# BURSTING THE BROADBAND BUBBLE

A thesis submitted for the degree of Doctor of Philosophy

by

Elizabeth Abimbola Enabulele

School of Information Systems, Computing and Mathematics, Brunel University

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Broadband has revolutionised the way the Internet is used and has become the critical enabling infrastructure of our modern and knowledge-based economy. Its widespread introduction has not only greatly enhanced the speed at which information online can be accessed, but also the range and sophistication of the content available. It is still penetrating the telecommunication market and is seen by some as the most significant evolutionary step since the emergence of the Internet. However in the rush to achieve market share, there is a risk that insufficient attention may be paid to quality issues, the central theme of this research.

The research addresses the issues of broadband quality with a stated objective of assessing broadband quality by means of an integrated framework that encompasses factors beyond strict technical characteristics of broadband networks. Indeed, the concept of quality is a multi-facetted one, for which various perspectives can be distinguished. In this work, broadband quality as perceived by users, ISP and Government in the United Kingdom (UK) is looked at and a survey report is given and analysed. The aim of this doctoral research was to provide much needed empirical broadband quality framework that would guide the service provider as well as the UK government in the provision of quality broadband to its consumers. It will also stand as a benchmark to countries wanting to provide quality broadband to its citizens.

A survey research approach was employed to achieve the overall aim and objective of this research. This was conducted using the response of 133 participants located in various boroughs in the UK. The results of the survey show that quality, though desired by many, has been short-changed by the desire to have access to the Internet via broadband at the lowest cost possible. However, this has not encouraged some consumers to switch to broadband from dial-up service despite continuous low prices being offered by service providers. Furthermore, the results also indicated that focusing on broadband quality will improve and promote investment in broadband capacity and decrease the uncertainty in consumer demand for applications such as multi-media content delivery, enhanced electronic commerce and telecommuting that exploit broadband access.

First and foremost, I would like to take this opportunity to express my gratitude to the Almighty God for giving me the wisdom and the strength used to carry out this research, for I can do all things through Christ, who strengthens me (Philippians 4:13).

I would like to thank my supervisor Dr. George Ghinea for his tremendous support, guidance and motivation throughout my research period. George, you are simply the best. I would also like to thank my second supervisor Dr. Natasha Papazafeiropoulou for her words of encouragement and Dr. Joyti Choudrie for her kind advice.

And last but not the least I would like to thank my husband Edoghogho and my children Simisola and Tumininu for their support, encouragement and understanding through out my research period. Furthermore I would like to express my thanks to all my friends and family who have one way or the other encouraged and believed in me, I appreciate you all.

I dedicate this work to the memory of my father Late Chief E.O.B. Fakolujo and to my mother, Chief (Mrs) Olabisi Fakolujo. You gave me a solid foundation in life. Thank you.

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# CHAPTER 1: Introduction

## 1.1 Introduction

The Internet continues to modernize the working manner and lifestyles of a growing share of the world's population, and in recent years this has been due to a significant extent to the emergent use of *broadband* (Ofcom, 2006). Broadband is a newly developed technology, which provides an always-open gateway to a new world of Internet-connected services delivered at lightning-fast speeds to homes, offices and businesses. It is considered to be the silver bullet for the Internet as it offers enhanced access and superior quality of content, applications and services (Dwivedi and Choudrie, 2004).

Broadband access is needed for the Internet to achieve its full potential and how these services are offered is likely to have important implications for the extent of competition for communication services from a service provider to a customer (Gillett and Lehr, 1999). It also gives users the ability to send and receive data at speeds far greater than the dial-up Internet access over traditional telephone lines (Smith et al 2001). Furthermore, broadband has opened the door for many new and innovative services such as Access 'On-demand', IP based Virtual Private Network (VPN), Online Media delivery, new forms of entertainment and new and improved public services. Broadband also offers the consumer new opportunities to work or learn more productively (both at home and the office), publish multimedia, switch from viewers of entertainment to participants, and, most importantly, dramatically expand their communication possibilities.

The effect of broadband has changed the way we live and work and the extent and speed of these changes is overwhelming (Spero and Stone, 2004). As a result of these opportunities offered by broadband, many countries, cities and communities are trying to accelerate the deployment and usage of broadband networks. This concerted effort towards widespread broadband connectivity is also steering companies towards the adoption of new business models, while at the same time enhancing business productivity and competitiveness (Turner et al, 2003). It allows businesses that are willing to embrace Internet business solutions to transform business processes and realize significant returns on investment (ROI).

Communication remains the single major reason for going online. Communication applications such as Email, IP telephony, video conferencing, digital photo exchanging, unified messaging, and e-learning have been the top drivers for broadband demand (U.S Dept of Commerce, 2002). The contributing factors in the growth of broadband access as being the main source of connectivity to Internet users has been government driven, private sector driven, and users' social background (Yun et al, 2002). Indeed, the government, telecommunication companies, and service providers in the UK are now interested in putting in place access to broadband that would enable applications and services that transform the economy, education, health-care, homeland security, military effectiveness, entertainment, government and the quality of life for citizens around the world. Moreover, it is envisaged that the deployment and usage of broadband will significantly impact the global competitiveness of nations and businesses in the 21st century (U.S Dept of Commerce, 2002).

In the UK, broadband availability has been concentrated in urban areas with greater linear population density, with smaller and rural communities seeing deployment less rapidly. Nonetheless, satellite and fixed wireless broadband solutions continue to emerge.

Although broadband growth has been monitored closely, research to date has focused on the penetration of the technology (Choudrie and Dwivedi, 2006; Correa, 2007; Sawyer et al, 2003), the market shares of the key service providers (Foros and Hansen, 2001; Shinohara, 2005; Zahariadis et al, 2002) and limited exploration of the nature of broadband use (Gunter et al, 2003). Broadband, however, means different things to different stakeholders (Choudrie et al, 2003). A reflection of this is the fact that for the *Federal Communications Commission* (FCC) in the USA, broadband is targeted through policy elaboration mechanisms, while the same technology is a focus point of *vendors* looking to differentiate their products, and of *service providers* looking to spruce up their offerings. Indeed, it comes as no surprise that this fragmentation is a characteristic of the broadband quality domain, as the next section will show.

## 1.2 Quality

The following quote is appropriate for broadband technology: "*Quality is never an accident; it is always the result of high intention, sincere effort, intelligent direction and skillful execution. It represents the wise choice of many alternatives*" (Foster, 2000). As the central issue in this thesis will be quality which is one of the main concerns experienced in today's systems (Ekenberg and Johanneson, 2004). Emphasis on quality has emerged in a variety of organisation and in several fields (Smart, 2002), which includes the Information Technology (IT) industry and has become an important concept in the marketplace (Yiannakos, 1984).

From a technical viewpoint, quality can have two meanings:

a) The characteristics of a product or service that bear on its ability to satisfy stated or implied needs (ISO 8402: 1986).
b) A product or service free of deficiencies (Yang and El-Haik, 2003).

As far as a) above is concerned it comes as no surprise that, in the IT field, the issue of quality is a multi-faceted one: this ranges from the network Quality of Service (QoS) concept, which is a collection of technologies currently being developed that allows network-aware applications to request and receive predictable service levels, letting networks allocate resources or differentiated levels of service among shared resources (Karthigeyan et al, 2005; Liu et al, 2005; Okumus et al, 2004; Sansò et al, 2005; Zhu, 2004), to software quality, which targets quality assurance and control ensuring that products meet customer needs and requirements (Chirinos et al, 2005; Manvi and Venkataram, 2004; Marçal de Oliveira et al, 2002; Wheeler and Duggins, 1998; Zulkernine and Seviora, 2005). Moreover, another important aspect of the quality is quality as perceived by the end user (D'Antonio et al, 2004; Räisänen, 2004; Su and Gellman, 2004), a concept that targets the expectation and the approval of the individual.

As far as b) above is concerned, quality in the IT field has also been traditionally measured by product failure (Krishnan, 1993). This relates to the characteristics by which customers or stakeholders judge an organisation, product or service. In the past, freedom from problems with services was considered to be a positive

concept because customers expected significant problems; presently the quality focus is generally on issues pertaining to process quality, such as the avoidance and elimination of flaws (Trifu and Dragos, 2003). It is certain that failure to conform to a standard will produce dissatisfaction on the part of customers.

However, this only addresses negative aspects of quality. Service providers and telecommunication companies now seek to produce services which will be chosen by the customer because they create what is often described as 'excitement', as customers expect basic requirements to be met and do not gain a feeling of excitement when only these are achieved. Indeed, one of the issues in the poor quality in software is as a result of the haste to rush it to the commercial software market and this has led to numerous updates and patches to correct this problem (Peslak, 2004). Broadband could face a similar situation if quality is neglected.

## 1.3 Broadband Quality

Previous research on broadband quality has approached the issue in a disintegrated manner. Again, this is unsurprising given the multi-faceted nature of quality. Although quality is a subjective concept for which each person has his/her own definition, however, in the broadband realm, this is manifested through the different perspectives that the stakeholders accept as true.

Accordingly, earlier work on broadband quality has been systems oriented (Fischer and Leue, 1998; Ichiko et al, 2001; Marchetti, 2004; Wada et al, 2003), focusing on issues such as traffic analysis (Albizuri, 2003; Berger et al, 1998; Chang and Hsu, 2003; Huang and Chang, 2004; Leung, 2002; Markopoulou et al, 2003; Pechiar et al, 2002), scheduling (Arts et al, 2004; Chen and Lee, 2000; Gao et al, 2004; Shan et al, 2003; Sriram, 1993), cost (Bolotin et al, 2004; Lorenz and Orda, 2002; Sansò et al, 2005), routing (Grimm et al, 1998; Gyires and Wen, 2005; Mitra et al, 1999; Orda, 1999), user-level issues (Rayes, 2003; Seibert and Tobaji, 2003; Subramanian and Lewis, 2003) and the policy-role of Government (Cava-Ferreruela and Alabau-Munoz, 2006; Picot and Wernick, 2007).

