Effect of Ageing on Perception of Quality of IP-based Personal Communication Applications

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***Abstract*—IP-based personal communication applications are popular around the world, especially, in developing countries. User perception of quality of service is one key concern for making a decision to adopt an IP application as a personal communication tool. However, user perception of quality is different among various groups even with the same intrinsic technical quality. Perception changes with many factors which include ageing. In this study we investigated the effect of ageing on user perception of quality of service of IP-based personal communications. We selected 5 related characteristics on IT usage to study their effect on user perception: IT knowledge, IT experience, physical expectancy, coping with unexpected events and ability to notice. The study randomly selected 101 subjects from population of different ages which include the Baby Boom Generation, Generation X, and Generation Y. The results confirm that the selected factors can differentiate users and reveal that there are 4 significant differences among groups of users which are based on Ward's method, minimizing Sum of Square Errors (SSE) and analysis of variance. The four resulting groups are advanced users, moderate users, slow users, and practitioners. The study also finds that perception of quality of IP-based personal communication is similar for 3 of the user groups, only the practitioner group has different perception. We found in this study that it is possible to develop IP-based personal communication applications that will be well adopted by the majority of users.**

Keywords— Ageing Dimension; Perceived Quality of Service; Generation; User Perception; IT Related Characteristics

I. INTRODUCTION

Internet Protocol (IP)-based personal communication applications are widely used at the present time in the world due to the technology revolution in telecommunication systems, IT products and services. Mobile phones, especially, smart phones and tablets are devices that have increased the popularity and use of the Internet in daily life. From the Household Survey on Information and Communication Technology (ICT) of the National Statistical Office (NSO) [1] of Thailand, during 2008-2012, the tendency of using the Internet and mobile phones increased to 26.5% (16.6 million) and 70.2% (44.1 million), respectively. Most of the company's expense was on communication part. Therefore, convergence between Internet and mobile communication has occurred.

Voice over Internet Protocol (VoIP) applications are one of the important IP-based personal communication applications in the world of communication. Skype is a popular VoIP commercial application [2]. There are 300 million users worldwide [3]. LINE is also a popular VoIP application. Thailand has been ranked second in the world with 18 million LINE users [4].

Many IP applications have been developed to meet the user requirements. There are various fields of research focused on human perception which is a key concern for developing new IP applications in the IT industry. The Technology Acceptance Model (TAM) developed by Davis [5] is a basic model for understanding adoption behavior. In TAM, there are two main constructs which are perceived usefulness and perceived ease of use. TAM has been continuously studied, and the Unified Theory of Acceptance and Use of Technology (UTAUT) [6] is the latest proposed model, which has four constructs. These are performance expectancy, effort expectancy, social influence and facilitating conditions. Many IT products and services were studied by using models such as e-Government [7], e-Health [8], Mobile Banking [9], Mobile Applications [10] including VoIP applications [11]. User perception remains a key concern for technology adoption. However, there are few studies that focus on the Perceived Quality of Service (PQOS) construct which is based on human centric factors of IP-based personal communication applications.

The aim of this study was to investigate the effect of ageing on user perception of quality of service of IP-based personal communication based on IT related characteristics. In the context of IP-based personal communication applications, we focused on VoIP applications such as Skype, LINE, Facetime, so on. This paper was a two-fold study:

1) To differentiate groups of users by IT related characteristics

2) To investigate user perception of quality of service among groups of users

From the results of this study, it is possible to develop IP-based personal communication applications that will be well adopted by the majority of users.

This paper is organized into five sections. In the next section, we present the approach to classifying groups of users based on IT related characteristics. Section III explains the methodology, data collection and data analyses. In Section IV, the results and discussion are given. Finally, the conclusion and future direction of the research are provided in Section V.

2014 IEEE Canada International Humanitarian Technology Conference - (IHTC)
978-1-4799-3996-1/14/$31.00 ©2014 IEEE

II. RESEARCH PROPOSED

A. Perceived Quality of Service

Quality of Service (QOS) is the technical term used in the fields of computer networking. The ITU-T recommendation [12] defined the quality of service as "*the collective effect of service performance, which determines the degree of satisfaction of a user of a service."* It is normally known that QOS is used to guarantee the level of service performance in terms of technical view: a required bit rate, delay, jitter and packet loss. However, both the technical and behavioral components need attention to optimize the quality of service. Wu [13] explored user's behavior intentions to use 3G mobile communication applications using the UTAUT model. The results of the study found that output quality was correlated with the perceived quality of service of an application.

