PLANNING FOR HIGH SPEED INTERNET SERVICE EXPANSION

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A THESIS SUBMITTED IN PARTIAL FULFILLMENT
OF THE REQUIREMENTS FOR
THE DEGREE OF MASTER OF SCIENCE
(TECHNOLOGY OF INFORMATION SYSTEM MANAGEMENT)
FACULTY OF GRADUATE STUDIES
MAHIDOL UNIVERSITY
2011

Thesis
entitled

PLANNING FOR HIGH SPEED INTERNET SERVICE EXPANSION

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PLANNING FOR HIGH SPEED INTERNET SERVICE EXPANSION

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for the degree of Master of Science (Technology of Information System Management)
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ACKNOWLEDGEMENTS

This thesis can be succeeded by the attentive support from my thesis advisor and members of the thesis committee, Lect. Kritsanat Surakit, Asst. Prof. Bunlur Emaruchi and Asst. Prof. Pisit Phokharatkul without his guidance, patience and time devotion throughout the period of the study. I would never accomplish this thesis.

I would like to extend my sincere thanks to many people especially Miss Katika Srithong, my good friend, who help everything during fieldwork and Miss Sukhuman Wuttikhet, who help gathering information during fieldwork.

I am also grateful to the officers in traffic engineering department of the TOT Corporation PCL. for assisting me in support information and good recommendation in this thesis.

I am also grateful to the officers in the TRUE Corporation PCL. for their great help in information and good recommendation in this thesis.

I would like to thank the entire respondent who was the sampling in this study.

Last but not least, I would like to express thank to my parents. Without them, this thesis could not be done successfully.

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PLANNING FOR HIGH SPEED INTERNET SERVICE EXPANSION

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ABSTRACT

The purpose of this study was to investigate the need to use high speed Internet in Thailand. The results of this study was a tool for efficiently providing ADSL service. Participants both had and did not have telephone lines. The random sampling method was used to collect samples. The method started with randomly collecting data by Yamane's formula using 400 questionnaires. SPSS was used to analyze the data for arithmetic percentage, mean, standard deviation, moving average, Pearson's product moment correlation, and stepwise multiple regression that was accounted for the prediction equation.

The results of this study showed that the variables that affected the percentage of demand for the Internet usage in model 1 were the logarithm of the area that had been authorized for construction, Telecommunication GDP, and Electricity GDP growth rate. The model accuracy test results showed that the MSE=10.66 and MAPE = 17.9%. As for model 2, the variable that affected the percentage of demand for the Internet usage is the percentage of employees with the minimum qualification of a bachelor degree. This variable is the best variable for this forecast as it was able to predict the Internet demand with the accuracy of 93.1%. The model accuracy test results showed that the MSE=3.94 and MAPE = 7.93%, which could be written in the standard score equation of P_POPUSENET=0.965(P_BECHEL_GRAD).

KEY WORDS: ASDL / BROADBAND / MULTIPLE LINEAR REGRESSIONS

140 pages

การวางแผนสำหรับการขยายเครือข่ายอินเทอร์เน็ตความเร็วสูง
PLANNING FOR HIGH SPEED INTERNET SERVICE EXPANSION

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บทคัดย่อ

งานวิจัยนี้มีวัตถุประสงค์เพื่อศึกษาแนวโน้มความต้องการของการใช้อินเทอร์เน็ตความเร็วสูงในประเทศไทย เพื่อวางแผนการให้บริการอินเทอร์เน็ตความเร็วสูงแก่กลุ่มลูกค้าที่ทั้งมีและไม่มีโทรศัพท์บ้านได้อย่างมีประสิทธิภาพ การศึกษาครั้งนี้เริ่มด้วยการสอบถามประชาชน โดยการสุ่มตัวอย่างแบบ Random Sampling ในการเก็บข้อมูลกลุ่มตัวอย่าง โดยใช้สูตร Yamane จำนวน 400 ตัวอย่าง จากนั้นทำการวิเคราะห์โดยใช้โปรแกรม SPSS โดยนำข้อมูลมาวิเคราะห์หาค่าร้อยละ ค่าเฉลี่ย ค่าเบี่ยงเบนมาตรฐาน ค่าเฉลี่ยเคลื่อนที่ ค่าสัมประสิทธิ์สหสัมพันธ์พหุคูณและเลือกตัวทำนาย

ผลการศึกษาสรุปได้ดังนี้โมเดลที่ 1 ปัจจัยที่มีผลต่อร้อยละของประชากรที่มีความต้องการใช้อินเทอร์เน็ต คือ Log ของพื้นที่ที่ได้รับการอนุมัติให้ก่อสร้างใหม่ ผลิตภัณฑ์มวลรวมในประเทศด้านโทรคมนาคม อัตราการขยายตัวของผลิตภัณฑ์มวลรวมในประเทศด้านไฟฟ้าและการทดสอบความถูกต้องของโมเดล มีค่า MSE=10.66 ,MAPE = 17.9% ส่วนโมเดลที่ 2 ปัจจัยที่มีผลต่อร้อยละของประชากรที่มีความต้องการใช้อินเทอร์เน็ต คือ ร้อยละของผู้ที่จบการศึกษาในระดับปริญญาตรีขึ้นไปแล้วมีงานทำ โดยปัจจัยนี้เป็นตัวทำนายที่ดีที่สุด สามารถทำนายความต้องการใช้อินเทอร์เน็ต ได้ร้อยละ 93.1 % และการทดสอบความถูกต้องของโมเดล มีค่า MSE = 3.94 ,MAPE = 7.93 % สามารถเขียนสมการในรูปคะแนนมาตรฐาน ดังนี้ P_POPUSENET= .965 (P_BECHEL_GRAD)

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LIST OF ABBREVIATIONS

Abbreviation	Term
ADSL	Asymmetric Digital Subscriber Line
DSL	Digital Subscriber Line
FTTX	Fiber to the X
CDMA	Code Division Multiple Access
EDGE	Enhanced Data rates for GSM Evolution
GPRS	General Packet Radio Service
DSLAM	Digital Subscriber Line Access Multiplex
PSTN	Public switch telephone network
ISP	Internet Service Provider
HTTP	Hypertext Transfer Protocol
GIS	Geographic Information system
POTS	Plain Old Telephony System
FDM	Frequency Division Multiplexing
HDSL	High data rate Digital Subscriber Line
CAP	Carrier less Amplitude/Phase
DMT	Discrete Multi-Tone
VPN	Virtual Private Network
IPTV	Internet Protocol television
ATM	Asynchronous Transfer Mode
PCL	Public Company Limited
ATU-Cs	ADSL Transmission Unit Central Office
ATU-R	ADSL Transmission Unit Remote
ISDN	Integrated Services Digital Network
HDSL2	High data rate Digital Subscriber Line2
SDSL	Single line Digital Subscriber Line
IDSL	ISDN Digital Subscriber Line

LIST OF ABBREVIATIONS (cont.)

Abbreviation	Term
CDSL	Consumer DSL from Rockwell
VDSL	Very high data rate Digital Subscriber Line
SHDSL	Symmetric, High rate Digital Subscriber Line
kHz	Kilohertz
MHz	Megahertz
ANSI	American National Standards Institute
ICT	Information Communication Technology

CHAPTER I
INTRODUCTION

1.1 Background and statement of problem

In the last decade, the demands for high speed internet have increase rapidly, today, that demand is expected to increase even more maybe exceed 550 Million in 2012 (Research and Markets,2009). This is due to the fact that internet play important roles in today live. It is so important that nearly everyone needs it, because internet is ubiquitous it allows rapid communication from every side of the world, it's allow huge data to be transfer in a matter of second or minutes. With all these advantages, almost all sectors will need internet to aid them in their operation. For example, school and university would benefit from having access to rich media content, which facilitate the learning process of students. Business industry would benefit from being able to communicate with branch office face to face, real time via voice over IP. The potential of the internet is infinite for response user demand changed. (Anastassios Gentzoglannis, 2005: Randall S. Sexton, Richard A. Johnson and Michael A. Hignite, 2002).

Today, internet services provider are competing against each other by the speed of the internet they offer. Signal modulation technique is the main key to determine the speed of the connection via copper line. The most widely used technique is Asymmetric Digital Subscriber Line (ADSL), the main feature of ADSL is the upstream and downstream speed will always be different, usually downstream is higher than upstream. ADSL (ADSL over Public switch telephone network (PSTN)) has the theoretical limited of downstream data rate 8 Mbps and upstream data rate from 128-512 Mbps respectively. With ADSL, the internet can be used simultaneously with the phone with no affect. In ADSL system, there are three frequency range in used. One for PSTN and the other for upstream and downstream. Each of them has their own frequency range, therefore, will not interfere with each other (Tanit

Sahuannat and Suttisak Nuttakul and others. ,2002; Chaohuang Zeng,2001; Eric Pimpler and Eric Cabading,2005; Daniel Won-Kyu Hong and Choong Seon Hong, 2003; David Greggains,1998). ADSL is a cost effective solution for general internet usage. It can handle all type of data transferred, some examples are Hypertext Transfer Protocol (HTTP) data, voice and video data, Virtual Private Network (VPN), Internet Protocol television (IPTV) and many more. Some application such as voice and video require high bandwidth usage which may exceed what ADSL can accommodate. This problem can be fixed with the introduction of ADSL2 and ADSL2+ which will offer maximum downstream up to 24 Mbps (Tanit Sahuannat, 2009; True Corporation Public Company Limited (PCL), 2009; Vince Vitore, 2003). And foreign countries developing Bonded ADSL2+ that links using multiple copper phone lines, which can then be used to dramatically increase the bandwidth provisioned to subscribers via a single Asynchronous Transfer Mode (ATM) data stream. Supporting services such as broadcast video and video on demand (Aware, 2005), In the present more interesting transition strategies that telecommunications carriers use to enter to the cable TV market (Victor Glass and Sal Talluto, 2003) and construct high-speed backbone for access network that apply fiber optic for transfer hi-speed internet directly to the home/building, delivery as far as 100 km from the customer's premises. (H.Stewart, 1999). At this speed, it is even possible to work from home. Employee can stay at home and use the internet to connect to the office, meeting can be don though internet as well.

Digital Subscriber Line (xDSL) are high speed internet technology which will allow user to browse the internet at the speed from 128 Kbps to 52 Mbps (currently the maximum speed offer by ISP in Thailand is 16 Mbps by True Corporation PCL) and research result find out, hi-speed internet can transfer hi-speed data rate and useful various that influencing factor for select service (Dungjai lumyai, 2007). With DSL system, there is no extra cost in dialing the phone like dial up modem which means that other problems such as signal drop and line busy are eliminated accordingly. Ministry of Information Communication Technology (ICT) has promote the use of ADSL which cause the price of ADSL service to drop rapidly which make very affordable for most consumer, from home use to enterprise. This is

also beneficial to the Internet Services Provider (ISP) as well since they don't have to invent in the new infrastructure (ADSL works on PSTN), they also gain benefit from having more customers. Sources reveal that the demand of ADSL service increases in all area in Thailand after the price of ADSL services drop. However, problems arise when the ISP cannot keep up these high demands of the consumer in all area, which is quite normal as no ISP would be able to service everyone everywhere. They have to prioritize the demand of each location whether it's suitable to invest and install a Digital Subscriber Line Access Multiplex (DSLAM) in that area. Moreover, they have to consider the size of DSLAM and other essential equipment. In some location where demand of ADSL is relatively low, the ISP can choose to install and ADSL co-modem instead of a DSLAM in order to save cost.

Because of the problems above, researcher has incorporate Geographical Information System (GIS) to aid displaying the result visually. With GIS, it is easy to see the amount of ADSL user and density of the ADSL user in a selected area. GIS can be used to study the demand of the ADSL as well, this information is useful for strategic planning in expanding the ADSL services. The research conducted by Tony H Grubesic and Mark W Horner, uses GIS to study about how to expand xDSL service in rural area. Another researcher also uses GIS to study about how to expand xDSL service in rural area in order to reduce digital divide in USA.

The researcher will use demand forecasting method for this research to predict curtain data such as the amount of sale (based on history sale) so that production plan and resource acquisition can be carried out proportionally to the future demand. Researcher (Dijana Mocˇnik and Karin Širec, 2010) seeks to explain the intensity of Internet use in terms of information and communication technology (ICT) and other socioeconomic indicators. according to income. Using factor analysis and regression analysis to estimate impact on Internet usage. And related with researcher Sangwon Lee (2007) use both non-linear and linear regression analysis for estimates broadband penetration of global broadband. These empirical studies find variable that increase fixed broadband adoption. This study also might suggest that various demand and supply side variables such as broadband speed, ICT infrastructure, internet use, popular density, international internet bandwidth, content, and Institutional

environment contribute to the global broadband adoption. And researcher Kim,Jin Ki (2004) use regression analysis for find the characteristics of leading customer of high speed internet user for diffusion of high-speed internet service. Researcher Watcharin Peyasakul had used demand forecast to aid the production planning in agriculture industry. The technique used in the forecast is Single exponential smoothing method. And have research take demand forecasting for use power demand forecasting that compose simple linear regression. (Onurai noohawm, 2001). Some research applies Neural Network to predictive internet use and e-commerce (Randall S. Sexton, Richard A. Johnson and Michael A. Hignite, 2002). And (So Young Sohn, Yoonseong Kim and Ho Young Hwang, 2008) use demand forecasting for forecast hi- speed internet but not consider time-varying that use exponential model

Mahidol University doesn't have any study about expansion of ADSL service; therefore it is the researcher intention to research on ADSL service plan and to acquire information regard the density of ADSL demand in both Bangkok metropolitan area and in rural area. So that correct planning can be made in expansion of ADSL service to various locations depend on the needs of each area.

1.2 Objective of the study

1. To understand the trend of high speed internet demand
2. To prioritize ADSL service

1.3 Scope of work

- Population Group is Thai population all region in the Thailand. Populations is selected one province from each region that tax gathering conclusion from The Revenue Department (2008) is taken into account; each province has good economic, Participants are 11,282,085 person in total; Chiang mai, North of Thailand, Nakhon Ratchasrima, North East, Songkhla, South and Bangkok, center of Thailand (Department Of Provincial Administration, 2008).

- Sample group for gathering questionnaires data composed of home installed fixed line and not installed fixed line, that use Accidental Sampling method 400 sampling, the level of significant at 0.05 and 95 % of confident level calculate by Yamane formula. Presenting demand trend wire line and wireless internet information with ArcGIS 9.2 will appeal by province.

- Target area for gathering questionnaires data aspect in Chiang mai province, Nakhon ratchasrima province, Bangkok and Songkhla province.

- Prepare questionnaires and gathering data from sample group both home installed fixed line and not installed fixed line 400 Sampling. These questionnaires composed of 5 parts as follow.

Part 1: Participants' general information

Part 2: Data about using internet

Part 3: Data about using wire line internet

Part 4: Data about using wireless internet

Part 5: Problems and propositions

- Gathering data method used multiple methods by telephone and distributes questionnaires in target area by investigator and assistant.

- Investigator was performed data collection during 20 November 2009 to 30 January 2010.

- Gathering questionnaire data and analyze, develop with application program

1. Tool of display spatial data used Arc GIS 9.2 program
2. Analysis data used SPSS 16.0 for window
3. Prepare data used Microsoft Excel

- To calculate percentage of the demand trend to use high speed internet including ADSL, FTTX, Cable Modem, CDMA and EDGE/GPRS from questionnaire done by sampling group.

- Analyze data taken from National Statistical Office by using predicting model. P_BACHEL_GRAD is independent variable and P_POPUSENET is dependent variable. There are two dataset used to construct the model, the first set is the historical data of internet usage in Thailand 10 years ago. Using the first 6 years

(2543-2548) as the data to create the model and the later 4 years (2549-2552) to check the accuracy of the model. The second set uses the same data as the first set but use the first 8 years to construct the model and the later 2 years to check for accuracy.

- The model accuracy test by using the statistical analysis on the MSE, MAPE and MAD.

- Variable in research. Note that some variable were transformed using logarithmic, Inverse, SQRT function since data were positively skewed and distribution is normal. Variable in research as follow (see Appendix B)

1.4 Expectation of study

1. ADSL service plan (as a result from Demand forecasting and GIS)
2. ISP can correctly plan and implement suitable network equipment according to the demand of each area.

1.5 Specific Vocabulary

1. Asymmetric Digital Subscriber Line (ADSL) is a high-bandwidth data communication technology that use new modem can change existing twisted-pairs telephone lines (POTS, Plain Old Telephony System) to transport high-bandwidth data. ADSL is one range of Digital Subscriber Line (DSL) technologies (xDSL) that have special characteristic downstream rate more than upstream rate, creating three information channels – a high speed downstream channel, a medium speed upstream channel, and POTS channel for voice that allows both data and voice to transmit over the same line.

2. ADSL Modem is a device to modulate signal which is adopted Frequency Division Multiplexing (FDM) to create three information channels; a high speed downstream channel, a medium speed upstream channel, and a Plain Old Telephone Service (POTS).

3. Traditional plain old telephone service (POTS) is a telephone system, transfer voice data between user premise and telephone organization premise for connect to terminal telephone number**.**

4. Public switch telephone network (PSTN) is fixed line telephone network. Function is switching voice signal for telephone service.

5. DSL Access Multiplexer (DSLAM) mixes DSL services from different subscribers premise into ATM virtual circuits. The DSLAM contains ADSL Transmission Unit Central Office (ATU-Cs) where ADSL signals are multiplexed onto a high-speed interface connected to an ATM network. The ATM network provides access to the internet through ISPs or corporate network.

6. Splitter is an electronic low pass filter that separates the analogue voice or Integrated Services Digital Network (ISDN) signal from ADSL data frequencies. There is a splitter located at the central office and at the subscriber premise. The splitters are totally passive devices requiring no power. This means that power outage that stops the ADSL modem does not affect the telephones, which can operate continuously. The splitter at the central office may be incorporated into the DSLAM or a separate device.

7. Asynchronous Transfer Mode (ATM) is a high-speed, multiplexing and switching protocol that supports multiple traffic types including voice, data, video, and image.

CHAPTER II
LITERATURE REVIEW

Documentary

2.1 Background ADSL

Asymmetric Digital Subscriber Line (ADSL) is one range of Digital Subscriber Line (DSL) technologies (xDSL) that used new modem technology enable change existing twisted-pairs telephone lines (POTS, Plain Old Telephony System) to transport high-bandwidth data that use signal modulation technique. DSL has several technologies. Performances of each technology (See table 1)

Table 2.1 Performances of internet technology

Name	**Meaning**	**Data Rate**	**Mode**	**Max distance (ft)**	**Applications**
V.22,V.32,V.34	Voice Band Modems	1200 bps to 28,800 bps	Duplex		Data communications
DSL	Digital Subscriber Line	160 kbps	Duplex		ISDN service Voice and data communications
G.Lite or DSL Lite	"Splitterless" DSL without the "truck roll"	From1.544 Mbps to 6 Mpbs , depending on the subscribed service 128 - 384 Kbps or depend on ISP	Down Up	18,000 feet on 24 gauge wire	The standard ADSL; sacrifices speed for not having to install a splitter at the user's home or business

Name	**Meaning**	**Data Rate**	**Mode**	**Max distance (ft)**	**Applications**
HDSL2	High data rate Digital Subscriber Line2	up to 1.5 Mbps	Duplex Duplex	13200	Requires only one pair, extends the distance of standard HDSL, no voice service unless a second pair of wires is added.
SDSL	Single line Digital Subscriber Line	1.544 Mbps duplex on two twisted-pair lines; 2.048 Mbps duplex on three twisted-pair lines	Duplex Duplex	24000	Same as HDSL plus premises access for symmetric services
IDSL	ISDN Digital Subscriber Line	128 Kbps 128 Kbps	Duplex Duplex	18,000 feet on 24 gauge wire	Much slower than other xDSL platforms. same as ISDN, data-only service and lacks analog voice capability.use 2B1Q cable
CDSL	Consumer DSL from Rockwell	1 Mbps downstream; less upstream	Down Up	18,000 feet on 24 gauge wire	Home and small business service not requiring a splitter; similar to DSL Lite.
ADSL	Asymmetric Digital Subscriber Line	1.5 to 9 Mbps 16 to 640 kbps	Down Up	9000	Internet access, video on demand, simplex video, remote LAN access, interactive multimedia

Name	Meaning	Data Rate	Mode	Max distance (ft)	Applications
VDSL	Very high data rate Digital Subscriber Line	13 to 52 Mbps 1.5 to 2.3 Mbps	Down Up	1000	Same as ADSL plus HDTV (High-Definition TV),on ATM network
SHDSL	symmetric, high rate Digital Subscriber Line	up to 2.3 Mbps	duplex	20000	Data-only platform, does not carry voice, two pairs of wire can be used to extend reach, but speeds degrade severely with distance.

(AI Jackson, 1998; Newton, 2001)

2.1.1 ADSL overview

Asymmetric Digital Subscriber Line (ADSL) is a high-bandwidth data telecommunication technology that use new modem can change existing twisted-pairs telephone lines (POTS, Plain Old Telephone System) to transport high-bandwidth data. ADSL is one range of DSL technologies (xDSL) that has special characteristic downstream rate more than upstream rate. Data transmit rate from ISPs to subscriber premises is faster than user upload data to the ISPs (AI Jackson, 1998). ADSL has the theoretical limited of downstream rate is 8 Mbps and upstream rate is 128 -512 Kbps. Data rates depend on several factors including the length of the twisted-pairs copper wire, the wire gauge, presence of bridged taps, and cross-coupled interference. ADSL signal encoding requires a single copper pair configuration of a standard voice circuit with an ADSL modem at each end of the line, creating three information channels – a high speed downstream channel, a medium speed upstream channel, and POTS channel for voice that allows both data and voice to transmit over the same line. (TTC, 1998; Newton, 2001)

ADSL technology developed from TCP/IP Protocol on ATM is a high-speed, multiplexing and switching protocol that supports multiple traffic types including multimedia, voice, data, video, and imaging, ADSL ideal for Internet and intranet surfing, video-on-demand, and remote Local Area network (LAN) access, Multi-Service, Tele Education, Fast Internet, News Clipping, Telecommuting, Distance Learning

2.1.2 Infrastructure ADSL Network

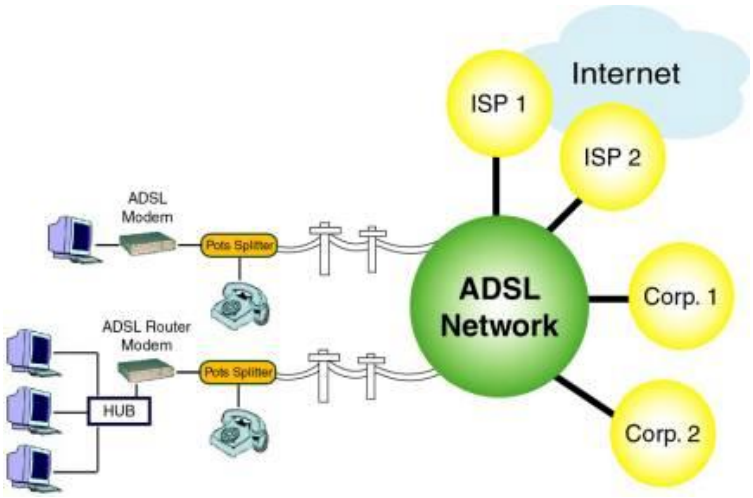


Figure 2.1 Infrastructure ADSL Network

2.1.3 ADSL Network Components

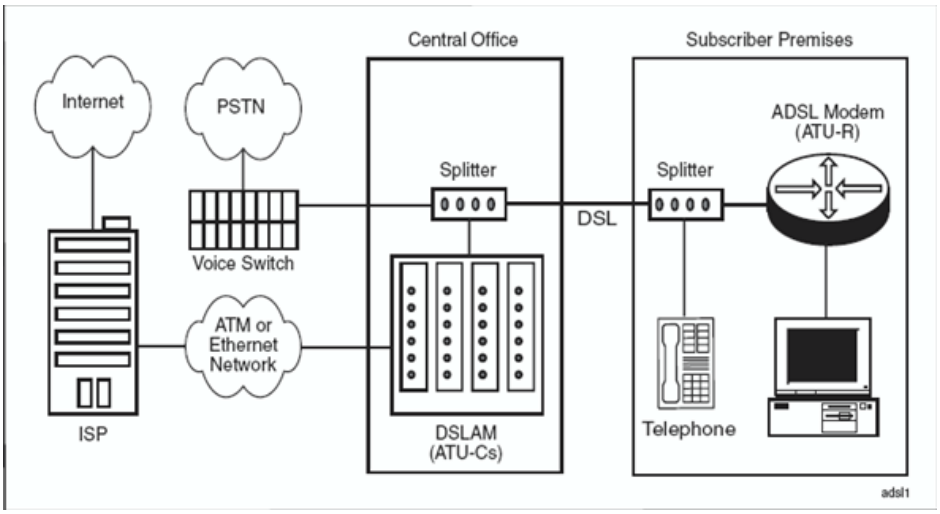


Figure 2.2 ADSL Network Components

ADSL Modem (ADSL Transmission Unit Remote, ATU-R)

The ADSL modem at the customer premises, also known as ATU-R, provides local loop termination on the customer side. It may also operate as either a router or a bridge.

ADSL Transmission Unit Central Office (ATU-C)

The ADSL modem at the central office, or ATU-C, terminates the ADSL local loop at the central office premises. Many ATU-Cs can be inserted into a DSLAM.

DSL Access Multiplexor (DSLAM)

The ATU-C units are collected together in a chassis unit called a DSLAM. The DSLAM may also incorporate a splitter. The DSLAM can connect through an ATM or Ethernet access network to the Internet.

ADSL Splitter

The splitter is an electronic low pass filter that separates the analogue voice or ISDN signal from ADSL data frequencies. There is a splitter located at the central office and at the subscriber premised. The splitters are totally passive devices requiring no power. This means that a power outage that stops the ADSL modem does not affect the telephones, which can continue to operate normally. The splitter at the central office may be incorporated into the DSLAM, or may be a separate device.

2.1.4 How ADSL work

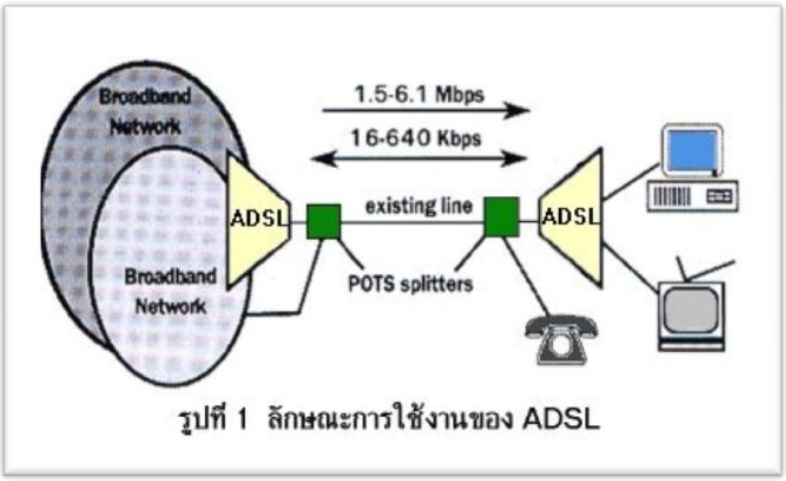


Figure 2.3 ADSL work

Delivery of ADSL services must installed ADSL modem and splitter at each end of the line either Central Office or subscriber premises, creating three information channels – a high speed downstream channel less than 8 Mbps, a medium speed upstream channel 128-512 Kbps, and POTS channel for voice. At the Central Office, a main distribution frame collects the cables from many subscribers and uses a splitter to distribute the data traffic to a DSLAM and routes the regular telephone traffic to the Public Switched Telephone Network (PSTN). DSL Access Multiplexer DSLAM mixes DSL services from different subscribers into ATM virtual circuits. The DSLAM contains ADSL Transmission Unit Central Office (ATU-Cs) where ADSL signals are multiplexed onto a high-speed interface connected to an ATM network. This ATM network provides access to the internet through internet service providers (ISPs) or corporate network (TTC, 1998).

