World Academy of Science, Engineering and Technology
International Journal of Economics and Management Engineering
Vol:4, No:4, 2010

Internet Bandwidth Network Quality Management: The Case Study of Telecom Organization of Thailand

Sriaroonnirun Sittha and Rotchanakitumnuai Siriluck

Abstract — This paper addresses a current problem that occurs among Thai internet service providers with regard to bandwidth network quality management. The IPSTAR department of Telecom Organization of Thailand public company (TOT); the largest internet service provider in Thailand, is the case study to analyze the problem that exists. The Internet bandwidth network quality management (iBWQM) framework is mainly applied to the problem that has been found.

Bandwidth management policy (BMP) and quality of service (QoS) are two antecedents of iBWQM. This paper investigates internet user behavior, marketing demand and network operation views in order to determine bandwidth management policy (e.g. quota management, scheduling and malicious management). The congestion of bandwidth is also analyzed to enhance quality of service (QoS). Moreover, the iBWQM framework is able to improve the quality of service and increase bandwidth utilization, minimize complaint rate concerns to slow speed, and provide network planning guidelines through Thai Internet services providers.

Keywords— Internet bandwidth management, Internet service provider, Internet usage behavior, Quality of Service.

I. Introduction

INTERNET bandwidth is a public resource that all subscribers of internet service providers attend to share together. The necessary of using internet is totally obviously in the present time since the internet users perceived usefulness, enjoyment and ease of use. [18] These advantages have become the reasons of why there is an exponentially growing of internet users around the world. Many business services have been developed toward internet conceptualization. A huge of websites tend to be dominated by single intermediate site [15] in order to make internet's user performs easier when accesses through the internet searching.

In addition, developing technology transmission of data is a factor that is able to persuade the internet's user to pay more attention on internet cycle during a couple previous years.

Thailand is the one of the countries that has exponentially internet user's growing. There is 20% of Thai population that using internet as their lifestyle. However, there is still high internet usage demand occurring since there are around 16 million of internet users exists in Thailand but just only 2-3 million ports [24] are available. Thai internet service providers, therefore, stimulate their marketing strategies in order to capture more market share and occupy all remained internet users; promotions of Thai's ISPs have been launched into market as follows;

- High speed value: 1 - 16 Mega bit per second (Mbps).
- Low price: 300 - 2,000 Baht per month. (9 – 60 $US)
- Good Quality of Service (QoS).

Majority of Thai's internet users made their decision by only considering high speed value and low price aspect without realizing on quality of services. The reason to make this behavior exists is the less experience of using internet by consumers themselves. Thai populations are mostly not familiar to the in-depth meaning of QoS and they are not able to easily compare each ISP's services themselves. In the countries that have more experience on internet using, their people totally admired on high quality of service outer pricing concerned [13].

According to well-response towards internet cycle; spending more time, more frequency on enjoy using internet, all ISPs are affected and generate many problems such as lower speed, error and others technical problems etc. Concerning to internet operation view, internet traffic congestion is decidedly a problem. Unfortunately, the internet network operation cannot handle with a traffic congestion problem by putting more bandwidth resource, but marketing demand (ISP's business economic view), internet promotions, a bandwidth sharing and less investment are.

The problems of network operation team are the limitation of bandwidth resource itself; high internet user and marketing demand lead to the question of "How to balance these factors; marketing demand (MD), Internet user behavior (IUB) and network management (NM), and make them suitable for everyone?"

Generally, the previous researches only studied on these follows factors; motivation for internet using, internet pricing, promotions, and network engineering for QoS. This study, therefore, simplify these three dimensions as a progressive framework for the network operation in order to achieve internet bandwidth network quality management (iBWQM). With its result, after applied the initial iBWQM framework on, an internet bandwidth is much improved.

Sriaroonnirun S. is currently a master student of Management Information Systems, Faculty of Commerce and Accountancy, Thammasat University, Bangkok 10200, Thailand (e-mail: sittha_ee@hotmail.com).

Rotchanakitumnuai S., corresponding author, is now the professor of Department of Management Information Systems, Faculty of Commerce and Accountancy, Thammasat University, Bangkok 10200, Thailand (siriluck@tu.ac.th).

II. Literature Review

A. Marketing Demand

A high profit occurs from high ISP marketing demand since a number of internet subscribers perform under bandwidth resource limitation (a bandwidth sharing). In the other word, high contention ratio (CR) makes ISPs gain high profit, but the internet bandwidth is limited to serve internet user demand.