Indeed, most of the research, as the enumeration above exemplified, has focused on broadband quality in a fragmented manner. Moreover QoS in broadband has

until now been assumed by many to be the same as quality in broadband, however, quality is made up of many facets, of which QoS is but one of them. In this research, a unified multidimensional broadband quality framework will be proposed, as none yet exists. Indubitably, relatively little work has been done looking at broadband quality issues from a unified perspective. A similar study conducted by Donahue and Ferrigno-Stack (2001) proposes a quality monitoring system for broadband networks and Internet Service Providers and Access Providers as a policy vehicle.

However, it does not address any specific technical standards nor does it address the rich and significant body of literature evaluating the interplays of standards settings and innovations. Their work only places the notion of service quality metrics, which is of use to the consumer and of value to the corporation and regulator.

Nevertheless, they do not provide a consolidated structural framework that covers all aspects of the broadband delivery, as this research is proposing. Similarly the Australian Communication Authority (ACA), (2003) identified a range of quality issues raised by their survey on consumers' perspectives of broadband quality. Some suggestions were presented which customers could potentially find useful when choosing a broadband service. However, it did not put forward a framework and the survey on quality itself only covered limited aspects pertaining to the relationship between consumer and the service provider. Related work was undertaken by Reininger et al (1998a) who, however, proposed a quality framework only for video in broadband, and by Jiang et al (2003) who provided a method for measuring service quality that included both the user and service provider perspective.

There is thus no consolidated quality framework in broadband communications. Consequently, there is a need to aid and guide society with respect to the various quality facets as expected by the stakeholders of broadband technology. This would be achieved by the provision of a broadband quality framework. An integrated quality broadband framework would serve two purposes. Firstly, it will form a guide to the specification of quality parameters to the consumers, service

provider/telecommunication companies and the governments as to what is expected for the provision of a quality broadband service. Secondly, it will act as a work plan for the study of quality assurance and the development of new ideas.

The framework resulting out of this project would be of benefit to consumers who expect a good quality service at great value for the delivery of their broadband services, and also the service providers/content providers who are under enormous pressure to improve the quality their of services at considerable reduced cost to their company. Moreover, bearing in mind the UK government's stated intention and vision to make the UK one of the top broadband users in the world (Choudrie and Papazafeiropoulou, 2006), the proposed framework would also be of benefit as it would highlight broadband quality issues and how to achieve excellence in broadband deployment and implementation so as to attain a long term sustainability of the broadband industry.

Subsequently, this framework is also necessary in order to avoid a repetition of the dot.com bubble burst, which had no quality framework in place to protect it from the burst. In this thesis a generic broadband quality framework is developed that will serve as a reference point for broadband Service Providers to its users. This will also provide a common platform on which all broadband services can be evaluated. Moreover it will also aim to reduce the quality, assurance time of broadband service to its users.

## 1.4 Research Aim and Objectives

The overall aim of this research work is to create a framework for the structuring of quality monitoring concepts in broadband service that would ensure that quality levels and expectations are met and maintained in order to guarantee the confidence and growth in the broadband services.

In other to achieve this aim, the following research objectives will be undertaken:

- Provide a taxonomy of broadband quality issues.
- Measure the perception of users on broadband quality.
- Integrate the dimensions of broadband quality and examine the interplay between them.

- Propose an integrated broadband quality framework and provide recommendations to practice and contributions to theory.

## 1.5 Research Approach

Since the aim of this research is to build a broadband quality framework that embodies the many facets of broadband quality, a qualitative method, using a survey approach is incorporated into this study. A survey approach will enable the understanding of broadband users' perspectives on broadband quality. Furthermore this approach can be a powerful and useful means for collecting data on human characteristics, attitudes, thoughts, and behaviour (Doyle, 2001).

Data was collected from the UK household consumers. In order to collect empirical data from the target population, a self-administered questionnaire by means of mail was considered to be the most appropriate data collection method. The self administered questionnaire was utilised as it addresses the issue of reliability of information by reducing and eliminating differences in the way in which the questions are asked (Cornford and Smithson, 1996); it involves relatively low costs of administration; it can be accomplished with minimal facilities; it provides access to widely dispersed samples; respondents have time to provide thoughtful answers; it assists with asking long questions as well as complex response categories; it also allows asking of similar repeated questions and the respondents do not have to share answers with interviewers (Fowler, 2002).

A sequential progression from exploratory investigation used to extract relevant studies on broadband quality (Phase I) to qualitative method (Phase II and III) across different phases of a study allows for a much richer and grounded understanding of the research phenomenon. The strength of this research method approach comes from its ability to draw on existing theoretical perspectives, while remaining open to new ideas that emerge from a grounded approach and theoretical development (Tiwana and Bush, 2005). The description of the methods used and how it was employed is given in chapter 4

## 1.6 Thesis Outline

Following the introduction, the rest of the thesis is arranged into seven chapters. Chapter two presents the definition of broadband technology and its applications. This is important in order to understand the broadband and its technology in depth. Chapter three presents the concept of quality through its many facets as related to broadband. Chapter four presents the research approach and methods used for this project. Chapter five describes and analyses the results of a survey on user perspectives of broadband quality. Chapter six proposes the BiQF multi-dimensional framework and discusses the development approach used and presents the evaluation for the proposed framework. Chapter seven is the concluding chapter of this thesis, in which the thesis is summarised, the research contributions are presented and future research is identified.

## 1.7 Summary

The first chapter provides an introduction to the themes of this research: Broadband and Quality. It presented a brief genealogy of broadband and stressed the importance of quality on broadband as a whole despite the widespread used of this technology and then provides a discussion of the research problem. It also provides details of the research aims and objectives. A guideline as to the structure of the thesis is presented. The next two chapters provide the literature review and give a conjectural perspective of this research. Chapter two begins by offering a more detailed insight into broadband, its technologies and the various issues that surrounds broadband, while chapter three defines quality and introduces the many facets of quality in regards to broadband.

# CHAPTER 2: Broadband Technologies, Applications and Issues

## 2.1 Introduction

This chapter takes a look at the current broadband technologies and their applications studied as part of this research. This process is of central importance to this research as it addresses the key aspects of broadband technology. The chapter also considers the advantages and disadvantages of various types of broadband technologies. Issues relating to broadband are also identified.

Accordingly, with the objective of providing a thorough and clear background on this research, chapter two is structured as follows: Section 2.2 provides a definition of broadband with its technology background being detailed in section 2.3. Transport protocols are an important component of the broadband picture and are then described in section 2.4. Section 2.5 discusses broadband applications and, finally, section 2.6 highlights the outstanding challenges that broadband faces.

## 2.2 Definitions of Broadband

There exist diverse definitions of broadband, as various groups have struggled to develop appropriate broadband definitions, and these definitions have changed over time (Shelanski, 1999) and vary from one country to country (Firth and Kelly, 2001); hence choosing a particular broadband definition can become exclusive and would tend towards obsolescence as technologies progress (Xin et al, 2002).

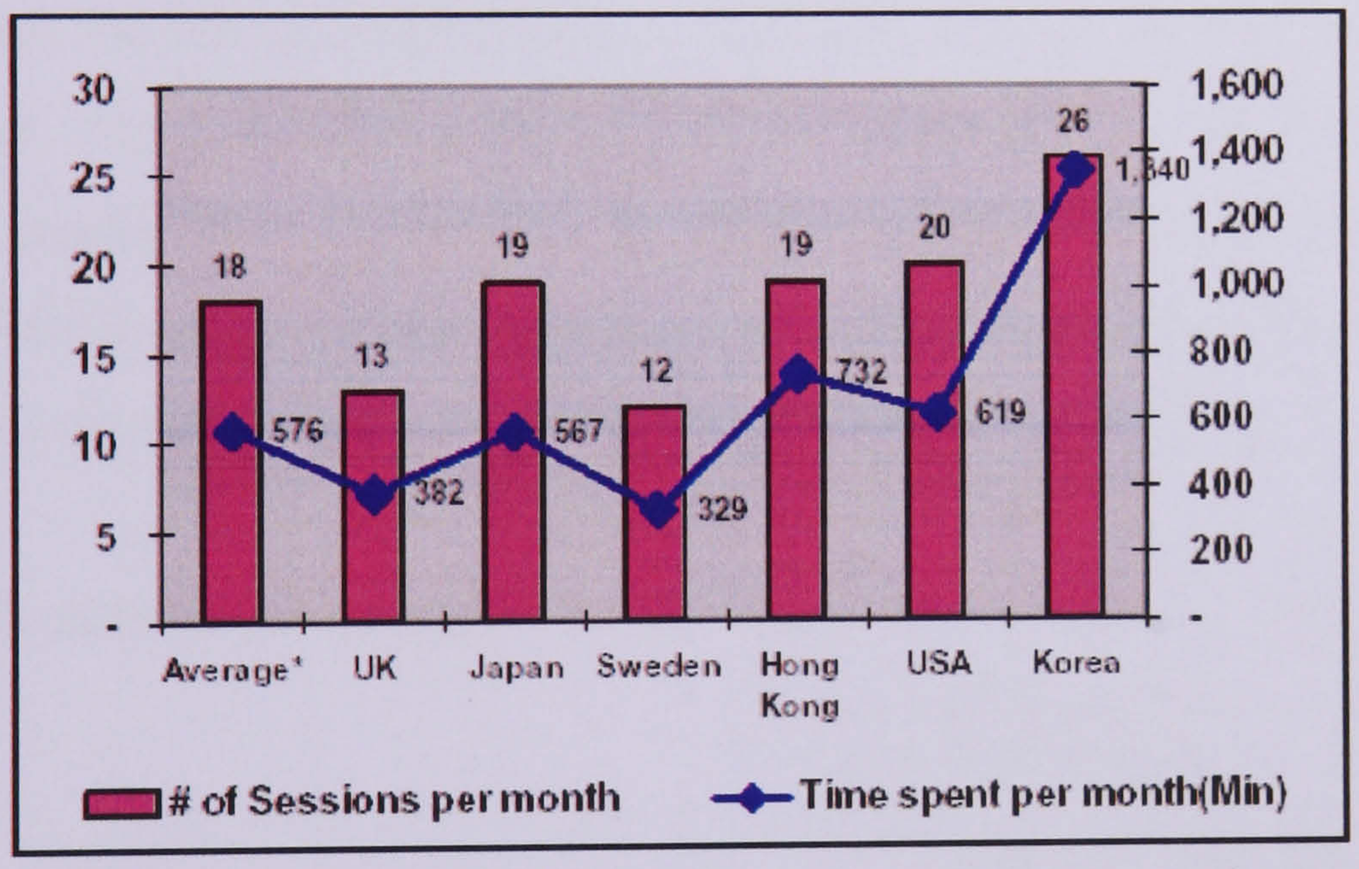
Consequently, functional definitions are generally used in the literature for broadband definition, such as the following:

- The FCC defines broadband as "*a descriptive term for evolving digital technologies that provide consumers as a signal-switched facility offering integrated access to voice, high-speed data service, video-on-demand services, and interactive delivery services*" (FCC, 2004).
- "*Broadband can be defined as any communication technology that permits clients to play streaming audio and video files at acceptable speeds-generally anything above 100Kbps*" (Laudon and Laudon, 2002).
- "*Broadband is always on access, at work, at home or on the move provided by a range of fixed line, wireless and satellite technologies to*

> *progressively higher bandwidths capable of supporting genuinely new and innovative interactive content, applications and services and the delivery of enhanced public services*" (UK Online, 2002).

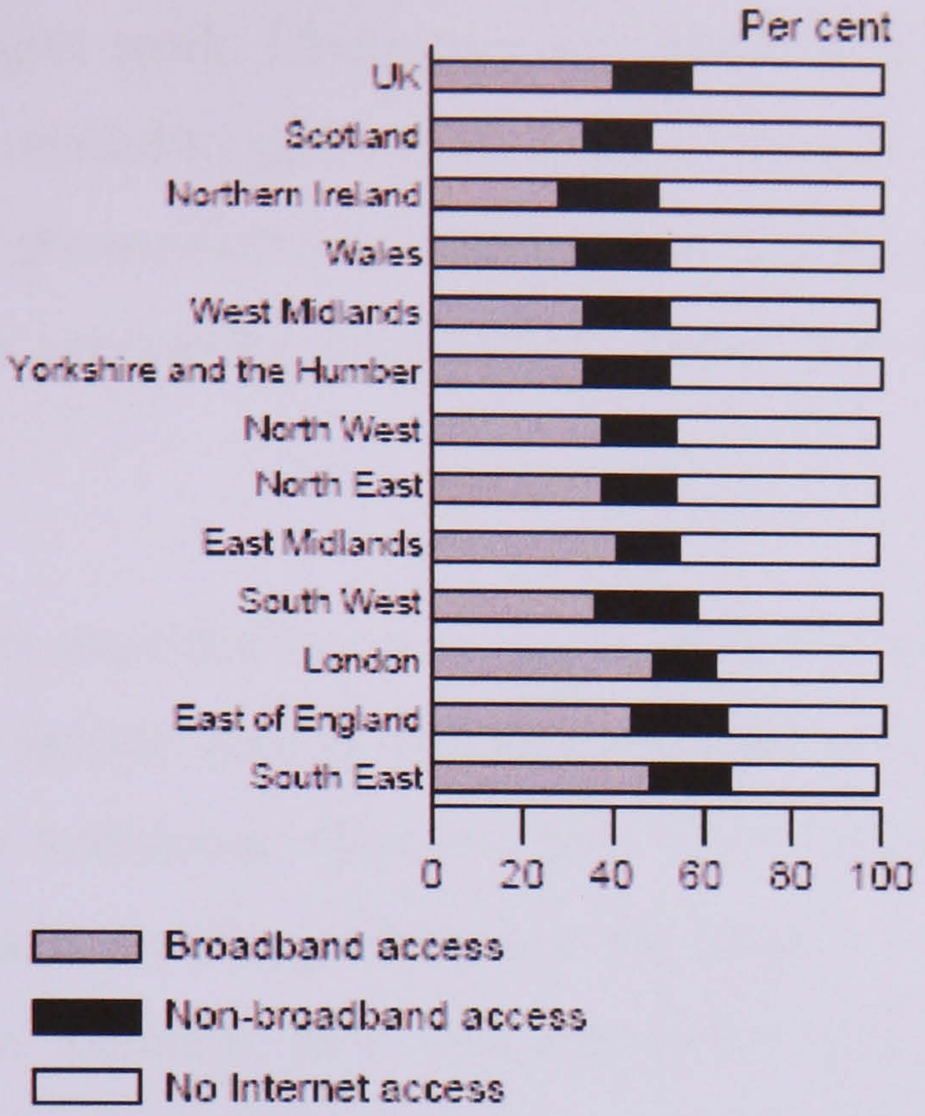
Broadband thus provides the consumer with the ability to connect to the Internet with a high-speed, always on connectivity. It is an umbrella term used to describe a wide range of technologies that allow high-speed, always-on access to the Internet and other electronic services at a much higher speed than the standard 56k dial-up modem. The "always on" access means that users do not have to dial up every time they want to surf the web; this, thus plays a pivotal role not just for business, but for people and government as well. The effect of the widespread use of broadband has changed the way people use the Internet bringing new data and media-intensive applications to the mass-market.

**Figure 2.1 Internet Usages, (Nielsen/ Net Rating, 2001)**



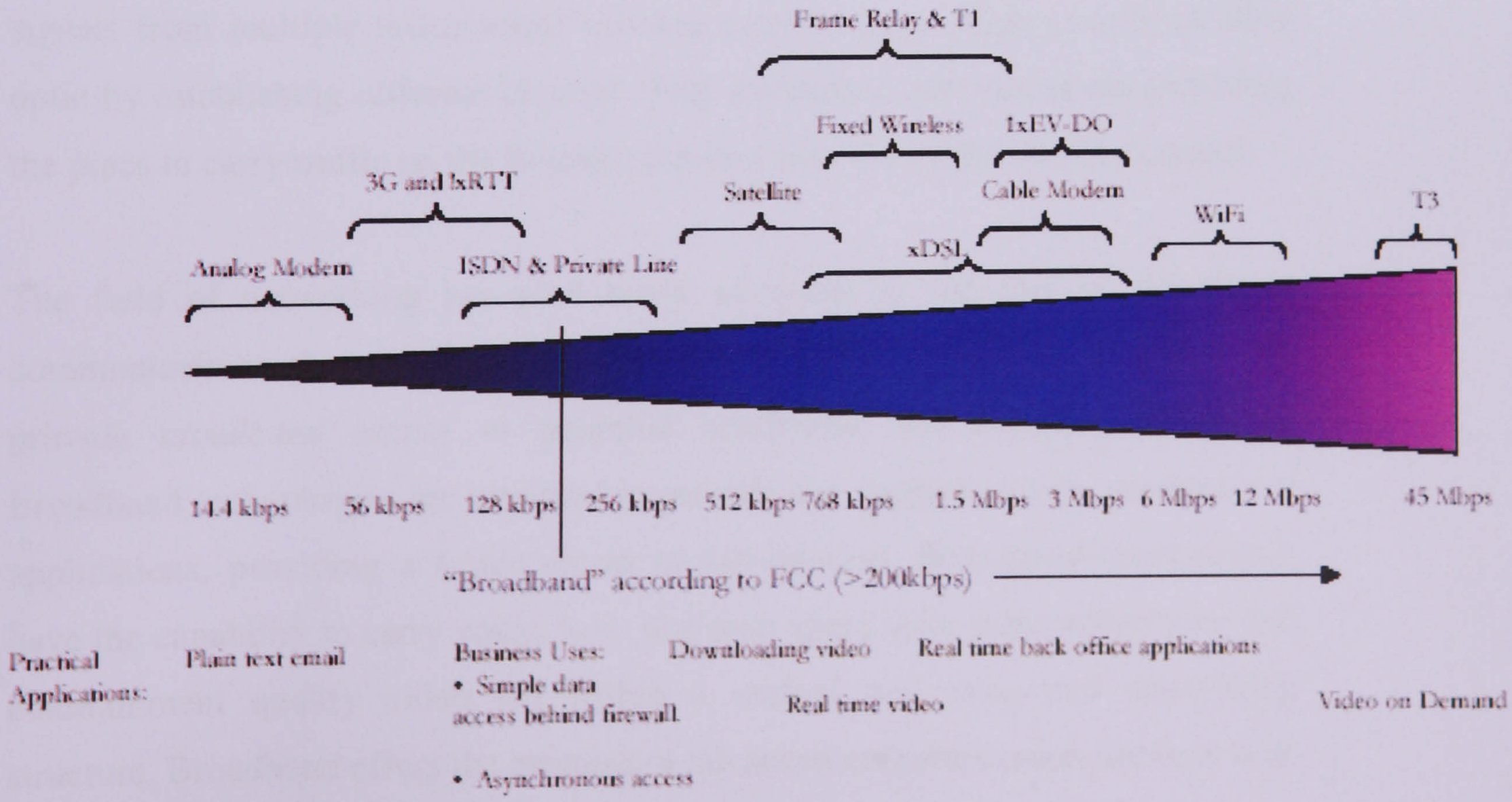

Figures 2.1 and 2.2 show both the Internet usage and percentage of those households with Internet access by region and type of connection in the UK and other countries.

**Figure 2.2 Percentage of those household with Internet access by region and type of connection (From First release, 2006)**




Although broadband uses the standard telephone line, it repackages the data and sends it down the line at high frequency; this line is also shared with voice calls (Gunter et al, 2003). According to the FCC in the United States of America, bi-directional speeds above 200kbps are considered broadband, however the UK classifies 384kbps as broadband (Krikke, 2003). Figure 2.3 shows the typical data rates for existing technology compared with broadband technology.