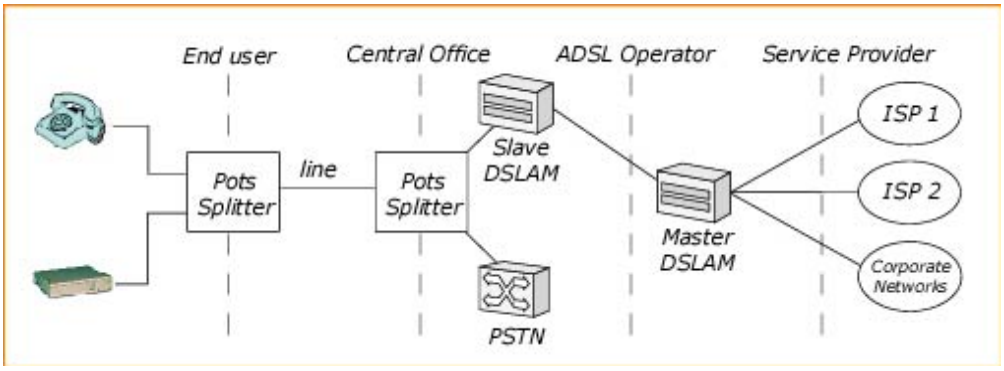


Figure 2.4 Operator Map Network

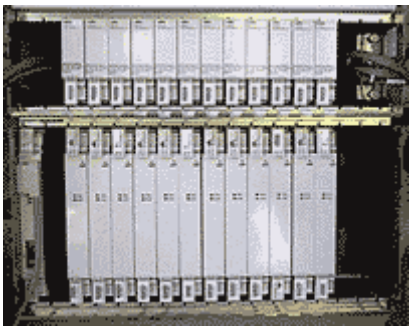


Figure 2.5 DSLAM

Pots Splitter

ADSL splitter separates the voice frequencies from the data frequencies, the lower 0 to 4 kHz frequency reserve for voice, fax and the frequency band from 1-2 MHz reserve for ADSL data for transmit upstream data and downstream data, splitter capable separate three frequencies signal that can transmit data both voice and ADSL signal simultaneously. There is a splitter located at the central office and at the subscriber premised. Voice frequencies will transmit through twisted-pairs copper wire to central office and Public Switch Telephone Network (PSTN) to connect to terminal telephone number and data frequencies will transmit to DSLAM to connect to ISPs or Network Corporation.

Splitter Connection

Subscriber premises require a single twisted-pairs copper wire with an ADSL modem and splitter. Splitter appearance is similar to telephone outlet that has two outlets, one outlet for connecting to ADSL modem and another one for twisted-pairs copper telephone line that capable high speed data transmission and telephone simultaneously.

Figure 2.6 Splitter

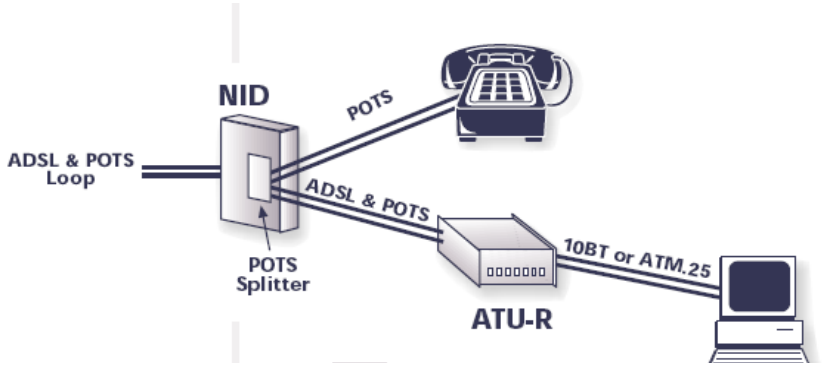


Figure 2.7 Connection ADSL Modem

2.1.5 ADSL signal encoding

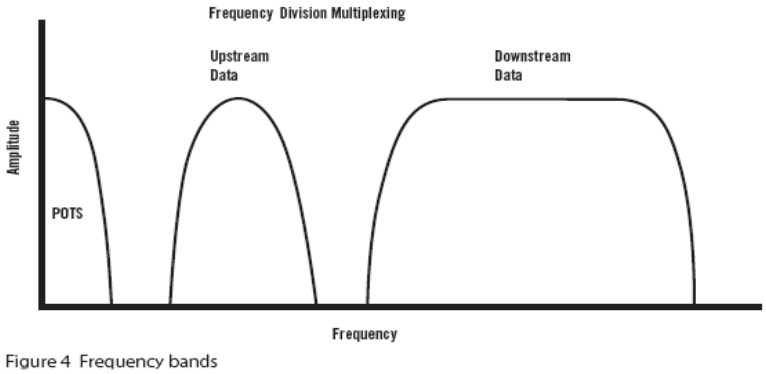


Figure 4 Frequency bands

Figure 2.8 ADSL signal encoding

ADSL transmission technology**,** traditional Plain Old Telephone Service (POTS), uses a narrow 4 kHz base band frequency to transmit analog voice signals. Although a typical twisted-pairs copper line can transmit usable signals up to approximately 1-2 MHz, ADSL uses the rest of the full copper line frequency spectrum, from above the voice frequencies up to 1.1 Mhz. ADSL uses a frequency range from approximately 20 kHz to 1.1 MHz. Frequency Division Multiplexing (FDM) creates multiple frequency bands to carry upstream and downstream data. The lower 0 to 4 kHz frequency range is reserved for POTS service. The frequency band from 25 - 138 kHz is used to transmit upstream data. In addition, the larger and higher frequency band from138 kHz to 1.1 MHz is used for downstream data (TTC, 1998).

ADSL uses technique for modulation signal, normally traditional Plain Old Telephone Service (POTS) uses a narrow 0- 4 kHz baseband frequency to transmit analog voice signals. ADSL increases the usable frequency range from 4 kHz to 1.1 MHz. FDM allows ADSL to create multiple frequency bands to carry upstream and downstream data simultaneously with the POTS signal over the same copper pairs. In the present, Discrete Multi-Tone (DMT) modulation and Carrier less Amplitude/Phase (CAP) modulation techniques are standard techniques for ADSL frequencies. Splitter capable separates voice and ADSL frequencies that can transmit data both voice and ADSL signal simultaneously.

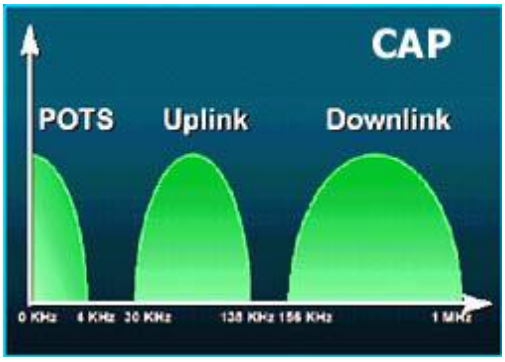


Figure 2.9 Carrier less Amplitude/Phase (CAP) modulation

Carrier less Amplitude/Phase (CAP) modulation

Carrier less Amplitude/Phase (CAP) modulation is a technique consists of three frequency ranges: POTS, Uplink, and downlink.

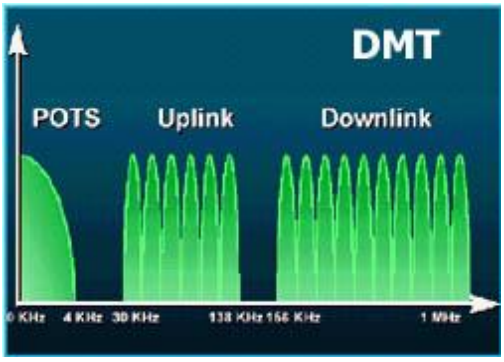


Figure 2.10 Discrete Multi-Tone (DMT) modulation

Discrete Multi-Tone (DMT) modulation

Discrete Multi-Tone (DMT) modulation has been chosen by the American National Standards Institute (ANSI) as the standard T1.413 line code. The basic idea of DMT is to split the available bandwidth into 256 sub channels, or tones, ranging from 20 kHz to 1.1 MHz. Each tone has a spacing of 4.3 kHz and supports a maximum number of 15 bits, as limited by its signal-to-noise ratio. Upstream data transfer frequencies range from 20-160 kHz (32upstream frequency bins), and downstream data transfer frequencies range from 240 kHz to 1.1 MHz (224 downstream frequency bins) .DMT is able to allocate data so that the throughput of every single sub channel is maximized. If a sub channel can't carry any data, power is conserved by not transmitting on that sub channel and the use of available bandwidth is optimized. (David Ginsburg, 1991; TTC, 1998)

2.1.6 New technology ADSL (ADSL2/ADSL2/2+)

ITU or International Telecommunication Union has certified ADSL2 and ADSL2+, new ADSL technologies, since January 2003.

ADSL2

ADSLs is developed its distance and signal capability. It optionally extends the capability of basic ADSL in data rates to 12 Mbps and distance increasing 600 feet (with a mandatory capability of ADSL transceivers of 8 Mbps distance 18,000 feet). The upstream rate is still the same 1 Mbps.

ADSL2+

For ADSL2+, the maximum data transmission is 25 Mbps to support any upcoming multimedia applications. ADSL2+ is capable high frequency range of typical ADSL connections from 1.1 MHz to 2.2 MHz. At first 5,000 feet from Central Office, the maximum downstream rate is 25Mbps.

The new standard applies better signal modulation and can cooperate properly with ADSL (Tanit Sa-ngounnete, 2007).

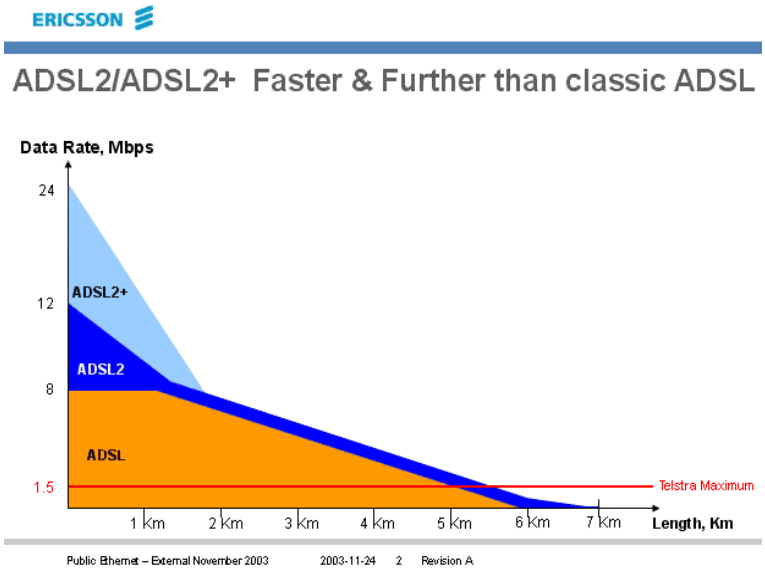


Figure 2.11 ADSL2/ADSL2+

Indispensable things for subscriber premises

1. Fixed line in the area providing ADSL.
2. A computer with CPU Pentium 200 MHz or higher which connects to modem with Ethernet LAN Card or USB Port.
3. ADSL modem or ADSL modem/router.
4. POTS splitter (always comes with modem).
5. ADSL passport from ISP.

2.1.7 Advantages and Limitations / Cautions of ADSL Advantages

(NEXTEP Broadband, 2001)

1. ADSL can transmit data both analog voice signal and ADSL signal in the same line simultaneously.
2. Compare with analog modem, speed rate of ADSL modem is 140 times faster.
3. ADSL comes up with adjustable high-speed upstream and downstream rate.
4. ADSL provides always on access - ready to be used all time without dialing up and telephone charges each time.
5. ISP provides enough line for users so they will not encounter with

jam line.

6. Compare with analog modem, ADSL is more stable. In addition, it can reduce busy signal problem.

7. ADSL bandwidth is constant. (at the selected rate)

8. ADSL is the independent transmission line - without sharing line with other people. So, it is reliable and safe.

9. Users pay constant amount of money for ADSL because it is monthly expense without telephone charges for dialing up each time.

10. ADSL supports multimedia applications including data, voice, and image.

11. ISPs provide various services.

Limitations / Cautions (NEXTEP Broadband, 2001)

1. ADSL share bandwidth, transmission data rate will slowly when users access to the internet simultaneously.
2. Electric appliances easily interrupt ADSL signal.
3. Lack of ISP services in some areas
4. Transmission rate depends on distance.
5. Distance between computers and Central Office should not be more than 5 kilometers because signal quality depends on
    - Length of the twisted-pairs copper wire; more length causes low quality and vice versa.
    - The wire gauge.
    - Presence of bridged taps.
    - Cross-coupled interference.
    - Performance of computer.
    - ADSL package.
    - Number of user that use internet simultaneously.

2.2 Review internet demand forecasting

Conclusion of internet use need forecast methods presently used by companies providing internet services.

Grid Survey was formerly used by forecast group to forecast internet use need. As it is not suitable for the present situation due to limited budget and there are more business rivals, forecast model is used in the present time.

At present, there are two following divisions forecasting internet use need; Market Division plans in the short period such as month by month because it has to carry out the marketing to meet changing needs of users. Traffic Engineering Division quarterly forecasts need in the provincial level. It used the organization data to forecast internet use need and planned forecast results again in the traffic level. Forecast is divided into best forecast, medium forecast, and worst forecast. The statistics of MSE and MAPE were used to measure model accuracy. And data on number of internet users in each year were compared for accuracy of forecast model.

At present, extension of internet network is planned based on marketing strategy. Network is extended by specifying which province needing to use and specifying the target group with payment potential. Internet is extended in the workplace, industrial estate, business zone, commercial zone, educational zone and tourism zone which tend to have more need than other point. After the service is fully provided, the service is extended to houses in the nearby areas. The network extension depends on the network which the company can provide service.

True Company has hired the foreign company to forecast tendency on internet use need. Then various obtained data are considered again by the company's Marketing Division to specify that where the internet service network is extended. Like TOT, the service is emphatically extended in the industrial estate zone, business zone, commercial zone, educational zone, tourism zone, and places where there are ATM, banks. Initially, the service will be extended to places where there is more spending. After that the service will be extended to the nearby areas where the company can provide the service.

2.3 Forecasting Theory (Roberta, 2009)

Meaning

Forecasting is a statement of what will happen in the future, especially in connection with a particular situation. Forecasting result will be useful for making a decision.

Steps for forecasting

1. Specify purpose(s).
2. Specify forecasting time horizons.
3. Adopt forecasting techniques.
4. Collect and analyze data.
5. Apply and evaluate result.
6. Follow up.

Forecasting Time Horizons

Short-Term Forecasting

Short-Term Forecasting took less than 3 months. This prediction is made from known facts and figures. Managers and corporate officers know what has already been ordered and can draw plans based on these numbers. Very little guesswork is needed, just due diligence in making sure scheduled tasks are completed on time. These forecasts are good for purchase transactions, cash requirements, work schedules, work force levels, job assignments, and production levels.

Medium-Term Forecasting – 3 months to 3 years

Medium Range forecasts are believed to be fairly accurate. Values of recent activities are already known and trends can be calculated based on this. Quantitative methods of forecasting tend to be used very frequently in this time frame. These prognoses tend to focus on sales plans, production plans, capacity plans, operating cash budgets, management levels, and subcontractor needs.

Long-Term Forecasting

These long term forecasts can have low accuracy; therefore, requiring constant revisions and updates. The long range time frame is excellent for

capital expansion plans, new investment, new product development, facility location, research and development programs, strategic plans, implementing new technology, and acquisition.

Forecasting Techniques Forecasting Techniques are as bellows:

1. Informal forecasting technique: Conjecture is used in forecasting.

2. Formal forecasting technique

2.1 Qualitative forecasting will not use former information in forecasting process. Instead, information below is used:

- Executive opinions
- Sales staff opinions
- Customer survey
- Expert opinions

Delphi method, developed by The Rand Corporations in 1948, is the way to get expert opinions. Chosen experts will receive questionnaires and send them back to sender after completing them. After collecting data, sender will send forecasting result to experts to let them know results. If the results are not consentaneous, they must do these three times. This method is suitable for technology forecasting being used in organizations.

2.2 Quantitative forecasting

2.2.1 Time series forecasting

- Naïve

The naïve forecasting method simply states that the value for the period to be forecasted is equal to the actual value of the last period available. More formally, naïve 1: $F_t = A_{t-1}$. For example, products were sold 1,000 pieces last month, so this month may be sold 1,000 pieces as well.

- Simple Moving Average

When calculating successive values, a new value comes into the sum and an old value drops out, meaning a full summation each time is unnecessary.

$$Y_{(t)} = \frac{\sum_{t=1}^{N} y_{(t-i)}}{N} = \frac{y_{(t-1)} + y_{(t-2)} + y_{(t-3)} + ... + y_{(t-N)}}{N} \quad \text{....(1)}$$

- Weighted Smoothing Average

Weighted smoothing average is any average that has multiplying factors to give different weights to different data points. Mathematically, the moving average is the convolution of the data points with a moving average function; in technical analysis, a weighted moving average (WMA) has the specific meaning of weights which decrease arithmetically. In an *n*-day WMA the latest day has weight *n*, the second latest $n - 1$, etc, down to zero.

- Exponential Smoothing

An exponential moving average (EMA), sometimes also called an exponentially weighted moving average (EWMA), applies weighting factors which decrease exponentially. The weighting for each older data point decreases exponentially, giving much more importance to recent observations while still not discarding older observations entirely.

- Linear Least Square

- Exponential Least Square

2.2.2 Correlative forecasting (Regression Analysis)

It is the study of two random variables relationship, which are dependent variable and independent variable Dependent variable refers to circulation and production. Independent variable is factors which affect circulations or production. One of hypothesizes is random variables relationship will not change soon. The significant technique is Simple Regression Analysis. (Virat Panitchavong, 2549)

$$Y = a + bX \quad \text{…(2)}$$

Where

x and y are the variables.

b = the slope of the regression line

a = the intercept point of the regression line and the y axis.

X = First Score (dependent variable)

Y = Second Score (forecast variable)

Prediction Equation

$$\hat{Y} = a + b_1X_1 + b_2X_2 + ... + b_kX_k \quad \ldots(3)$$

Where

$\hat{Y}$ = prediction of dependent variable

a = the intercept

$b_1,.. , b_k$ = parameters for the independent variables

$X,.., X_k$ = independent variable

Standardized Equation

$$Z'_Y = B_1Z_{X1} + B_2Z_{X2} + \ldots + B_kZ_{Xk} \quad \ldots(4)$$

Where

Z'_Y = prediction of dependent variable

$B_1,\ldots,B_k$ = coefficient of standard equation

$Z_{X1},..,Z_{Xk}$ = independent variable

Measuring Forecast Error

Calculate Deviation error (Error, e_t) when compare with actual data in the past.

Deviation error (e_t) = Actual data (A_t) – Forecast data (F_t) …(5)

Measuring Forecast Error as follow:

Mean Absolute Deviation; MAD or Mean Absolute Error; MAE

$$MAD = \sum_{t=1}^{N} \frac{|A_t - F_t|}{N} \quad \ldots(6)$$

When N = Total number period of t time

A_t = Actual data at t time

F_t = Forecast data at t time

Mean Square Error; MSE

$$MSE = \sum_{t=1}^{N} \frac{(A_t - F_t)^2}{N} \quad \ldots(7)$$

When N = Total number period of t time

A_t = Actual data at t tim

F_t = Forecast data at t time

Mean Absolute Percentage Error; MAPE

$$MAPE = \left(\frac{100}{N}\right) \sum_{t=1}^{N} \left| \frac{A_t - F_t}{A_t} \right| \quad \ldots(8)$$

When N = Total number period of t time

A_t = Actual data at t time

F_t = Forecast data at t time

(quoting Makridakis et.al., 1998: 43; Roberta,2009; Lehmann, E. L.; Casella, George, 1998)

2.4 Geographic Information System

A geographic information system (GIS) integrates hardware, software, and data for capturing, managing, analyzing, and displaying all forms of geographically referenced information. GIS allows us to view, understand, question, interpret, and visualize data in many ways that reveal relationships, patterns, and trends in the form of maps, globes, reports, and charts. A GIS helps you answer questions and solve problems by looking at your data in a way that is quickly understood and easily shared (Supet Jirakajohnkul, 2552).

Figure 2.12 The Geographic approach

2.5 Transformation (Virat Panitchavong, 2549)

2.5.1 Transforming variables to satisfy assumptions

When a metric variable fails to satisfy the assumption of normality, homogeneity of variance, or linearity, we may be able to correct the deficiency by using a transformation.

Three transformations for normality, homogeneity of variance, and linearity:

- The logarithmic transformation. Using 2 types of transformation are logarithm base 10 and logarithm base 2 if the number of small data.
- The square root transformation, and
- The inverse transformation

Plus a fourth that is useful for problems of linearity:

- The square transformation

2.5.2 Computing transformations in SPSS

The square transformation in SPSS, transformations are obtained by computing a new variable. SPSS functions are available for the logarithmic (LG10) and square root (SQRT) transformations. The inverse transformation uses a formula which divides one by the original value for each case.

For each of these calculations, there may be data values which are not mathematically permissible. For example, the log of zero is not defined mathematically, division by zero is not permitted, and the square root of a negative number results in an "imaginary" value. We will usually adjust the values passed to the function to make certain that these illegal operations do not occur

2.5.3 Two forms for computing transformations

There are two forms for each of the transformations to induce normality, depending on whether the distribution is skewed negatively to the left or skewed positively to the right. Both forms use the same SPSS functions and formula to calculate the transformations. The two forms differ in the value or argument passed to the functions and formula. The argument to the functions is an adjustment to the original value of the variable to make certain that all of the calculations are mathematically correct.

Functions and formulas for transformations

Symbolically, if we let x stand for the argument passes to the function or formula, the calculations for the transformations are:

- Logarithmic transformation: compute log = LG10(x) ,
  LG10(X)/LG10 (2)
- Square root transformation: compute sqrt = SQRT(x)
- Inverse transformation: compute inv = 1 / (x)
- Square transformation: compute s2 = x * x

For all transformations, the argument must be greater than zero to guarantee that the calculations are mathematically legitimate.

2.5.3.1 Transformation of positively skewed variables

- For positively skewed variables, the argument is an adjustment to the original value based on the minimum value for the variable.

- If the minimum value for a variable is zero, the adjustment requires that we add one to each value, e.g. x + 1.

- If the minimum value for a variable is a negative number (e.g., –6), the adjustment requires that we add the absolute value of the minimum value (e.g. 6) plus one (e.g. x + 6 + 1, which equals x +7).

2.5.3.2 Transformation of negatively skewed variables

- If the distribution of a variable is negatively skewed, the adjustment of the values reverses, or reflects, the distribution so that it becomes positively skewed. The transformations are then computed on the values in the positively skewed distribution.

- Reflection is computed by subtracting all of the values for a variable from one plus the absolute value of maximum value for the variable. This results in a positively skewed distribution with all values larger than zero.

2.5.4 The Square Transformation for Linearity

The square transformation is computed by multiplying the value for the variable by itself. It does not matter whether the distribution is positively or negatively skewed. It does matter if the variable has negative values, since we would not be able to distinguish their squares from the square of a comparable positive value (e.g. the square of -4 is equal to the square of +4). If the variable has negative values, we add the absolute value of the minimum value to each score before squaring it.

2.6 Literature Reviews

Tony H. Grubesic had developed the spatial distribution of broadband providers in the United States. Abstract variations in the supply and demand of telecommunications infrastructure in the United States are well documented. However, amidst waning concerns of a broadband digital divide, the geographic aspects of broadband availability continue to be intriguing. While some areas benefit from a

robust selection of broadband providers, choices for consumers in other regions are often limited. The purpose of this paper is to explore the spatially unbalanced levels of broadband provision in the USA by providing an abbreviated longitudinal analysis of broadband regions and their development from 1999 to 2004. Broadband core and periphery regions are identified through the use of spatial statistical techniques and a geographic information system. A broadband competition index for ranking metropolitan and micropolitan areas is also introduced. And relate with research Tony H. Grubesic and Alan T. Murray had developed Waiting for Broadband: Local Competition and the Spatial Distribution of Advance telecommunication service in the united state. Abstract with the passage of the Telecommunications Act of 1996, Congress directed the Federal Communications Commission and all fifty U.S. states to encourage the deployment of advanced telecommunication capability in a reasonable and timely manner. Today, with the rollout of advanced data services such as xDSL, cable modems, and fixed wireless technologies, broadband has become an important component of telecommunication service and competition. Unfortunately, the deployment of last-mile infrastructure enabling high-speed access has proceeded more slowly than anticipated and competition in many areas is relatively sparse. More importantly, there are significant differences in the availability of broadband services between urban and rural areas. This paper explores aspects of broadband access as a function of market demand and provider competition. Data collected from the Federal Communications Commission is analyzed using a geographic information system and spatial statistical techniques. Results suggest significant spatial variation in broadband Internet access as a function of provider competition in the United States. And relate with research Randall S. Sexton, Richard A. Johnson and Michael A. Hignite had developed Predictive Internet/e-commerce use abstract use of the internet continues to grow at an explosive rate. While entertainment, education and communication serve as important application of the internet, e-commerce continues to emerge as an increasingly significant business phenomenon. However, little empirical research exists to identify factor that influence the extent to which individuals use the internet and e-commerce. With the aid of survey research and a neural network, this study analyzes a wide range of variables in an attempt to identify accurate predictors of this usage. The results of the analysis identify gender, overall computer usage, job-related

use, and home access as important characteristics that should influence use of the internet and e-commerce. And relate with research Dijana Mocˇnik and Karin Širec. (2010) developed the determinants of Internet use controlling for income level: Cross-country empirical evidence. Abstract this paper seeks to explain the intensity of Internet use in terms of information and communication technology (ICT) and other socioeconomic indicators (i.e., economic, investment, international trade, educational, and population distribution) according to income. Using factor analysis, the three most important factors were extracted; their factors scores are used for further regression analysis to estimate impact on Internet usage. The strongest positive and most significant impact on Internet use was the ICT infrastructure and people capabilities, followed by income distribution, and investment and international trade. These results demonstrate that the size of the impact differs across income groups, as hypothesized.

The Empirical Study

The Data and hypothesis

As the extent of the internet use depends on many factors, the current discussion proceeds from the relationship between the number of Internet users — represented as a dependent variable — and six groups of independent variables— namely, ICT, economic, investment, international trade, education, and population distribution variables. (Dijana Mocˇnik , Karin Širec, 2010) This research takes several group of factors into account — Educational variables, Population distribution variables, Infrastructure variables, Economic variables, Investment variable. Apart from these variables, the development prediction model for forecasting hi-speed internet demand tends to be an important determinant of the internet use.

Educational variables:

The education level of the population (SECOUNDARY, TERTIARY, P_BACHEL_GRAD) is also included in the model. P_BACHEL_GRAD were transformed using Logarithm base 10 function since data were linearity that is used in the model 1 (Lg_P_BACHEL_GRAD). These obtain from Office of Permanent Secretary, Ministry of Education. The NTIA(1995, 1998, 1999, 2000, 2002) found a strong correlation between internet access and level of education attained (Chaudhuri

et al., 2005). The relative novelty of the internet and its association with computers suggest that level of education have positive impact on the number of subscribers, Martha (Garcia-Murillo**,** 2005). Sampsa Kiiski and Matti Pohjola, (2002) found education variable a statically significant predictor of its diffusion of the internet. Chaudhui, Flamm and Horrigan (2005) found the influences of traditional socio-demographic variables like education on broadband deployment are strong. Savage and Waldman (2005) found that preference for high-speed access is apparent among higher income and college-educated households. The internet is less attractive to people with limited education because they have problems reading comprehensive text. People with higher education should be more familiar and comfortable with using information technology. They may also be interested in having access to more information from the internet. Badran, El Sherbini & Ragab (2009), found School enrollment especially the tertiary level of education is a significant determinant of the broadband uptake in these countries. Horrigan's recent survey demonstrates higher education may lead to greater broadband adoption (Horrigan, 2007). The educational variables herein include secondary and tertiary enrollment, and percentage of employees with the minimum qualification of a bachelor degreethe assumption that, the higher the education, the more internet users.

H1: Secondary levels of education (SECOUNDARY) have a positive impact on broadband access.

H2: Tertiary levels of education (TERTIARY) have a positive impact on broadband access.

H3:Percentage of employees with the minimum qualification of a bachelor degree(P_BACHEL_GRAD) has a positive impact on broadband access.

Economic Variable:

Gross Domestic Product per capital (GDP CAP) in current price measure for the income variable. GDP per cap is a key determinant of a person's decision to purchase goods or services. Income represented by GDP per cap that related to price. In addition to monthly fees, users have to pay connection and equipment charges. Price thus can be a major barrier to adoption of the technology in the poorer regions of the world. These obtain from Office of National Economic and

Social Development Board. This variable were transformed using inverse function since data were linearity that is used in the model 1 (Inv GDP CAP) and using Logarithm function since data were linearity that is used in the model 2 (Lg GDP CAP). Previous studies of Garcia-Murillo, (2005) found GDP per cap variable is positive effects on the number of subscribers. And also match with Grosso, (2006) found income measured by GDP per capital is related to broadband penetration among OECD countries. Turner (2006) contends income is influential factors of broadband deployment among nations. The economic variable herein includes GDP per cap.

H4: GDP per capital (GDP CAP) have a positive impact on broadband access.

Infrastructure variable:

Fixed telephone lines per 100 inhabitants (FIXED_PENE) or teledensity. Fixed lines are telephone mainlines or landlines connecting customer's telephone to the public switched telephone network, the data were obtained from The National Telecommunications Commission. Previous studies of Badran, El Sherbini & Ragab (2009), found Main fixed subscriber lines per 100 inhabitants plays a major role as a determinant of broadband penetration in the countries and Wallsten (2006) also determined teledensity to be a broadband adoption factor in OECD countries, Employing regression analysis.