Perceived QOS is one of two main components of QOS proposed by the previous research [14] that should be considered. The three dimensions for assessing Perceived QOS (on the same IP application) of users with different human centric factors are the cultural dimension, ageing dimension, and language dimension. Perceived QOS is different among various groups, even with the same intrinsic technical quality. Perception changes with many factors which includes ageing. This study builds on the results of the previous paper [14] and confirms that IT related characteristics can be used to differentiate users.

B. Ageing Dimension

The ageing dimension is defined as age-related changes in physical abilities and the level of IT knowledge and IT experience of people. Neil Charness and Walter R. Boot [15] said that *"Such changes lead to different interactions with tools and with people"*. Yoko Asano [16] studied the main problems that cover the lack of IT experience, physical impairment, and the cognitive processing of the elderly while using information and communications technology (ICT) services. When an unexpected event occurs while using an IP application, a young adult has a better ability to detect change than the elderly. When users have to use an application that requires more IT knowledge, it is considered to be of low quality for the elderly, but it can be high quality for young adults.

There is a large amount of previous research [17-19] which studied the computer and technology usage of the elderly. Normally, in terms of ageing, most research classified the groups of users based on their age range. Older users are commonly ages 60 and older. In this study, IT related characteristics were used as variables to classify groups of users. The five proposed IT related characteristics are:

1) IT knowlwdge: User perception of knowledge of electronic devices, Internet and social media.

2) IT experience: User perception of experience in using electronic devices, applications and social media.

3) Physical expectancy: User perception of hearing, reading and motor control ability.

4) Coping with an unexpected event: User perception of their ability to deal with unexpected events/problem while they use the application by themselves without any supporting.

5) Ability to notice relates to user perception of ability to learn and remember how to use an application.

III. RESEARCH METHODS AND ANALYSES

A. Measurements

The basic constructs of the ageing dimension have been presented in the previous paper [14]. The five variables chosen to reflect the characteristics of the ageing dimension were IT knowledge, IT experience, physical expectancy, coping with unexpected events and the ability to notice. The questionnaire was developed and modified based on collected suggestions and the use of Cronbach's alpha statistic. The preliminary study was performed with users who had already used a VoIP application.

B. Data Collection

The surveys were both paper-based and web-based and were distributed to respondents who were already users of a VoIP application such as Facetime, LINE, Skype and so on, from February to April 2013. This study used a convenient sampling method and the participation in this study was on a voluntary basis. The survey included three sections. The first section asked questions concerning demographic information, which allowed us to gather age, gender, and education. The second section asked questions concerning age characteristic variables. In the last section, questions were asked concerning perceived quality of service of VoIP applications. All items of section II-III were developed with a 5-point Likert scale [20], ranging from 1 as Strongly Disagree to 5 as Strongly Agree.

C. Data Analyses

This study used several statistical techniques for data analysis. Reliability analysis was used to construct reliable measurement scales, to improve existing scales, and to evaluate the reliability of scales already in use. One of the most popular reliability statistical methods is Cronbach's alpha that determines the internal consistency or average correlation of items in a survey instrument to gauge its reliability.

To classify a group of users, cluster analysis was used to organize observed data into meaningful taxonomies, groups, or clusters, based on combinations of individual variables. This method maximizes the similarity of cases within each cluster while maximizing the dissimilarity between groups that are initially unknown. The meaningful groups lead to capture the natural structure of data. Cluster analysis is used in many fields of study such as psychology, social science, machine learning and data mining. Both Hierarchical and K-Means cluster analysis were used in this study.

The analysis of variance (ANOVA) test was also conducted to test the differences among the means of clusters. The one-way ANOVA test compares the means between the clusters of interest and determines whether any of those means are significantly different from each other. Specifically, it tests the null hypothesis:

$$H_0: \mu_1 = \mu_2 = \mu_3 = \cdots = \mu_k$$

Where μ = cluster mean and k = number of clusters. If, however, the one-way ANOVA test returns a significant result, we accepted the alternative hypothesis, which is that there are at least two clusters means that they are significantly different from each other. We still may not know which group means differ and how many group means differ from each other. Hence, the multiple comparison/post-hoc tests were performed to answer these questions. Finally, we used the descriptive statistics to summarize the cluster profile and the mean score of each cluster.

