufacturers and service providers. The research found that cost effective converged application with maximum satisfaction is preferred by consumers and will play leading role in expansion of this market in future.

Keywords Utility theory · Convergence · Subscriber's satisfaction · Telecommunication applications

16.1 Introduction

Evolution for refinement driven by the motive of to bring more ease and comfort in human lives is as old as existence of human beings. Inventions by man are good example of it. In telecommunications sector, span of thousands of years from

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ancient times' conveying messages through fire lighting and drum beating to telegraphy in the recent past and modern mobile telephony and other state of the art telecom products in today's world contains the quest for evolution for refinement for ease and comfort. Since last two decades, huge developments have been made in this sector. Analog devices evolved to digital, wired to wireless, then wireless extended to mobile and nomadic access, narrowband transmission to broadband [1]. Many technologies play significant role in this mobile evolution. xG continues its developing process to meet new requirements from 1G, 2G, 2.5G, 2.75G, 3G and 3G+. WiFi, WiMAX, LTE all are strong competitors in this struggle. These all advancements have now changed dimension to the phenomena of convergence. However for telecommunications operators, it is continuously evolving subscriber's demand to communication, customization, convenience and personalization [2].

Our research is on the application layer and in the next two sections we discuss convergence and the vital players of this layer. In Sects. 16.4 and 16.5, we have used utility theory approach to quantize the satisfaction level of our subscribers and results are mentioned in Sect. 16.6 while Sect. 16.7 concludes this paper.

16.2 Convergence

According to International Telecommunication Union (ITU) recommendation Q.1761, convergence is a mechanism by which an IMT-2000 user can have his basic voice as well as other services through a fixed network as per his subscription option [3]. In opinion of European Telecommunication Standards Institute (ETSI), Fixed Mobile Convergence (FMC) is concerned with the provision of network capabilities which are independent of the access techniques.

An important annex of this rule is related to inter-network roaming; subscriber should be able to roam between diverse networks and to be able to use the same steady set of services through those visited networks [4]. Some examples of mobile/WLAN convergence are:

- WLAN/GPRS 'Handover' declared by Nokia
- WLAN/GSM VoIP terminal publicized by Motorola
- NTT DoCoMo: FOMA-WiFi
- BT "Fusion": GSM-WiFi
- France Telecom "Business Anywhere": GPRS-WiFi
- O2 Germany "surf@home": UMTS-WiFi
- Korean KT & KTF "OnePhone": CDMA-Bluetooth
- Dual Phone, by Deutsche Telekom's T-Com.

Convergence is depicted in Fig. 16.1.

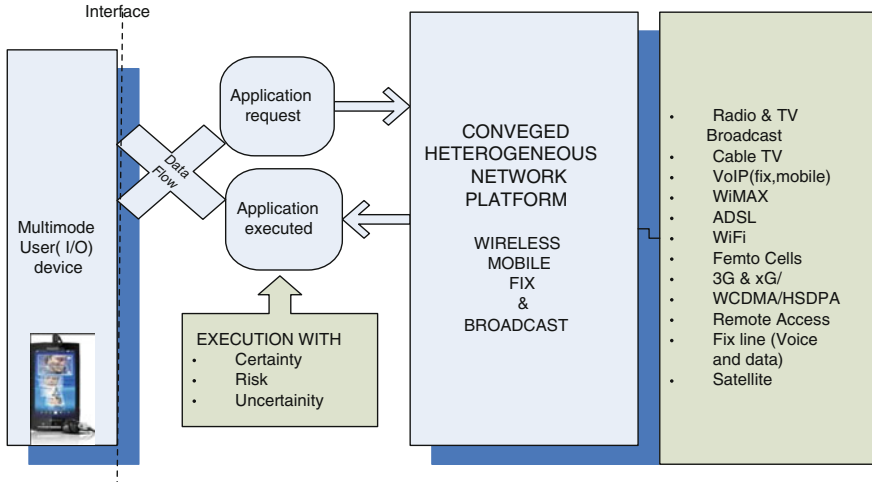


Fig. 16.1 Converged network platform

16.3 Key Players of Application Layer

In this section, we discuss three key players at application layer of any telecom environment namely subscribers, applications and devices measurement described.