Personal computer per 100 inhabitants (COM_PENE). Personal computers are the most common method of accessing the internet. It follows that the higher the number of computers in a country, the higher the probability that its inhabitants are connected to the internet. Similarly, internet access, even using dial-up, can be a factor that leads to the adoption of broadband. A person familiar with the internet could, over time, receive greater value from the resource and may consider switching to a faster connection. The data were obtained from National Statistic Office Of Thailand. This variable was transformed using SQRT function since data were positively skewed and distribution is normal that is used in the model 2 (SQRT COM_PENE. Recent studies on fixed broadband deployment demonstrate ICT factors such as PC infrastructure and teledensity have influenced broadband penetration (Wallsten, 2006; Trkman et al., 2008; Lee and Brown, 2008). Denni and Gruber

(2005) found that telecommunication density has been an influential factor of broadband deployment in the United States. Lee and Brown (2008) contend ICT infrastructure is a significant factor of global broadband adoption. The infrastructure variables herein include penetration of personal computers, penetration of fixed telephone line.

H5: Higher penetration of personal computers (FIXED_PENE) has a positive impact on broadband access.

H6: Higher penetration of fixed telephone line (COM_PENE) has a positive impact on broadband access.

Population Distribution:

Population size (P POPM6) included in this research. The population serves as a measure of total market size. A larger market has greater potential to spread the fixed costs of technology infrastructure across consumers. The data were obtained from The National Telecommunications Commission. This variable was transformed using Logarithm base 2 function since data were positively skewed and distribution is normal that is used in the model 2 (Lg2 P POPM6). According to previous studies determinant of using internet is population size, Garcia-Murillo**,** (2005) found population size variable is positive effects on the number of subscribers. The population size variable herein includes percentage of population aged above 6 years.

H7: Higher percentage of population aged above 6 years (P POPM6) has a positive impact on broadband access.

Electrical variable:

Electricity GDP growth rate (GRGDP ELEC) included in this research. The consumption of electric power functions as a proxy for access to energy and the level of infrastructure development in a region. Electricity is also an important complement for ICT, thus, a positive coefficient is probable. The data were obtained from The Office of National Economic and Social Development Board. This variable was transformed using Logarithm base 2 function since data were positively skewed and distribution is normal that is used in the model 1 (Lg2 GRGDP ELEC).

H8: Electricity GDP growth rate (GRGDP ELEC) has a positive impact on broadband access.

Unemployed rate:

Unemployed rate (UNEMP) included in this research. As previous empirical studies (e.g., Chaudhuri et al., 2005) have argued that the unemployment rate is an important variable for Internet access. A negative association with Internet use is expected—namely, the higher the unemployment rate, the smaller the Internet use—primarily because unemployed people do not have available funds to finance the service. The data were obtained from The National Telecommunications Commission. This variable was transformed using Logarithm base 10 function since data were linearity that is used in the model 1 and model 2 (Lg UNEMP).

H9: Unemployed rate (UNEMP) has a negative impact on broadband access.

Investment variable:

Telecommunication Gross Domestic Product (GDP TELE) and the area that have been authorized to construct per square meter (REAL ESTATE) included in this research. New technologies diffuse more rapidly in countries open to investment (Perkins and Neumayer, 2004). Furthermore, the Internet requires a relatively large capital investment. For investment variables, such as investment in telecommunications and real estate construction (e.g., Chaudhuri et al., 2005). Recent studies on fixed broadband deployment demonstrate ICT, Trkman et al. (2008) found communication technology expenditure and higher investment in telecommunication have affect internet use. The data were obtained from The National Telecommunications Commission. This variable was transformed using Logarithm base 10 function since data were linearity that is used in the model 1 (Lg GDP TELE).

H10: Telecommunication Gross Domestic Product (GDP TELE) has a positive impact on broadband access.

The areas that have been authorized to construct per square meter (REAL ESTATE) were obtained from The National Telecommunications Commission. This

variable was transformed using Logarithm base 10 function since data were linearity that is used in the model 1 and model 2 (Lg REAL ESTATE).

H11: The areas that have been authorized to construct per square meter (REAL ESTATE) has a positive impact on broadband access.

CHAPTER III
MATERIALS AND METRODS

This chapter described research methodology used in this paper as following:

3.1 Research Methodology

Study framework

This research is quantitative analysis investigates demand trend to use hi-speed internet for expansion services plan. Questionnaire is used to collect data and collect secondary data from the government office. Then, the data is analyzed and compiled with Statistical package for the Social Science (SPSS). There are two statistics used in this research including descriptive statistics and interference statistics which is demand forecasting that applied Multiple Linear Regression methods describe correlation between predictor variable and outcome variable and spatial data describe applied Arc GIS 9.2 program.

Preliminary study

Firstly, the researcher studied relevant documentary and journal paper about both internet wire line technology such as ADSL infrastructure, FTTX, Cable modem and internet wireless technology such as CDMA and EDGE/GPRS. Next, prepare tools for gathering data and application program for analysis data that applies ArcGIS 9.2 and SPSS for windows program. Then, study theories data analysis method, gathering data method from the previous researches, thesis, seminar papers, documentary, book, journals, data survey, and also other statistics reports and collect secondary data from the government office. Source of data and variable for predict internet demand as following:

Source of data

This research, researcher collected data for analysis as following:

1. National Statistical Office of Thailand.

2. Department Of Provincial Administration.

3. The Revenue Department.

4. Office of Permanent Secretary, Ministry of Education.

5. The National Telecommunications Commission.

6. National Electronics and Computer Technology Center.

Context of research

- Gathering data method used multiple methods by telephone interview and distributes questionnaires in targeted area by researcher and assistant.

- Target area for gathering questionnaires data aspect in Chiang mai, Nakhon ratchasrima Songkhla and Bangkok Metropolitan.

- Data collection starts from November 20th, 2009 to January 30th, 2010.

- To calculate percentage of the demand trend to use high speed internet including ADSL, FTTX, Cable Modem, CDMA and EDGE/GPRS from questionnaire done by sampling group.

- Analyze data taken from National Statistical Office by using predicting model. P_BACHEL_GRAD is independent variable and P_POPUSENET is dependent variable. There are two dataset used to construct the model, the first set is the historical data of internet usage in Thailand 10 years ago. Using the first 6 years (2543-2548) as the data to create the model and the later 4 years (2549-2552) to check the accuracy of the model. The second set uses the same data as the first set but use the first 8 years to construct the model and the later 2 years to check for accuracy.

- The model accuracy test by using the statistical analysis on the MSE, MAPE and MAD.

3.2 Population and Sample group

Questionnaires survey

Population group: Participants are Thai population from all regions of Thailand. Populations were selected from one province of each region, each province have good economic, consider tax gathering conclusion from revenue department in 2008 and per capital GDP, GPP obtain from Department of National Economic and

social development Board, The previous studies showed that these factors influence internet use (revenue department, 2008; Office of the National Economic and Social development Board, 2008; Sampsa Kiiski, Matti Pohjola, 2002; Richard Beilock and Daniela V. Dimitrova, 2003; Arnum & Conti, 1998; Elie, 1998; Hargittai,1999, Yuji Akematsu, 2008), The provinces are Chiang Mai, the North of Thailand, Nakhon Ratchasrima, the North East of Thailand, Songkhla, the South of Thailand, and Bangkok Metropolitan, the Central of Thailand. And Software Industry Promotion Agency (Public Organization) (2553) has organized the ICT City which aims to create a software distribution opportunities to the country and to have maximum impact on public services, economic development, society and education, in each province by 2008. The company launched the pilot project in five provinces including Bangkok, Chiang Mai, Nakhon Ratchasima, Phuket and Khon Kaen. And, the other two provinces, Songkla and Uttaradit, are under consideration (TOT Corporation PCL, 2548-2549). True Corporation PCL. (2552) argued with Software Industry Promotion Agency (Public Organization) that showed 2009 annual report, served Wi-Fi in Chiang Mai, Phuket, Hat Yai, Nakhon Ratchasima and Khon Kaen. TOT Corporation PCL. (2551) showed 2008 annual report that TOT plans to bring WIMAX network to provide wireless high-speed internet. They plan to serve the service in ICT City provinces and potential provinces with high demand for the internet.

Select sample group: Sampling samples method was collected by Accidental Sampling from population in Chiang mai, Nakhon Ratchasrima, Bangkok and Songkhla. Researcher calculated sample group with Yamane's (1967) formula 400 samples and weight with number of population for calculating sample group in each province.

Accidental Sampling method is used to random sampling samples. The level of significant at 0.05 and 95 % of confident level, to calculate with Yamane's formula (Yamane, 1967, 1973; Glenn D. Israel., 1992; Yamane, 1973 quote in Terawut Akakul, 2543; Sarocha Paepasa, 2549, Panida Ruedeeniraman, 2006) and table Taro Yamane (see Appendix A)

Taro Yamane's formula

$$\text{Sample size (n)} = \frac{N}{1 + Ne^2} \quad \ldots(9)$$

When
- n Number of sample group
- N Number of population group
- e The level of precision (0.05 or 95%)

$$n = \frac{11,282,085}{1+ 11,282,085\ (0.05)^{\ 2}} = 400$$

To proved the answer of sample size krejcie & Morgan's formula (krejcie & Morgan, 1970; Pichit Ritjaroon, 2544: 137, Krejcie and Morgan, 1970 quoting Terawut Akakul, 2543)

krejcie & Morgan's formula

$$\text{Sample size (n)} = \frac{X^2Np(1-p)}{d^2(N-1)+X^2P(1-P)} \quad \ldots(10)$$

Equation 3: Krejcie & Morgan's formula

When
- X^2 the table value of chi-square for one degree of freedom at the desired 95% ($x^2 = 3.841$)
- N Number of population group
- P The population proportion (assumed to be .50 since this would provide the maximum sample size)
- d The degree of accuracy expressed as a proportion (.05).

$$\text{Sample size (n)} = \frac{3.841 \times 11{,}282{,}085 \times 0.5 \times 0.5}{(0.05)^2 \times (11{,}282{,}085-1) + 3.841 \times 0.5 \times 0.5} = 384.08$$

Equation 4: The answer of sample size from Krejcie & Morgan's formula

Table 3.1 Number of sample group

number	Province	Number population	Number of sample group
1	Chiang mai	1,658,298	59
2	Nakhon Ratchasrima	2,555,587	91
3	Bangkok	5,695,956	203
4	Songkhla	1,317,501	47
Total		11,282,085	400

Number of sample group was consisted of 400 sampling; Accidental Sampling method is used to random sampling samples. Data has been collected occasionally until the completion of data.

3.3 Empirical model

The empirical model

To examine determinants of internet usage, this study employs a multiple linear regression model. The linear regression model employs the historical data of internet usage in Thailand 10 years ago and provincial wide level data of population graduated bachelor degree from National Statistical Office of Thailand and Department of Provincial Administration.

To examine the influences of quantifiable variable on internet usage, this study formulates the following linear regression model. Since the distribution of variable in this linear regression model is positively skewed and distribution isn't normal so that data transformations with logarithm was utilized.

$$Y_i \text{ (P\_POPUSENET)} = \beta_0 + \beta_1(\text{P\_BACHEL\_GRAD}) + \varepsilon_i \quad \text{.....(11)}$$

In the empirical model (11), the dependent Variable (Y_i) is population using internet that identifies how individuals access the Internet. It is figures obtained from National Statistical Office of Thailand. Independent Variable (X_i) is education factor, P_BACHEL_GRAD. Its figures obtained from National Statistical Office of Thailand (Appendix B).

Observations group: In the empirical model, analyze data taken from National Statistical Office by using predicting model. P_BACHEL_GRAD is Independent variable and P_POPUSENET is dependent variable. There are two dataset used to construct the model, the first set is the historical data of internet usage in Thailand 10 years ago. Using the first 6 years (2543-2548) as the data to create the model and the later 4 years (2549-2552) to check the accuracy of the model. The second set uses the same data as the first set but use the first 8 years to construct the model and the later 2 years to check for accuracy. And provincial wide level data approximately observation 76 province of population graduated bachelor degree.

In questionnaires data survey, to calculate percentage of the demand trend to use high speed internet including ADSL, FTTX, Cable Modem, CDMA and EDGE/GPRS from questionnaire done by sampling group.

Table 3.2 Percentage of respondents that need to use each type of internet.

Type of internet	**N = 400 (case) (missing = 20)**	**Number of respondent**	**Percentage of respondent**
ADSL total	380	285	75 %
ADSL now use	380	135	35%
ADSL want use	380	151	39%
FTTX	380	227	59%
Cable	380	166	43%
CDMA	380	243	63%
EDGE/GPRS	380	222	58%
Total	380 case	1144	297%

3.4 Tools used in the study

Tools used for gathering data and application program for data analysis in this research are as below:

Hardware

1. Computer Pentium 4
2. Memory 1 GB
3. Hard disk 160 GB
4. Monitor WXGA resolution 640*480 256 colors
5. Mouse, keyboard, Speaker, Microphone, Sound card

Software

1. Program Tool: Arc GIS 9.0, Microsoft excel
2. Statistic analysis: SPSS 10.0 for Windows

Questionnaire

Designed questionnaire is as below:

1. The objective of the questionnaire is to study demand trend to use ADSL hi-speed internet for expansion services plan.

2. To define content and variable correlate with objective of measure and estimate.

3. Designed questionnaire by study concept for designed questionnaire from theories, professional, documentary and literature review that composed of 5 parts as followings:

Part 1: Participants' general information

Part 2: Data about using internet

Part 3: Data about using wire line internet

Part 4: Data about using wireless internet

Part 5: Problems and propositions

Format of questionnaire is nominal, ratio and Likert rating scale (Rensis A. Likert, 1961), the level internet satisfaction in this study. Rating scale was used to measure satisfaction level in 5 scales as follow:

As most as = Participant the most satisfaction.

Most = Participant most satisfaction.

Moderate = Participant moderate satisfaction.

As least = Participant less satisfaction.

Least = Participant the least satisfaction.

Criteria Interpret of satisfaction level of hi-speed Internet Service, considering by absolute criteria calculated with interval formula was used mean score, divided in 5 levels of satisfaction (Boonchom Srisaart, 2545) which are as following formula:

$$\text{I= Interval scale} = \frac{(\text{Max} - \text{Min})}{\text{Number of interval}} \quad \ldots(12)$$

$$= \frac{5 - 1}{5}$$

$$= 0.8$$

Averages mean	**Interpret**
1.00-1.80	level of satisfaction is the least
1.80-2.60	level of satisfaction is least

2.60-3.40 level of satisfaction is moderate

3.40-4.20 level of satisfaction is most

4.20-5.00 level of satisfaction is the most

4. Professional proves to solve and adjust contents and language.

5. Try out questionnaire with sample group for the last adjustment and find reliability with Cronbach's Alpha Coefficient and schedule gathering questionnaire data (see table 4).

Reliability of questionnaire

Cronbach's Alpha formular

$$\alpha = \frac{k}{k-1}\left(1 - \frac{\Sigma s_i^2}{s_T^2}\right) \quad \ldots(13)$$

k = Number of item

S^2_i = the variance of the *i*th

S^2_T = the variance of the total score formed by summing all the items

If α >= 0.7 then Exploratory research

If α >= 0.8 then Basic research

If α >= 0.9 then Important research

It is concluding that the questionnaire is highly reliable. (Cronbach. 1951: 297-334, Jump, 1978, Kanlaya Wanitchabuncha, 2545)

Table 3.3 Cronbach's Alpha coefficient of each section

Section	Cronbach's Alpha
Satisfaction of ADSL	0.642
Satisfaction of CDMA	0.815
Satisfaction of EDGE/GPRS	0.835

From table 3.3, Cronbach's Alpha coefficient formula shows that the questionnaire is highly reliable.

3.5 Gathering data

The data collected are divided into 2 following groups.

Primary data

The primary data are the surveying data the study area adopted questionnaires to explore demand ADSL hi-speed internet. Collecting data use multiple methods by telephone interview method and distribute questionnaires in targeted area by researcher and assistant as follow:

1. Telephone interview method, randomly retrieving telephone number from online Thailand yellow pages. Later, make a phone call to collect fixed line for gathering data.
2. Distribute questionnaires in universities, parks and shopping centers in targeted area by investigator and assistant.

Secondary data

The secondary data were collected from the government office, in related field of study. The secondary data consists of the following data:

1. GIS database and Map obtained from Technology Development Center of Remote Sensing and GIS, Engineering faculty, Mahidol University**.** The database consists of the political boundary, Area Perimeter Length all regions of Thailand**.**

2. P_POPUSENET, P_BACHEL_GRAD, Lg UNEMP, Lg P POPM6, COM_PENE, Lg REAL ESTATE obtained from National Statistical Office of Thailand.

3. Tax gathering obtained from the Revenue Department.

4. Lg GDP CAP, GPP, per capital GPP, GDP TELE obtained from Department of National Economic and Social Development.

5. TERTIARY and SECONDARY obtained from Office of Permanent Secretary, Ministry of Education.

6. FIXED_PENE obtained from The National Telecommunications Commission.

3.6 Statistic for Research Evaluation

This research is quantitative analysis that used descriptive statistics is Percentage, Mean, Standard deviation and interference statistics is demand forecasting that apply stepwise multiple regression methods

1. Percentage (Kanlaya Wanitchabuncha, 2545)

$$P = \frac{F \times 100}{N} \quad \ldots(14)$$

P = Ratio Percentage

F = Number of user that answer in each choice

N = Number of all data

2. Mean (Kanlaya Wanitchabuncha, 2545)

$$\mu = \frac{\sum x}{N} \quad \ldots(15)$$

μ = Average or mean

X = Value of each data

$\sum x$ = A sum of value of all data

N = Number of all data

3. Standard deviation (Kanlaya Wanitchabuncha, 2545)

$$S = \frac{\sqrt{\sum(\overline{x} - X)^2}}{N\,(N-1)} \quad \ldots(16)$$

S = Standard deviation

x = the score of student

$\overline{X}$ = Average of mean

N = the total number of student

Simple Moving Average

When calculating successive values, a new value comes into the sum and an old value drops out, meaning a full summation each time is unnecessary.

$$Y_{(t)} = \frac{\sum_{t=1}^{N} y_{(t-i)}}{N} = \frac{y_{(t-1)} + y_{(t-2)} + y_{(t-3)} + \ldots + y_{(t-N)}}{N} \quad \ldots(17)$$

4. Demand forecasting

Simple Linear Regression (Virat Panitchavong, 2549)

$$Y = a + bX \quad \ldots(18)$$

$$a = \bar{Y} - b\bar{X}$$

$$b = \frac{\sum xy}{\sum x^2}$$

x and y are the variables.

b = the slope of the regression line

a = the intercept point of the regression line and the y axis.

X = First Score (dependent variable)

Y = Second Score (forecast variable)

ΣXY = Sum of the product of first and Second Scores

ΣX = Sum of First Scores

ΣX^2 = Sum of square First Scores

Standardized Equation

$$Z'_Y = B_1Z_{X1} + B_2Z_{X2} + \ldots + B_kZ_{Xk} \quad \ldots(19)$$

when Z'_Y = prediction of dependent variable

$B_1,\ldots,B_k$ = coefficient of standard equation

$Z_{X1},..,Z_{Xk}$ = independent variable

5. Measuring Forecast Error

Calculate Deviation error (Error, e_t) when compare with actual data in the past.

Deviation error (e_t) = Actual data (A_t) – Forecast data (F_t) …(20)

This research selects Mean Square Error (MSE) for errors measurement prediction model are in accuracy Measuring Forecast Error as following equation:

Mean Square Error; MSE (Lehmann, E. L.; Casella, George, 1998; quoting Makridakis et.al., 1998: 43; Roberta,2009)

$$MSE = \sum_{t=1}^{N} \frac{(A_t - F_t)^2}{N} \quad \ldots(21)$$

N = Total number period of t time

A_t = Actual data at t time

F_t = Forecast data at t time

3.7 Data Analysis

Researcher analyzed data using Statistical SPSS program for the level of significant at 0.05 and 95 % of confident level, divided into 2 parts following step:

3.7.1 SPSS Program analysis

1. Recheck data in questionnaire.

2. Summarize data from questionnaire and fill in Microsoft Excel program.

3. Prepare data from Microsoft Excel and analyze data with SPSS program for windows.

4. Analyze general information of participant and data about participant use internet data by Frequency and Percentage.

5. Data analysis about participant use wire line internet and wireless internet by Frequency, Percentage and satisfaction level use Standard deviation and Mean.

6. Analyze problems and propositions by divided group and analyze with Frequency and Percentage.

7. Prepare data to create wire line internet and wireless internet demand trend forecasting model, Analyze data taken from government organization by using predicting model. There are two dataset used to construct the model, the first set is the historical data of internet usage in Thailand 10 years ago. Using the first 6 years (2543-2548) as the data to create the model and the later 4 years (2549-2552) to check the accuracy of the model. The second set uses the same data as the first set but use the first 8 years to construct the model and the later 2 years to check for accuracy and provincial wide level data to forecast internet demand trend each province, variable determinates have dependent variable (Y_i) and Independent variable (X_i) for Multiple linear regression. Note that some variable were transformed using logarithmic function since data were positively skewed and distribution isn't normal. Variable in research (See appendix B)

8. Correlation variable and outcome variable that use Pearson's coefficients matrix (Kanlaya Wanitchatbuncha, 2545) of predictor Product moment Correlation and test significance with t-test statistic at significance level of .05.

9. Analyze Stepwise Multiple Regression

9.1 Check linear relationship between predictor variable and outcome variable with overall F test statistic in ANOVA table.

9.2 Check significance of Constant, Unstandardized Coefficients (B) and Standardized Coefficients (Beta) with t test in Coefficients table.

9.3 Create regression equation.

9.4 summary model forecasting by Coefficients of Correlation (R), Coefficients of determinant (R^2) and Std. Error of the Estimate in Model Summary table together with regression equation in item 9.3.

9.5 Multiple linear regressions: determine the contribution of dependent variable to predict the number of subscriber want to use internet in the future.

The basic regression equation can be specified as follows:

$P\_POPUSENET = \beta_0+\beta_1 P\_BACHEL\_GRAD$ …(22)

10. The model accuracy test by using the statistical analysis on the MSE and the MAPE.

11. 22^{th} equation is then used to forecast at provincial wide level. The provincial wide forecast is done by taking the variable P_BACHEL_GRAND (X) in each province then substitute them into the country wide model.

12. To calculate percentage of the demand trend to use high speed internet including ADSL, FTTX, Cable Modem, CDMA and EDGE/GPRS from questionnaire done by sampling group (Chieng Mai, Bangkok, Nakorn ratchasrima, and Songkhla) then take the result from the forecasting model multiply with the percentage of the demand of each internet type (ADSL, FTTX, Cable model, CDMA, EDGE/GPRS) in each province.

13. The final result is the number of people that need to use each specific type of internet in each province.

14. Internet expansion plan.

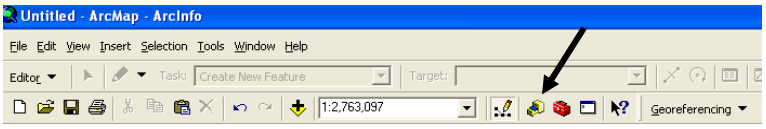
3.7.2 GIS Program analysis

1. Prepare data from Microsoft Excel and save data under the name '***.dbf to analyze spatial data with ArcGIS 9.2 Program.

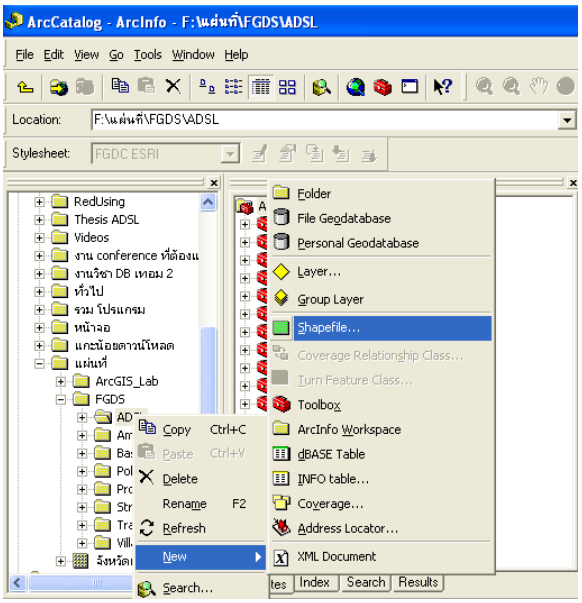
2. Create shape file demand trend wire line and wireless internet in all regions of the Thailand. Then, open application program Arc GIS 9.2 and create shape file Province use polygon type display wire line and wireless internet demand trend separated by polygon.

Crate Shape File -> Polygon> create three polygon shape file >Province

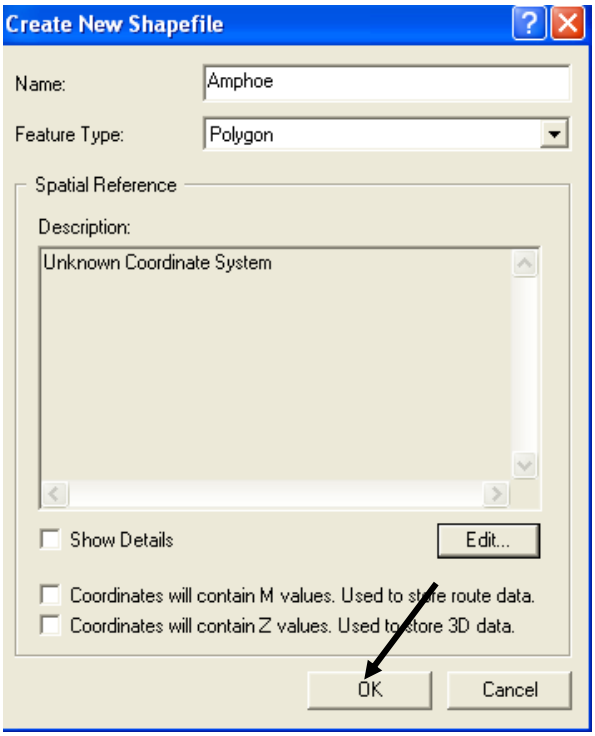
- Open ArcGIS 9.2
- Open ArcCatalog



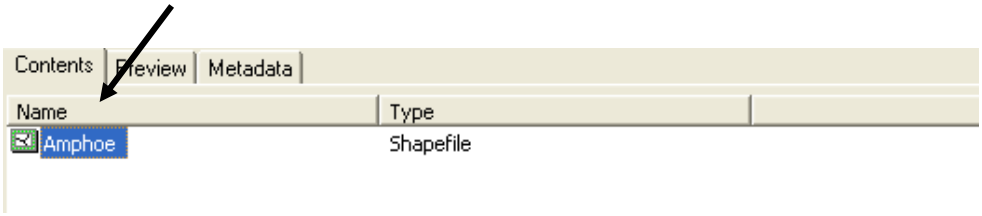
- Select required directory -> New -> Shapefile



- Type the name “Amphur” select feature Polygon -> OK

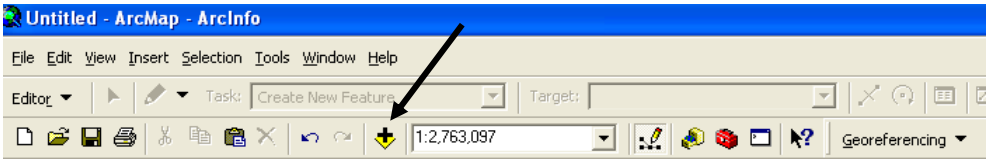


- Result Amphur polygon, type Shapefile



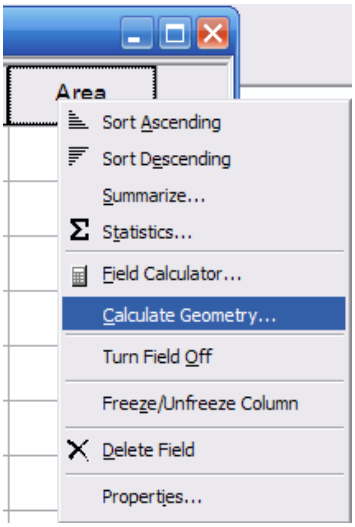
Calculate Area Perimeter Length

- Open ArcGis 9.2
- Add polygon data

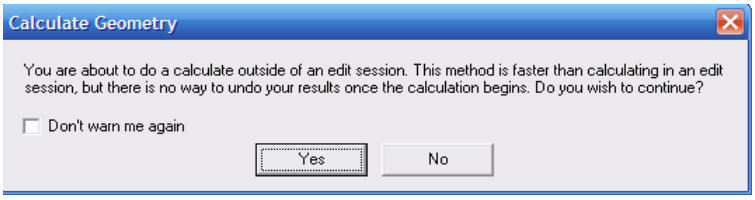


- Open Attribute table
- Add field “Area”