IV. Results

The survey was completed by 101 respondents. The demographic characteristics are shown below in Table I. The age of respondents were categorized to three groups based on Social Generation [21]: Baby Boomers as people born between 1946 and 1964, Generation X (Gen. X) as people born between 1965 and 1979, and Generation Y (Gen. Y) as people born between 1980 and 2002.

A. Reliability Analysis

For reliability analysis, we used Cronbach's alpha scores to evaluate the internal consistency reliability of questionnaire items. The results of Cronbach's alpha value are shown in Table II. We dropped and modified some questions to improve the alpha value to the acceptable level of 0.7 or greater [22]. All research variables fell within the acceptable range of the alpha value. The only exception was physical expectancy (alpha = 0.404). This may be a result of the questions that concerned the physical expectancy covered a wide range of physical abilities such as hearing, reading and motor control.

B. Cluster Analysis

To find a group of relatively homogeneous users or observations, this study exercised the cluster analysis to meet the requirements. One of the biggest problems with cluster analysis is that researchers usually do not know the number of groups or clusters that will emerge in their sample, and we wanted an optimum solution. To identify the optimum number of clusters, a hierarchical cluster analysis was used with a two-stage sequence of analysis:

1) Run a hierarchical cluster analysis using Ward's method to determine the optimum number of clusters

2) Rerun the hierarchical cluster analysis with our selected number of clusters

TABLE I. Profile of Respondents

Research Variables		n = 101
Gender	Male	45
	Female	56
Age	18 to 34 (Gen. Y)	64
	35 to 49 (Gen. X)	31
	50 and more (Baby Boomer)	6
Highest level of education	Below Bachelor Degree	8
	Bachelor Degree	34
	Master Degree	53
	Doctoral Degree	6

TABLE II. Composite Reliability Group Means

Research Variables	Number of Items	Cronbach α	Ageing Dimension	
			Mean	*SD*
IT knowledge	4	0.844	3.646	0.714
IT experience	4	0.861	4.030	0.782
Physical expectancy	3	0.404	3.650	0.666
Coping with unexpected events	3	0.822	3.769	0.874
Ability to notice	3	0.876	3.604	0.825

TABLE III. Re-formed Agglomeration Table

No. of Clusters	Agglomeration last step	Coefficients this step	Change
2	300.813	173.868	***126.945***
3	173.868	137.282	36.586
4	137.282	108.325	***28.957***
5	108.325	95.434	12.891
6	95.434	82.816	12.618

In the first stage, we ran a hierarchical cluster analysis using Ward's method using SPSS. The agglomeration schedule provided a solution for every possible number of clusters from 1 to 101 (the number of respondents). We rewrote the coefficients, as shown in Table III, so that it was easier to see the changes in the coefficients as the number of clusters increased. The change column enabled us to determine the optimum number of clusters.

In Table III, a clear difference point seems to occur at two points which are 2 cluster and 4 cluster. In this case, 2 or 4 clusters are selected to distinguish between cases. We also evaluated the values of the Sum of Square Error (SSE). SSE is an internal index that is used to measure the goodness of a clustering structure without respect to external information. Calculating the sum of squared error is commonly done in K-means cluster analysis; therefore, SSE can also be used to estimate the number of clusters. Figure 1 shows the SSE curve by the number of clusters.

In general, as the number of clusters increases, the SSE value should decrease because the clusters are smaller. Thus, an appropriate cluster solution could be defined as the solution