There are many marketing strategies have been initiated to create a promotion and calculate internet pricing. Gibbens [11] proposed three types of pricing 1) Smart Market: giving a bandwidth resource to user who has higher willingness-to-pay values or it seems auction [11]. 2) Paris Metro pricing: the internet user who pays more money will confront with less congestion. 3) Packet marking: user can control and adjust data transmission rate such as Peer-to-Peer (P2P) on demand [6]. From this, the user will be charged with the shadow price by the bandwidth resource that is consumed in a real data usage. Unfortunately, almost of promotion guarantee only internal-network of ISP's network on their owner. Therefore, it has opportunity to add value upon their service by charging for end-to-end guarantee [1].

The aforementioned pricing proposals cannot happen without a bandwidth policy management. Besides, the pricing also has a tendency that relevant to user's behavior and demand by depending on current context of situation for setting the balanced pricing [14]. These factors alert network designer, programmer and internet service providers to more concern on the complicated network system and provisioning system [11] in next-generation network.

However, ISPs conduct a sustainable competitive advantage by having a good relationship quality between an ISP and its customers. Sanchez-Franco [22] measured relationship quality in terms of loyalty based on commitment and trust theory. Loyalty can be perceived from customer's satisfaction such as introduce an ISP to friend, repurchase, or complaint a problem to ISP's employees etc. [22].

B. Internet User Behavior

There are many factors that have an effect to the portion of internet usage such as Availability of e-government, GDP, and international internet bandwidth [12].

NECTEC [21], the survey institution that investigates their principle on internet usage profile survey, started their work from 1999 to 2008. According to their report on 2008, it is indicated that there are top three internet activities have been found; information searching (31.4%), send & receive e-mail (23%) and news, timely report (10.3%). In addition, the report indicates that the people who is under 20 years old has a tendency to spend more time on entertainment activity when using internet; chatting, playing game online, music downloading, listening to radio online etc.

Taiwan's research tries to classify internet users by applying a business intelligence conceptualization to tracking this mission. They classify Taiwan's users into 9 groups; 1) Midnight group with medium usage (6.84%) 2) Weekend group (2.56%) 3) Overall heavy usage group (5.98%) 4) Midnight group with light usage (12.82%) 5) Mid-day group with medium usage (4.27%) 6) Office hour group with heavy usage (3.42%) 7) Overall light usage group (47.01%) 8) Office hour group with light usage (8.55%) 9) Office hour group with medium usage (6.84%) [13].

A deep understanding towards each segment of consumers could easily initiate marketing campaign and network operation management. [13] by using network parameters such as size, network complex, cost, connection speed [15], and internet user behavior. This seems very practical if the questions of "how ready for infrastructure?" and "how can ISPs conduct an equilibration among user's demand, economic capacity and stockholder's demand?" [2] have not raised.

C. Network Management

A proposal of network management is controlled and assigned on network resource in order to address service performance needs and network's objective [7]. Evolution of network management consists of three stages [7].

- 1979-1988: Network management activity was almost manual from network operator or administrator.
- 1989-1998: Developing more a network monitoring system automatically.
- 1999-2008: Focusing on service management.

Function of network management demonstrates into 5 levels as Fig. 1 [7].

There are two components of network management. 1) Manage information that relates to network management. 2) Shared management knowledge (SMK), regarding tangible (Hardware Software) and intangible network (Relationship of network stockholder). Since it's difficult to manage the perceived level; the useful of knowledge management (KM), Therefore, applied other useful theories such as Resource-Based-View (RBV), Social capital/network, and Real options to instead expose a necessary of KM [3].

Fig. 1 Function of network

There are many guidelines and frameworks, which had been proposed for quality of service in network management. We could finally conclude as follows.

1) Integrated Service (IntServ): IntServ utilize resource reservation schema (RSVP: Resource reservation protocol). This schema is separated into two types

1.1) Guaranteed service.

1.2) Controlled load [7], [19].

2) Differentiated Services (DiffServ): depends on classify information and use schema as priority [7], [19].

3) 801.2 p: is the IEEE 802 standard which applicable for local area network (LAN) [19].

4) Subnet bandwidth management: comprise with two sections

4.1) Bandwidth allocator.

4.2) Requestor module [19].

5) Multiple-protocol label switching (MPLS): this technique is used in router feature [7], [19].