Subscriber is any person availing the services of telecom network on payment. Their classification for research purpose is available in literature based on Age (Teenagers, Young, Adults, Old), Gender (Male, Female), Network access type (TDMA, CDMA, OFDMA), Network scale (PAN, LAN, MAN, WAN, GAN), Application type (Voice, Video, Combination of both), Technology (Fixed, Wireless, Mobile, Nomadic) and Market (Home, Enterprises, Corporate) but not limited to these.

Applications of telecommunication networks are being provided since 1970's starting from analog and then 1990's voice and in late 1990's with text and voice under 2.5G technology and progressing continuously 3G and 3G+. The drive behind is more and more data rate technically named as broadband. International Telecommunications Union (ITU) recommendation I.113 has defined: 'A broadband as a transmission capacity that is faster than primary rate ISDN at 1.5–2 Mbits/s' [5]. Federal Communications Commission (FCC) defined in 1999: 'Broadband is 200 kbits/s (0.2 Mbit/s) in one direction, the lower end of the broadband spectrum to be 200 kbits/s and advanced broadband is at least 200 kbit/s in both directions' [6] however in 2010, it defined as "high-speed, switched, broadband telecommunications capability that enables users to originate and receive high-quality voice, data, graphics, and video telecommunications using any technology" [7].

Future network requires multimode device that can be connected and switched between networks based on different technologies, including cellular, WiFi, DSL/Cable, Bluetooth, UWB and more. Qualcomm is behind the multimode dimension

by developing power efficient chipsets that integrate a growing array of functionality and supporting many access technologies while LG and Samsung are launching their own chipset. Multimode devices have a key position in the commercialization of LTE. Commercial launch of LTE with multimode devices is taken off.

16.4 Utility Theory Based Approach

It is human instinct that possession and consumption of goods give pleasure or satisfaction. In economics, this pleasure or satisfaction is named utility. Jeremy Benthan (1784–1832) gave the idea to measure pleasure and pain in his famous book ‘Introduction to the Principals of Morals and Legislation’ in 1780s which laid the foundation stone of the utility theory and this theory was further developed by William Stanley Jevons and others in mid 19th century. The theory assumes/postulates that consumer derives satisfaction from goods, wants to maximize the satisfaction, income is limited, and the satisfaction increases as per law of diminishing marginal utility and utility is measureable [8]. It is human behavior that he wants to maximize the satisfaction but his income is constrained. To analyze this behavior, the concepts of indifference curve and budget constraint in economics are helpful.

Indifference curve shows different combinations of two commodities that gives same level of satisfaction or in other words set of various quantities of two goods which are equally desirable. The indifference curves have the properties: i. farther from origin preferred to closer ones, ii. There is an indifference curve through every possible bundle, iii. Indifference curves cannot cross and iv. Indifference curves slope downward [9].

Budget constraint is important concept in utility theory and shows various combinations of goods that a consumer can buy given his income and price of goods. In [10] budget line is defined as ‘a line showing the possible combinations of two goods that a consumer can purchase’.

After mapping the indifference curves and budget line, we can find out the point where consumer satisfaction is maximized. Graphically it will be the intersection of budget line and the farther most indifference curve from origin.

16.5 Applying Utility Theory Approach to Convergence of Telecom Net-work Application

In view of human behavior of maximizing the utility given the limited resources, a telecom subscriber would naturally want to get more and more benefit and satisfaction from telecom application, device or network by spending certain amount of

Table 16.1 Wireless mobile application and sample data rate

Application	Data rate
VoIP	4–64 kbps
Interactive gaming	50–85 kbps
Music, Speech, Video Clips	5–384 kbps
Web browsing, email, instant messaging, telnet, file download	0.01–100 Mbps
IPTV, movie download, P2P video sharing	>1 Mbps

money and utility theory help here to find the solution. For our purpose, some important factors that contribute to the approach and analysis are following.

The term ‘subscribers’ is used instead of consumers and they are of three types i.e., home or individuals, enterprise and corporate. Each kind spends a range of their income for the purpose of execution of applications. A general framework for their respective budget has been taken for analysis (Table 16.1).

Voice and video are taken as two goods for our utility analysis and their different combination encompasses various applications’ demands. Satisfaction level means the quantified utility level. Our range of satisfaction is depicted in following table.