Fig. 1. SSE curve by the number of clusters

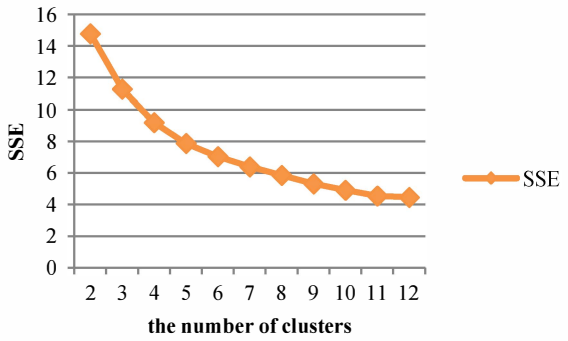

TABLE IV. CLUSTER MEMBERSHIP

Cluster	1	2	3	4
n	40	16	4	41

at which the reduction in SSE value decreases dramatically. As can be seen in Figure 1, it seems that there is a sharp bend between cluster 4 to cluster 6. The clusters with an SSE of more than 6 do not have a substantial impact on the total SSE value. In this case, however, there was not an obvious break in the distribution of SSE values against clusters. Finally, from the results of using Ward's method of hierarchical cluster analysis and minimizing Sum of Square Errors (SSE), four similar user subgroups were identified in this study.

In the second stage, the hierarchical cluster analysis with four clusters was reran to produce four subgroups of users. The cluster membership is shown in Table IV. Normally, the analysis of variance is next conducted to determine which classifying variables are significant between the groups.

C. Comparison Analysis

After four clusters were produced by hierarchical cluster analysis, this study also conducted ANOVA to confirm the cluster differences based on means values. The proposed hypotheses are the following:

H1: There is a difference in IT knowledge among the means of the four clusters

H2: There is a difference in IT experience among the means of the four clusters

H3: There is a difference in physical expectancy among the means of the four clusters

H4: There is a difference in coping with unexpected events among the means of the four clusters

H5: There is a difference in the ability to notice among the means of the four clusters

For hypothesis testing, the significance of the F-ratio identified mean differences and suggested a divergence in characteristics among the clusters. $P < 0.05$ was considered to indicate statistical significance. Table V provides a comparison between the four clusters of our respondents.

The results showed a full acceptance of the hypothesis in each research variable. There were significant differences among the four clusters in terms of IT knowledge, IT experience, physical expectancy, coping with unexpected events and Ability to notice. A Tukey post-hoc test was used to determine where the differences lie. The Tukey test results revealed that all variables reliably differentiate the four clusters through their cluster means except for physical expectancy, which was only significantly differentiated between clusters 1 and 2 and clusters 1 and 3. Clusters 1 and 4 were not significantly different in this variable.

TABLE V. HYPOTHESIS TESTING

Research Variables	Result			
	Proposed Hypo.	***F***	***Sig.***	***Hypo. Testing***
IT knowledge	H1	61.329	.00	***Accept***
IT experience	H2	80.942	.00	***Accept***
Physical expectancy	H3	45.122	.00	***Accept***
Coping with unexpected events	H4	60.985	.00	***Accept***
Ability to notice	H5	74.244	.00	***Accept***

TABLE VI. CLUSTER PROFILES

Research Variables	Cluster	N	Mean	S.D	Min.	Max.
IT-KW	1	40	3.1750	.36777	2.50	4.00
	2	16	4.3750	.60553	3.00	5.00
	3	4	2.0625	.62500	1.75	3.00
	4	41	3.9756	.42133	3.25	5.00
	Total	101	3.6460	.71350	1.75	5.00
IT-EX	1	40	3.5250	.46271	2.25	4.50
	2	16	4.8125	.30957	4.00	5.00
	3	4	2.0000	.35355	1.75	2.50
	4	41	4.4146	.45965	3.50	5.00
	Total	101	4.0297	.78205	1.75	5.00
PHE	1	40	3.3917	.47006	2.67	4.33
	2	16	4.6669	.45526	3.67	5.00
	3	4	2.4975	.57639	2.00	3.33
	4	41	3.6183	.41912	2.67	4.67
	Total	101	3.6503	.66570	2.00	5.00
UNE	1	40	3.2590	.57228	2.00	4.33
	2	16	4.7075	.32066	4.33	5.00
	3	4	1.4975	.33500	1.33	2.00
	4	41	4.1212	.53697	3.33	5.00
	Total	101	3.7687	.87411	1.33	5.00
ANO	1	40	3.1668	.50680	2.33	4.67
	2	16	4.6888	.33278	4.00	5.00
	3	4	1.4975	.57639	1.00	2.33
	4	41	3.8127	.48315	3.00	5.00
	Total	101	3.6040	.82475	1.00	5.00

Finally, descriptive statistics were used to explain each cluster profile. The clusters were reported along with the statistical measures in terms of Mean and Standard Deviation (SD) as shown in Table VI.