6) The Real Time Protocol (RTP): is suitable for streaming application such as voice over internet protocol (VOIP) [7], [19].

Erfani and their team had concluded service and network management as Table I.

TABLE I
SERVICE AND NETWORK MANAGEMENT

Service	Network implications	Management implications
Voice, video, multimedia	▪ Latency of no more than 200 ms ▪ Bandwidth of 6 to 300 kbps	▪ Bandwidth management ▪ QoS management
Electronic commerce	▪ Continuous availability ▪ Trust mechanisms	▪ Security management
Consumer lifeline services	▪ Continuous availability ▪ Low and high bandwidth ▪ Low cost	▪ Efficient configuration management ▪ Fault management
Network access (VPN, wireless, RADIUS)	▪ Bandwidth of at least 64 kbps ▪ Security ▪ Security management	▪ Efficient configuration management ▪ Fault management

Another model of network management, which populated for ISP is Telecom Operations Map (TOM). This model is totally covering customer service, management view and network management view for next-generation network coming soon [17].

D. Bandwidth Policy Management

Internet bandwidth management is issued in ISP's operation because of the ability to access various internet applications at the same time of internet user's behavior. Both of policy strict priority and scheduling algorithm can support to QoS. However, both of those methods cannot support well on the network utility maximization (NUM) concept [16].

In general, by using internet for the whole day, the users' behavior is affected. This can be called "Time of Day" (TOD) and almost bandwidth setting cannot serve through bandwidth utilization concept [10].

The author has observed an internet bandwidth value in terms of IPSTAR TOT as Fig. 2 and agrees step towards bandwidth utilization conceptualization. It is important to have a plan stating on bandwidth policy based on revenue, high profit and various services [8].

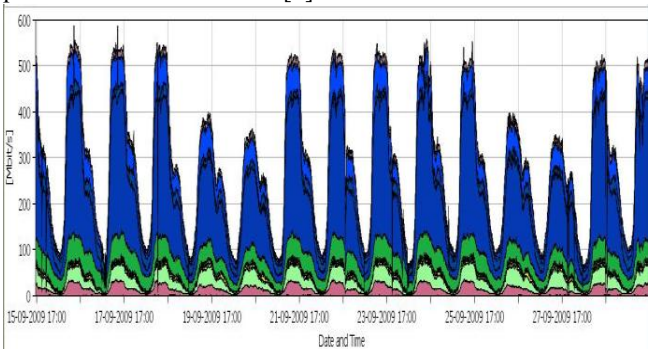

Fig. 2 IPSTAR TOT internet bandwidth value [23]

E. Quality of Service

Quality of Service (QoS) is one of key indicators that could determine performance of internet services. Main QoS's indicator composts by four parameters; Bandwidth, Latency, Jitter, and Loss [19] while another indicator of QoS, which popular, is measured internet user satisfaction.

There are many standards that had been proposed such as OSI QoS Model, ITU-T Network performance model, ATM service forum model and Internet Engineering Task Force (IETF) [5]. IETF rises two types of QoS managed comprises Integrated Service and Differentiated Service. For DiffServ concept, it can apply many network methods such as Class of Service (CoS), Traffic shaping, Policing, Queuing, and Scheduling [19].

In practically, we should consider both of network methods and bandwidth policies for suitable internet bandwidth network quality management. By this, we can finally get a high efficiency and effective internet service [4].

F. Internet Bandwidth Network Quality Management

We have developed initial concept of internet bandwidth network quality management (iBWQM) as Fig. 3 that comprises of five constructs based on three dimensions as mentioned in the first section.

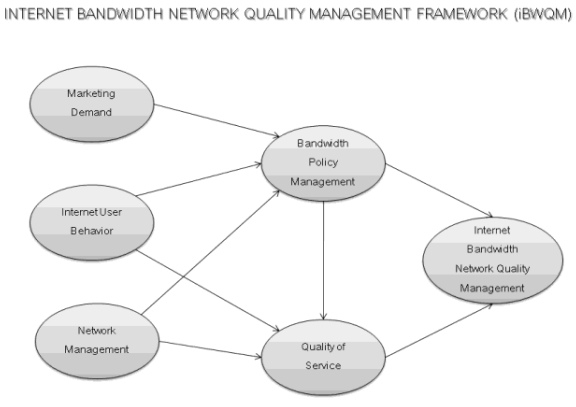

Fig. 3 Research model framework

iBWQM framework can measure each subjects as followed.