Satisfaction levels are classified as ‘E’, ‘G’, ‘F’ and ‘P’. In first type, the bandwidth and data rate required by the application request is equal or greater than needed. There is no delay and all parameters for Quality of Service (QoS) are maintained by network. Hence leading to conclusion that subscriber satisfaction level is ‘E’. In second and third alternative, satisfaction level is not as much of ‘E’ but still satisfaction and is denoted as ‘F’ and ‘G’ in Table 16.2. ‘P’ type subscriber is unsatisfied.

Indifference Curves are named as satisfaction curves in this analysis and shows different combinations of two commodities that gives same level of satisfaction. When a subscriber’s satisfaction level changes, the curve also changes otherwise not. These curves for satisfaction levels ‘E’, ‘G’ and ‘F’ are shown in Fig. 16.2 and labeled as ‘SE’, ‘SG’ and ‘SF’ respectively. As long as the subscriber has same satisfaction level, his curve is same. These curves never touch zero levels. ‘SE’, ‘SG’ & ‘SF’ hold all combination of video and voice units at respective satisfaction levels of ‘E’, ‘G’ and ‘F’. At level ‘P’, there is dissatisfaction, so, satisfaction curve is not drawn. For plotting these curves, the different combinations of voice and videos are used and units for both goods i.e., video and voice are kbits/sec.

Table 16.2 Wireless mobile application and sample data rate

Level	Satisfaction status
00	Poor (P) Unsatisfied
01	Fair (F) Partially satisfied
10	Good (G) Partially satisfied
11	Excellent (E) Satisfied

Fig. 16.2 Satisfaction curves

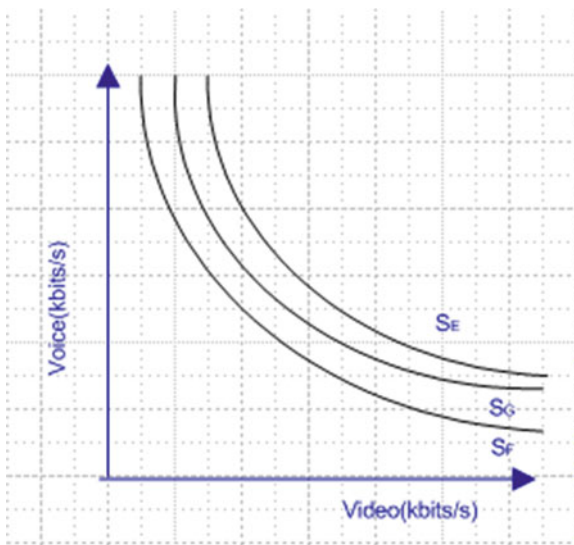
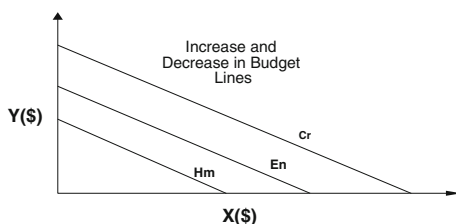


Fig. 16.3 Budget lines

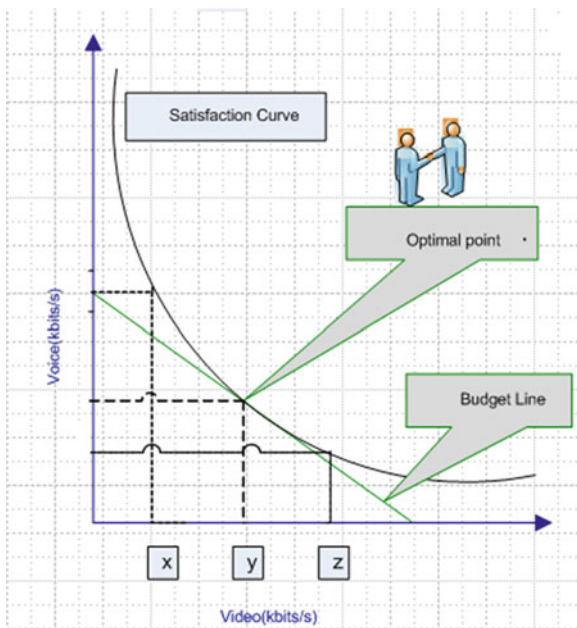


Budget constraint is very important in telecommunications. If the applications are executed with good quality of service and cheap rates then it is attracted by common subscribers so it is a significant factor in implementing and penetration of any network. If the converged network is providing all its services at very high rates that are not affordable to its subscribers then convergence phenomenon for wireless mobile applications will not be a success story. Figure 16.3 shows budget line for purchase of two commodities namely voice (V_c) and video (V_d):