Each cluster profile was summarized as follows:

- Cluster 1 was characterized by moderate scores in all five characteristics. The users in this cluster are called moderate users. 55 percent of users were Gen. Y, and 45 percent were Gen. X users. There were no Baby Boomer users in this cluster.
- Cluster 2 was characterized by high scores in all five characteristics. The users in this cluster are called advanced users. 62.5 percent of these were Gen. Y users, 25 percent were Gen. X users and 12.5 percent were Baby Boomer users.

- Cluster 3 was predominant and characterized by low scores in all five characteristics. The users in this cluster are called slow users. 100 percent of these users were Baby Boomer users.
- Cluster 4 was characterized by high IT experience, high coping with unexpected events, moderate IT knowledge, moderate physical expectancy and moderate ability to notice. The users in this cluster are called practitioners. 78 percent of these were Gen. Y users and 22 percent were Gen. X users. There were no Baby Boomer users in this cluster.

The four groups are advanced users, moderate users, slow users, and practitioners. All slow users are Baby boomers that consistent had low scores in all IT related characteristics, especially, in IT knowledge and experience. The advanced users were dominated by Gen. Y. It seems that moderate users were also dominated by Gen. Y. However, most Gen X users of this study were classified as moderate users while only a third of Gen. Y users were classified as moderate users.

Based on user perception of quality of service of VoIP applications, a 5-point Likert scale was used to measure the level of user perceived quality of service from 1 as Very low to 5 as Very high. The results showed that there were no users who rated level 1 in perceived quality of service. The number of users at each level of PQOS and the clusters are presented below in Table VII.

It is noticeable in Table VII that most users of Clusters 1, 2 and 3 rated the same level of PQOS as moderate while those of Cluster 4 rated the level of PQOS as high. The results reveal that the perception of quality of IP based personal communication is similar for 3 user groups which are advanced users, moderate users and slow users. Only practitioner group had different perception of the perceived quality of service.

V. Conclusion and Research Direction

This paper has described the effect of ageing on perception of quality of service based on IT related characteristics. Four clusters were produced using cluster analysis. The four clusters are advanced users, moderate users, slow users, and practitioners. The advanced users, moderate users, and slow users have scores in all IT related characteristics as high, moderate, and low, respectively. The fourth group, practitioners, has high scores in IT experience and Coping unexpected events and scored moderate in other ageing characteristics. Also, only this group has a different perception of quality of service with a dominant rating of high while the advanced users, moderate users, and slow users have a dominant rating of moderate. Therefore, in terms of IT industry, it is possible to develop IP-based personal communication applications that will be well adopted by the majority of users. After new IT products or services are launched, a training session of users, will be considered to enhance user perceived quality of service.

TABLE VII. The level of perceived QOS in each cluster

PQOS_LEVEL	Cluster Number of Case				Total
	1	*2*	*3*	*4*	
2 (Low)	2	0	0	3	5
3 (Moderate)	**21**	**9**	**3**	12	45
4 (High)	16	3	1	**23**	43
5 (Very high)	1	4	0	3	8
Total	40	16	4	41	101

This research is a preliminary study that is limited by the number of respondents, especially, when comparing the small sample groups of older respondents. In addition, the Cronbach's alpha of physical expectancy is quite low; therefore, the support hypothesis H3 remains questionable. A full scale survey shall be accomplished to provide a better understanding of user perception of quality of service and to improve the reliability of questionnaire items related to physical expectancy. For the new research direction, future research will focus on a new measurement to differentiate PQOS based on human-centric factors. An effective approach may lead to a better understanding of user perceived quality of service. The better the perceived quality of service, the better the technology adoption.

Acknowledgment

The authors would like to thank Association Professor Dr. Wichian Chutimaskul, Dr. Vithida Chongsuphajaisiddhi, and Assistant Professor Dr. Chakarida Nukoolkit, Lecturers of School of Information Technology (SIT), King Mongkut's University of Technology Thonburi for their invaluable contributions to this paper. We also thank Mr. David Hargrave Cook and Mr. Prince Paul Obenza Ranara who revised and corrected our English through his English Language Coordinating Section (ELCS). This work was supported by the Higher Education Research Promotion and the National Research University Project of Thailand, Office of the Higher Education Commission.