- Marketing Demand (MD)
  - Promotion/Pricing

  - Bandwidth sharing
  - Customer Loyalty
- Internet User Behavior (IUB)
  - Application/Protocols
  - Period of time
  - Time usage
  - Business transaction
- Network Management (NM)
  - Resource management
  - Monitoring management
  - Queue management
  - Network knowledge management
- Bandwidth Policy Management (BPM)
  - Class of Service (CoS)
  - Quota management
  - Scheduling management
  - Malicious management
  - Situation management
- Quality of Service (QoS)
  - Delay/Latency
  - Jitter
  - Error
  - Out of order delivery
  - Dropped packets
- Internet Bandwidth Network Quality Management (iBWQM)
  - Service Level Agreement (SLA)
  - Bandwidth available
  - Bandwidth utilization
  - Response time
  - Network resource investment

III. Methodology

An experiment was conducted in IPSTAR TOT Laboratory in order to collect data after applying iBWQM to a bandwidth shaper (Cisco Service Control Engine: SCE). We selected one project from IPSTAR TOT portfolio which is a household project (Sat-One) (1,886 subscribers). We, after that, separated this experiment into three scenarios as follows;

- Scenario1: All condition based on marketing demand or current situation.
- Scenario2: Real user behavior or user demand.
- Scenario3: Applied iBWQM framework in the bandwidth shaper (Cisco SCE).

We set up two personal computer robots in order to simulate the internet using. Detail of robot exists as bellow.

- Access 7 websites.
- Download FTP 4 files.

The network experiment was conducted as Fig. 4

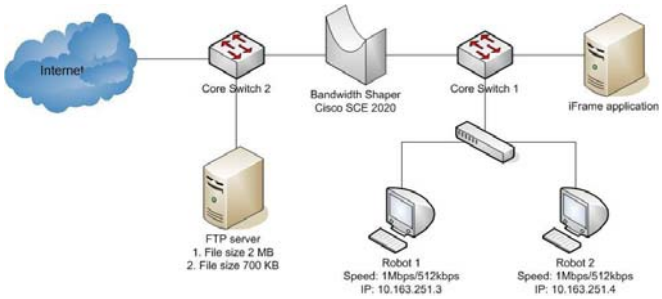

Fig. 4 Robot test network diagram

IV. Result

Part 1

Scenario 1: All condition based on marketing demand or current situation. We compared bandwidth value and response time with different contention ratio.

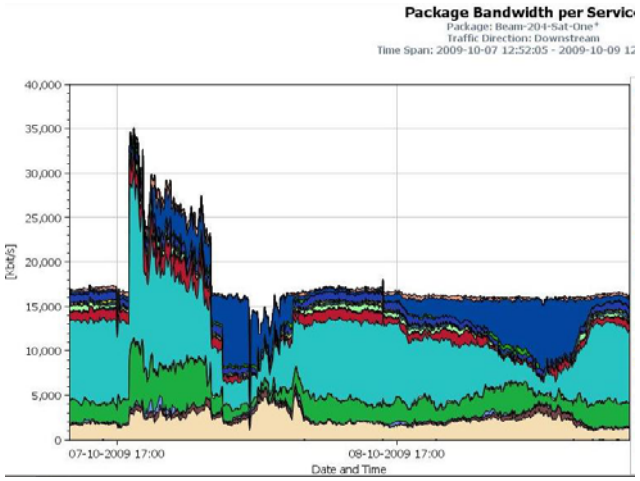

Fig. 5 Bandwidth value of home user project with high contention ratio.

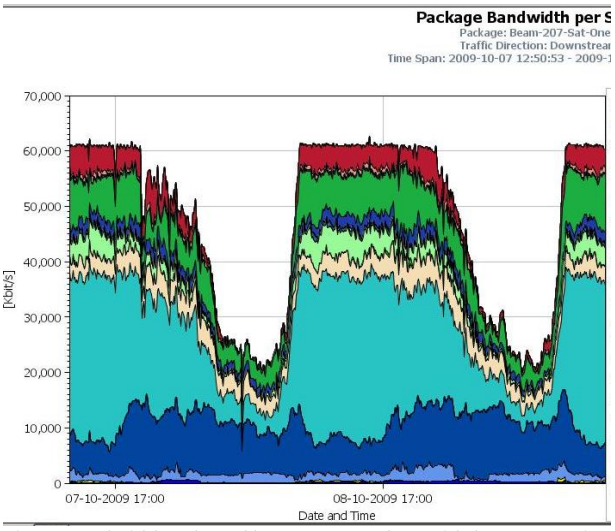

Fig. 6 Bandwidth value of home user project with low contention ratio.