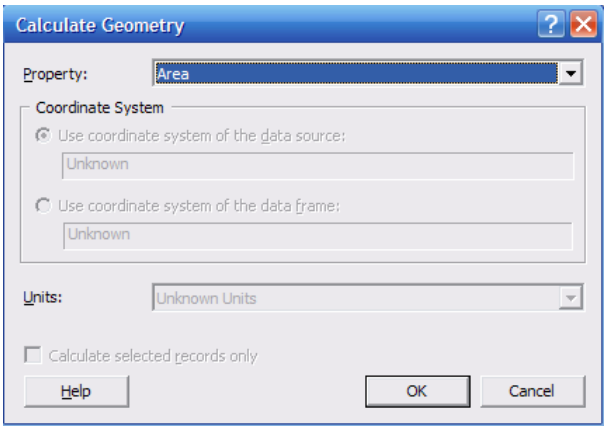
- Right click at Area field -> select calculate geometry



- Click Yes

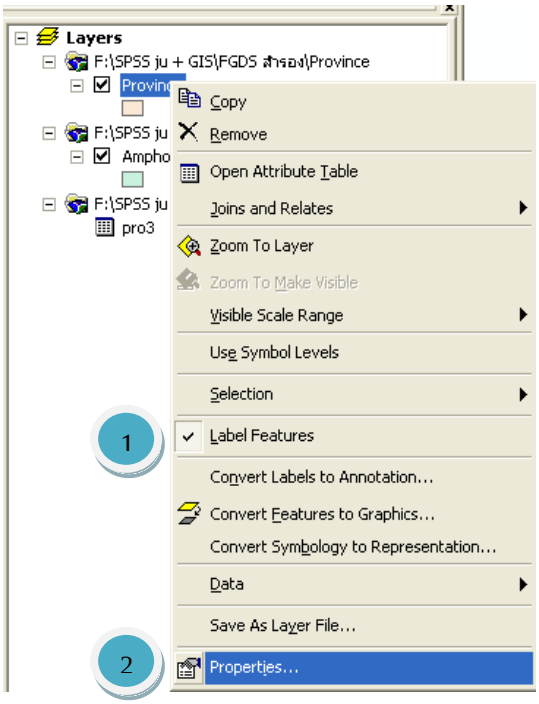


- Property -> Area -> OK

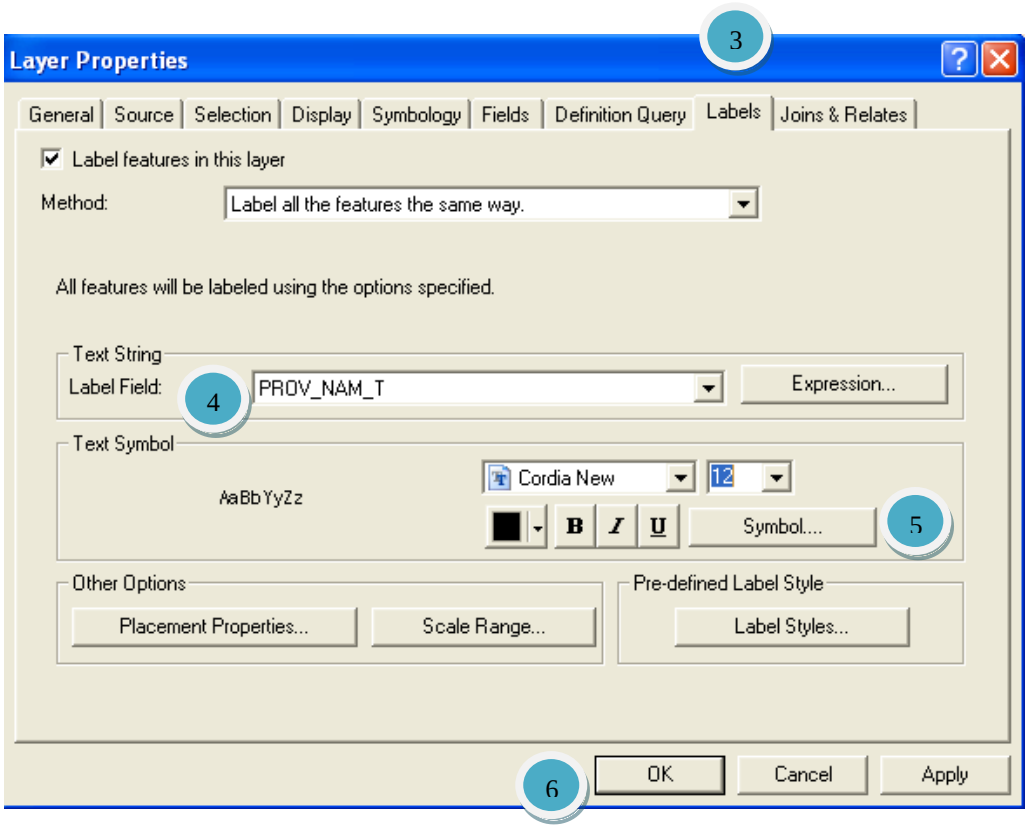


Crate label

- Right click at Province layer -> label Features -> Properties

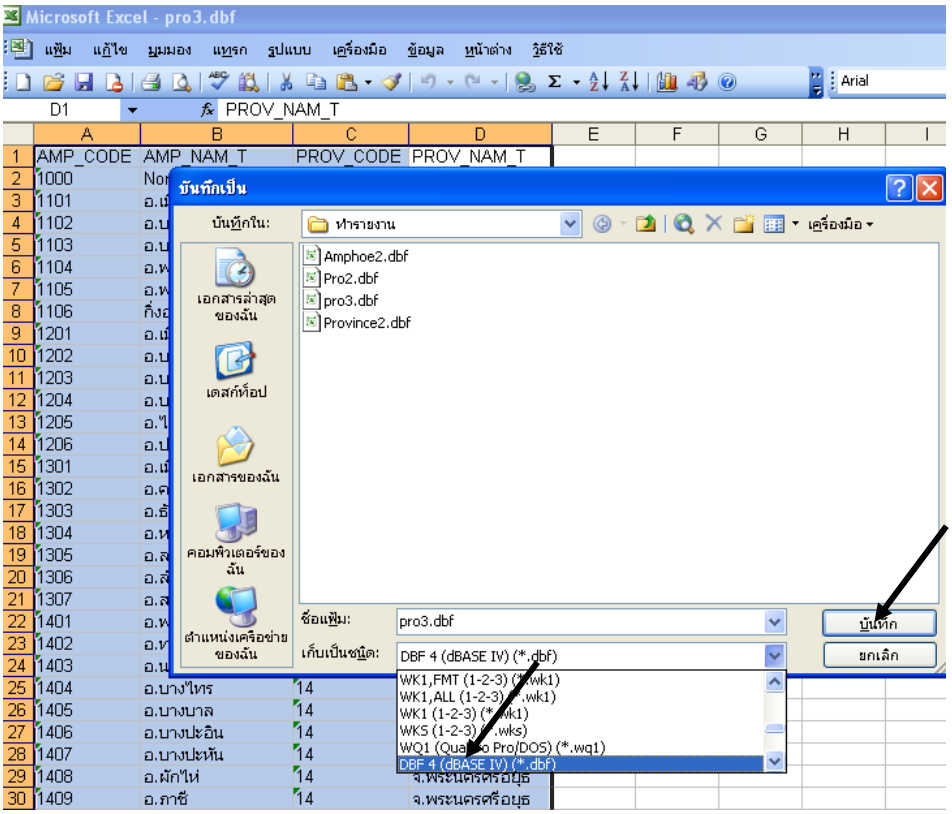


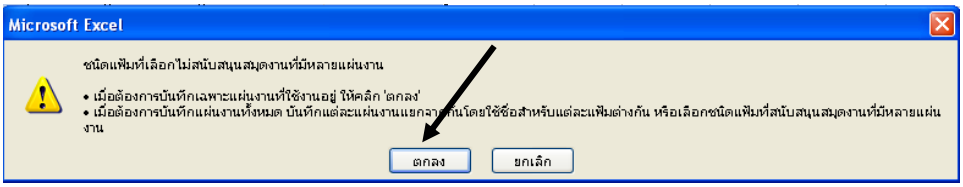
- Select Labels -> Label Field -> can change Text Symbol -> OK

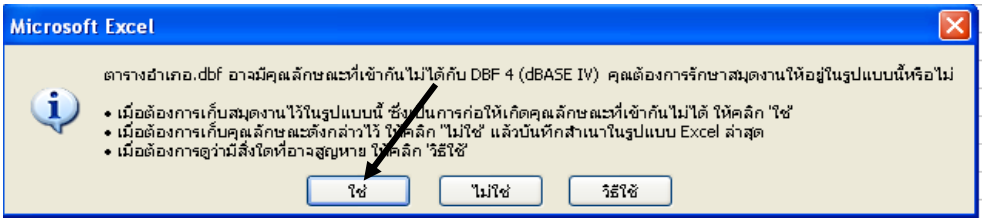


Join table

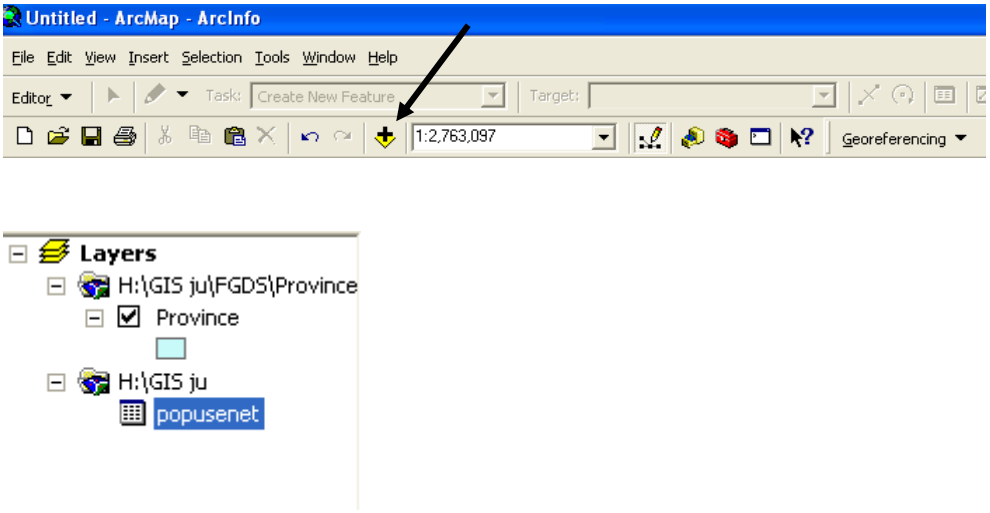
- Copy heading from the original table, paste in the Excel table, then prepare the join data
- Highlight the merging data and save as .dbf format



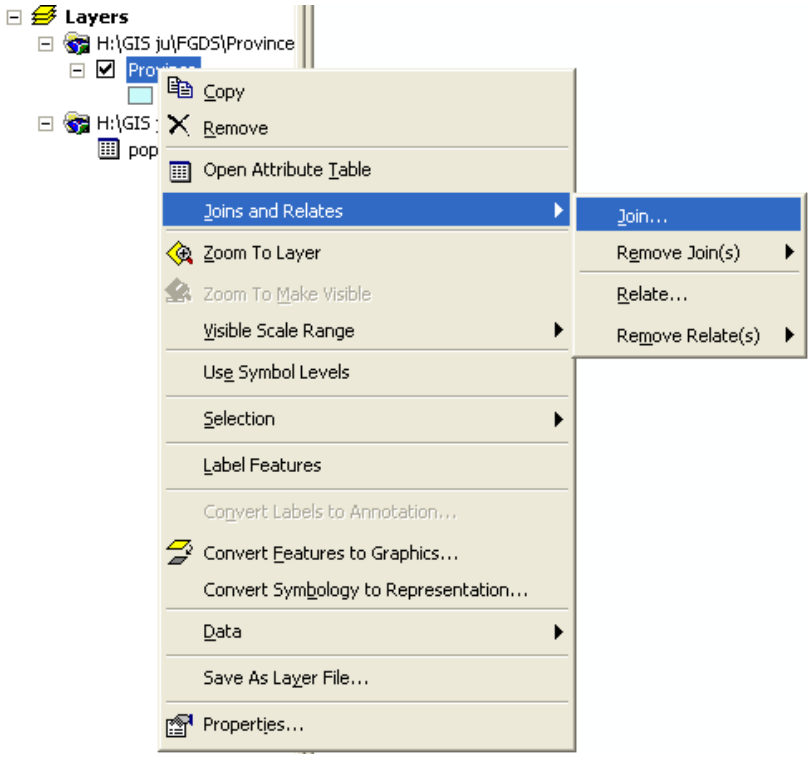




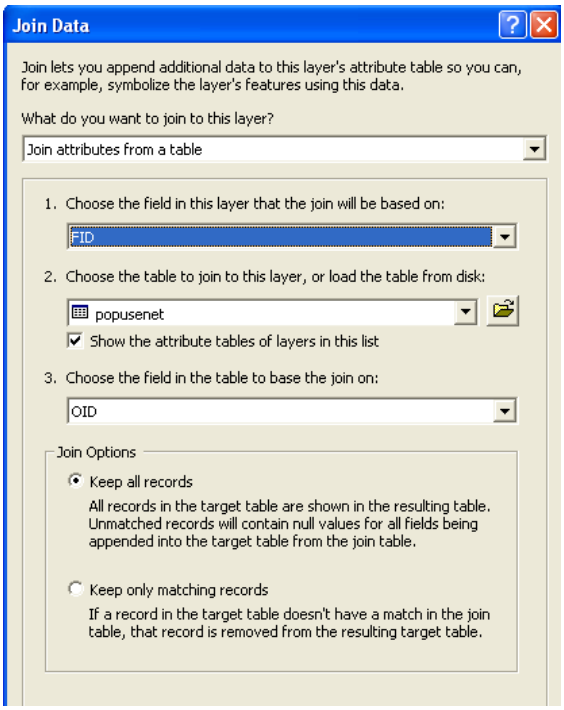
- Add data .dbf file



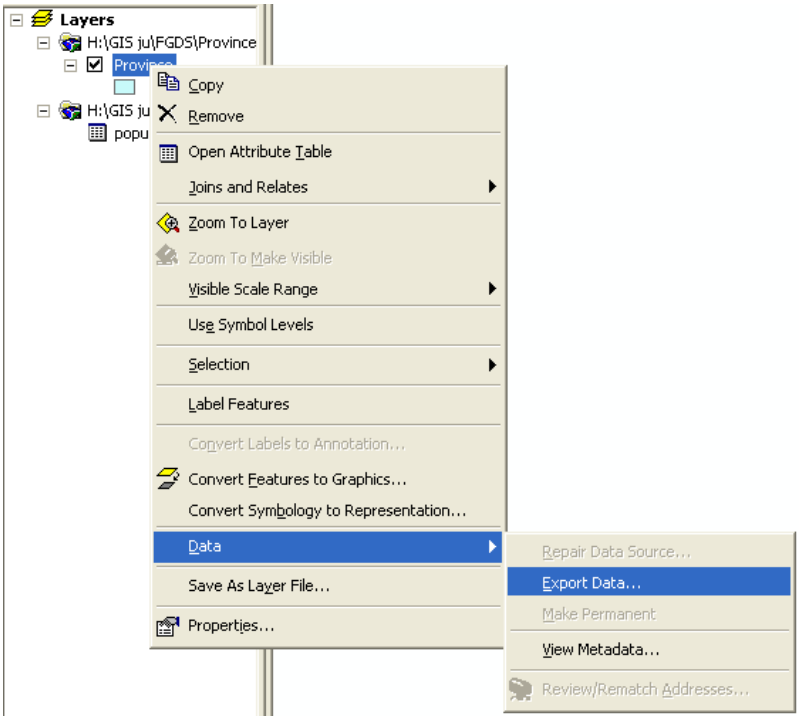
- Right click at Province layer -> Joins and Relates -> join.

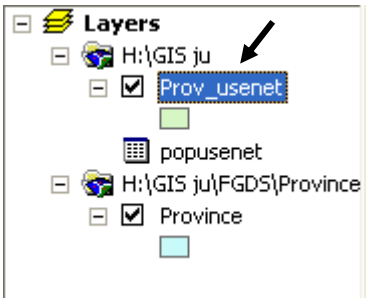


- Join data FID field from Province layer with OID field in popusenet.dbf -> OK



- Export join data = Prov_usenet.shp





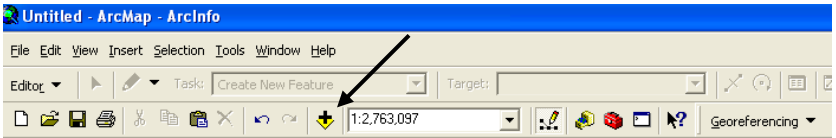
Join table and layer

- Copy heading from the original table = AMP_CODE, AMP_NAME_T, PROV_CODE from Amphur table and Province table, paste in the Excel table, then prepare the join data

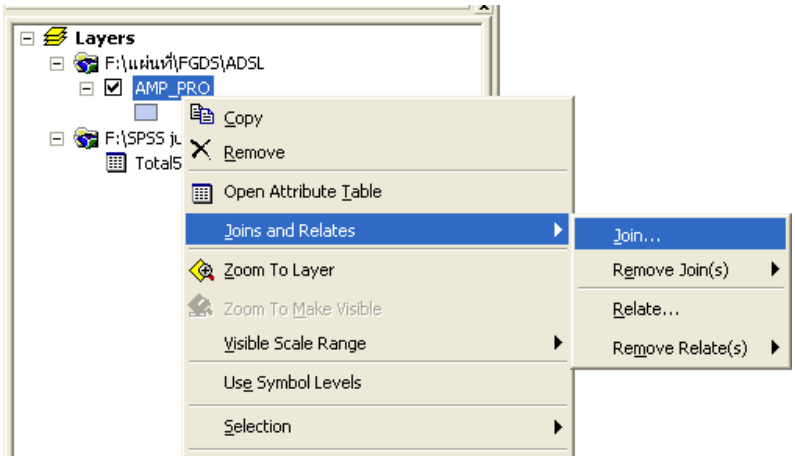
total3.xlsx

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1	AMP_CODI	AMP_NAM	PROV_COI	NUM_ANS	PER_ANS	NOWUSE_	PER_NOW	NUMWAN	PER_WAN	6_MONTH	PER_6	1_YEAR	PER_1	M1_YEAR	PER_M1
2	8102	เขาพนม	81	1	0.00	0	0.00	1	1.00	1	1.00	0	0.00	0	0.00
3	8106	อ.ปลายพระ	81	1	0.00	1	1.00	0	0.00	0	0.00	0	0.00	0	0.00
4	8101	อ.เมืองกร	81	1	0.00	1	1.00	0	0.00	0	0.00	0	0.00	0	0.00
5	8108	อ.เหนือคล	81	1	0.00	1	1.00	0	0.00	0	0.00	0	0.00	0	0.00
6	7111	อ.ด่านมะข	71	2	0.01	0	0.00	1	0.50	0	0.00	0	0.00	1	1.00
7	7106	อ.ท่าม่วง	71	3	0.01	0	0.00	3	1.00	1	0.33	1	0.33	1	0.33
8	7109	อ.พนมทวน	71	3	0.01	0	0.00	2	0.67	1	0.33	0	0.00	1	0.33
9	7101	อ.เมืองกา	71	7	0.02	2	0.29	4	0.57	2	0.29	0	0.00	2	0.29
10	7102	อ.ไทรโยค	71	3	0.01	0	0.00	1	0.33	1	0.33	0	0.00	0	0.00
11	4603	อ.กมลาไส	46	1	0.00	0	0.00	1	1.00	1	1.00	0	0.00	0	0.00
12	6201	อ.เมืองกำ	62	3	0.01	1	0.33	1	0.33	1	0.33	0	0.00	0	0.00
13	4001	อ.เมืองขอ	40	1	0.00	1	1.00	0	0.00	0	0.00	0	0.00	0	0.00
14	2205	อ.มะขาม	22	1	0.00	0	0.00	1	1.00	1	1.00	0	0.00	0	0.00
15	2401	อ.เมืองฉะ	24	2	0.01	2	1.00	0	0.00	0	0.00	0	0.00	0	0.00
16	2007	อ.ต.ศรีรา	20	3	0.01	2	0.67	1	0.33	1	1.00	0	0.00	0	0.00
17	2009	อ.สัตหีบ	20	1	0.00	0	0.00	1	1.00	1	1.00	0	0.00	0	0.00
18	2001	อ.เมืองชล	20	2	0.01	2	1.00	0	0.00	0	0.00	0	0.00	0	0.00
19	8601	อ.เมืองชุ	86	2	0.01	1	0.50	0	0.00	0	0.00	0	0.00	0	0.00
20	9201	อ.เมืองตร	92	4	0.01	2	0.50	2	0.50	1	0.25	0	0.00	1	0.25
21	9205	อ.สิเกา	92	2	0.01	1	0.50	1	0.50	1	0.50	0	0.00	0	0.00
22	9203	อ.ย่านตาข	92	1	0.00	1	1.00	0	0.00	0	0.00	0	0.00	0	0.00
23	9204	อ.ปะเหลีย	92	1	0.00	1	1.00	0	0.00	0	0.00	0	0.00	0	0.00
24	6302	อ.บ้านตาก	63	1	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00

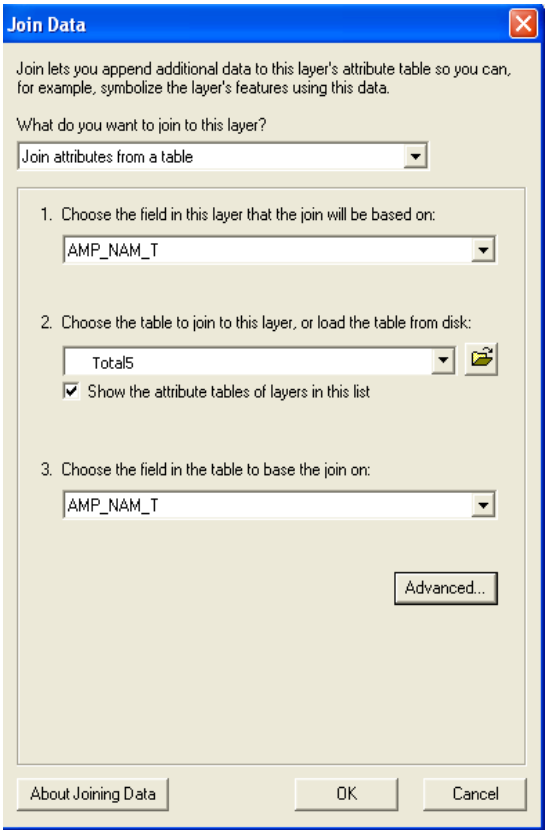
- Highlight the join data and save as .dbf format
- Open Arc GIS9 9.2 -> ArcMap -> Add data



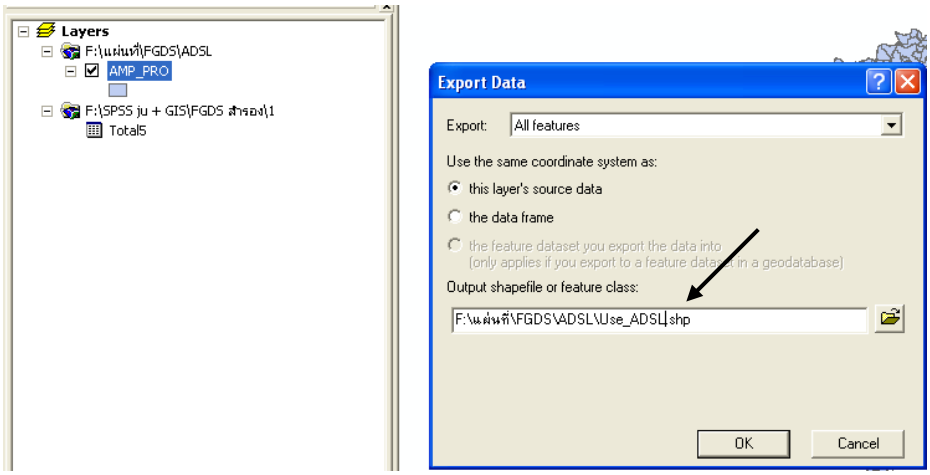
- Add AMP_PRO.shp and Total 5.dbf
- Right click at AMP_PRO layer -> Joins and Relates -> Join.



- Join table use AMP_NAM_T filed in table Total 5 and AMP_NAM_T filed in Amphur layer. -> OK-> Yes

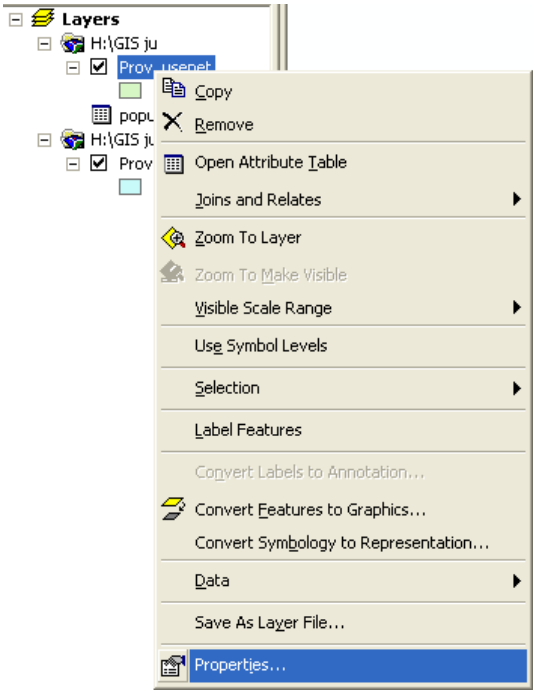


- Right click at AMP_PRO layer -> Data -> Export data = Use_ADSL.shp -> OK

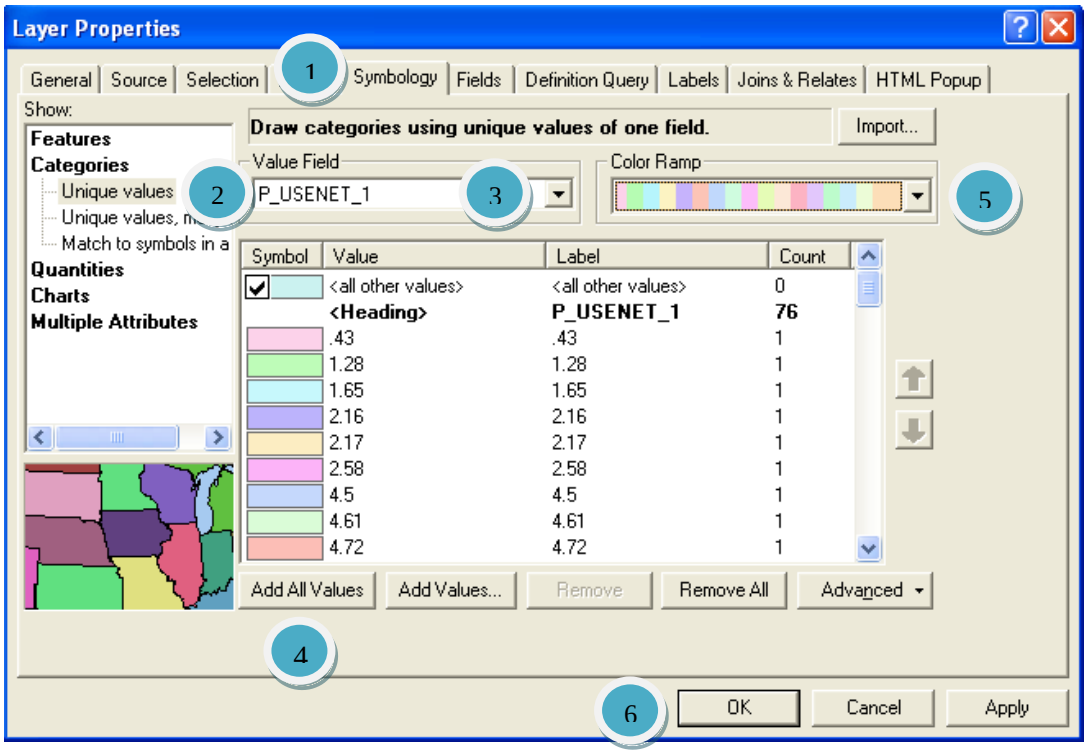


Create quantity symbol

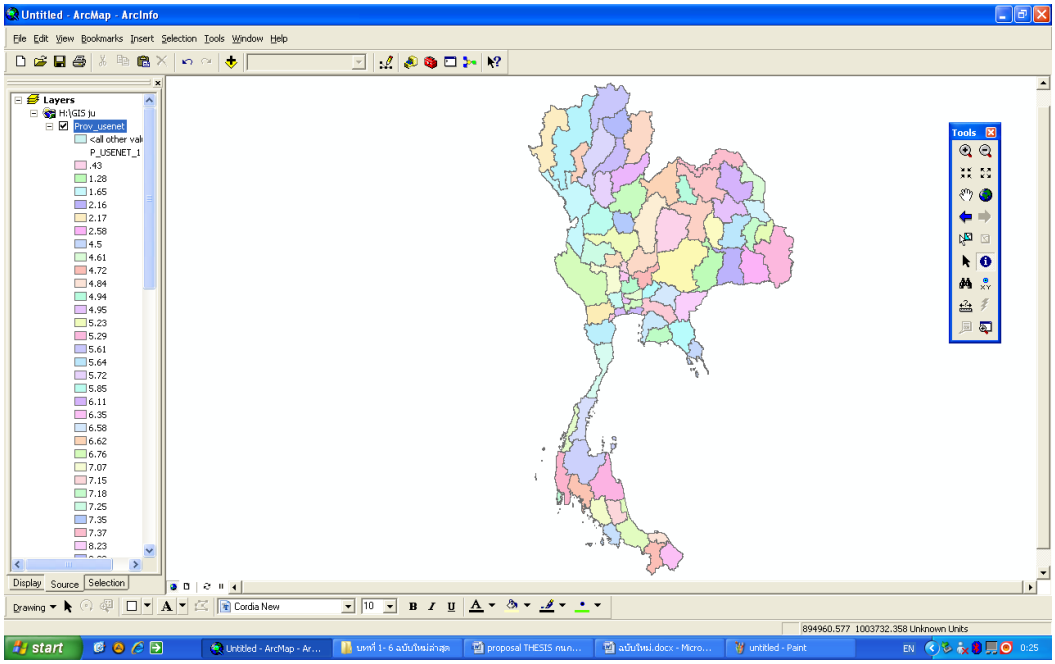
- Right click at Prov_usenet layer -> Properties