References

[1] National Statistical Office. (2012). Report on the Household Survey on Information and Communication Technology, 2012. Database and Statistics Division, National Statistical Office

[2] G. Samrat, B. Sudeept, VoIP: wireless, P2P and new enterprise voice over IP, 2008.

[3] Skype Internal Data, January 2013, unpublished

[4] www.adge-asia.com, LINE, September 30, 2013, unpublished

[5] F. D. Davis, R. P. Bagozzi, and P. R. Warshaw, "User Acceptance of Computer Technology: A Comparison of Two Theoretical Models", Management Science, vol. 35, pp. 982-1003, 1989

[6] V. Venkatesh, M.G. Morris, F.D. Davis, and G.B. Davis, "User Acceptance of Information Technology: Toward a Unified View", MIS Quarterly, vol. 27, no. 3, pp. 425-478, 2003

[7] B. Papasratorn, "Mobile Broadband Application Framework for E-Government Services for Aging Society.", The Asia-Pacific Telecommunity (APT) Workshop on e-Application / e-Government, Bangkok, Thailand, 2010

[8] W. Boontarig, W. Chutimaskul, V. Chongsuphajaisiddhi and B. Papasratorn, "Factors Influencing The Thai Elderly Intention to Use Smartphone for e-Health Services", IEEE Symposium on Humanities, Science and Engineering Research (SHUSER), pp. 479-483, 2012

[9] C-S. Yu, “Factors affecting individuals to adopt mobile banking: empirical evidence from the UTAUT model”, Journal of Electronic Commerce Research, vol.13, no. 2, pp. 104-121, 2012

[10] C. Srisawatsakul and B. Papasratorn, "Factors Affecting Consumer Acceptance Mobile Broadband Services with Add-on Advertising: Thailand Case Study", Wireless Personal Communications, vol.69, no. 3, pp. 1055-1065, 2013

[11] E. Esteva-Armida and A. Rubio-Sanchez, “Adoption Process for VoIP: The UTAUT Model”, International Journal of E-Services and Mobile Applications (IJESMA), vol. 4, no. 4, pp. 15-31, 2012

[12] ITU-T Recommendation E.800 (08/94). Terms and definitions related to quality of service and network performance including dependability.

[13] Y. Wu, Y. Tao, and P. Yang, “Using UTAUT to explore the behavior of 3G mobile communication users.”, The International Conference on Industrial Engineering and Engineering Management (IEEM), 2007

[14] S. Sathapornvajana, B. Papasratorn, “Effect of Culture, Age, and Language on Quality of Services and Adoption of IP Applications”, Wireless Personal Communications, vol. 69, no. 3, pp. 1067-1075, 2013

[15] N. Charness and W. R. Boot, “Aging and Information Technology Use: Potential and Barriers”, Current Directions in Psychological Science, Association for Psychological Science, vol. 8, no. 5, pp. 253-258, 2009

[16] Y. Asano, S. Yonemura, A. Hayashi, and R. Hashimoto, “ICT Service Design for Senior Citizens Based on Aging Characteristics”, NTT Technical Review, vol.9, no. 9, pp. 1-5, 2011

[17] S. R. Cotton, G. Ford, S. Ford, T. M. Hale, “Internet use and depression among older adults”, Computers in Human Behavior, vol.28:2, pp.496-499, 2012

[18] H. Lee, P. Baniqued, J. Cosman, S. Mullen,, E. McAuley, J. Severson, and A.F. Kramer, “Examining cognitive function across the lifespan using a mobile application.”, Computers in Human Behavior, vol. 28:5, pp.1934-1946, 2012

[19] K. Slegers, M. Van Boxtel, and J. Jolles, “Computer use in older adults: Determinants and the relationship with cognitive change over a six year episode”, Computers in Human Behavior, vol.28:1, pp. 1-10, 2012.

[20] R. Likert, "A Technique for the Measurement of Attitudes", Archives of Psychology, Vol.140, pp.1–55, 1932

[21] A. Tolbize, “Generational differences in the workplace.”, Research and Training Center on Community Living, University of Minnesota, 2008.

[22] J. C. Nunnally, Psychometric Theory (2nd ed.). New York: McGraw-Hill, 1978.