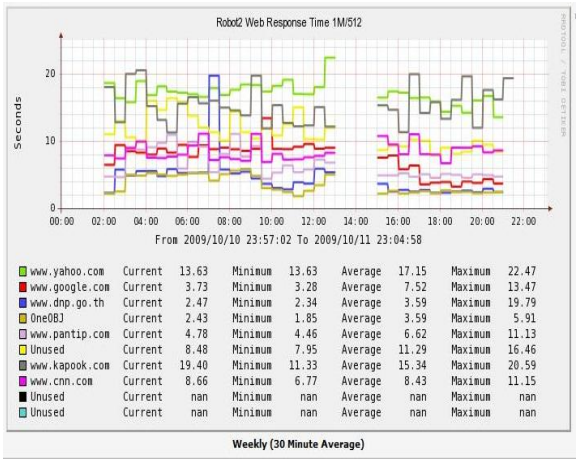

Fig. 7 Response time of the robot with high contention ratio.

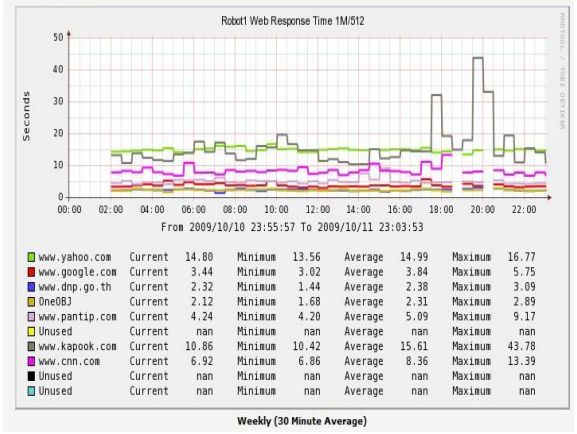

Fig. 8 Response time of the robot with low contention ratio.

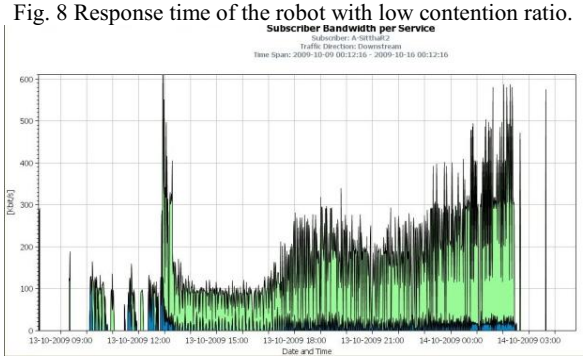

Fig. 9 Bandwidth value of robot with high contention ratio.

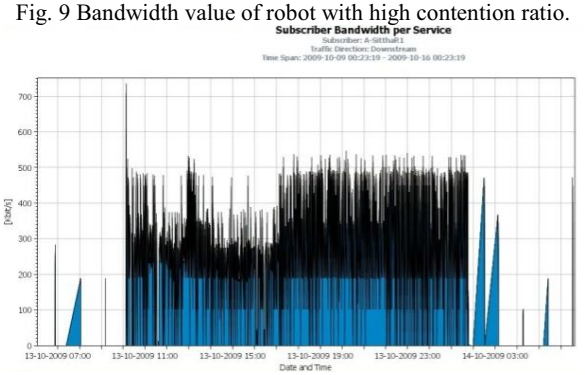

Fig. 10 Bandwidth value of robot with low contention ratio.

TABLE II
COMPARE EFFECTIVE OF INTERNET SERVICE

	PC Robot 1[a]	PC Robot 2 [b]
Contention Ratio	High	Low
Response Time from access website (Second)	3.59-17.15	2.31-15.61
Bandwidth value from download FTP files (kbps)	80-540 kbps	280-540 kbps

[a] Robot 1 is internet usage with high contention ratio
[b] Robot 2 is internet usage with low contention ratio

The contention ratio/bandwidth sharing effects to the repose time and bandwidth value for internet service. In other words, bandwidth policy with concerning marketing has direct impact on the internet service.