**Figure 2.3 Speeds, Application and Technology**



## 2.3 Broadband Technologies /access Networks

The focus of this section is to gain knowledge of how different phenomena in broadband technologies work. Ubiquitous broadband access to the Internet is an essential ingredient needed to gain the most out of what the Internet has to offer. This is as a result of the pervasive influence of the Internet and the introduction of many Internet-ready appliances, which have fuelled the demand for broadband access.

Broadband access is provided by a series of technologies that give users the ability to send and receive data at volumes and speeds far greater than dial-up Internet access over traditional telephone lines (CRS, 2003). Furthermore, high-speed connections radically change the use of the Internet by improving its quality and capabilities. In parallel, new communication platforms have emerged, multiplying ways through which people can access broadband and benefit from it (Liikanen, 2002). Broadband access is one of the most important issues for telecom equipment manufacturers and content and technology providers, as well as for cable operators, satellite providers, and fixed wireless operators.

Broadband connections to the Internet are like fat pipelines running into and out of a home or business (Thiara, 2004). Telecommunication companies or independent service providers in most cases are responsible for these pipes being laid. Nahar (2001) described a broadband connection as a medium that can carry signals from multiple independent network carriers on a single coaxial or fibre optic by establishing different channel. This medium is not only about providing the pipes to carry traffic on the Internet, but also how that traffic will be carried.

The field of networking has seen many advances in the area of broadband communications through multiple transmission media or technologies that can provide broadband access to potential residential and business customers. Broadband technologies are intended to provide the support to new services and applications, providing a faster access to information. Broadband technologies have the capability to carry voice, low- and high-speed data, teleconferencing and entertainment quality video, all within a unified and integrated networking structure. Broadband offers the promise of advanced communication services with

minimised cost to society (McDonald, 1989) and technologies include Digital Subscriber Line (DSL) and digital cable, satellite-based Internet access, IEEE 802.11-based wireless systems, and fixed broadband wireless such as Local Multipoint Distribution System (LMDS) and Multi-channel Multipoint Distribution Service (MMDS). LMDS is a broadband wireless technology that enables point to multi-point connectivity through high frequency radio transmission while MMDS similar to LMDS technology is an established medium for television transmission.

Each technology has its respective advantages and disadvantages, and will likely compete with each other based on performance, price, quality of service, geography, user friendliness, and other factors with subscribers increasingly confronted with multiple choices as far as access is concerned. However marketing is often centred on the technological options rather than the added value of the proposed services (Velez et al, 2001).

Presented in sections 2.3.1 to 2.3.4 below are in-depth features of DSL, Cable and other widely known broadband access technologies.

### 2.3.1 Digital Subscriber Line (DSL)

With the tremendous growth in Internet usage, the need to provide faster connection speeds continues. Traditional technologies such as dial-up modems often cannot provide the desired increase in speed (bandwidth). New technologies are being developed with DSL that provide high speed over existing telephone cabling becoming increasingly popular (Vicomsoft, 2000). DSL technology was developed in the late 1980s and was first widely used for non-Internet specific applications. DSL technology increases the speed and volume of information that can be sent to the home or office, allowing customers to download and experience web pages, graphics, music, video and text in real time.

Gilroy and Kruger (2006) described DSL as a modem technology that converts existing copper telephone lines into two-way high-speed data conduits. The DSL's twisted-pair environment involves a telephone central office with its equipment interfacing to the traditional circuit-switch telephone network, and

dedicated lines to each house (Samueli, 2000). DSL technologies employ highly sophisticated techniques that limit near-end cross talk, the noise interference between channels and therefore greatly expand the bandwidth potential over a single pair of copper wires.

As an added benefit, these techniques not only permit the Plain Old Telephone System (POTS) service to continue over wire pairs in the same binder; they also permit POTS service to continue simultaneously on the same wire pair upon which DSL transmission takes place. These techniques have been made possible by the continuing advancement of lower-cost and more powerful digital signalling processing (DSP) chips which require increasingly lower electric power (Humphrey and Freeman, 1997). DSL comes in a wide variety of forms, including ADSL, R-ADSL, HDSL, HDSL2, IDSL, SDSL, M-SDSL, SHDSL, and VDSL, and is often generically referred to as xDSL. The xDSL family of technologies provides a wide variety of line driving schemes to accomplish and satisfy different market needs over today's infrastructure (ITU, 2001).

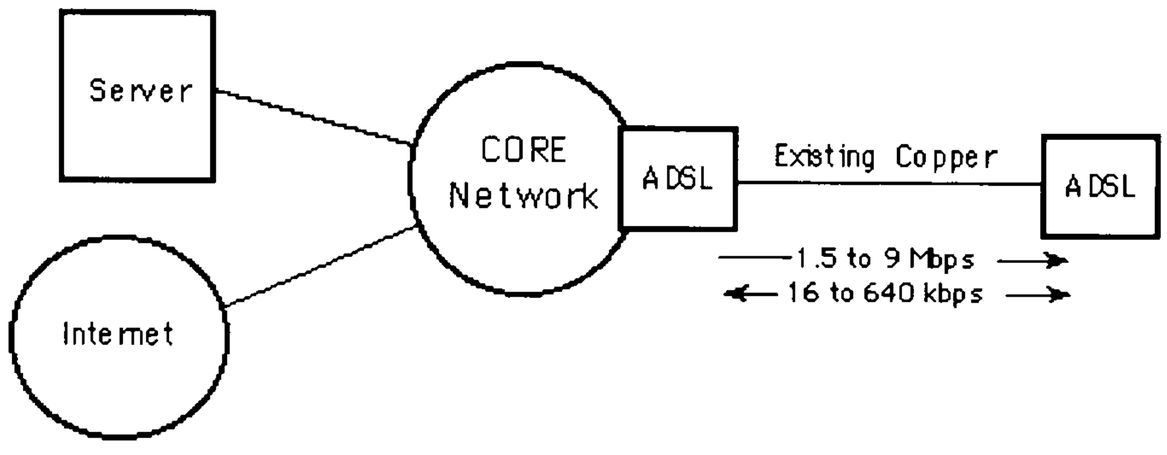
These xDSL technologies are capable of carrying 100kbps to 10Mbps but each has different characteristics and limitations. Below are the various types of xDSL:

#### 2.3.1.1 Asymmetric DSL (ADSL)

ADSL is the type emerging as the primary DSL method for mass-market broadband Internet connections. It is called asymmetric because its downstream speed (from the telephone company to the customer) is much faster than its upstream speed (back to the telephone company), which is suitable for surfing the Internet and downloading music and information. It is also a modem technology, which converts existing twisted-pair telephone lines into access paths for multimedia and high-speed data communications (BAP, 2000). The ADSL technology splits the standard telephone line into separate channels for voice and data so a user can make and take calls even when online. It can also transmit up to 6 Mbps to a subscriber, and as much as 832 kbps or more in both directions. Such rates expand existing access capacity by a factor of 50 or more without new cabling (BAP, 2000).

ADSL is transforming the existing public information network from one limited to voice, text and low resolution graphics to a powerful, ubiquitous system capable of bringing multimedia, including full motion video, to everyone's home which makes it particularly suitable for the needs of home and small business users (DSL Forum, 2001b). ADSL can only offer broadband data speeds where the telephone line between the home or office and the telephone exchange is a maximum of 6km (BIG, 2004). Figure 2.4 shows an ADSL connection.

**Figure 2.4 ADSL Connection (DSL forum, 2001b)**




### 2.3.1.2 Rate Adaptive Digital Subscriber Line (R-ADSL)

R-ADSL technology is used to automatically adjust the speed of a line by conducting a series of initial tests to determine the maximum speed possible on a particular line (Vicomsoft, 2002). In a section where there is a large variation in the length of the local loop that is distance between the service user and the central office, the gauge of the wire, and the condition of the line, it becomes hard to determine what speeds should be provisioned over each line. Moreover, fluctuating weather conditions additionally change the maximum possible throughput on a given line (ITU, 2001). R-ADSL, like ADSL allows users to have telephone conversations and transfer data simultaneously over a single copper pair (Vicomsoft, 2002).

### 2.3.1.3 ISDN Digital Subscriber Line (IDSL)

IDSL allows data transmission at speeds of 128 Kbps over a single copper pair specifying loops up to 18,000 feet at a wire thickness of 0.5mm (Vicomsoft, 2002). IDSL utilises the 2B1Q line-coding standard for ISDN BRI circuits. As IDSL uses the same industry-standard line coding technique as ISDN, customers with ISDN BRI terminal adapters (TA) can use their current TAs, routers and bridges for connecting to IDSL lines. Commonly used transport protocols such as

PPP, MP, MP+ or Frame Relay can be used over the IDSL line, allowing rapid and transparent integration into Internet, remote LAN access and telecommuting (Vicomsoft, 2002). IDSL can also be used for data-only applications

#### 2.3.1.4 High-bit rate DSL (HDSL)

HDSL is used over a two-twisted copper pairs with a speed of up to 2Mbps (Jarrett and Goleniewski, 2007). HDSL provides a better way of transmitting T1/E1 over copper wires, using less bandwidth without repeaters (DSL Forum, 2001a). It uses more advanced modulation techniques to transmit 1.544Mbps over up to 12,000 feet long (IEC, 2004a). The main disadvantage is that it does not support the normal voice service without special modifications. HDSL is a good option for connections exclusively intended for data traffic (Velez et al, 2001).

#### 2.3.1.5 High-bit-rate DSL2 (HDSL2)

HDSL2 is the successor of HDSL and has some advantages, as it provides the same throughput as HDSL on a single copper pair, and supports the normal phone service (Velez et al, 2001). However it is a more expensive solution, though.