- Select menu Symbology -> Unique Value -> Select Value Field -> Add All Values -> Can change Color Ramp -> OK

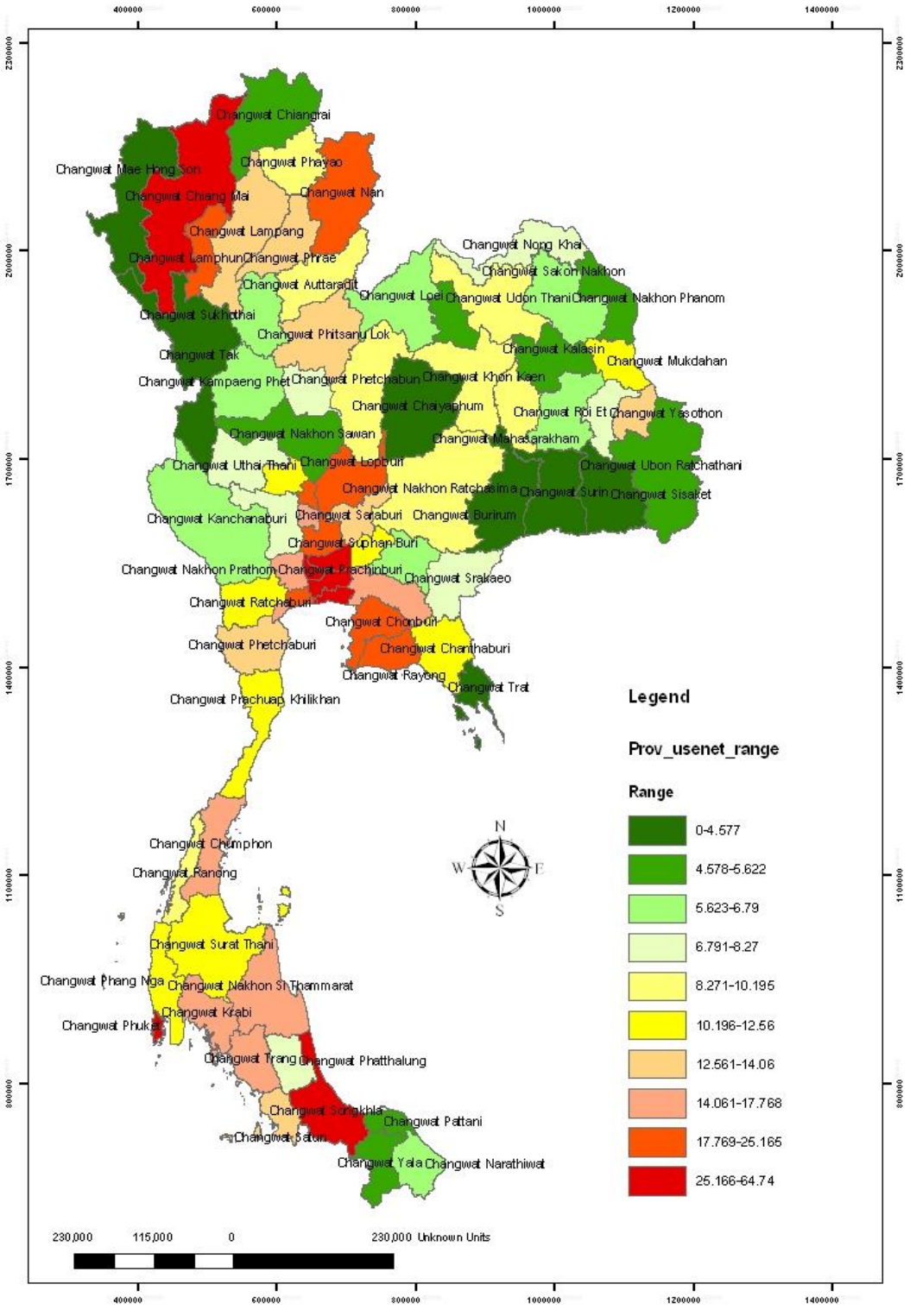


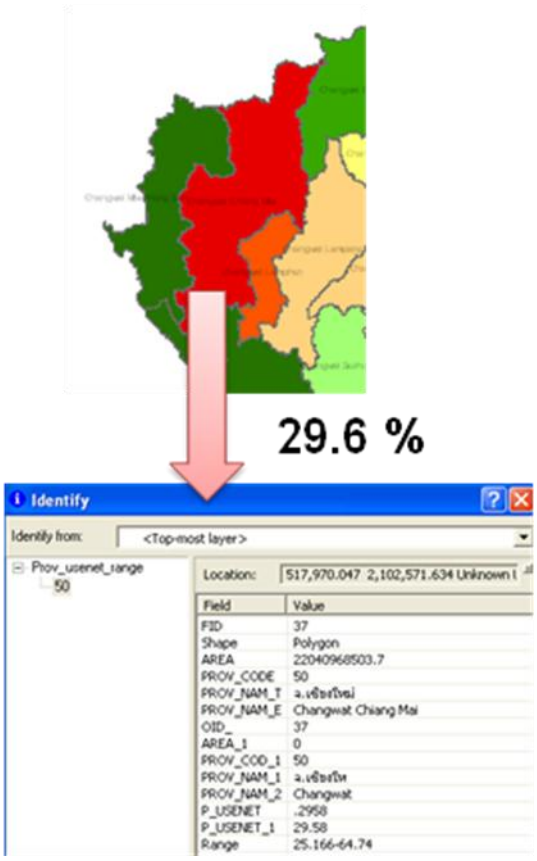
- Can change color, double click each color and change color



- Display demand trend hi-speed internet

ADSL Service Plan

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CHAPTER IV
RESULTS

The Results

The purpose of this study is to investigate the need to use land line and wireless high speed internet by gathering questionnaire survey and creating the prediction model “Multiple Linear Regression Analysis” and using the computer program “Statistical Package for the Social Sciences Personal Computer” (SPSS) in order to find all statistic findings of the model. Consequently, the researcher can find the appropriate equation of internet use prediction and be able to design the internet service expansion correctly. Questionnaire surveys submitted 400 respondents. The surveys contains general information of the participants, data about using internet, data about using wire line internet, data about using wireless internet. The result and explanation of the study is presented in the table; as following,

Data from questionnaire

Part 1: General information of the participants

Part 2: Data about using internet

Part 3: Data about using wire line internet

Part 4: Data about using wireless internet

Part 5: Problems and propositions

Data from the prediction model

Part 6: Data from the model experiment

Part 7: Data of prediction influence on the future internet use by multiple linear regression

Part 8: Accuracy comparison of model

Part 9: Internet expansion plan

Part 10: Spatial display with GIS

4.1 Questionnaires survey

Part 1: General Information of Participants

Table 4.1 Reveals numbers and percentages of participants decomposed of occupation, income, study.

General Information	N=400	Percentage
Occupation		
a student	221	55.2
an employee	84	21.0
an government employee	67	16.8
Self-employed	18	4.5
a farmer	9	2.2
Others (Please specify)……	1	.2
Income		
less than 5,000 baht/month	119	29.8
5,001 – 10,000 baht/month	160	40.0
10,001 – 20,000 baht/month	90	22.5
20,001 – 30,000 baht/month	18	4.5
30,001 – 40,000 baht/month	9	2.2
more than 40,000 baht/month	4	1.0
Study		
Under high school level	15	3.8
High school level/	49	12.2
Vocational Certificate		
Higher Vocational	19	4.8
Certificate Undergraduate	290	72.5
Postgraduate	27	6.8

From table 4.1, when consider number and percentage of participants decomposed of occupation, income and study, it reveals that the majority of the participants is student, at 55.2 percent, and an employee at, 21.0 percent. As for income, it reveals that the majority, 40.0 percent, is between 5,001 – 10,000

baht/month. For study, it reveals that the majority, 72.5 percent, is Certificate Undergraduate, and High school level, 12.2 percent.

Part 2: Data about using internet

Table 4.2 reveals numbers and percentages of internet use and need, and the number of participant using the internet at home.

General Information	N=400	Percentage
Using internet now		
Yes, I am	364	86.5
No, I am not	54	13.5
Want to use internet		
Yes, within 6 month(s)	25	6.2
Yes, within 1 year(s)	8	2.0
Absolutely not	20	5.0
No answer/Skipped	347	86.8
Household size		
1 person	82	20.5
2 persons	122	30.5
3 – 4 persons	113	28.2
more than 4 persons	60	15.0
No answer/Skipped	23	5.8

From table 4.2, when consider numbers and percentages of participants that use the internet, it reveals that majority of the participant already uses the internet. For the rest, they (6.2 percent) never use the internet and have a need to use the internet within six months. About 2.0 percent, they have needs to use the internet within one year. Besides, about 30.5 percent, there are two household sizes at home.

Table 4.3 Reveals numbers, percentage, mean and SD of participants that want to use the internet.

Description	**Number (n=400)**	**Percentage**	**N=400**		**Level**
			$\bar{X}$	SD	
Play game….hour(s)/day					
Selected	183	45.7			
Unselected	195	48.8	1.20	1.60	least
No answer	22	5.5			
Search …. hour(s)/day					
Selected	266	66.5	2.18	2.04	As least
Unselected	112	28.0			
No answer	22	5.5			
E-mail.... hour(s)/day					
Selected	233	58.3	.75	.96	least
Unselected	145	36.2			
No answer	22	5.5			
Chat.…hour(s)/day					
Selected	211	52.7	1.83	2.25	As least
Unselected	167	41.8			
No answer	22	5.5			
Music....hour(s)/day					
Selected	171	42.7	1.13	1.51	least
Unselected	207	51.8			
No answer	22	5.5			
Other....hour(s)/day					
Selected	22	5.5	.16	.77	least
Unselected	356	89.0			
No answer	22	5.5			
Total			1.21	1.52	least

From table 4.3, when consider the numbers and percentages of participants that want to use the internet, it reveals that the majority, 66.5 percent of the participant wants to use the internet in order to search information, to send/receive e-mails, 58.3 percent, and another use, 5.5 percent.

When consider the average and SD of participants who want to use the internet, it reveals that the participants want to use the internet at "least level", at the average at 1.2102.

For each item analysis, it reveals that the majority of participants tend to use the internet to search information, at the average at 2.1804, and for online communication (Chit-Chat), at the average at 1.8325, and, for the minority, to upload/download information, at the average at .1648.

Table 4.4 Reveals numbers and percentages of each internet need of participants.

Type of Preferred Internet	N=400	Percentage
ADSL		
Selected	286	71.5
Unselected	94	23.5
No answer/Skipped	20	5.0
fiber to the home		
Selected	226	56.5
Unselected	154	38.5
No answer/Skipped	20	5.0
Cable Modem		
Selected	166	41.1
Unselected	214	53.5
No answer/Skipped	20	5.0
CDMA		
Selected	244	61.0
Unselected	166	34.0
No answer/Skipped	20	5.0

Type of Preferred Internet	n=400	Percentage
EDGE/GPRS		
Selected	222	55.5
Unselected	158	39.5
No answer/Skipped	20	5.0

From table 4.4, when consider numbers and percentages of each internet need of participants, it reveals that the majority, 71.5 percent, of participants want to use ADSL internet, and 61 percent want to use CDMA, and, the minority, 41.1 percent want to use cable modem internet.

Part 3: Data about using wire line internet

Table 4.5: Reveals numbers and percentages of ADSL internet need of participants.

Description	N=400	Percentage
Now, use ADSL and in the future want to use		
Now, use ADSL	135	35.5
In the future want to use ADSL	151	39.7
No, I don't	94	23.5
User's attention install ADSL hi-speed internet		
Within 6 months	93	23.2
Within 1 year	35	8.8
More than 1 year	23	5.8
Rate ADSL		
256Kbps/128 Kbps at 490 baht/month	6	1.5
512Kbps/256 Kbps at 490 baht/month	15	3.8
1Mbps/512 Kbps at 490 baht/month	15	3.8
2Mbps/512 Kbps at 590 baht/month	26	6.5
3 Mbps/512 Mbps at 590 baht/month	128	32.0
4 Mbps/512 Mbps at 860 baht/month	26	6.5
5 Mbps/512 Mbps at 999 baht/month	9	2.2

Description	N=400	Percentage
8 Mbps/512 Mbps at 1,100 baht/month	17	4.2
10 Mbps/512 Mbps at 490 baht/month	12	3.0
12 Mbps/512 Mbps at 1600 baht/month	9	2.2
16 Mbps/512 Mbps at 2,200 baht/month	17	4.2
Others ……Mbps at..... baht/month	6	1.5

From table 4.5, when consider numbers and percentages of data about user's attention to install Asymmetric Digital Subscriber Line (ADSL) hi-speed internet, it reveals that the majority 39.7 percent, want to use the internet. For those using ADSL, 35.5 percent, they still want to use it. For those who are not using ADSL, 23.2 percent, want to use it within six months. For, the minority, 5.8 percent, they tend not to use the internet within one year.

For the ADSL transfer rate, the majority, 32.0 percent, of participants want to use 3 Mbps/512 Mbps (590 baht/month), for 6.5 percent, want to use 2 Mbps/512 Kbps (590 baht/month), and the minority, 1.5 percent, of participants want to use 16 Mbps/512 Mbps (2,200 baht/month) and 256Kbps/128 Kbps (490 baht/month).

Table 4.6: Reveals numbers and percentages of FTTx internet need of participants.

Description	N=400	Percentage
FTTx		
Yes, I do	227	56.8
No, I don't	155	38.8
Missing/ No answer/Skipped	18	4.5
User's attention install FTTx hi-speed internet		
Within 6 months	121	30.2
Within 1 year	57	14.2
More than 1 year	48	12.0
Missing/ No answer/Skipped	174	43.5

Description	N=400	Percentage
Price FTTx		
1/1 Mbps (950 baht/month)	157	39.2
2/2 Mbps (25,900 baht/month)	28	7.0
4/2 Mbps (60,900 baht/month)	10	2.5
more than 8/2Mbps (90,900 baht/month)	22	5.5
Others.....Mbps at..... baht/month	9	2.2
Missing/ No answer/Skipped	174	43.5

From table 4.6, when consider numbers and percentages of data about user's attention installed FTTx hi-speed internet, it reveals that the majority, 56.8 percent, of participants want to use FTTx hi-speed internet. For those who are not using the internet and want to use it, for 30.2 percent tend to install it within six months, another 12.0 percent tend not to install it within one year. For the FTTx hi-speed internet transfer rate, the majority, 39.2 percent, want to use 1/1 Mbps (950 baht/month), another 7.0 percent want to use 2/2 Mbps (25,900 baht/month).

Table 4.7: Reveals numbers and percentages of Cable modem internet need of participants.

Description	N=400	Percentage
Use Cable TV		
Yes, I did	176	44.0
No, I didn't	173	43.2
Will use Cable Modem		
Yes, I will	169	42.2
No, I will not	211	52.8
User's attention Install Cable modem hi-speed internet		
Within 6 months	74	18.5
Within 1 year	52	13.0
More than 1 year	45	11.2
Price cable Modem		
3 Mbps/512 kbps price 590 baht	79	19.8
4 Mbps/512 kbps price 690 baht	41	10.2
10 Mbps/512 kbps price 990 baht	23	5.8
12 Mbps/1 Mbps price 1,490 baht	22	5.5
Others…...Mbps at..... baht/month	6	1.5

From table 4.7, when consider numbers and percentage of data about user's attention install Cable modem Hi-speed internet. It reveals that the majority, 44.0 percent, of participants is now using Cable TV and 42.2 percent of them are interested in Cable modem Hi-speech internet but most of them, 52.8 percent, are not interested in it. For participants' attentions who want to install Cable modem hi-speed internet information, 18.5 percent of participants will install Cable modem Hi-speech internet within six months. 13.0 percent of them will install it within a year. Another 11.2 percent of them will not install within one year. For transfer rate, the majority,

19.8 percent, of participants want to use 3 Mbps/512 kbps (590 baht/Month), while another 10.2 percent of them want to use 4 Mbps/512 kbps (690 baht/Month).

Table 4.8: Reveals numbers and percentages of CDMA internet need of participants.

wireless interest	N=400	Percentage
CDMA		
Yes, I do	248	62.0
No, I don't.	132	33.0
When CDMA		
Within 6 months	129	32.2
Within 1 year	74	18.5
More than 1 year	45	11.2
Rate CDMA		
153 Kbps 20 hour/month at 99 baht/month	33	8.2
153 Kbps 08.01-17.00 at 259 baht/month	15	3.8
153 Kbps Unlimited at 599 baht/month	51	12.8
3.1 Mbps 20 hour/month at 590	29	7.2
baht/month	111	27.8
3.1 Mbps Unlimited at 790 baht/month	8	2.0
Others.....Mbps at.....baht/month		

From table 4.8, considering numbers and percentages of participant, it reveals that the majority, 62.0 percent, of participant wants to use CDMA, another 32.2 percent of who are not using the internet yet but plan to use it want to use CDMA within six months, and the minority, 18.5 percent want to use CDMA within one year, respectively. For transfer rate, the majority, 27.8 percent, of participants want to use 3.1 Mbps, 20 hour/month (590 baht/month), while another 12.8 percent want to use 153 Kbps Unlimited promotion (599 baht/month).

Table 4.9: Reveals numbers and percentages of EDGE/GPRS internet need of participants.

wireless interest	N=400	Percentage
EDGE/GPRS		
Yes, I do	222	55.5
No, I don't	158	39.5
When EDGE/GPRS		
within 6 month	143	35.8
within 1 year	48	12.0
more than 1 year	27	6.8
Rate EDGE/GPRS		
AIS, DTAC 3 hour/month at 30 baht/month	11	2.8
AIS, DTAC 6 hour/month at 50 baht/month	7	1.8
AIS, DTAC 20 hour/month at 99 baht/month	46	11.5
AIS, DTAC 50 hour/month at 199 baht/month	28	7.0
AIS, DTAC 100 hour/month at 350 baht/month	9	2.2
AIS, DTAC 140 hour/month at 399 baht/month	19	4.8
AIS, DTAC Package unlimited at 999 baht/month	13	3.2
True Package unlimited at 250 baht/month	41	10.2
True EDGE/GPRS + Wi-Fi unlimited at 450 baht/month	23	5.8
AIS,DTAC 1 hour at 20 baht/time	2	.5
AIS ,DTAC 2 hour at 30 baht/time	3	.8
AIS, DTAC 5 hour at 50 baht/time	0	0
AIS, DTAC 15 hour at 100 baht/time	5	1.2
DTAC 1 day at 39 baht/time	5	1.2
DTAC 7 day at 249 baht/time	2	.5
True 1 day unlimited at 10 baht/day	3	.8
True EDGE/GPRS + Wi-Fi 1 day unlimited at 20 baht/day	4	1.0
Others (please specify)…….....	1	.2

From table 4.9, when consider numbers and percentages of participant, it reveals that the majority, 55.5 percent, of participants are now using EDGE/GPRS via their mobile internet. For those who are not now using it, 35.8 percent of participants plan to use it within six months, and 12.0 percent of participants plan to use it within one year. For the transfer rate, the majority, 11.5 percent of participants want to use AIS, DTAC 20 hour/month (99 baht/month), 10.2 percent of participants want to use True Package unlimited (250 baht/month), and, the minority, 0.2 percent of participant want to use another transfer rate promotion.

Table 4.10 Reveals mean and standard deviation of satisfactory towards ADSL customers

Satisfactory level of ADSL customers	$\overline{X}$	**S.D.**	**Level**
ADSL hi-speed internet provided by public companies	3.11	0.840	moderate
Connection Equipment	3.16	0.770	moderate
ADSL internet service rate	3.16	1.138	moderate
ADSL data transfer rate	3.18	0.818	moderate
total	3.15	0.891	moderate

From table 4.10, when consider mean and standard deviation of satisfaction of ADSL customer, it reveals that the overall satisfaction of the majority of participants is Moderate, at the average at 3.15.

For each item analysis, it reveals that the average ADSL data transfer rate is 3.18, the average ADSL internet service rate and Connection Equipment is 3.16, and the average ADSL hi-speed internet provided by public companies 3.11.

Part 4: Data about using wireless interest

Table 4.11 Reveals mean and standard deviation of satisfaction towards CDMA High Speed Internet Service.

Satisfactory level for CDMA High Speed Internet Service	$\bar{X}$	**S.D.**	**Level**
CDMA High Speed Internet Provided by public companies	2.87	0.876	moderate
Connection Equipment	3.05	0.816	moderate
Connection Equipment Price	2.95	0.884	moderate
Internet Service Price	2.96	0.834	moderate
Data transfer rate	3.14	0.865	moderate
total	2.99	0.855	moderate

From table 4.11, when consider mean and standard deviation of satisfaction of High Speed Internet Service of CDMA customers, it reveals that the overall satisfaction of participants towards High Speed Internet Service of CDMA is Moderate, at the average at 2.99.

For each item analysis, it reveals that the overall satisfaction of participants towards the data transfer rate of CDMA is the highest, at the average at 3.14, then, towards connection equipment, at the average at 3.05, and, the lowest, CDMA High Speed Internet Provided by public companies, at the average at 2.87.

Table 4.12 Reveals mean and standard deviation of satisfaction towards EDGE/GPRS hi-speed Internet Service

Satisfactory Level for EDGE/GPRS hi-speed Internet Service	$\bar{X}$	**S.D.**	**Level**
EDGE/GPRS High Speed Internet Provided by public companies	3.03	0.813	moderate
Connection Equipment	3.09	0.792	moderate
Internet Service Price	3.05	0.857	moderate
Data transfer rate	2.94	0.850	moderate
total	3.02	0.828	moderate

From table 4.12, when consider mean and standard deviation of satisfaction towards EDGE/GPRS hi-speed Internet Service, it reveals that the overall satisfaction of participants towards EDGE/GPRS is Moderate, at the average at 3.02.

For each item analysis, it reveals that the overall satisfaction of participants towards the connection equipment of EDGE/GPRS hi-speed Internet Service is the highest, at the average at 3.09, then, towards internet service price, at the average at 3.05, and, the lowest, towards data transfer rate, at the average at 2.94.

Table 4.13: Reveals mean and standard deviation of satisfaction towards using the internet ADSL, CDMA, and EDGE/GPRS.

Satisfactory Level hi-speed Internet Service	$\bar{X}$	**S.D.**	**Level**
Satisfaction of ADSL	3.15	0.891	moderate
Satisfaction of CDMA	2.99	0.855	moderate
Satisfaction of EDGE/GPRS	3.02	0.828	moderate
total	3.05	0.858	moderate

From table 4.13, when consider mean and standard deviation of satisfaction towards hi-speed Internet Service, it reveals that the overall satisfaction of participants towards using the internet is Moderate, at the average at 3.05.

For each item analysis, it reveals that the overall satisfaction of participants towards ADSL Internet Service is the highest, at the average at 3.09, while, the overall satisfaction towards CDMA internet service is the lowest, at the average at 2.99.

Part 5: Problems and propositions

The participants have problems and propositions for internet use and each internet type need; ADSL, Cable Modem, CDMA, EDGE/GPRS; as followings,

- The instability of ADSL internet connection
- The need of internet accessible areas

4.2 Empirical Model Results

Part 6: result from model experiment

Results of regression analysis

The results for Multiple Regression to find which variable affect the demand of internet usage by using the pass 10 years of historical data to create the forecasting model and to check the accuracy of the model. There are two models here, the first model is the forecast model which is created from the pass 6 years of historical data and the model is created from the pass 8 years of historical data.

Model 1: Forecast model created from the past 6 years of historical data, from year 2543-2548

Initially, all eleven independent variable were deployed for the multiple linear regression analysis. The independent that are used in the equation are variable Lg UNEMP, Inv GDPCAP, Lg P_BACHEL_GRAD, P POPM6, TERTIA, Lg GDPTELE, FIXED_PENE, COM_PENE, Lg REAL ESTATE, SECONDARY and Lg GRGDP_ELEC. Variables Inv GDPCAP, Inv P_BACHEL_GRAD,

SECONDARY were excluded from the analysis because of the colinearity of the independent variable with high relation. Variable COM_PENE were also excluded from the analysis because of the Autocorrelation (Durbin Watson = 3.282). Variables that were passed to the equation were LG REAL ESTATE, LG GDPTELE and LG GRGDP_ELEC all of which passes the assumption relation test. As for the autocorrelation, Durbin Watson = 2.9 which is slightly over the limit, once the model is checked for it accuracy, the result shows that the error is more than 10% and it is very likely that this number increase as time progress.

Table 4.14 Result stepwise multiple regression analysis of model 1

Constant / Variable	**b**	**SE_b**	**Beta**	**t**	**P-value**
Constant (a)	-139.139	8.036		-17.314	.003
Lg REAL ESTATE	9.967	.372	.679	26.792	.001
Lg GDPTELE	18.169	1.649	.263	11.020	.008
Lg GRGDP_ELEC	-.646	.107	.679	-6.025	.026
SE_{est}=±. 0.05631 R= 1.00 ; R^2= 1.00 ; F = 4494.3533; p-value =.000 Dubbin-Watson = 2.960					

From table 4.14, in Stepwise Multiple Linear Regression analysis, there is a significant relationship between P_POPUSENET and P_BACHEL_GRAD that correlation coefficient is 1.0, all of which passes the assumption relation test. As for the autocorrelation, Durbin Watson = 2.960 which is slightly over the limit, once the model is checked for it accuracy, the result shows that the error is more than 10% and it is very likely that this number increase as time progress.