Part 2

Scenario 2: Real user behavior or user demand. We show bandwidth value

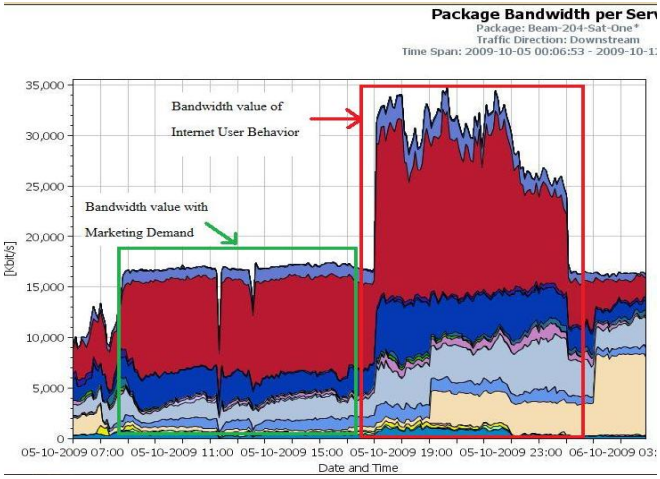

Fig. 11: Bandwidth value of home user's project

TABLE III
COMPARE CONTENTION RATIO

	Marketing Demand	User Demand
Bandwidth value (Mbps)	17 Mbps	35 Mbps
Contention ratio	110	53

This part is represented a pure user's behavior in internet usage term. This result will be an important issue to design the bandwidth policy management with an objective to make a bandwidth more useful and also concerns about service level agreement.

Part 3

Scenario 3: Applied iBWQM framework to the bandwidth shaper (Cisco SCE). iBWQM framework is used as tool in order to design the internet bandwidth policy. We show all final bandwidth value after analyzing all factors of iBWQM.

- Marketing Demand (MD)
  - Promotion/Pricing: 1Mbps
  - Bandwidth sharing: 75 User per 1 Mbps
- Internet User Behavior (IUB)
  - Application/Protocols: Highest priority 1st Browsing but limited P2P, Bittorrent.

  - Period of time: There is significant of internet usage during 07:00-17:00, 18:00-22:00, 24:00-04:00
- Network Management (NM)
  - Resource management: reserve 17 Mbps
  - Monitoring management: Set up Multi Routing Traffic Grapher (MRTG).
- Bandwidth Policy Management (BPM)
  - Class of Service (CoS): Download = 1 Mbps, Upload = 512 kbps.
  - Quota management: Default quota = 50 MB and P2P quota = 20 Mbps in during 08:00-17:00.
  - Scheduling management: Move browsing to available bandwidth.
  - Malicious management: Limit spam e-mail 1,000 transactions.
  - Situation management: Set up high priority to top 3 populated websites.
- Quality of Service (QoS)
  - Delay/Latency: less than 10 second for responding time of website access.
- Internet Bandwidth Network Quality Management (iBWQM)
  - Service Level Agreement: At peak time (10:00 – 14:00) user must get 25% of class of service/promotion (Download = 250 kbps).
  - Bandwidth utilization: Use more bandwidth at night time by P2P usage
  - Response time: Average of browsing = 10 second.
  - Network resource investment: No extend internet bandwidth.

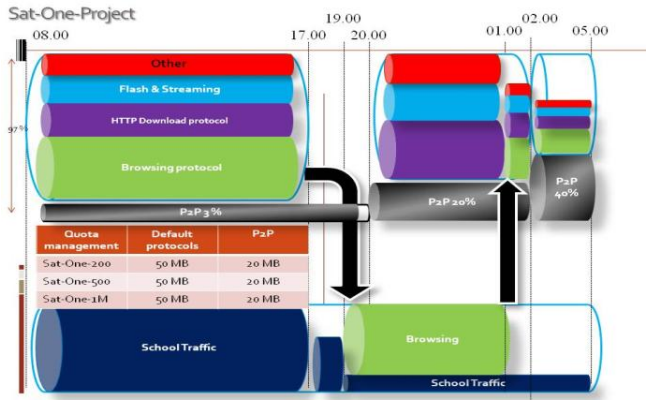

Fig. 12 Internet Bandwidth policy of IPSTAR TOT in home user project

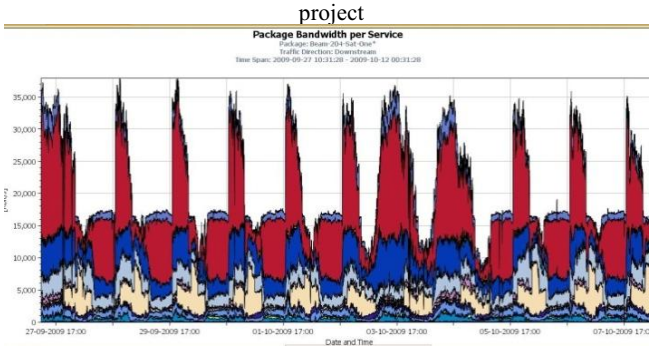

Fig. 13 Bandwidth value after applied iBWQM Framework.