#### 2.3.1.6 Symmetric Digital Subscriber Line (SDSL)

SDSL is a single twisted pair implementation of HDSL. SDSL has become more generic over time and is also used to refer to a symmetric service at a variety of rates over a single loop (Vicomsoft, 2002). It offers the same broadband speed for uploading and for downloading information with a maximum throughput of 2.3 Mbps with ISDN technology in a single pair. SDSL can reach an entire T1 or E1 line speed over a single copper pair specifying loops up to 11,000ft at a wire thickness of 0.5mm (Vicomsoft, 2002). SDSL services are designed for businesses that regularly need to send and receive large amounts of data.

#### 2.3.1.7 Multi-rate Symmetrical Digital Subscriber Line (M-SDSL)

M-SDSL is built on single pair SDSL technology. It can automatically adjust the speed of the line. It supports eight distinct rates and allows data transmission speeds between 64 Kbps and 128 Kbps specifying loops up to 29,000 ft at a wire thickness of 0.5mm and stepping down to 15,000 ft at a full 2 Mbps rate

(Vicomsoft, 2002). With auto-rate ability (similar to R-ADSL), symmetric applications can now be universally deployed. M-SDSL uses CAP modulation.

#### 2.3.1.8 Symmetric High-speed DSL (SHDSL)

SHDSL is the first standardized multi-rate symmetric DSL and is a product of the International Telecommunications Union - Telecommunications (ITU-T). It is designed to transport rate-adaptive symmetrical data across a single copper pair with ATM technology at data rates from 192 kbps to 2.3 Mbps or 384 kbps to 4.6 Mbps over two pairs (DSL Forum, 2004). Voice and data are carried over IP/ATM networks.

Due its symmetric nature, SHDSL is perfectly suited for any kind of multiple voice or video services. Furthermore, symmetric data services, as typically found in more business-oriented applications like remote LAN access, can also be addressed by SHDSL (DSL forum, 2004).

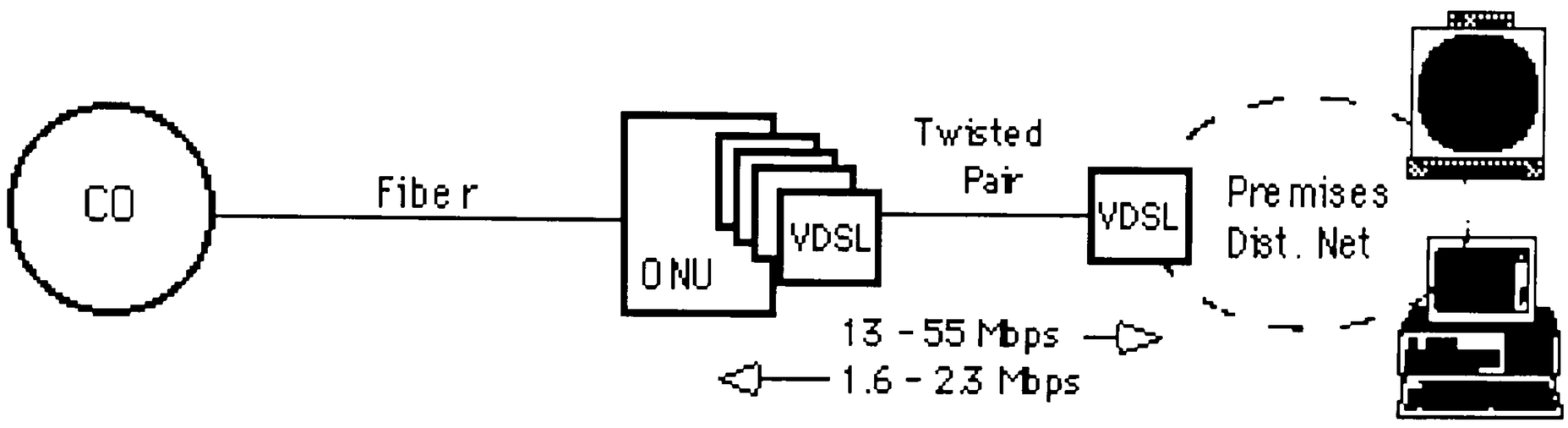
#### 2.3.1.9 Very High Data rate DSL (VDSL)

VDSL is supported on optical fibre for most of the path from the local exchange, which makes it a more complex variant, with the final sections being copper pairs (Velez et al, 2001). It offers a much higher throughput (2.3 Mbps in upstream, 52.8 Mbps in the downstream) and due to the price, is appropriate for big companies with heavy traffic.

VDSL, in simple terms, transmits high-speed data over short reaches of twisted-pair copper telephone lines, with a range of speeds depending upon actual line length (DSL forum, 2001a). The maximum downstream rate under consideration is between 51-55 Mbps over lines up to 300 meters in length. Downstream speeds as low as 13 Mbps over 1500 meters length are also in the picture. Upstream rates in early models will be asymmetric, just like ADSL, at speeds from 1.6 to 2.3 Mbps. Both data channels will be separated in frequency from bands used for POTS and ISDN, enabling service providers to overlay VDSL on existing services (Figure 2.5).

At present the two high-speed channels will also be separated in frequency. As needs arise for higher speed upstream channels or symmetric rates, VDSL systems may need to use echo cancellation. VDSL is the next step up the speed ladder beyond ADSL. However, the price paid for VDSL's increased speed is a shorter distance range. Additionally, VDSL comes in two variants, a "symmetrical" and an "asymmetrical" version (DSL forum, 2001a).

**Figure 2.5 VDSL Connections (DSL forum, 2001a)**




VDSL technology provides the final delivery of data over the existing phone line. Over short ranges, the asymmetrical versions of VDSL offers a slower data rate but still proportionately higher than for ADSL. Like ADSL, VDSL must transmit compressed video; a real time signal unsuited to error retransmission schemes used in data communications. To achieve error rates compatible with compressed video, VDSL will have to incorporate Forward Error Correction (FEC) with sufficient interleaving to correct all errors created by impulsive noise events of some specified duration. Interleaving introduces delay to the order of 40 times the maximum length correctable impulse (Vicomsoft, 2001).

#### 2.3.1.10 Voice Over DSL (VoDSL)

VoDSL is a means of leveraging the copper infrastructure to provide both quality services as well as support a wide variety of data applications over the same existing line to the customer's site. It allows service providers to offer multiple telephone lines over a single subscriber access line in addition to high-speed data transmission services (Figure 2.6 and Figure 2.7). These phones lines can be offered in addition to traditional lifeline telephone service (using ADSL), or instead of traditional lifeline telephone service (using other forms of DSL).