Model forecasting of population that needs to use internet

The basic regression equation is shown as follow

P_POPUSENET = -139.139+ 9.967(Lg REAL ESTATE) +18.169 (Lg GDPTELE) -.646(Lg GRGDP ELEC) … (23)

Table 4.15 Display the variables of model 1

Year	Lg REAL ESTATE	Lg GDP TELE	Lg GRGDP ELEC
2549	4.8269072599	5.7536971707	2.3504972471
2550	4.7438068569	5.7968905731	2.2326607568
2551	4.7656834904	5.8097616651	2.1043366598
2552	4.7540834347	5.8111183545	-0.1520030934

Substitute X in table 4.15 in the 23th equation

Table 4.16 Display the data of the accuracy of the forecasting of model 1

No.	Year	Yf	Yact	error	Error2	%error
1	2549	11.99	12.96	0.97	0.94	7.48%
2	2550	12.02	14.16	2.14	4.58	15.11%
3	2551	12.55	16.58	4.03	16.24	24.30%
4	2552	13.92	18.49	4.57	20.88	24.71%
						MAPE = 17.9%

$$MSE = \frac{42.64}{4} = 10.66$$

Table 4.17 Display the error detected by using moving average forecasting model of model 1

year	The need of internet (% person) (Yt)	Prediction (%person) (Ft)	Error= $\|At - Ft\|$
2543	3.68	-	-
2544	5.61	-	-
2545	7.56	-	-
2546	9.43	-	-
2547	10.77	-	-
2548	10.92	7.41	3.51
2549	12.96	8.86	4.1
2550	14.16	10.32	3.84
2551	16.58	11.64	4.94
2552	18.49	13.07	5.42
2553		14.62	-

$\sum |At - Ft| = 21.81$

MAD = $\frac{\sum |At-Ft|}{n} = \frac{21.81}{5} = 4.36$

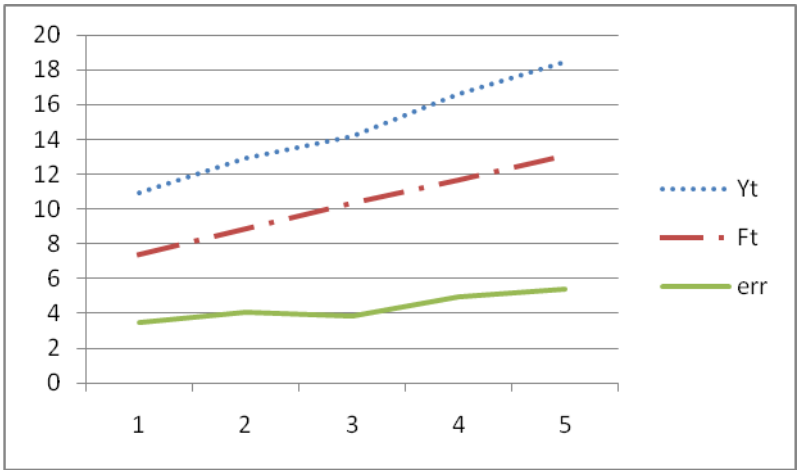

Figure 4.1 Graph shows the actual value and the forecast value

Table 4.18 Adjust the parameters with moving average of model 1

year	Yf	The need of internet (% person) (Yt)	Prediction (%person) (Ft)	Error= $\|At - Ft\|$
2543	-	3.68	-	-
2544	-	5.61	-	-
2545	-	7.56	-	-
2546	-	9.43	-	-
2547	-	10.77	-	-
2548	-	10.92	7.41	3.51
2549	11.99	12.36	8.86	3.5
2550	12.02	13.02	10.2	2.82
2551	12.56	15.27	11.3	3.97
2552	13.93	21.31	12.47	8.84
2553			14.57	-
				$\sum \|At - Ft\| = 22.64$

MAD $= \frac{\sum |At-Ft|}{n} = \frac{22.64}{5} = 4.52$

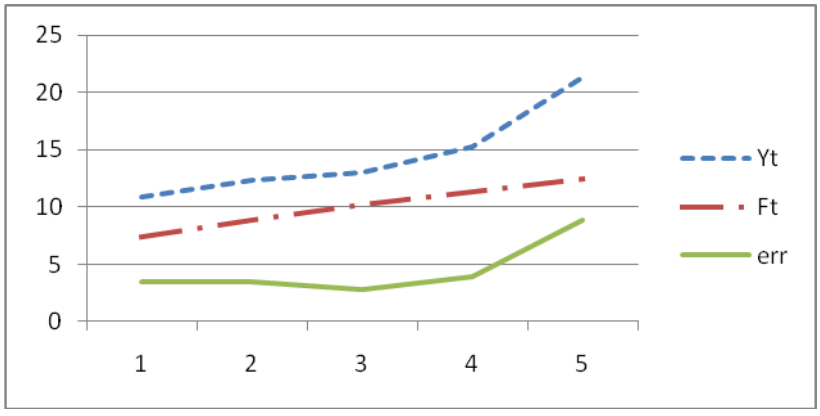

Figure 4.2 Graph shows adjust the parameters of actual value and the forecast value

Reason for result deviation

The analysis shows that the forecast for year 2548 - 2552 have slip more than 10% of the forecast result. The primary reason for this is at that time, the ADSL market stared to be popular and the government supports the consumer to use ADSL. Moreover, many ISP were born at a rapid pace and some variables in equation are economic variables. The values of the variables are quite stable. The reason that led economic variable to research in the equation because it was found that GDP is a variable that affects the need to use the Internet which is why the result of the forecast is slightly off from the actual fact.

Model 2: Forecast model created from the past 10 years of historical data, from year 2543-2550

Initially, all ten independent variable were deployed for multiple linear regression analysis. The independent variables used in the equation are Lg UNEMP, Lg GDP CAP, P BACHEL GRAD, Lg P POPM6, TERTIARY, GDP TELE, FIXED_PENE, COM_PENE, Lg REAL ESTATE and SECONDARY. Variable Lg UNEMP and variable COM_PENE were excluded from the analysis because it doesn't pass accuracy of model test .Also, variable Lg GDP CAP was also excluded because once we consider the assumption of the linear regression, variable Lg GDP CAP has an Autocorrelation (Durbin Watson = 0.866) and unstable error. The variable that is next used in the analysis is the variable P BACHEL GRAD which has the level of significant of 0.01 and passes the accuracy of model test, therefore this variable is the variable that affect the result of internet demand as shown in table 4.20.

Table 4.19 Correlation matrix (Pearson correlation) of model 2

Variable	X	Y
X P_BACHEL_GRAD		.965**
Y P_POPUSENET	.965**	

*p<.05 **P<.01 ***p<.001

Table 4.19 reveals that there is a positive and significant relation between P_BACHEL_GRAD and P_POPUSENET at .01 (r=.965, P < .01).

Part 7 Data of prediction influence on the future internet use by multiple linear regression

Table 4.20 Result stepwise multiple regression analysis of model 2

Constant / Variable	**b**	**SE_b**	**Beta**	**t**	**P-value**
Constant (a)	-14.532	3.021		-4.811	.005
P_BACHEL_GRAD	3.609	.438	.965	8.235	.000
SE_{est}=±. 0.85091 R=.965 ; R^2=.931; F = 67.820; p-value =.000 Dubbin-Watson = 1.866					

All Value:

t-ratio = result calculated from SPSS

P-value = Significant of T-Statistics

R^2 = correlation coefficient (showing the relationship between independent and dependent variable.

S.E.E. = Standard Error of Estimation (showing the deviation of the equation estimation)

Durbin –Watson = Showing that error of the equation is independent (no autocorrelation)

From table 4.20, in Stepwise Multiple Linear Regression analysis, there is a significant relationship between P_POPUSENET and P_BACHEL_GRAD that correlation coefficient is .965 and it can predict P_POPUSENET correctly at 93.1 percentages, at significant level at.05. The standard deviation of the prediction is ±.0.85091

Based on the regression coefficients of predictors, P_BACHEL_GRAD were able to predict the need to use the internet at the level of significance of .05. The

regression coefficient and regression coefficients in standard scores (b,β) is 3.609 and .965

Model forecasting of population that needs to use internet

The basic regression equation is shown as follow

P_POPUSENET = -14.532 + 3.609 (P_BACHEL_GRAD) … (24)

Standardized regression equation is shown as follow

P_POPUSENET = .965 (P_BACHEL_GRAD) … (25)

From Multiple Linear Regression equation 24th, it reveals that the equation has R^2 =.931 which means that the independent variable can correctly predict the deviation of internet need at 93.1 percentages and other variable can correctly predict the internet need at 6.9 percentages.

At any rate, the other variable is constant when P_BACHEL_GRAD (X) increases unit --- (person), which causes P_POPUSENET (Y) increase 3.609 people as well.

The coefficient of P_BACHEL_GRAD independent variable has positive value which can describe relationship between P_BACHEL_GRAD (increase, decrease) with P_POPUSENET (Y) (increase, decrease) in the same direction.

Part 8 Accuracy Comparison of Model

From Part 7, the prediction equation of the need of internet use (24th equation) which is use to predict the need of internet use, as, P_POPUSENET and P_BACHEL_GRAD. (show in table 4.21)

Table 4.21 Display data dependent variable and independent variable for accuracy of model.

Year	P_POPUSENET_100 (Y)	P_BACHEL_GRAD (X)
2550	16.58	8.29
2551	18.49	8.69

Then substitute P_BACHEL_GRAD in the prediction equation (24^{th} equation) in order to find Forecast data (Y'_F) of the internet user number. (show in table 4.22)

Test the accuracy of forecasting

Researcher tested the accuracy of forecasting Divided into two parts. At first, the Plot graph to compare the forecasted and actual values to check the accuracy of forecasting using the Mean Square Error, MSE and Mean Absolute Percentage Error, MAPE as a basis of comparison.

Part 1 Graph shows the actual value and the forecast value of model 2

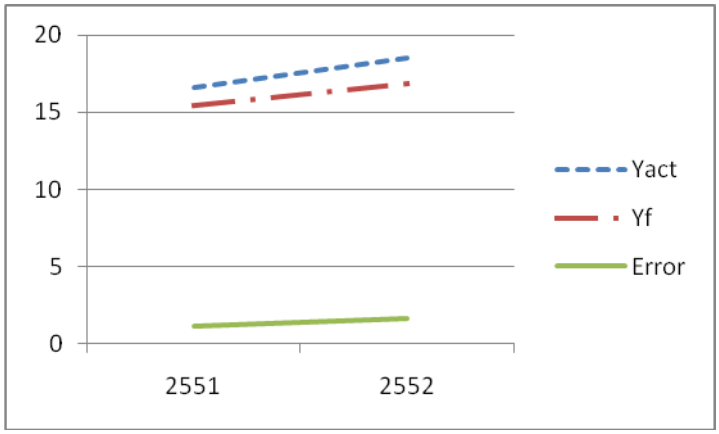

Figure 4.3 Graph shows the actual value and the forecast value of model 2

Part 2 Forecasting the need to use the internet and error measurement

Table 4.22 Test the accuracy of forecasting

Year	Y'_F	Y_{ACT}	Error	% error
2551	15.41	16.58	1.17	7.5%
1552	16.85	18.49	1.64	8.86%

Note: Y_{ACT} = Actual data, Y'_F= Forecast data

$$MSE = \frac{7.8961}{2} = 3.9480$$

$$MAPE = 0.1586 * (100/2) = 7.9348$$

Part 9 Internet expansion plan

At first, take P_BACHEL_GRAD independent variable of each required area to calculate with the prediction model (24^{th} equation) in order to find P_POPUSENET**.** Then, use P_POPUSENET to compare with the portions of each internet type preferred by internet users, based on the data shown in Table 4.26, in order to find to the number of each internet type users.

Table 4.23 Display data dependent variable and independent variable each provinces

No.	Province	P_BACHEL_GRAD (X)
1	Chiang Mai	12.22
2	Lamphun	9.87
3	Lampang	7.73
4	Uttaradit	6.64
5	Phrae	7.70
6	Nan	8.98
7	Phayao	6.31

No.	Province	P_BACHEL_GRAD (X)
8	Chiang Rai	5.58
9	Mae Hong Son	4.62
10	Nokhon Sawan	5.47
11	Uthai Thani	6.03
12	Kamphaeng Phet	5.64
13	Tak	4.48
14	Sukhothai	5.61
15	Phitsanulok	7.60
16	Phichit	6.06
17	Phetchabun	6.42
18	Nakhon Ratchasima	6.79
19	Buri Ram	4.38
20	Surin	4.62
21	Si Sa Ket	4.74
22	Ubon Ratchathani	5.49
23	Yasothon	6.01
24	Chaiyaphum	4.14
25	Am Nat Charoen	7.55
26	Nong Bua Lam Phu	5.39
27	Khon Kaen	6.61
28	Udon Thani	6.62
29	Loei	5.86
30	Nong Khai	6.07
31	Maha Sarakham	6.64
32	Roi Et	5.58
33	Kalasin	5.39
34	Sakon Nakhon	5.72
35	Nakhon Phanom	5.30
36	Mukdahan	6.90
37	Nakhon Si Thammarat	8.02

No.	Province	P_BACHEL_GRAD (X)
38	Krabi	8.00
39	Phangnga	7.33
40	Phuket	12.63
41	Surat Thani	7.49
42	Ranong	6.40
43	Chumphon	8.24
44	Songkhla	12.00
45	Satun	7.64
46	Trang	8.79
47	Phatthalung	6.00
48	Pattani	5.36
49	Yala	5.33
50	Narathiwat	5.78
51	Samut Prakan	12.72
52	Nonthaburi	21.96
53	Pathum Thani	11.33
54	Phranakhon Si Ayutthaya	9.89
55	Ang Thong	8.90
56	Lop Buri	8.97
57	Sing Buri	9.91
58	Chai Nat	7.04
59	Saraburi	7.71
60	Chon Buri	10.85
61	Rayong	9.96
62	Chanthaburi	7.14
63	Trat	5.27
64	Chachoengsao	8.19
65	Prachin Buri	5.85
66	Nakhon Nayok	7.14
67	Sa Kaeo	6.30

No.	Province	P_BACHEL_GRAD (X)
68	Ratchaburi	7.21
69	Kanchanaburi	5.89
70	Suphan Buri	5.98
71	Nakhon Pathom	8.87
72	Samut Sakhon	9.54
73	Samut Songkhram	7.93
74	Phetchaburi	7.82
75	Phachuap Khiri Khan	7.36
76	Bangkok	19.35

Table 4.24 Result of model forecasting, percentage of people that need to use internet in each provinces.

Arranged demand	Province	P_POPUSENET (Y_f)
1	Nonthaburi	64.74
2	Bangkok	55.31
3	Samut Prakan	31.40
4	Phuket	31.05
5	Chiang Mai	29.58
6	Songkhla	28.80
7	Pathum Thani	26.36
8	Chon Buri	24.65
9	Rayong	21.43
10	Sing Buri	21.24
11	Phranakhon Si Ayutthaya	21.17
12	Lamphun	21.11
13	Samut Sakhon	19.91
14	Nan	17.88
15	Lop Buri	17.88
16	Ang Thong	17.60

Arranged demand	**Province**	**P_POPUSENET (Y_f)**
17	Nakhon Pathom	17.51
18	Trang	17.19
19	Chumphon	15.21
20	Chachoengsao	15.05
21	Nakhon Si Thammarat	14.42
22	Krabi	14.37
23	Samut Songkhram	14.10
24	Phetchaburi	13.70
25	Lampang	13.39
26	Saraburi	13.33
27	Phrae	13.28
28	Satun	13.06
29	Phitsanulok	12.90
30	Am Nat Charoen	12.72
31	Surat Thani	12.52
32	Phachuap Khiri Khan	12.06
33	Phangnga	11.93
34	Ratchaburi	11.52
35	Chanthaburi	11.24
36	Nakhon Nayok	11.24
37	Chai Nat	10.89
38	Mukdahan	10.39
39	Nakhon Ratchasima	10.00
40	Maha Sarakham	9.46
41	Uttaradit	9.45
42	Udon Thani	9.38
43	Khon Kaen	9.34
44	Phetchabun	8.65
45	Ranong	8.58
46	Phayao	8.28

Arranged demand	**Province**	**P_POPUSENET (Y_f)**
47	Sa Kaeo	8.23
48	Nong Khai	7.37
49	Phichit	7.35
50	Uthai Thani	7.25
51	Yasothon	7.18
52	Phatthalung	7.15
53	Suphan Buri	7.07
54	Kanchanaburi	6.76
55	Loei	6.62
56	Prachin Buri	6.58
57	Narathiwat	6.35
58	Sakon Nakhon	6.11
59	Kamphaeng Phet	5.85
60	Sukhothai	5.72
61	Roi Et	5.64
62	Chiang Rai	5.61
63	Ubon Ratchathani	5.29
64	Nokhon Sawan	5.23
65	Kalasin	4.95
66	Nong Bua Lam Phu	4.94
67	Pattani	4.84
68	Yala	4.72
69	Nakhon Phanom	4.61
70	Trat	4.50
71	Si Sa Ket	2.58
72	Mae Hong Son	2.17
73	Surin	2.16
74	Tak	1.65
75	Buri Ram	1.28
76	Chaiyaphum	0.43

Questionnaire result

Table 4.25 Number and percentage of respondent wants to use each type of internet.

Type of internet	**N = 400 (case) (missing = 20)**	**Number of respondent**	**Percentage of respondent**
ADSL total	380	285	75 %
ADSL now use	380	135	35%
ADSL want use	380	151	39%
FTTX	380	227	59%
Cable	380	166	43%
CDMA	380	243	63%
EDGE/GPRS	380	222	58%
Total	380 case	1144	297%

Table 4.26 Number and percentage of respondents want to use each type of internet in each sample provinces.

Province		**ADSL**	**FTTx**	**Cable modem**	**CDMA**	**EDGE/ GPRS**
Bangkok (N=203)	Sum	156	124	109	132/	125
	Percentage	**76%**	**61%**	**53%**	**65%**	**61%**
Nakhon ratchasrima (N=91)	Sum	73	58	26	44	48
	Percentage	**80%**	**63%**	**28%**	**48%**	**52%**
Songkhla (N=47)	Sum	25	17	15	34	28
	Percentage	**53.1%**	**36.1%**	**31.9%**	**72.3%**	**59.5%**
Changmai (N=59)	Sum	32	27	16	34	21
	Percentage	**54%**	**45%**	**27%**	**57%**	**35%**

Table 4.27 Percentages of participants need to use each type of internet (ADSL, FTTX, Cable Modem, CDMA, EDGE/GPRS) in each sample provinces.

Province	**The need of internet (%)**	**The need of internet (person)**	**Type of internet**	
Chiang Mai	29.58	439,338	ADSL	237,242
			FTTX	197,702
			Cable modem	118,621
			CDMA	250,422
			EDGE/GPRS	153,768
Bangkok	55.31	3,479,239	ADSL	2,644,221
			FTTX	2,122,335
			Cable modem	1,843,996
			CDMA	2,261,505
			EDGE/GPRS	2,122,335
Nakhon Ratchasrima	10.00	254,877	ADSL	203,901
			FTTX	160,572
			Cable modem	71,365
			CDMA	122,340
			EDGE/GPRS	132,536
Songkhla	28.80	371,564	ADSL	196,928
			FTTX	133,763
			Cable modem	115,184
			CDMA	267,526
			EDGE/GPRS	219,222

Part 10: Spatial display with GIS

Percentage of people that need to use internet in each provinces.

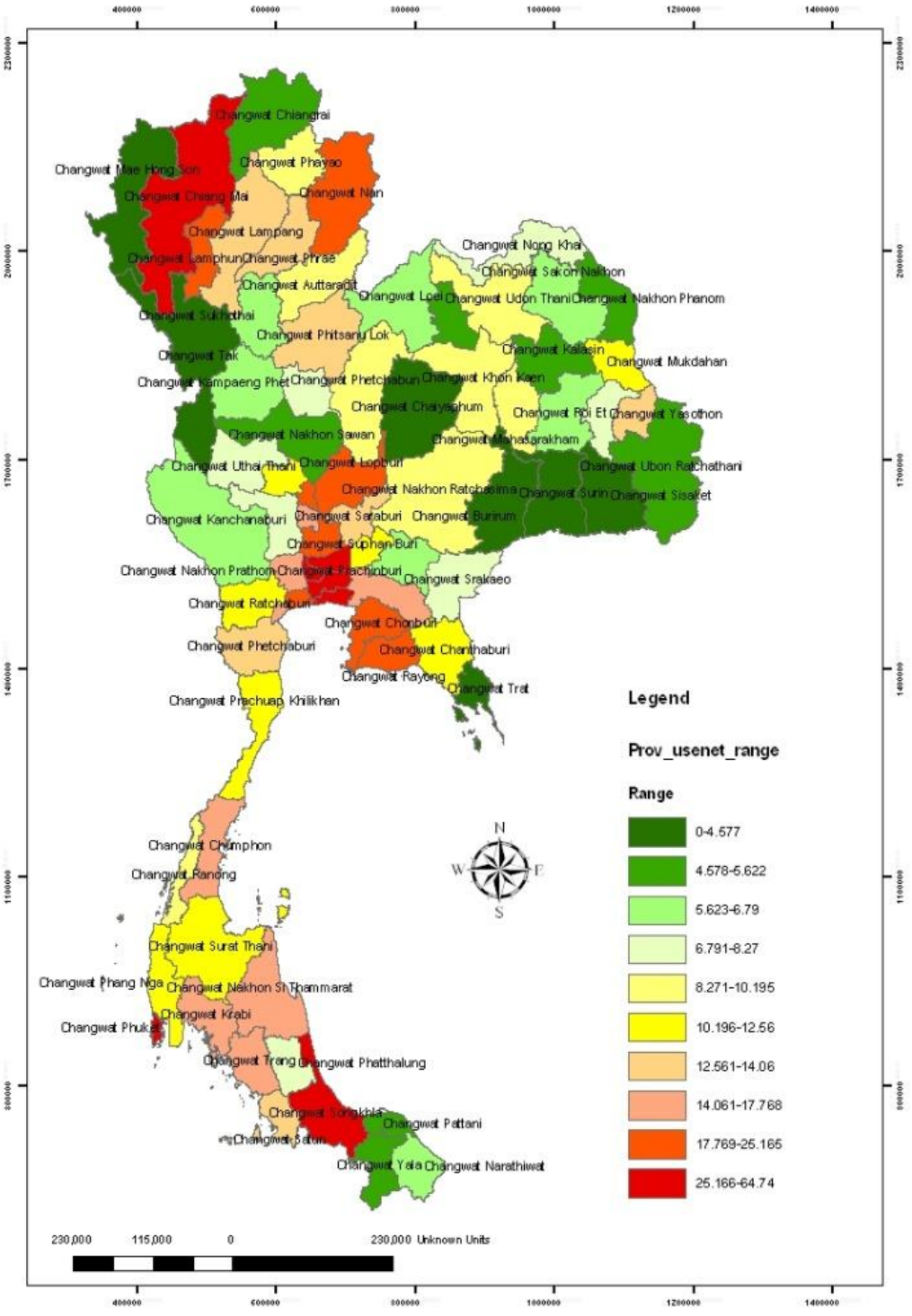

Figure 4.4 The need to use internet in each provinces.