After IPSTAR TOT applying iBWQM to their bandwidth shaper, the result bandwidth value comes up as Fig. 13. The bandwidth of user is appearing more constantly. End user was browsing a webpage more smoothly than non-bandwidth policy see Fig. 14, 15.

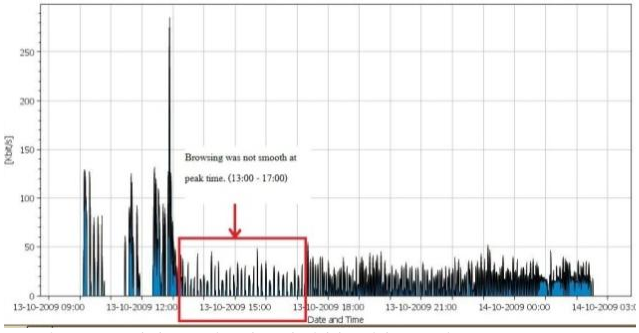

Fig. 14 Web browsing bandwidth with non-iBWQM concept

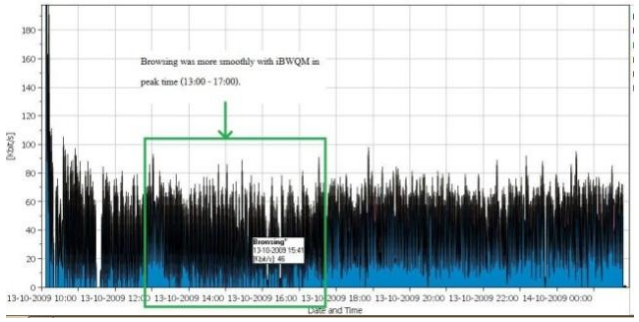

Fig. 15 Web browsing bandwidth with iBWQM concept.

TABLE IV
RESULT AFTER APPLIED IBWQM FRAMEWORK

	During 10:00 – 14:00
Bandwidth value (kbps) from website access	50 – 90 kbps
Bandwidth value (kbps) from FTP download	260 – 550 kbps
Response Time from access website (Second)	2.31 – 9.85

IPSTAR TOT bandwidth is more effectively utilize, more space for browsing, lower response time and importantly, more user could attend without extends internet bandwidth.

V. Conclusion

The objective of this study is to find out current ISP's bandwidth problems. The paper, principally, take an attention on three dimensions; internet user behavior, marketing demand and network management. Initiating internet bandwidth network quality management (iBWQM) in order to create an excellent delivery internet service to internet end-user is the method to generate high profit of internet service to internet service providers. The authors strongly recommended all ISPs to recognize and craftily their internet user's behavior in order to provide the suitable bandwidth policy towards business view of ISP. Even it is difficult to respond all user's demand, ISP is able to handle with this problem since iBWQM's framework is efficiency on balancing three factors as mentioned above.

This research has partial issue that should be continual investigated such as managing heavy user's method, managing the high bandwidth consumption from new internet

applications. This next proving will ultimately improve and develop the internet bandwidth's quality.

REFERENCES

[1] Aboulfadl, M., Gupta, A., Pradhan, R., & Kalyanaraman, S. (2002). "A Spot Pricing Framework to Enable Pricing and Risk Management of Inter-Domain Assured Bandwidth Services". *IEEE Xplore., Proceedings of the 2002 Winter Simulation Conference*, 1551-1523.

[2] Brockmann, P. (1998). "User demand for internet services: is the infrastructure ready?". *Computer Standards & Interfaces*, (20), 117-121.

[3] Bruton, G. D., Dess, G. G., & Janney, J. J. (2007). "Knowledge management in technology-focused firms in emerging economies: Caveats on capabilities, networks, and real option". *Asia pacific J Manage*, (24), 115-130.