**Figure 2.6 VoDSL Service Equipment** (http://www.iec.org/online/tutorials/acrobat/voice_dsl.pdf)

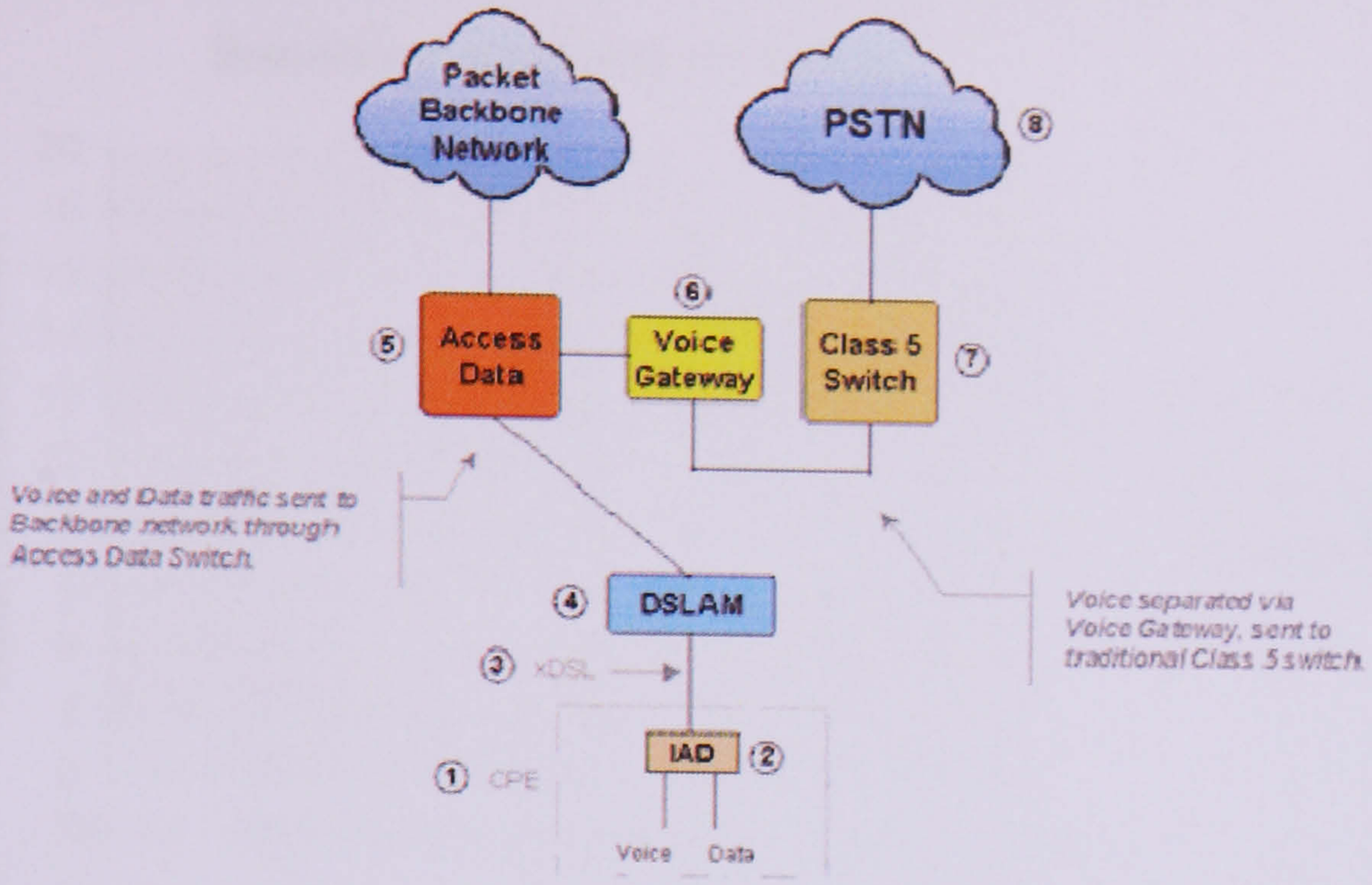
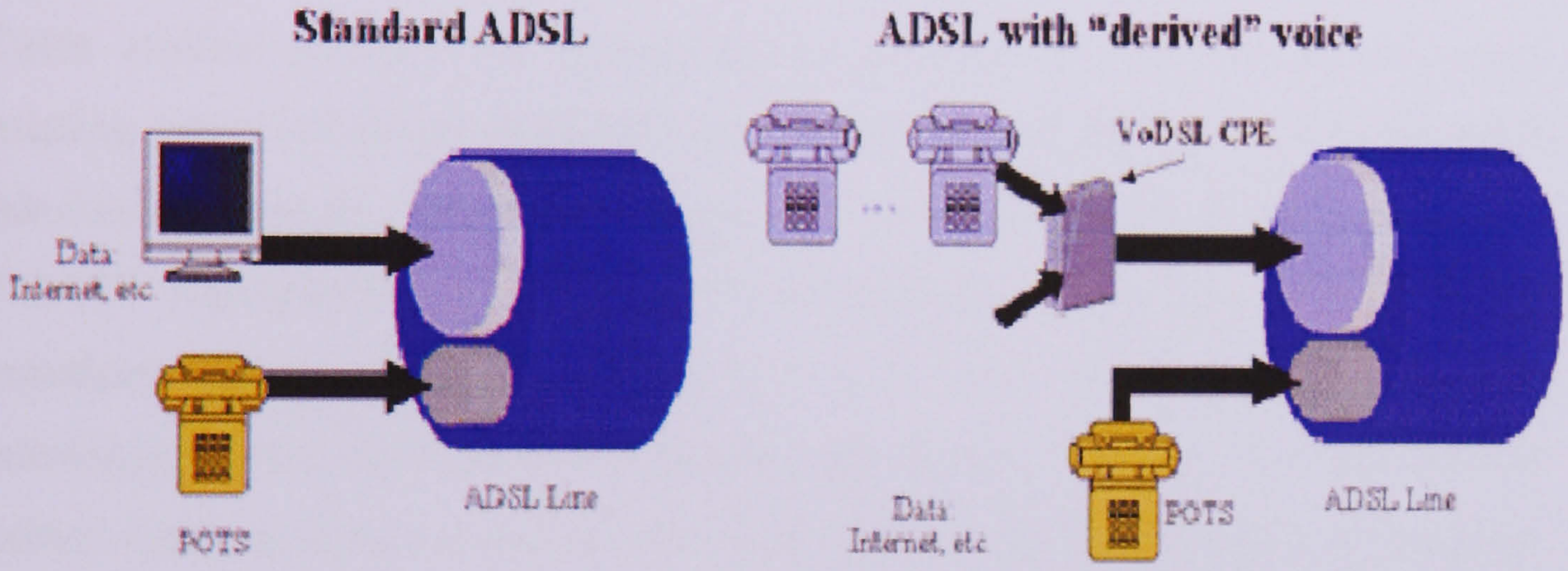
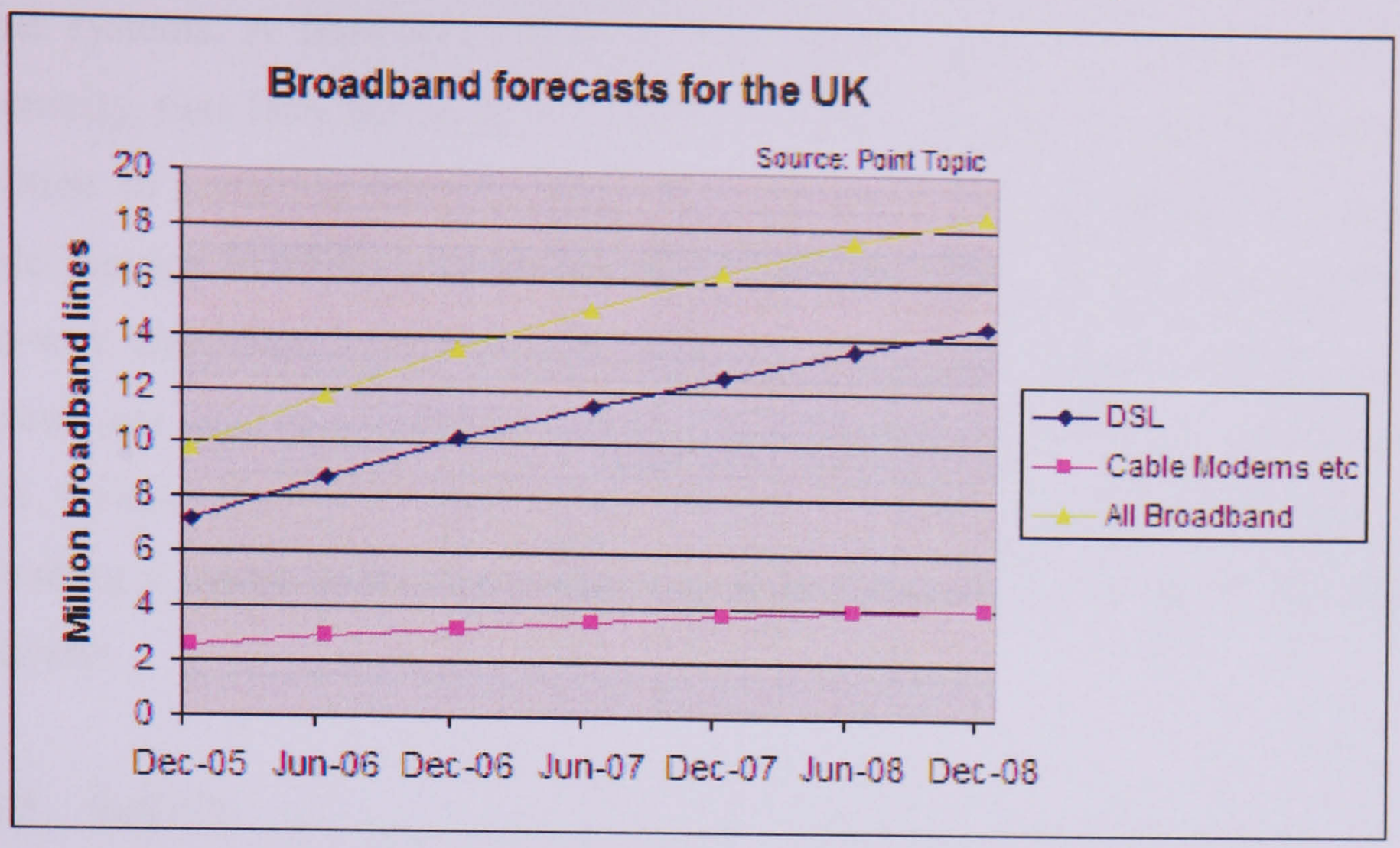



**Figure 2.7 VoDSL** (http://www.iec.org/online/tutorials/acrobat/vodsl_revenue.pdf)




From the subsections of 2.3.1, it was observed that there exist many variations of DSL, as different applications require different data rates and the various DSL technologies deliver those speed variations. For example, HDSL and SDSL deliver services at T1/E1 speeds. R-ADSL can automatically adjust the speed of the line. ADSL can achieve speeds between 1.5Mbps to 8Mbps downstream. IDSL delivers services at 128 Kbps and M-SDSL can support eight distinct rates. Moreover different variations of DSL technology have been implemented to meet the specific needs of home users, small and medium size businesses, schools and colleges, and corporate sectors. One of the main limitations observed in DSL performance is cross talk. However static spectrum management (SSM) ensures that DSL lines in the same cable are spectrally compatible under worst-case crosstalk assumptions (Bostoen et al, 2004). Figure 2.8 shows the broadband penetration fuelled by the rapid adoption of DSL-based broadband in the UK.

**Figure 2.8 Broadband penetration fuelled by DSL across UK, Website Optimization (2006)**




### 2.3.2 Cable

Cable modem service is a high-capacity connection to the Internet that uses existing cable television wires without interfering with channels. Modern cable televisions systems had their origin in "community antennae television" ("CATV") systems that served remote communities that could not receive distant broadcast signals. The CATV system used a large satellite dish to receive television signals, and then distributes the signals to the community using coaxial cables. Cable systems capable of delivering many more channels than commonly broadcast even in major cities, and cable will soon spread to areas that could receive broadcast signals (BAP, 2000).

Original cable systems had capacity for perhaps 50 channels of analogue video, and only supported one-way (downstream) transmission of video signals. Between the cable "head end" (typically where satellite dishes received the signals) and subscribers' homes, numerous signal amplifiers were placed to boost the strength of the signal sent on the coax cable (BAP, 2000). The Centre for Democracy and Technology ("CDT") stated that in the early to mid-1990's, the cable industry undertook the massive and expensive conversion of its traditional cable facilities into systems that (a) could support two-way transmission of signals, for example, interactive video and video-on-demand systems (Rowe and Larson, 1993), and (b) had a much higher capacity to support analogue video signals, digital video signals, and data signals.

These upgraded systems are commonly called "hybrid fibre-optic coax" (HFC) cable systems. A fibre-optic cable, which carries signals with light instead of electricity, runs from the cable head end to "nodes" in residential communities. In addition to installing fibre trunks, cable companies also upgraded the coaxial cable running from the nodes to homes. Old amplifiers were removed and new two-way amplifiers were installed. But even with these upgrades, HFC cable systems are sensitive to electrical "noise" and other interference that can interfere with service. Cable TV is distributed over a hybrid fibre coaxial network providing a nearly 1-GHz bandwidth, whereas a phone line has 10 to 100 KHz available.