Number of people that need to use ADSL internet in sample provinces

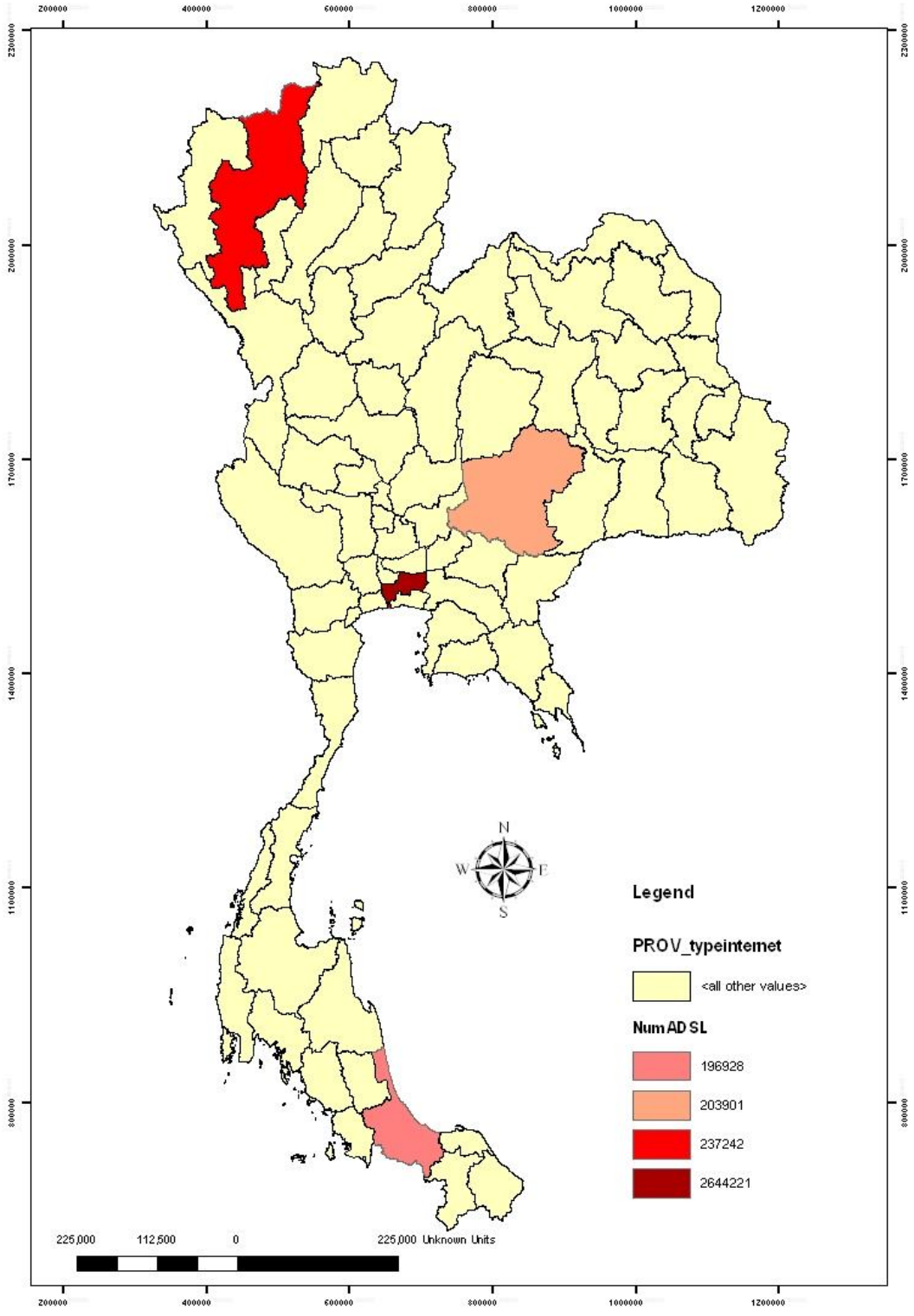

Figure 4.5 The need to use ADSL internet in sample provinces

Number of people that need to use FTTX internet in sample provinces

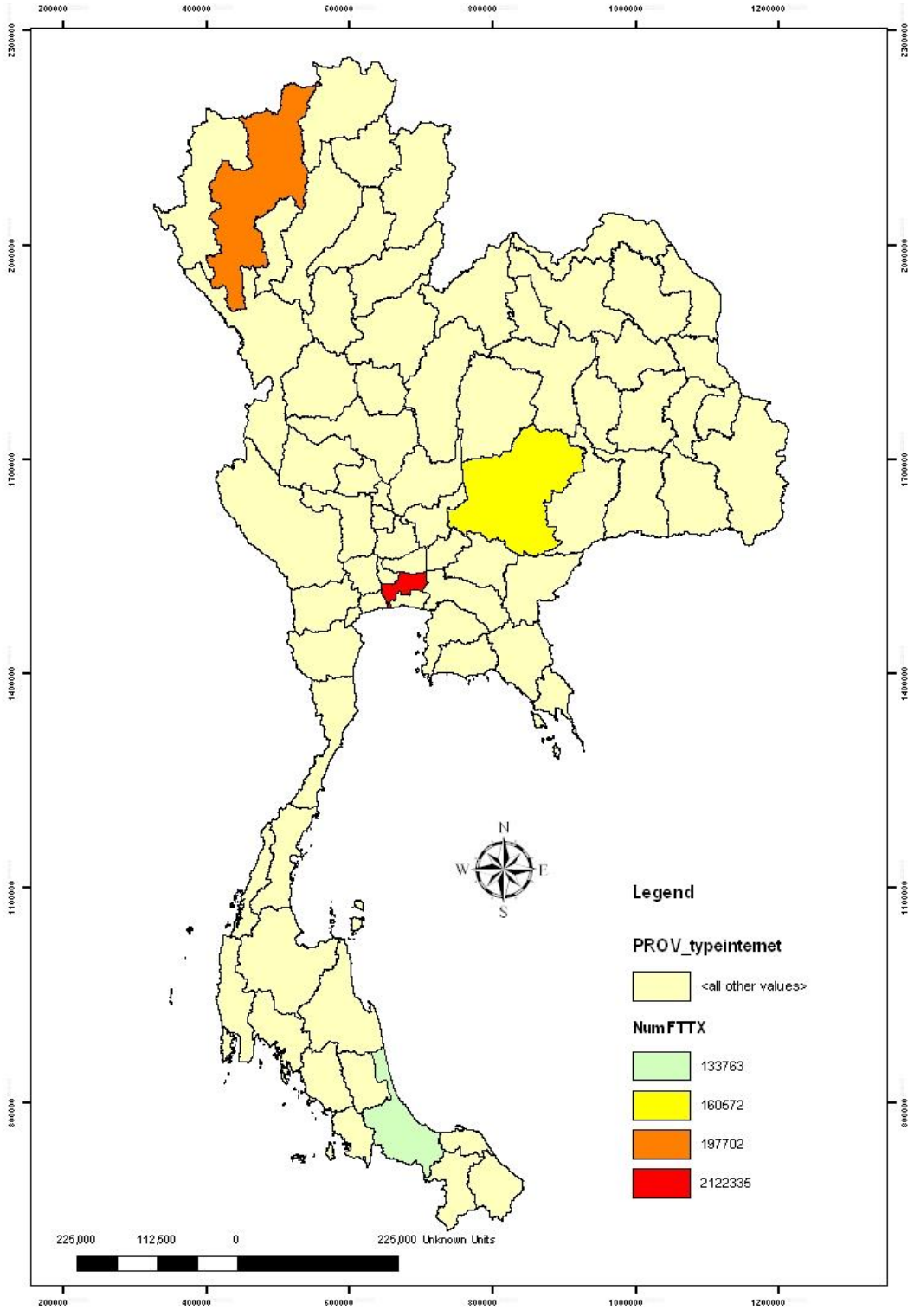

Figure 4.6 The need to use FTTX Internet in sample provinces

Number of people that need to use Cable Modem internet in sample provinces

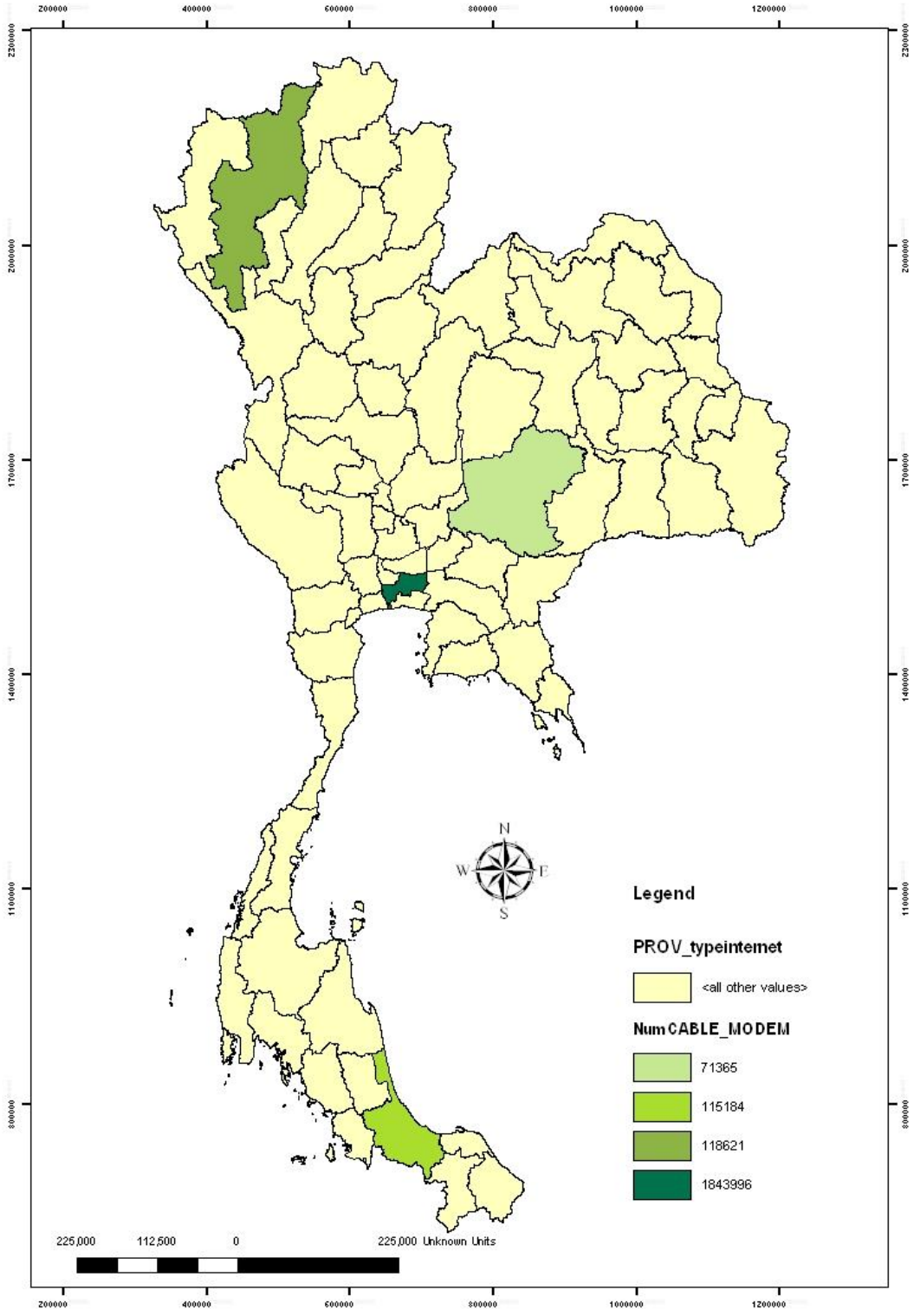

Figure 4.7 The need to use Cable Modem internet in sample provinces

Number of people that need to use CDMA Internet in sample provinces

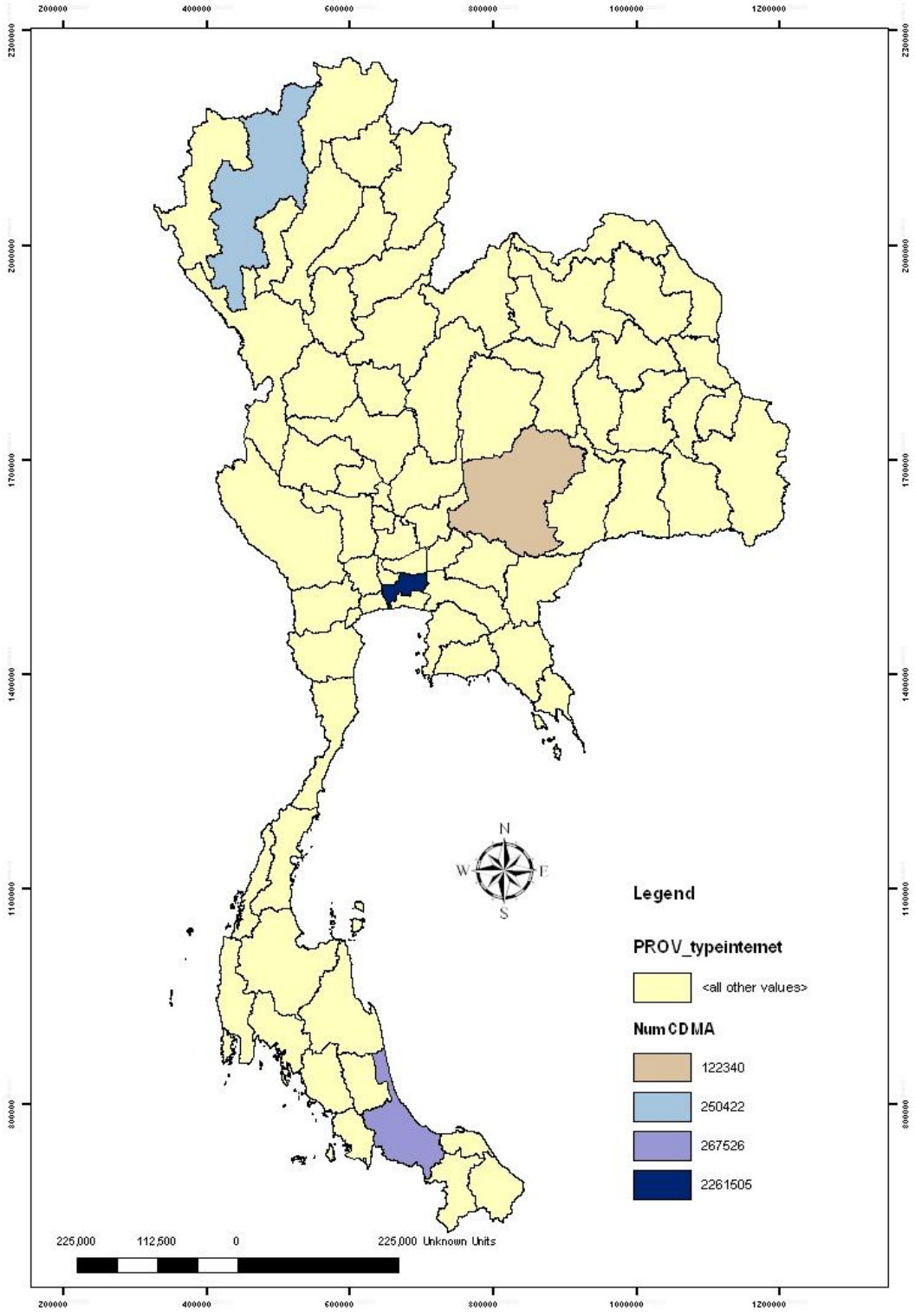

Figure 4.8 The need to use CDMA internet in sample provinces

Number of people that need to use EDGE/GPRS internet in sample provinces

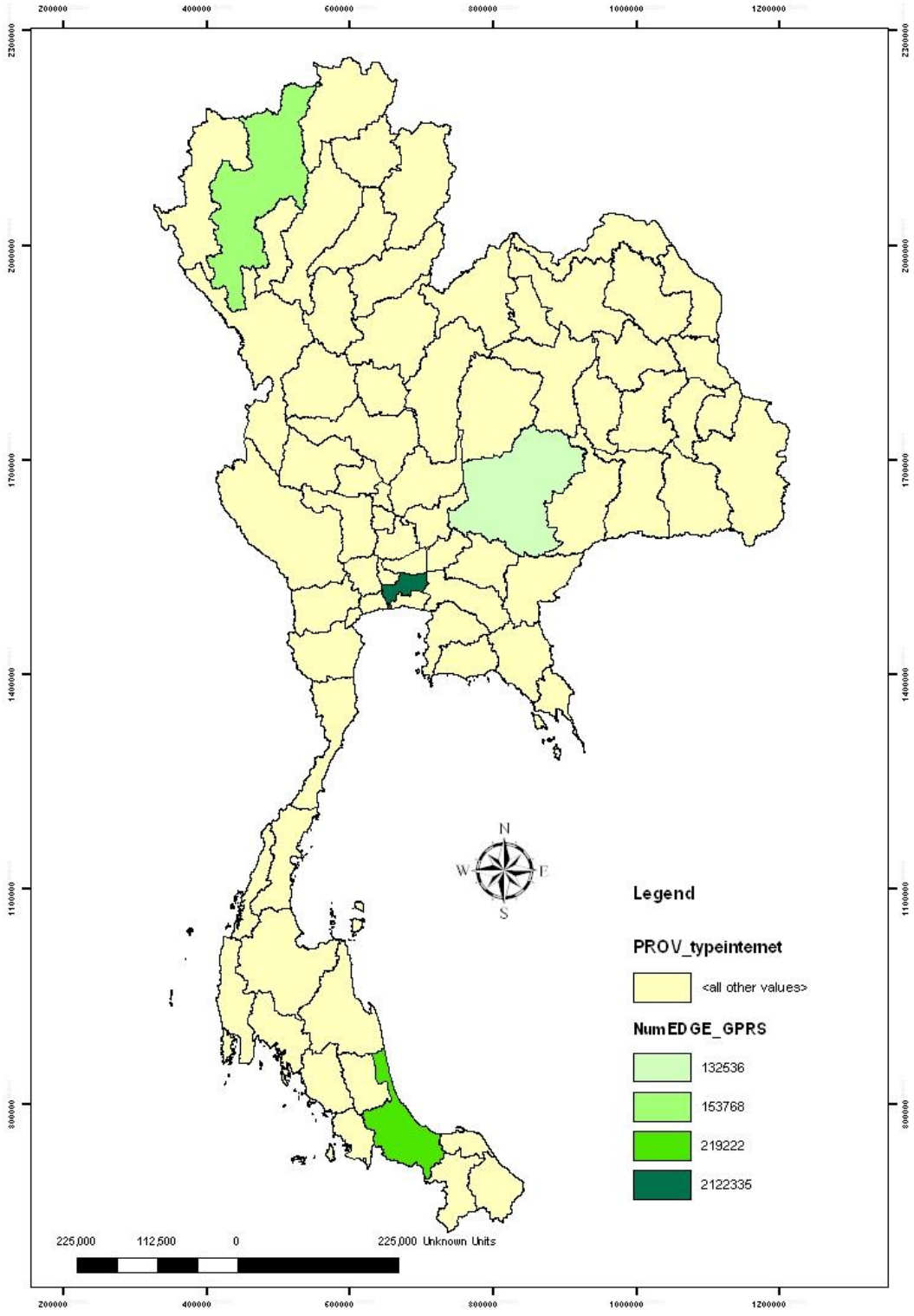

Figure 4.9 The need to use EDGE/GPRS internet in sample provinces

CHAPTER V
DISCUSSION

The Result Discussion

In the study, Planning for high speed internet service expansion, there is an analysis used to create the empirical model which has P_BACHEL_GRAD as the independent variable and P_POPUSENET as the dependent variable. The result of the empirical model experiment is shown as follow.

The basic regression equation is shown as follow

P_POPUSENET = -14.532 + 3.609 (P_BACHEL_GRAD) … (24)

The hypothesis of the study is there is a positive and significant relationship between the P_BACHEL_GRAD and P_POPUSENET. The result reveals that there is a positive and significant relationship between P_BACHEL_GRAD and P_POPUSENET at .01 ($r = .965$, $P < .01$), and the P_BACHEL_GRAD variable can predict the P_POPUSENET variable at 93.1%, at the significant level at .01, as calculated beforehand.

The result reveals that the coefficient of P_BACHEL_GRAD independent variable has positive value which can describe relationship between POPULATION SIZE (increase, decrease) with P_POPUSENET (Y) (increase, decrease) in the same way all the time. This means that if there is big number of percentage of employees with the minimum qualification of a bachelor degree(or up) in each particular area, there would be a strong need of the internet in that particular area, and vice versa.

The result of this study also matches with the result from previous literatures such as The NTIA(1995, 1998, 1999, 2000, 2002) found a strong correlation between internet access and level of education attained (Chaudhuri et al., 2005). Martha Garcia-Murillo (2005) found level of education have positive impact on the number of subscribers. Sampsa Kiiski and Matti Pohjola, (2002) found education variable a statically significant predictor of its diffusion of the internet. Chaudhui, Flamm and Horrigan (2005) found the influences of traditional socio-demographic

variables like education on broadband deployment are strong. Savage and Waldman (2005) found that preference for high-speed access is apparent among higher income and college-educated households. Some previous empirical studies on fixed broadband deployment suggest that high levels of education are positively correlated with broadband penetration (Horrigan, 2005; Chaudhuri et al., 2005; Clements and Abramowitz, 2006; Trkman et al., 2008). Horrigan's recent survey demonstrates younger age, higher education and income, and urban living share of population may lead to greater broadband adoption (Horrigan, 2007). Badran, El Sherbini & Ragab (2009), found School enrollment especially the tertiary level of education is a significant determinant of the broadband uptake in these countries.

CHAPTER VI
CONCLUSION AND RECOMMENDATION

This study is quantitative analysis investigates demand trend to use Hi-speed internet for services plan expansion which examined the variables associated with demand to use internet, focusing on several distribution variable such as Educational variable, Population distribution variable, Income variable, Economic variable, Investment variable that affect the extent of internet use. Here are the objectives of the study.

1. To understand the trend of high speed internet demand
2. To prioritize ADSL service

From the questionnaires survey, the population of the study is Thai population collected from one province of each region in Thailand. Each province has well economy judging from tax gathering per capital GDP and GPP. The sampling method is random sampling technique. The samples were collected from population in Chiang mai, Nakhon Ratchasrima, Bangkok and Songkhla. The researcher calculated sample group with Yamane's (1967) formula using 400 samples and weight with number of population for calculating sample group in each province. The level of significant is at 0.05 and 95 % of confidential level. The researcher used questionnaire to gather data from responders and adjustment and find reliability with Cronbach's Alpha Coefficient. Finally, correct by the supervisor.

From the empirical model, P_BACHEL_GRAD is the independent variable and P_POPUSENET is the dependent variable. There are two dataset used to construct the model, the first set is the historical data of internet usage in Thailand 10 years ago. Using the first 6 years (2543-2548) as the data to create the model and the later 4 years (2549-2552) to check the accuracy of the model. The second set uses the same data as the first set but use the first 8 years to construct the model and the later 2 years to check for accuracy. The model accuracy test by using the statistical analysis

on the MSE and the MAPE. After the country wide model is created and pass the accuracy test, the model is then used to forecast at provincial wide level. The provincial wide forecast is done by taking the variable P_BACHEL_GRAND(X) in each province then substitute them into the country wide model. The result will be the percentage of the internet demand in each province. Afterward, the survey result from Chieng Mai, Bangkok, Nakorn ratchasrima, and Songkhla are processed and result from the forecasting model, then take the result and multiply with the percentage of the demand of each internet type (ADSL, FTTX, Cable model, CDMA, EDGE/GPRS) in each province. The final result is the number of people that need to use each specific type of internet in each province.

6.1 Conclusion

Questionnaire survey

General information of respondent

From the study of planning for high speed internet service expansion, it reveals that the sample has following characteristics; the majority, 55.2 percent of participants is students also match with Pasika Yoowatana, (2007) whose income, 40.0 percent, is about 5,001 – 10,000 Baht/month. The majority, 72.5 percent, has Certificate Undergraduate education this result also matches with the result from previous literatures such as Pasika Yoowatana, (2007) and Santi Sukarnjanapria, (2550). The previous studies of Savage and Waldman (2005) found that preference for high-speed access is apparent college-educated households. For the internet use data, the majority, 86.5 percent of participants are now using the internet, while the rest is for whom never use internet. 6.2 percent of participants plan to use internet within six months. Besides, for the family which plan to use internet at home, there will be at least 2 Household sizes in that family, or 30.5 percent that match with research of Santi Sukarnjanapria, (2550). Regard to the objective of internet use, the majority, 66.5 percent of participants use internet to search information also match with Pasika Yoowatana, 2007. Regard to the type of the internet, the majority, 71.5 percent of participants uses ADSL hi-speed internet, and 61.0 percent of participants tend to use CDMA internet service.

Wire line Internet

ADSL: the majority, 35.5 percent of participants is now using ADSL. For the rest who are not yet using ADSL, they, 23.2 percent plan to have it within six months. For ADSL transfer rate, the majority, 32.0 percent of participants want to use 3 Mbps/512 Mbps (590 baht/month)

FTTx: the majority, 56.8 percent of participants want to use FTTx hi-speed internet. For the rest who are not yet using it, they, 30.2 percent plan to have it within six months. For FTTx transfer rate, the majority, 39.2 percent of participants want to use 1 Mbps/1 Mbps (950 baht/month)

Cable modem: 42.2 percent of participants are interested in Cable modem Hi-speed internet but most of them, 52.8 percent, are not interested it. 18.5 percent of participants will install Cable modem Hi-speech internet within six months. For Cable modem transfer rate, the majority, 19.8 percent of participants want to use 3 Mbps/512 Mbps (590 baht/month)

Findings of Wire Line Internet Data Analysis

The overall satisfaction of ADSL internet use is Moderate. When consider each aspect, it reveals that the satisfaction of every aspect is Moderate also. In details, the highest satisfaction is the data transfer rate, connection equipment, and internet service rate of ADSL.

Wireless Internet

CDMA, the majority, 62.0 percent of participants want to use CDMA. For the rest who are not yet using it, they, 32.2 percent plan to have it within six months. For CDMA transfer rate, the majority, 27.8 percent of participants want to use 3.1 Mbps/1 Mbps, 20 hours/month (590 baht/month)

EDGE/GPRS, the majority, 55.5 percent of participants is now using EDGE/GPRS via internet mobile. For the rest who are not yet using EDGE/GPRS, they, 35.8 percent plan to have it within six months. For EDGE/GPRS transfer rate, the majority, 11.5 percent of participants want to use AIS, DTAC 20 hour/month (99 baht/month)

Findings of Wireless Internet Data Analysis

The overall satisfaction of CDMA internet use is Moderate. When consider each aspect, it reveals that the satisfaction of every aspect is Moderate also. In details, the highest satisfaction is ADSL data transfer rate and connection equipment.

The overall satisfaction of EDGE/GPRS internet use is Moderate. When consider each aspect, it reveals that the satisfaction of every aspect is Moderate also. In details, the highest satisfaction is connection equipment and EDGE/GPRS High Speed Internet Provided by public companies.

Problems and propositions

The participants have problems and propositions for internet use and each internet type need; ADSL, Cable Modem, CDMA, EDGE/GPRS; as followings,

1. The instability of ADSL internet connection
2. The need of internet accessible areas

Empirical model

For finding of what factors have influence towards using internet, P_BACHEL_GRAD has a positive relationship with P_POPUSENET at significant level of .01 ($r = .965$, $P < .01$) and P_BACHEL_GRAD variable can predict P_POPUSENET variable correctly 93.1 percentages at significant level at .01. The prediction equation can be made in standard form, as P_POPUSENET =.965(P_BACHEL_GRAD)

Hypothesis Results

The result reveals that the result is in accordance with the researcher hypothesis which is there is a positive and significant relationship between P_BACHEL_GRAD and P_POPUSENET.

6.2 Limitations of the Study and Recommendations for Future Study

There are some limitations in this study. Firstly, this study focuses on the case of general people who want to use internet only. Therefore, this research might not be able to be applied to other particular areas such as businessmen who want to use Internet because the samples have different characteristics.

Secondly, the rapid adoption of the broadband/internet technology in the consumer marketplace, the number of people who use broadband internet has increasing. The changes in the market potentially mean large changes in the demographics of the broadband use community which means that the prediction model still works if both variables still share the common relationship. If not, a new prediction model is needed.

Thirdly, there is a limitation of data being predicted, so it is impossible to use all significant variables to absolutely predict the internet use.

Fourthly, the study reflects only the result of high financial status samples chosen from one high financial status province of each region. Thus, it is impossible to refer to people who are in bad financial status province.

For recommendations in this study, the result reveals that P _BACHEL_GRAD is the factor can predict the internet use need. It means that if an area has high percentage of employees with the minimum qualification of a bachelor degree; the need of internet use of that area will be high, and vice versa. Therefore, the internet provider should provide internet expansion in the area which has low number of percentage of employees with the minimum qualification of a bachelor degree area so that it will be worthwhile investing.

For recommendations for future study

Firstly, the researcher recommends future study researcher to study other types of prediction models to measure the internet use. It would be better to present other types of prediction model which is more flexible in collecting data.

Secondly, the researcher recommends future study researcher to collect data from different financial status, high and low financial status, so that there would be different findings.

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APPENDICES

APPENDIX A

The determining sample sizes of Taro Yamane' formula

Number of population	Significant level					
	± 1%	± 2%	± 3%	± 4%	± 5%	± 10%
500	b	b	b	b	222	83
1,000	b	b	b	385	286	91
1,500	b	b	638	441	316	94
2,000	b	b	714	476	333	95
2,500	b	1,250	769	500	345	96
3,000	b	1,364	811	517	353	97
3,500	b	1,458	843	530	359	97
4,000	b	1,538	870	541	364	98
4,500	b	1,607	891	549	367	98
5,000	b	1,607	909	556	370	98
6,000	b	1,765	938	566	375	98
7,000	b	1,842	959	574	378	99
8,000	b	1,905	976	580	381	99
9,000	b	1,957	989	584	383	99
10,000	5,000	2,000	1,000	588	385	99
15,000	6,000	2,143	1,034	600	390	99
20,000	20,000	2,222	1,053	606	392	100
25,000	7,143	2,273	1,064	610	394	100
50,000	50,000	2,381	1,087	617	397	100
100,000	9,091	2,439	1,099	621	398	100
∝ 100,000	10,000	2,500	1,111	625	400	100

Note: b refers to the size of the sample must be greater than 50 percent of the population size

Reference: Taro Yamane, *Elementary Sampling Theory*, 1967, p. 398.

APPENDIX B

Variable, Measurement and data sources for regression Analysis

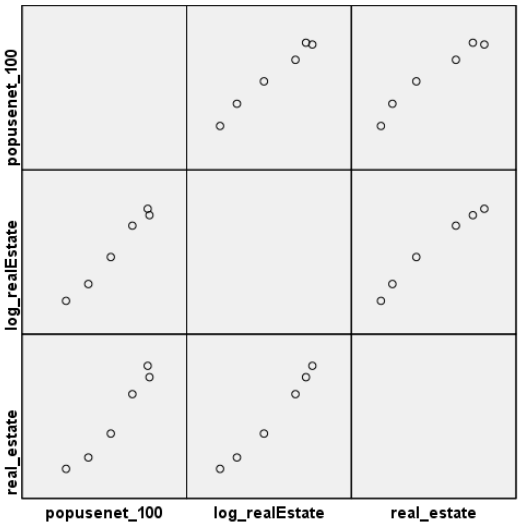
Variables	Measurement	Data Source
Y: P_POPUSENET (person)	Percentage of population using internet	National Statistic Office Of Thailand, Information and communication technology ministry. (2008). And National Electronics and Computer Technology Center
X:P_BACHEL_GRAD (person)	Percentage of employees with the minimum qualification of a bachelor degree	National Statistic Office Of Thailand, Information and communication technology ministry. (2008).
X:Lg P_BACHEL_GRAD (person)	Logarithm of percentage of employee with minimum qualification of bachelor degree	
X: Lg REAL EATATE (square meter)	logarithm of the area that had been authorized for construction	National Statistic Office Of Thailand, Information and communication technology ministry. (2008).
X: Lg GDP TELE (Million)	Logarithm of Telecommunication Gross Domestic Product	National Statistic Office Of Thailand, Information and communication technology ministry. (2008).
X: GDP TELE (Million)	Telecommunication Gross Domestic Product	

Variables	**Measurement**	**Data Source**
X: Lg GRGDP ELEC (Million)	Logarithm of Electricity GDP growth rate	Office of National Economic and Social Development Board (2443-2552)
X:(Lg UNEMP)	Logarithm of unemployed rate	National Statistic Office Of Thailand, Information and communication technology ministry. (2008).
X:(P POPM6)	Percentage of population aged above 6 years	National Statistic Office Of Thailand, Information and communication technology ministry. (2008).
X:(Lg P POPM6)	Logarithm of Percentage of population aged above 6 years	
X:(TERTIA)	Ratio of total enrollment in tertiary education	Office of Permanent Secretary, Ministry of Education. (2443-2552)
X:(FIXED_PENE)	Fixed telephone line per 100 inhabitant	The National Telecommunications Commission (2443-2552)
X:(COM_PENE)	Personal computer per 100 inhabitant	National Statistic Office Of Thailand, Information and communication technology ministry. (2008).
X:(SECONDARY)	Ratio of total enrollment in secondary education	Office of Permanent Secretary, Ministry of Education. (2443-2552)

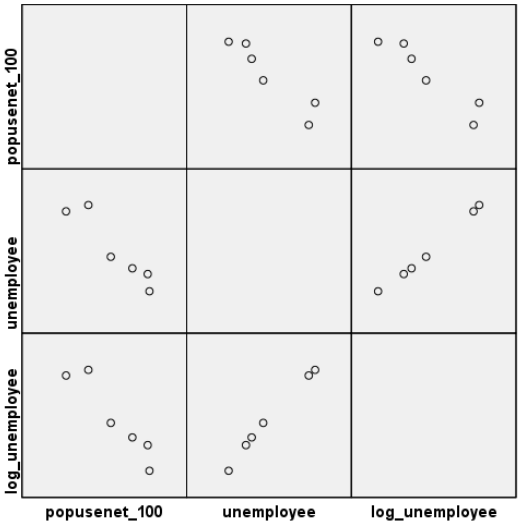
Variables	Measurement	Data Source
X:(Inv GDPCAP)	Inverse of Gross Domestic Product per capital	Office of National Economic and Social Development Board (2443-2552)
X:(Lg GDPCAP)	Logarithm of Gross Domestic Product per capital	

Model 1: Transformation of variables

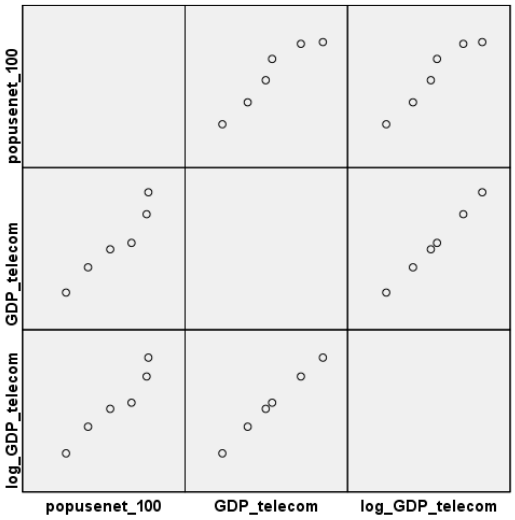
REAL ESTATE, UNEMP, GDP TELE, GDP CAP, P_BACHEL_GRAD Variables



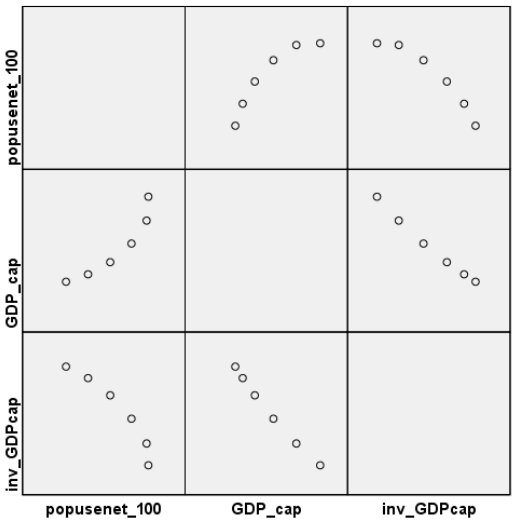
REAL ESTATE variable was transformed using Logarithm base 10 function since data were linearity that is used in the model 1and model 2.



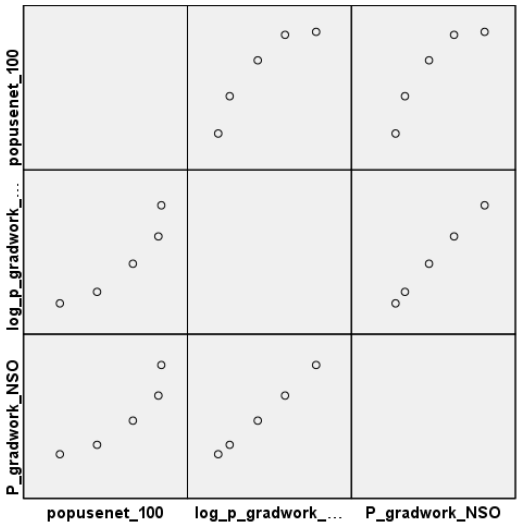
UNEMP variable was transformed using Logarithm base 10 function since data were linearity that is used in the model 1 and model 2.