[4] Carter, S. F., Macfadyen, N. W., Martin G. A. R., & Southgate, R. L. (2002). "Techniques for the study of QoS in IP network". *BT Technology Journal,* 20 (3), 100-115.

[5] Cekro, Z. (1999). "Quality of Service: Overview of Concepts and Standards". *University of Brussels*.

[6] Clark, J. A., & Tsiaparas, A. (2002). "Bandwidth-on-demand networks: a solution to peer-to-peer file sharing". BT Technology Journal, 20 (1), 53-63

[7] Erfani, S., Lawrence, V. B., Malek, M., & Sugla, B. (1999). "Network Management: Emerging Trends and Challenges". *Bell Labs Technical Journal*, October-December 1999, 3-22.

[8] Frahang, B., & Kopeikin, R. (2004). "Policy-Based Quality of Service in 3G Network". *Bell Labs Technical Journal*, 9 (1), 31-40.

[9] Flickenger R. (2006). *How to Accelerate Your Internet*. BMO Book Sprint Team.

[10] Fulp, E. W., & Reeves, D. S. (2004). "Bandwidth provisioning and pricing for networks with multiple classes of service". Computer Networks, 46, 41-52.

[11] Gibbens, R. (2000). "Control and Pricing for Communication Networks". *Royal Society*, 358 (1765), 331-341.

[12] Leroux, C. G., Zo, H., & Rho, J. J. (2008). "Factors Affecting Internet Adoption in Latin America". *IEEE Computer Society*, 947-951.

[13] Li, S-T., Shue, L-Y., & Lee, S-F. (2008). "Business intelligence approach to supporting strategy-making of ISP service management". Expert Systems with Applications, 35, 739-754.

[14] Mason, R. A. (2000). "Competitive Internet Pricing". *Royal Society,* 358 (1773), 2309-2318.

[15] Sgroi, D. (2008). "Social network theory, broadband and the future of the World Wide Web". *Telecommunication Policy*, 32, 62-84.

[16] Shi, L., Liu, C., & Liu, B. (2008). "Network utility maximization for triple-play services". *Computer Communications*, 31, 2257-2269.

[17] Silverman, K. S., Brenner, M. R., & Shannon, G. E. (2000). "Toward a Vision for Network and Service Management". *Bell Labs Technical Journal*, October-December 2000, 21-30.

[18] Teo, T. S. H., Lim, V. K. G., & Lai, R. Y. C. (1999). "Intrinsic and extrinsic motivation in Internet usage". *Omega, Int. J. Mgmt. Sci.*, 27, 25-37.

[19] Wood, S. & Chatterjee, S. (2002). "Network Quality of Service for the Enterprise: A Broad Overview". *Information Systems Frontiers,* 4 (1), 63-84.

[20] Internet world stats (September, 2009). *ASIA INTERNET USAGE AND POPULATION.* Retrieved September 23, 2009, from www.internetworkdstats.com

[21] National Electronics and Computer Technology Center (September 2008). *Internet User Profile of Thailand 2008*. Retrieved September 23, 2009, from http://pld.nectec.or.th/websrii/images/stories/documents/books/internetuser_2008.pdf

[22] Sanchez-Franco, M. J., Ramos, A. F. V., & Velicia, F. A. M. (2009). "The moderating effect of gender on relationship quality and loyalty toward Internet service providers". Information & Management, 46, 196-202. (Wring sequence)

[23] Sriaroonnirun, S. (2006). Cisco SCABB (Version 3.1.0 Build 20) [Computer software]. USA: Cisco.

[24] The national Telecommunications Commission (September 2009). Internet service provider of Thailand. Retrieved September 23, 2009, from http://www.ntc.or.th/license/index.php?show=all

Sittha Sriaroonnirun Sittha Sriaroonnirun was born in Phitsanulok, Thailand. He received his Bachelor Degree (2003) in Electrical Engineering from Thammasat University. And he is studying in Master Degree (2009) in Department of Management Information Systems, Faculty of Commerce and Accountancy, Thammasat University. He is engineer in IPSTAR operation department at THAICOM public company.

Siriluck Rotchanakitumnuai Siriluck Rotchanakitumnuai is a professor of Department of Management Information Systems, Faculty of Commerce and Accountancy, Thammasat University. Her research interests are E-service, E-business, E-commerce, ERP, Database, Strategic IS/IT Planning, MIS, Management of Technology, Knowledge Management, Structural Equation Modeling (SEM) Research. She is an Executive Board of International Conference on Electronic Business.