### 2.3.3 Satellite

For people in remote and rural areas, broadband services can be delivered by satellite and radio across mobile and wireless networks. Satellites are unique components of communication systems that have singular properties. Some of these properties include breadth of broadcast 'reach', ubiquitous access, low-cost global coverage, large capacity, etc. which represent significant advantages (Chotikapong et al, 2000). The next-generation broadband satellite technology is being developed to carry bursty and multimedia traffic in addition to circuit-switched traffic on a universal basis. These satellites provide direct network access for personal applications as well as inter-connectivity to the terrestrial remote network segments. The key goal of the satellite technology is to offer a ubiquitous means of communications for multimedia and high-data rate Internet-based application (Jamalipour, 2001). Most often grouped with cable, DSL and wireless satellites access technology uses satellites to deliver Internet to homes and businesses. This has started gaining popularity in rural areas around the world (BAP, 2000).

Like cable, satellite is a shared medium, meaning that privacy may be compromised and performance speeds may vary depending upon the volume of simultaneous use. Another disadvantage of Internet over satellite is its susceptibility to disruption in bad weather. On the other hand, the big advantage of satellite is its universal availability (Gilroy and Kruger, 2006). The satellite broadcast system consists of the satellite head-end, direct broadcast satellite(s), a

low-noise outdoor unit with a dish antenna, a receiver, and a PC equipped with a modem. At the head-end, TV and digital data streams are combined and modulated into a radio frequency (RF) signal.

The satellite receives this signal, and converts it to a frequency in one of its downlink channels. The dish then receives this data and transmits it to the modem in one's PC. The upstream data signal is usually transmitted by terrestrial modems to a central hub, which transmits the information to the satellite. The satellite can deliver data streams of multiple audio, video, and data channels at between 400 Kbps to 19 Mbps to the satellite dish at the receiving end. However, current limitations of satellite modem technologies limit effective data rates to the user to 400 Kbps (Cuffie et al, 1999). The interest in satellites and their role in the future broadband multimedia communications systems has grown considerably since they can very quickly and economically extend the boundaries of the terrestrial mobile and fixed networks coverage.

### 2.3.4 Broadband Wireless

Although significantly less established and deployed than cable and DSL broadband services, terrestrial wireless services using land-based transmitters can also provide broadband services to businesses and individuals (BAP, 2000). There are a number of different technological approaches to wireless broadband services, and it is far from clear which of these approaches will be successful in the marketplace. Broadband wireless communications are divided into two groups (Velez et al, 2001):

1. **Cellular networks (UMTS)**

These networks are being developed presently and their broadband capabilities are based in spread-spectrum encoding techniques, which allow multiple users to share the same radio spectrum. The encoding system used in Europe is Wide-Code Division Multiple Access (W-CDMA).

## 2. Fixed Wireless Broadband Access

Wireless broadband services are often called "fixed wireless" because the transmitting and receiving stations (of both the service provider *and* the customers) are in fixed, stationary positions. In other words, terrestrial or fixed wireless services are quite distinct from mobile cellular telephone services. Typically, a company offering fixed or terrestrial wireless services will operate one or more master microwave antennas installed on top of tall buildings or possibly mountains adjacent to populated areas. The users will rely on relatively small antennas on top of their office buildings or homes. There are various systems such as LMDS, MMDS and Point-to-Multipoint System (PMP) in the wireless broadband access.

However, the two leading types of wireless services that can support broadband access to the Internet are LMDS and MMDS. LMDS and MMDS generally both require a "line of sight" between a central antenna and a customer's antenna. LMDS provides faster speeds than MMDS, but can only support customers within two or three miles of a central antenna. LMDS is therefore best suited for businesses located in dense urban areas but is susceptible to interference from rain and snow.

In contrast, MMDS technology cannot support such high speeds, but it can reach customers who are located much farther from an antenna than would be impossible using an LMDS system. Technically, MMDS' zone of coverage could extend 35 miles in every direction from a central tower (covering over 3500 square miles compared to less than 50 square miles covered by a single LMDS station). MMDS can be deployed more cheaply and can reach more efficiently into suburban and rural areas.

LMDS, MMDS, and other approaches (such as the Wireless Local Loop being tested by AT&T), however, all still require a line-of-sight, or near-line-of-sight, path between master and customer locations. As a result, buildings, trees, and other impediments can prevent wireless technology from serving many potential customers in an area. Because of this limitation, many leading providers (like AT&T and MCI WorldCom) in the USA are likely to use wireless technology to fill in gaps in their DSL or cable coverage.

On the whole, wireless technology will probably be an important aspect of widespread broadband availability, but it is unlikely that wireless will ever become a ubiquitous option for all consumers (BAP, 2000). Some of the broadband technologies will coexist, as there is no single technology able to ensure a complete coverage of the whole of the UK. Furthermore, diversity in technology will help solving access in different geographical areas, according to local needs. For example, Fixed Wireless Access and satellite fill in where fixed facilities cannot reach (Liikanen, 2002).

There are currently six contenders for the broadband wireless technology, which are Wi-Fi, proprietary, 3G, 4G, 802.16/WiMax and 802.20 (Sandy and Dave, 2003).

- Wi-Fi is based on the IEEE 802.11 standards for wireless local area networking (WLAN). It was designed to operate in and near a building so users can link to the Internet via broadband if user is in the building or near the building. However, in a metropolitan area network Wi-Fi is restricted, as it was not designed to cover wide area, to support mobility and to scale as a carrier-grade network with thousand of users (Broadband Wireless Exchange, 2006).
- Proprietary provides wireless access to business and homes in competition with wired technologies. Most of these are designed for fixed access and some are being extended for portable and mobile use.
- 3G- In many ways the most logical way to get to broadband anywhere is through today's wireless carriers, who already serve millions of customers' mobile voice needs and some low-speed mobile data needs (Sandy and Dave, 2003).
- 4G, also known as the Fourth-Generation communication System. A 4G system provides a comprehensive IP solution where voice, data and streamed multimedia can be given to users on an "Anytime, Anywhere" basis, and at higher data rates than previous generations (Young Kyun and Prasad, 2001).
- 802.16/WiMax is the newest wireless technology that provides wireless broadband. The Worldwide Interoperability for Microwave Access is a telecommunications technology aimed at providing wireless data over long

distances in a variety of ways, from point-to-point links to full mobile cellular type access. It is based on the IEEE 802.16 standard (Nuaymi, 2007).

- 802.20/MBWA (Mobile Broadband Wireless Access) is intended for the provision of an efficient packet-based air interface with high-speed downlink and uplink capabilities. It is aimed to provide for low latency as well as enables telephony using Voice over Internet Protocol (VoIP) and activities needing rapid network response times, such as online gaming and financial transactions. The standard also supports other IP-centric applications, so the many native IP applications can be used without alteration (Klerer, 2003).

## 2.4 Broadband end-to-end Transport Protocol

The deployment of a broadband infrastructure implied dramatic changes in the way Internet is used. It is not simply a faster way to connect users and business but it challenges the traditional services delivery methods as connections become immediate and large volumes of data can be almost instantly transmitted.

The Asynchronous Transfer Mode (ATM) is an efficient transport mechanism. The telecommunication operators developed it in the early 1990s as a way of carrying all kinds of traffic: voice, data and multimedia (Sharpe, 2003). ATM is based on virtual connections using small fixed size packets called cells which mean it is a cell-based switching and multiplexing technology designed to be a general-purpose, connection-oriented transfer mode for a wide range of services.

Since ATM was proposed to support services with vastly different requirements, it was adopted as the transport scheme for the broadband backbone networks (Ma and El Zarki, 2002). This is because ATM technology can carry a large volume of data and can support diverse services like audio, video, and data uniformly (Varghese Panicker et al, 1999).

In order to achieve ubiquitous connection, wireless ATM is used as the extension of ATM over wireless links. ATM certainly plays a major role in the emerging provision of broadband communications; it is expected to integrate efficiently

both real-time and non-real-time traffic, while providing quality of service guarantees per connection.

The latest developments and experimentation with the ATM technology shows that ATM is going to be the future transport mechanism in many private and public networks (Hotch, 1999). This is driven by the need to efficiently support a large population of wideband/broadband users with different data traffic characteristics and certain QoS guarantees.

## 2.5 Broadband Applications

The benefits of broadband are highlighted by the potential of their use. As a result of the widespread use of broadband, applications such as motion picture, games, and videoconferences have increased Internet traffic (Kondo et al, 2004). This in turn has influenced the growth of broadband networks to support applications beyond Internet access by sharing the distribution and use of content in the home (Witowsky, 2004).

Using broadband, Internet speeds are up to 12 times faster than a typical ISDN connection and 25 times faster than a traditional 56 Kbps modem, which in reality means that web sites with media rich content such as movie trailers, on-line games, music videos, and cartoons can be viewed and interacted with as their makers intended. Spending a few hours researching and downloading documents or files no longer becomes an irritating or costly hassle.

The speed and cost effectiveness of broadband makes this technology extremely attractive not only to home users, but also to small to mid-sized businesses, small office/home office (SOHO) workers, companies with branch offices, who wish to move away from analogue modems and ISDN. Broadband will facilitate the creation of home-based businesses though web serving, e-commerce with customers and financial functions. Broadband also allows a wider range of entertainment activities, including web surfing at higher speeds with richer video content, video on demand, and interactive, multi-player video games (BAP, 2000).

The convergence of telecommunications, computing and content industries has been one of the major trends during the recent years. This convergence has lead to the creation of a wide range of multimedia services, which are available in digital form through broadband networks (Raatikainen, 2003). Multimedia applications consist of heterogeneous content, for example video, audio and images encoded using different compression schemes (e.g. MPEG, JPEG) at variable presentation quality levels for example quantity, display size, frame rate and session interactivity for example image scaling, VCR-like control (Reininger et al, 1998b).