GDP TELE variable was transformed using Logarithm base 10 function since data were linearity that is used in the model 1.



GDP CAP variable was transformed using inverse function since data were linearity that is used in the model 1 and using Logarithm function since data were linearity that is used in the model 2.



P_BACHE_GRAD variable was transformed using Logarithm base 10 function since data were linearity that is used in the model 1.

GRGDP ELEC Variable

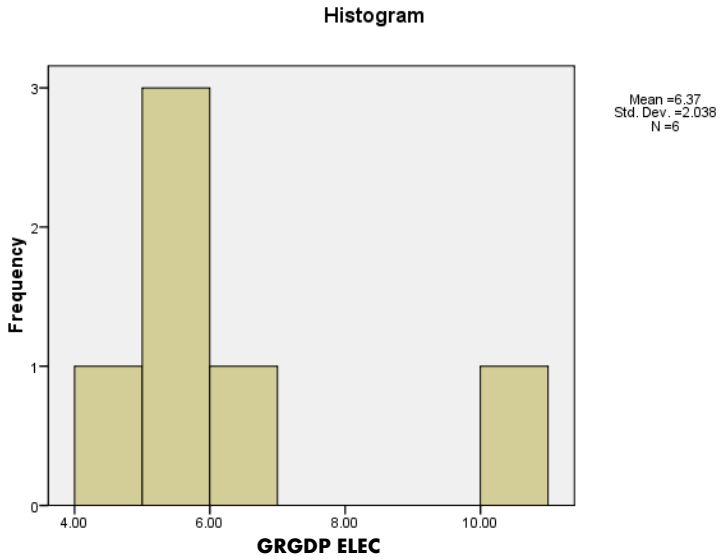
Descriptives

		Statistic	Std. Error
GRGDP ELEC	Skewness	2.118	.845
	Kurtosis	4.811	1.741

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
GRGDP ELEC	.366	6	.012	.732	6	.013

a. Lilliefors Significance Correction

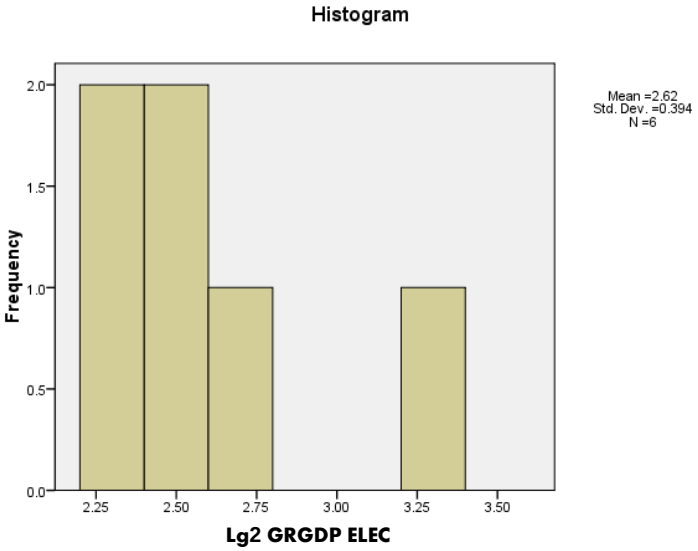


Adjust GRGDP ELEC variables for normality

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Lg2 GRGDP ELEC	.322	6	.052	.809	6	.071

a. Lilliefors Significance Correction



Model 2: Transformation of variables

P POPM6 and COM_PENE variable

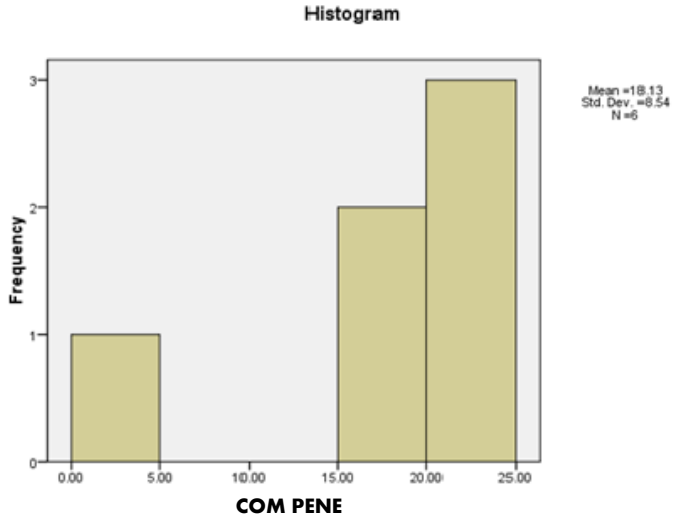
Descriptives

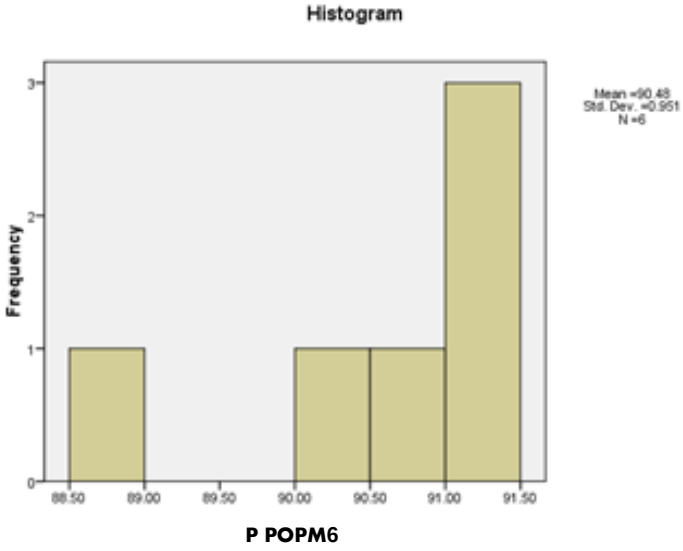
		Statistic	Std. Error
COM_PENE	Skewness	-1.994	.845
	Kurtosis	4.221	1.741
P POPM6	Skewness	-1.914	.845
	Kurtosis	3.865	1.741

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
COM_PENE	.314	6	.065	.758	6	.024
P POPM6	.308	6	.079	.749	6	.019

a. Lilliefors Significance Correction





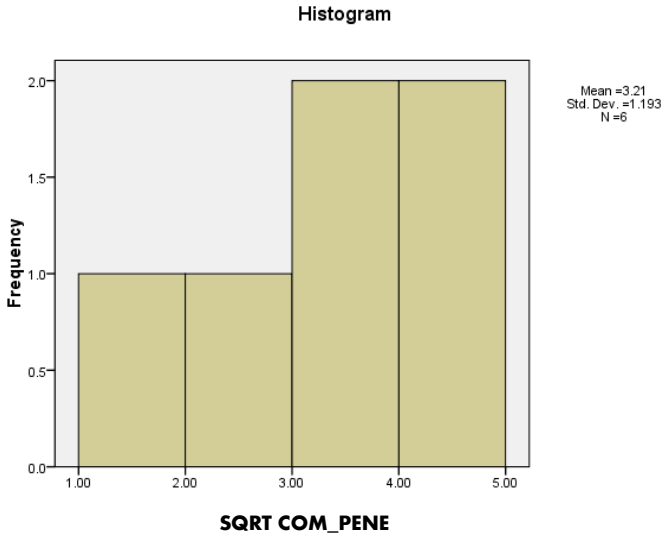
Adjust P POPM6 and COM_PENE variable variables for normality

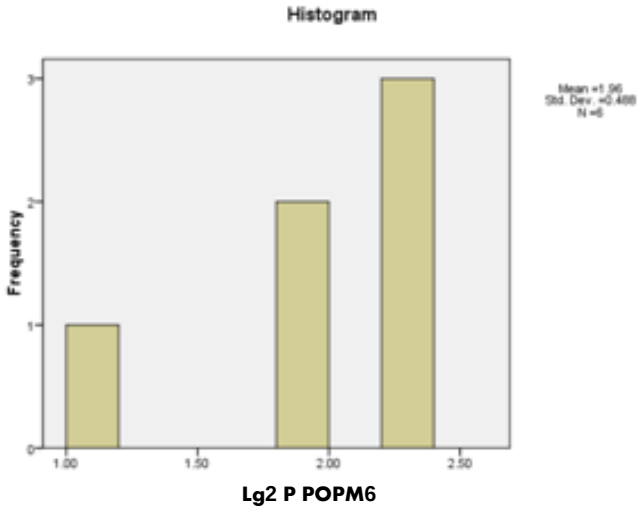
Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
SQRT COM PENE	.247	6	.200*	.852	6	.164
Lg2 P POPM6	.251	6	.200*	.817	6	.083

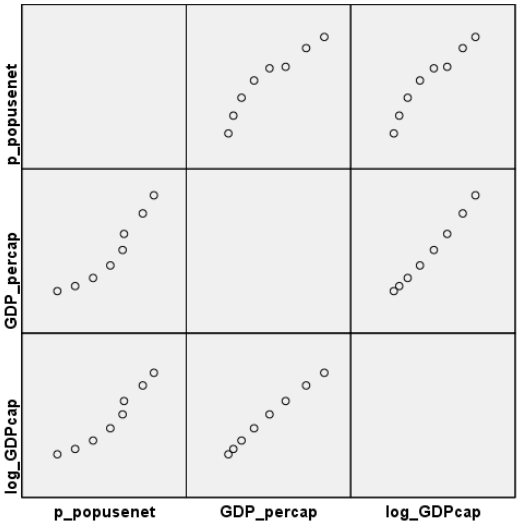
a. Lilliefors Significance Correction

*. This is a lower bound of the true significance.

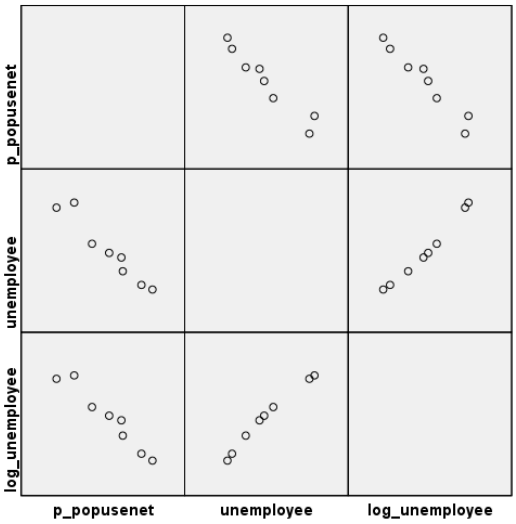

Histogram
Mean =3.21
Std. Dev. =1.193
N =6
Frequency
2.0
1.5
1.0
0.5
0.0
1.00
2.00
3.00
4.00
5.00
SQRT COM_PENE


Histogram
Mean =1.96
Std. Dev. =0.488
N =6
Frequency
3
2
1
0
1.00
1.50
2.00
2.50
Lg2 P POPM6

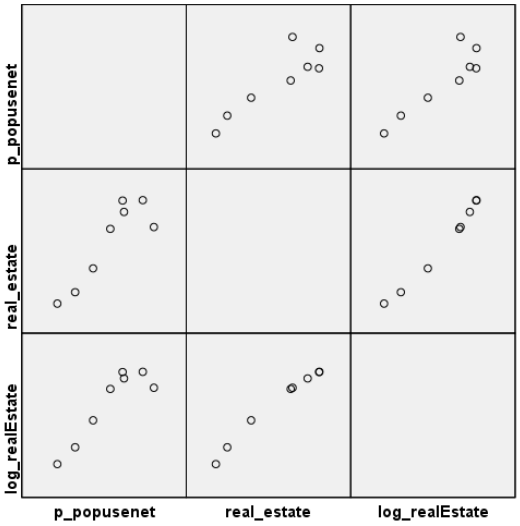
GDP CAP, UNEMP, REAL ESTATE Variables



GDP CAP was transformed using Logarithm function since data were linearity that is used in the model 2 (Lg GDP CAP).



UNEMP was transformed using Logarithm base 10 function since data were linearity that is used in the model 2 (Lg UNEMP).



REAL ESTATE was transformed using Logarithm base 10 function since data were linearity that is used in the model 2 (Lg REAL ESTATE).

APPENDIX C

Questionnaire

The Study of the demand trend of hi-speed internet both wire line and wireless hi-speed internet for efficient everywhere service plan

Objective

The objective of this questionnaire is to explore the demand trend of hi-speed internet both wire line and wireless for efficient everywhere service plan. Please regard your answer to come true. In any cases, your answers will be confidential. Thank you for your cooperation.

This questionnaire consists of 5 parts (7 pages).

Part 1: Participants' general information (4 items)

Part 2: Data about using internet (5 items)

Part 3: Data about using wire line internet (12 items)

Part 4: Data about using wireless internet (15 items)

Part 5: Problems and propositions

Special Vocabulary

- **Asymmetric Digital Subscriber Line (ADSL)** is a high-bandwidth data communication technology that have special characteristic downstream rate more than upstream rate, creating three information channels – a high speed downstream channel, a medium speed upstream channel, and a Plain Old Telephone Service (POTS) channel for voice that allows both data and voice to transmit over the same line.
- **Fiber to the home** is a kind of technology sending data by using fiber optic to quickly and completely receive and send data. This system can be simultaneously used on television, telephone, and internet. And its bandwidth

is higher than general internet service without dividing speed with other users and house telephone is not needed for this system.

- **Cable Modem** is to provide internet service via existing Cable TV network to member users without telephone line. Users can watch Cable TV programs and use internet in the same time. Its speed is approximately 256-1024 kbps.
- **CDMA** is high-speed wireless multimedia communication system for 3G Era by transforming sound wave into digital data and encoding by using code to send high speed internet data via several kinds of wireless equipment to receive – send internet data. Internet can be used everywhere at all times even travelling. The highest speed of CDMA2000 1xEV-DO Rev A to receive and send data is 3.1 Mbps and the highest speed of CDMA2000 1x to receive and send data is 153 kbps.
- **GPRS** is wireless internet system of mobile phone network which sends package data on GSM mobile phone. Data are sent via internet by using mobile phone supporting GPRS to connect to computer or internet can be directly used via mobile phone. Speed for receiving and sending data is approximately 54 kbps.
- **EDGE** is a kind of technology receiving and sending data with high-speed wireless network via GSM system mobile phone developed from GPRS. Data are sent via internet by using mobile phone which supports EDGE system to connect to computer or internet can be directly used via mobile phone. Speed for receiving and sending data is approximately 236 kbps.

Suggestions: Please put / in the provided space in front of right answers.

Part 1: General Information

1. Address

tambon.....Amphoe…….

Province.....

2. Occupation

[ ] a student [ ] an employee

[ ] an government employee [ ] Self-employed

[ ] a farmer [ ] others (Please specify)……

3. Income

[ ] less than 5,000 baht/month

[ ] 5,001 – 10,000 baht/month

[ ] 10,001 – 20,000 baht/month

[ ] 20,001 – 30,000 baht/month

[ ] 30,001 – 40,000 baht/month

[ ] more than 40,000 baht/month

4. Education

[ ] Under high school level

[ ] High school level/ Vocational Certificate

[ ] Higher Vocational Certificate

[ ] Undergraduate

[ ] Postgraduate

Part 2: Data about using internet

5. Are you using internet now?

[ ] Yes, I am. (Continue to No.7)

[ ] No, I am not. (Continue to No.6)

6. If not, will you want to use internet?

[ ] Yes, within……..month(s) [ ] Absolutely not.

7. In what way do you use internet? (Record more than 1 answers)

[ ] Play game…….hour(s)/day

[ ] Research information……..... hour(s)/day

[ ] E-mail ……..... hour(s)/day

[ ] Chat…….. hour(s)/day

[ ] Listen to radio/music…….. hour(s)/day

[ ] other (please specify)…….. hour(s)/day

8. How many family Household sizes or employees in an organization who want to use internet?

[ ] 1 person [ ] 2 persons

[ ] 3 – 4 persons [ ] more than 4 persons

9. Which one of the followings do you prefer? (Record more than 1 answers)

[ ] ADSL [ ] fiber to the home

[ ] Cable Modem [ ] CDMA

[ ] EDGE/GPRS

Part 3: Data about using wire line internet (12 items)

10. Do you want to use ADSL hi-speed internet in the near future?

[ ] Yes, I do.

[ ] No, I don't. (Continue to No. 17)

11. When do you want to install ADSL hi-speed internet?

[ ] Within 6 months [ ] within 1 year

[ ] More than 1 year

12. How much data transfer rate and internet service rate do you use now (in case of you already installed ADSL hi-speed internet)? If you didn't install ADSL, which one of the followings do you prefer?

[ ] 256Kbps/128 Kbps at 490 baht/month

[ ] 512Kbps/256 Kbps at 490 baht/month

[ ] 1Mbps/512 Kbps at 490 baht/month

[ ] 2Mbps/512 Kbps at 590 baht/month

[ ] 3 Mbps/512 Mbps at 590 baht/month

[ ] 4 Mbps/512 Mbps at 860 baht/month

[ ] 5 Mbps/512 Mbps at 999 baht/month

[ ] 8 Mbps/512 Mbps at 1,100 baht/month

[ ] 10 Mbps/512 Mbps at 490 baht/month

[ ] 12 Mbps/512 Mbps at 1,600 baht/month

[ ] 16 Mbps/512 Mbps at 2,200 baht/month

[ ] Others (pleases specify) .....Mbps at..... baht/month

Satisfactory level of ADSL customers

Satisfactory Level	Least	As least	Moderate	Most	As most as
13. ADSL hi-speed internet provided by public companies					
14. Connection Equipment					
15. ADSL internet service rate					
16. ADSL data transfer rate					

17. If there is fiber to home hi-speed internet, are you interested in using it?

[ ] Yes, I am.

[ ] No, I don't. (Continue to No.21)

18. When do you want to install fiber to the home hi-speed internet?

[ ] Within 6 months [ ] Within 1 year

[ ] More than 1 year

19. How much data transfer rate of fiber to the home and internet service price do you prefer? (First number is download data transfer rate and last number upload data transfer rate)

[ ] 1/1 Mbps (Home use price 950 baht/month)

[ ] 2/2 Mbps (SME price 25,900 baht/month)

[ ] 4/2 Mbps (Large Organization price 60,900 baht/month)

[ ] more than 8/2Mbps
(Large Organization price 90,900 baht/month)

[ ] Others (pleases specify) .....Mbps at..... baht/month

20. Did you install cable TV at your resident now?

[ ] Yes, I did. [ ] No, I didn't.

21. If there is a new technology that is cable modem which signal comes through cable TV line, will you be interested in it? (If you cancel cable TV service, the internet will also be cancelled.)

[ ] Yes, I will.

[ ] No, I will not. (Continue to No. 24)

22. When will you install cable modem hi-speed internet?

[ ] Within 6 month [ ] Within 1 year

[ ] More than 1 year

23. How much data transfer rate of fiber to the home and internet service price do you prefer? (First number is download data transfer rate and last number upload data transfer rate)

[ ] 3 Mbps/512 kbps price 590 baht

[ ] 4 Mbps/512 kbps price 690 baht

[ ] 10 Mbps/512 kbps price 990 baht

[ ] 12 Mbps/1 Mbps price 1,490 baht

[ ] Others (pleases specify).....Mbps at..... baht/month

Part 4: Data about using wireless interest (15 items)

24. Do you want to install new technology CDMA wireless hi-speed internet?

[ ] Yes, I do.

[ ] No, I don't. (Continue to No. 32)

25. When do you want to install CDMA wireless hi-speed internet?

[ ] Within 6 months [ ] Within 1 year

[ ] More than 1 year

26. What are data transfer rate and internet service price do you prefer for installing CDMA wireless hi-speed internet?

[ ] 153 Kbps 20 hour/month price 99 baht/month

[ ] 153 Kbps between 08.01-17.00 price 259 baht/month

[ ] 153 Kbps Unlimited price 599 baht/month

[ ] 3.1 Mbps 20 hour/month price 590 baht/month

[ ] 3.1 Mbps Unlimited price 790 baht/month

[ ] Others (pleases specify).....Mbps at..... baht/month

Satisfactory level for CDMA High Speed Internet Service

Satisfactory Level	Least	As least	Moderate	Most	As most as
27. CDMA High Speed Internet Provided by public companies					
28. Connection Equipment					
29. Connection Equipment Price					
30. Internet Service Price					
31. Data transfer rate					

32. Do you want to use EDGE/GPRS via mobile phone modem?

[ ] Yes, I do. [ ] No, I don't.

(Continue to Part 5)

33. When do you want to install EDGE/GPRS wireless hi-speed internet?

[ ] with in 6 month [ ] with in 1 year

[ ] more than 1 year

34. In your opinion, what is reasonable internet service price for EDGE/GPRS hi-speed internet service?

[ ] AIS, DTAC 3 hour/month at 30 baht/month

[ ] AIS, DTAC 6 hour/month at 50 baht/month

[ ] AIS, DTAC 20 hour/month at 99 baht/month

[ ] AIS, DTAC 50 hour/month at 199 baht/month

[ ] AIS, DTAC 100 hour/month at 350 baht/month

[ ] AIS, DTAC 140 hour/month at 399 baht/month

[ ] AIS, DTAC Package EDGE/GPRS unlimited at 999 baht/month

[ ] True Package EDGE/GPRS unlimited at 250 baht/month

[ ] True EDGE/GPRS + Wi-Fi unlimited at 450 baht/month

[ ] AIS, DTAC 1 hour at 20 baht/time

[ ] AIS, DTAC 2 hour at 30 baht/time

[ ] AIS, DTAC 5 hour at 50 baht/time

[ ] AIS, DTAC 15 hour at 100 baht/time

[ ] DTAC 1 day at 39 baht/time

[ ] DTAC 7 day at 249 baht/time

[ ] True 1 day unlimited at 10 baht/day

[ ] True EDGE/GPRS + Wi-Fi 1 day unlimited at 20 baht/day

[ ] Others (please specify)…….....

Satisfactory Level for EDGE/GPRS hi-speed Internet Service

Satisfactory Level	Least	As least	Moderate	Most	As most as
35. EDGE/GPRS High Speed Internet Provided by public companies					
36. Connection Equipment					
37. Internet Service Price					
38. Data transfer rate					

Part 5: Suggestions

……

……

……

……

……

Thank you

for your help

APPENDIX D

Multiple Linear Regressions of Model 1

Descriptive Statistics

	Mean	Std. Deviation	N
P_POPUSENET	7.9960	2.92469	6
Lg UNEMP	.3871	.10442	6
P POPM6	89.9155	1.08523	6
TERTIARY	3.1776	.22365	6
Lg GDP TELE	5.6581	.04232	6
FIXED PENE	10.3033	.86590	6
Lg REAL ESTATE	4.6180	.19920	6
Lg2 GRGDP ELEC	2.6207	.39411	6

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	Lg REAL ESTATE	.	Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).
2	Lg GDP TELE	.	Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).
3	Lg2 GRGDP ELEC	.	Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).

a. Dependent Variable: P_POPUSENET

Model Summary[d]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.993[a]	.987	.984	.37517	
2	.999[b]	.997	.995	.20124	
3	1.000[c]	1.000	1.000	.05632	2.960

a. Predictors: (Constant), Lg REAL ESTATE

b. Predictors: (Constant), Lg REAL ESTATE, Lg GDP TELE

c. Predictors: (Constant), Lg REAL ESTATE, Lg GDP TELE, Lg2 GRGDP ELEC

d. Dependent Variable: P_POPUSENET

ANOVA[d]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	42.206	1	42.206	299.858	.000[a]
	Residual	.563	4	.141		
	Total	42.769	5			
2	Regression	42.648	2	21.324	526.550	.000[b]
	Residual	.121	3	.040		
	Total	42.769	5			
3	Regression	42.763	3	14.254	4.494E3	.000[c]
	Residual	.006	2	.003		
	Total	42.769	5			

a. Predictors: (Constant), Lg REAL ESTATE

b. Predictors: (Constant), Lg REAL ESTATE, Lg GDP TELE

c. Predictors: (Constant), Lg REAL ESTATE, Lg GDP TELE, Lg2 GRGDP ELEC

d. Dependent Variable: P_POPUSENET

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-59.357	3.893		-15.249	.000
	Lg REAL ESTATE	14.585	.842	.993	17.316	.000
2	(Constant)	-151.019	27.839		-5.425	.012
	Lg REAL ESTATE	10.761	1.243	.733	8.656	.003
	Lg GDP TELE	19.321	5.852	.280	3.302	.046
3	(Constant)	-139.139	8.036		-17.314	.003
	Lg REAL ESTATE	9.967	.372	.679	26.792	.001
	Lg GDP TELE	18.169	1.649	.263	11.020	.008
	Lg2 GRGDP ELEC	-.646	.107	-.087	-6.025	.026

a. Dependent Variable: P_POPUSENET

Excluded Variables[d]

Model		Beta In	t	Sig.	Partial Correlation	Collinearity Statistics
						Tolerance
1	Lg UNEMP	-.104[a]	-.570	.608	-.313	.119
	P POPM6	.135[a]	.863	.452	.446	.144
	TERTIARY	.140[a]	1.308	.282	.603	.245
	Lg GDP TELE	.280[a]	3.302	.046	.886	.132
	FIXED PENE	.290[a]	1.449	.243	.642	.065
	Lg2 GRGDP ELEC	-.105[a]	-1.146	.335	-.552	.360
2	Lg UNEMP	.035[b]	.289	.800	.200	.095
	P POPM6	.047[b]	.471	.684	.316	.127
	TERTIARY	-.211[b]	-2.703	.114	-.886	.050
	FIXED PENE	.175[b]	1.783	.217	.783	.057
	Lg2 GRGDP ELEC	-.087[b]	-6.025	.026	-.974	.355
3	Lg UNEMP	-.017[c]	-.460	.726	-.418	.087
	P POPM6	.026[c]	1.186	.446	.765	.124
	TERTIARY	.010[c]	.074	.953	.074	.008
	FIXED PENE	.015[c]	.188	.882	.184	.023

a. Predictors in the Model: (Constant), Lg REAL ESTATE

b. Predictors in the Model: (Constant), Lg REAL ESTATE, Lg GDP TELE

c. Predictors in the Model: (Constant), Lg REAL ESTATE, Lg GDP TELE, Lg2 GRGDP ELEC

d. Dependent Variable: P_POPUSENET

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	3.6889	10.9373	7.9960	2.92448	6
Residual	-.02846	.06903	.00000	.03562	6
Std. Predicted Value	-1.473	1.006	.000	1.000	6
Std. Residual	-.505	1.226	.000	.632	6

a. Dependent Variable: P_POPUSENET

Multiple Linear Regressions of Model 2

Descriptive Statistics

	Mean	Std. Deviation	N
P_POPUSENET	10.2023	2.96439	7
P_BACHEL_GRAD	6.8533	.79267	7
Lg2 P POPM6	1.9358	.44876	7
TERTIARY	3.3813	.31240	7
GDP TELE	505,613.43	71,240.242	7
FIXED PENE	5.4015E4	26345.11950	7
Lg REAL ESTATE	4.7048	.14765	7
SECOUNDARY	6.8022	.30993	7

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	P_BACHEL_GRAD	.	Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).

a. Dependent Variable: P_POPUSENET

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.965[a]	.931	.918	.85092	1.886

a. Predictors: (Constant), P_BACHEL_GRAD

b. Dependent Variable: P_POPUSENET

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	49.106	1	49.106	67.820	.000[a]
	Residual	3.620	5	.724		
	Total	52.726	6			

a. Predictors: (Constant), P_BACHEL_GRAD

b. Dependent Variable: P_POPUSENET

Coefficients[a]

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
1 (Constant)	-14.532	3.021		-4.811	.005		
P_BACHEL_GRAD	3.609	.438	.965	8.235	.000	1.000	1.000

a. Dependent Variable: P_POPUSENET

Collinearity Diagnostics[a]

Model	Dimension	Eigenvalue	Condition Index	Variance Proportions	
				(Constant)	p_gradwork_NSO
1	1	1.994	1.000	.00	.00
	2	.006	18.731	1.00	1.00

a. Dependent Variable: P_POPUSENET

Excluded Variables

		Beta In	t	Sig.	Partial Correlation	Collinearity Statistics		
						Tolerance	VIF	Minimum Tolerance
1	Lg2 P POPM6	.247[a]	.964	.389	.434	.213	4.698	.213
	TERTIARY	.026[a]	.063	.952	.032	.101	9.913	.101
	GDP TELE	.294[a]	.758	.491	.354	.100	10.023	.100
	FIXED PENE	.234[a]	.795	.471	.369	.171	5.841	.171
	Lg REAL ESTATE	.197[a]	1.048	.354	.464	.382	2.614	.382
	SECOUNDARY	.075[a]	.070	.947	.035	.015	66.905	.015

a. Predictors in the Model: (Constant), P_BACHEL_GRAD

b. Dependent Variable: P_POPUSENET

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	6.5461	13.7550	10.2023	2.86081	7
Residual	-1.22757	.78048	.00000	.77678	7
Std. Predicted Value	-1.278	1.242	.000	1.000	7
Std. Residual	-1.443	.917	.000	.913	7

a. Dependent Variable: P_POPUSENET

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