Let 'N' is the amount in dollars for purchase and the cost/kbps of V_c is PV_c and cost/kbps of V_d is as PV_d . The straight line connecting N/PV_c and N/PV_d will be the budget constraint of a subscriber with defined 'N' dollar for purchase of units of V_d and V_c . This line shows the combination of V_d and V_c that a subscriber can get in the given budget. Different subscribers such as individuals, enterprises and corporations have different budget constraints for access of broadband applications and their budget lines are straight with certain ratios of voice and video units.

Optimal solution to choose between different combinations of voice and video given the budget constraint of the subscriber lies at intersection point between budget line and satisfaction curve. In Fig. 16.4, points 'x', 'y' and 'z' contains different quantities or units of voice and video but they give same level of

Fig. 16.4 Satisfaction maximization point



satisfaction to the subscriber as all three points lie on the same satisfaction curve. However, Point ‘y’ is intersection point with budget line while points ‘x’ and ‘z’ lies above the budget line and hence not attainable at this level. Therefore subscriber will opt for point ‘y’.

16.6 Analysis and Results

Analysis is done in this section to aid our idea of quantizing satisfaction through utility theory. Analytical approach is scientific aspect that leads to decision making. Previous section shows the qualitative analysis, whether subscriber is satisfied, unsatisfied or partially satisfied depending upon the execution level of his/her request. Once we know the preference level of the particular group of subscribers, it is helpful for the telecom service provider to design and offer products keeping in view of the groups’ specific requirements and price level.

Now we quantify and analyze the relation of satisfaction and change in budget and first we define some probabilities in this regard.

$P(S)$ = Probability of satisfaction, $P(PS)$ = Probability of partial satisfaction, $P(US)$ = Probability of un satisfaction, $P(S|BI)$ = probability of satisfaction given the budget increase or Probability that increase in budget will be favourable for satisfaction, $P(PS|BI)$ = probability of partial satisfaction given the budget increase or Probability that increase in budget will be favourable for partial

satisfaction, $P(\text{US|BD})$ = probability of un satisfaction given the budget decrease or Probability that decrease in budget will be favourable for un satisfaction.

Based on results obtained from survey, we have calculated the following probabilities:

- | | | |
|-------|--|--------|
| i. | Probability of satisfaction $P(S)$ | = 0.3 |
| ii. | Probability of un satisfaction $P(US)$ | = 0.2 |
| iii. | Probability of partial satisfaction $P(PS)$ | = 0.5 |
| iv. | Probability of satisfaction given the budget increase $P(S BI)P(S BI)$ | = 0.7 |
| v. | Probability of partial satisfaction given the budget increase $P(PS BI)$ | = 0.2 |
| vi. | Probability of un satisfaction given the budget decrease vi. $P(US BD)$ | = 0.6 |
| vii. | Joint probability of Satisfaction and budget increase
$P(S\&BI) = P(S BI). P(S) = (0.7) (0.3)$ | = 0.21 |
| viii. | Joint probability of partial Satisfaction and budget increase
$P(PS\&BI) = P(PS BI). P(PS) = (0.2) (0.5)$ | = 0.15 |
| ix. | Joint probability of un-satisfaction and budget decrease
$P(US\&BD) = P(US BD). P(US) = (0.6) (0.2)$ | = 0.12 |

16.7 Conclusion

The research concludes that the global adoption of converged telecom applications depends on many factors. Service operators, vendors and manufacturers aim to promote fixed and mobile converged applications. This utility theory based analysis highlights the fact that service provision without subscriber satisfaction and adoptability is nothing. The approach emphasizes on application layer platform, shedding light on one of the important issues of convergence-subscriber satisfaction. Less cost converged solution with maximum subscriber satisfaction would be deployed. In conclusion, subscriber preference, contentment and inclusion of budget factor are important aspects to be considered in making telecommunication converged application thriving.

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