Modem pioneer Kim Maxwell grouped potential residential broadband applications into three general categories: "professional" (activities related to users' employment), "entertainment" (from game playing to movie watching), and "consumer" (all other non-employment and non-entertainment activities) (Maxwell, 1999). Maxwell closely considered each potential application in terms of its potential to contributing to the cost of implementing broadband services.

The use of the above-mentioned broadband access technologies in section 2.3 has led to the proliferation of high speed Internet and killer-applications. Killer applications can be games or applications, operating systems or multimedia platform. Examples are IP telephony, video conferencing, online gaming, telemedicine, multimedia services, Voice over IP (VoIP) and Video-on demand, some of which was looked at in more detail below.

### I. Online Gaming

Broadband gaming is fast becoming a global industry. South Korea, for example, found the online gaming called Massive multi-player online Role-playing games (Mmorpgs), which has captivated millions of Korean people (Krikke, 2003). It is also no surprise that Korea ranks first in broadband gaming (Krikke, 2003). The broadband high speed improves the response time for on-line games and gives enthusiasts a more enjoyable experience. Online games come in many forms, some can be played free of charge, some require a one-off fee to purchase the software and others require a monthly subscription to join in the fun.

### II. Video on Demand (VoD)

The recent demand for fast Internet access to the home has made the development and rollout of broadband access networks and video-on-demand service commercially viable (Green et al, 2001). VoD provides distance learning, movies and special event broadcasting. Broadband high bandwidth allows users to not only download music, but also full-length movies.

On-line movie services that operate over the Internet allow broadband-connected users to purchase and download digital versions of both new and old movies on demand. Consumers can view the downloaded movies on their computers or on a television connected to the computer via video cable. Users have access to a library of movies at their fingertips, and save time by not having to visit a video store. Internet movies also come in the form of movie trailers such as short clips used to market a full-length movie or TV program. These are generally free of charge and are short enough to download in a reasonable time on broadband.

### III. Video Conferencing

Developments in telecommunications over the past few years, especially broadband communications, have demonstrated the benefits and efficiencies that such technologies can bring to office occupiers, for example, the faster and more efficient transfer of data and the use of video conferencing (Spurge and Almond, 2004). Videoconferencing allows people in different locations to see and hear each other in real time. The advent of broadband has made videoconferencing cheaper and more readily available and improved the quality of the video picture. The chief advantage of videoconferencing is that it saves on travel and accommodation costs and saves the time involved in travelling to other locations.

## IV. Voice over IP (VoIP) /Internet Telephony

VoIP telephone services are already making inroads into corporate communications because of the cost advantages. They are poised to be a major driver of consumer broadband networks (Rath, 2000). Early adopters use the broadband network for additional telephone lines and for routing long-distance calls.

VoIP or Internet Telephony is the latest cost effective means of communication made more feasible by broadband. It allows one to make telephone calls and send faxes over data networks such as the Internet and intranets. While it currently does not offer the same quality of service as direct telephone connections, it is expected to expand rapidly in the near future and it does have many advantages over traditional telephone calls.

Internet telephony has long been thought of as an emerging application for broadband networks. However, its equipment costs and network requirements have so far prevented its adoption outside corporate circles. Internet telephony will also allow innovations that the existing telephone system cannot compete with, such as voice-annotated documents and the transfer of multimedia files. It carries one's telephone calls over the Internet, so there are no charges payable to a telephone company, only an Internet service provider.

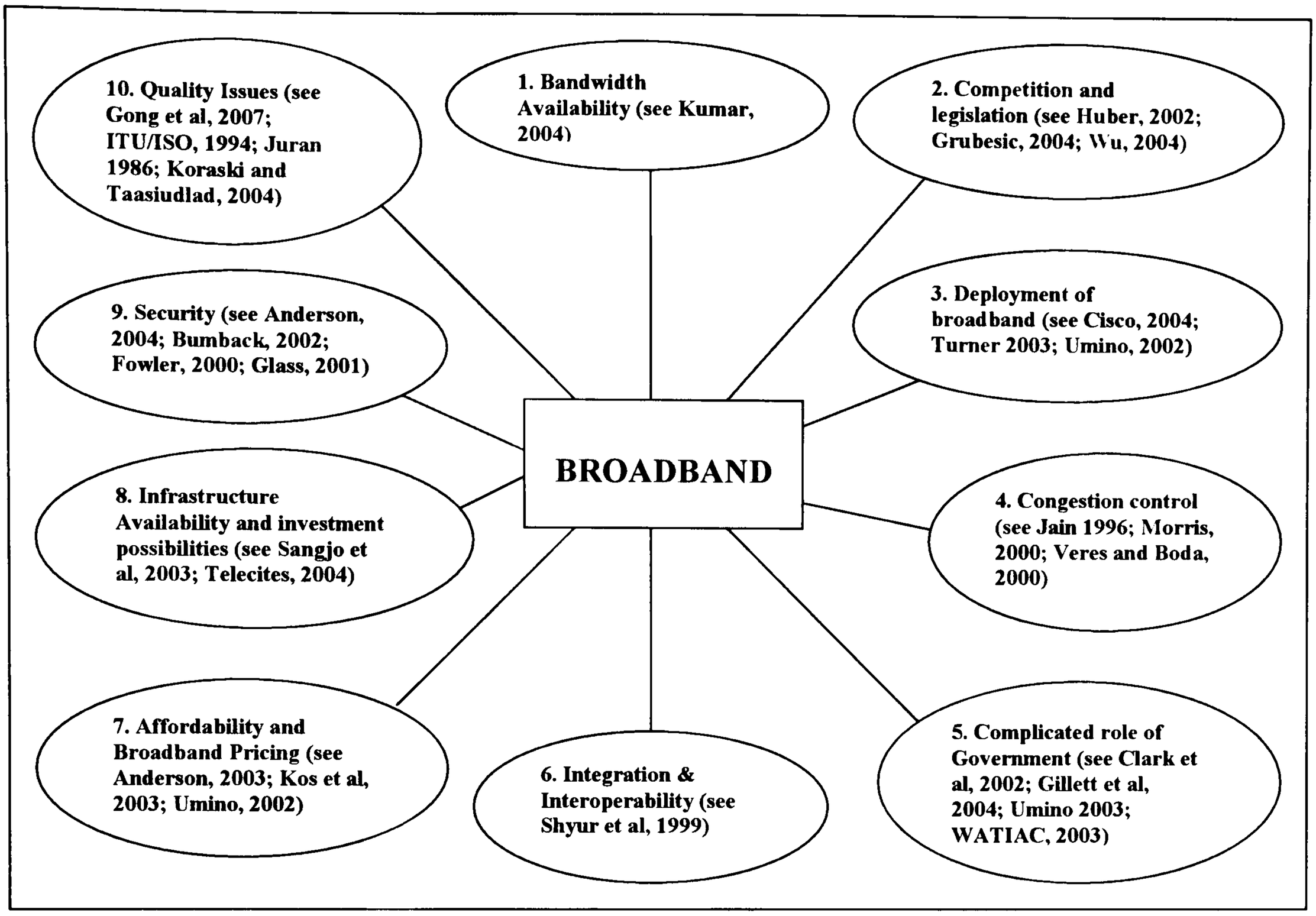
All these applications discussed above have different bandwidth requirements. For example, all of the "professional" activities will likely be supported with less than 1.0 Mbps of bandwidth. Similarly, web surfing and home shopping will be supported with less than 1.0 Mbps of bandwidth. Movies and video, however, demand more bandwidth. Feature length movies can probably be delivered with 1.5 Mbps of bandwidth, but broadcast quality video will probably require as much as 6.0 Mbps.

## 2.6 Broadband Issues

The focus of earlier research on the distribution and adoption of broadband Internet access has been primarily on the construction of a national-level infrastructure or on macro-level factors such as government policies, market competition and the density of population (Sangjo et al, 2003). As the adoption of broadband has moved into millions of businesses and homes in the UK, consumers are becoming more dependent on broadband connections for their Email, Web surfing, games, and particularly the size of large attachments. While the many variables involved in creating commercially viable broadband media services are in place, several technological and legal factors are involved in bringing large amounts of content to consumers; broadband is also affected by similar issues affecting other segments of the computer industry – privacy, security and encryption, and Internet access.

The role of the operating system, bandwidth requirements, network optimisation, policies, security and privacy are part of the huge concern in the United Kingdom and indeed throughout the European Union for the provision of broadband services. These issues need to be addressed and overcome by the government, telecommunications companies and service providers in order to provide a quality broadband to its consumers. Figure 2.9 displays ten issues that could contribute to the degradation of broadband service in the context of commitment to the stakeholders. These issues have been identified and extracted from secondary research sourced from academic papers, government and agency documents. The issues are discussed in more detail in the following subsections below.

**Figure 2.9 Overview of broadband issues**




### 2.6.1 Bandwidth Availability

Bandwidth availability is a major driver for broadband services. In a competitive environment, service providers are expected to take appropriate steps for making required bandwidth available in a time bound manner within their licence framework. Moreover, the cost of bandwidth constitutes a major cost component for broadband service and can also impact availability (Kumar, 2004).

### 2.6.2 Competition and legislation: legislative issues (EU and National levels)

Effective protection of content is essential to the long-term development of broadband network. The best long-term protection for providers of content lies in robust competition among providers of broadband connectivity (Huber, 2002). The UK telecommunication Act of 1996 established a regulatory policy that promoted competition, innovation, and investment in broadband services and facilities (Grubesic, 2004). From a global perspective, Canada and South Korea seek out to create a regulatory environment that allows for effective competition in communication. This competition is based on different broadband platforms,

whether these are wire line telecom network, cable network and wireless (Wu, 2004).

Intellectual property and copyright issues are factors raised in this area. Copyrights law trades off costs of limiting access to information against the benefits of providing incentives to create information in the first place. The development of digital rights management (DRM) may disturb the balance between creation and distribution of information (Arkenbout et al, 2004).

### 2.6.3 Deployment of broadband in the UK

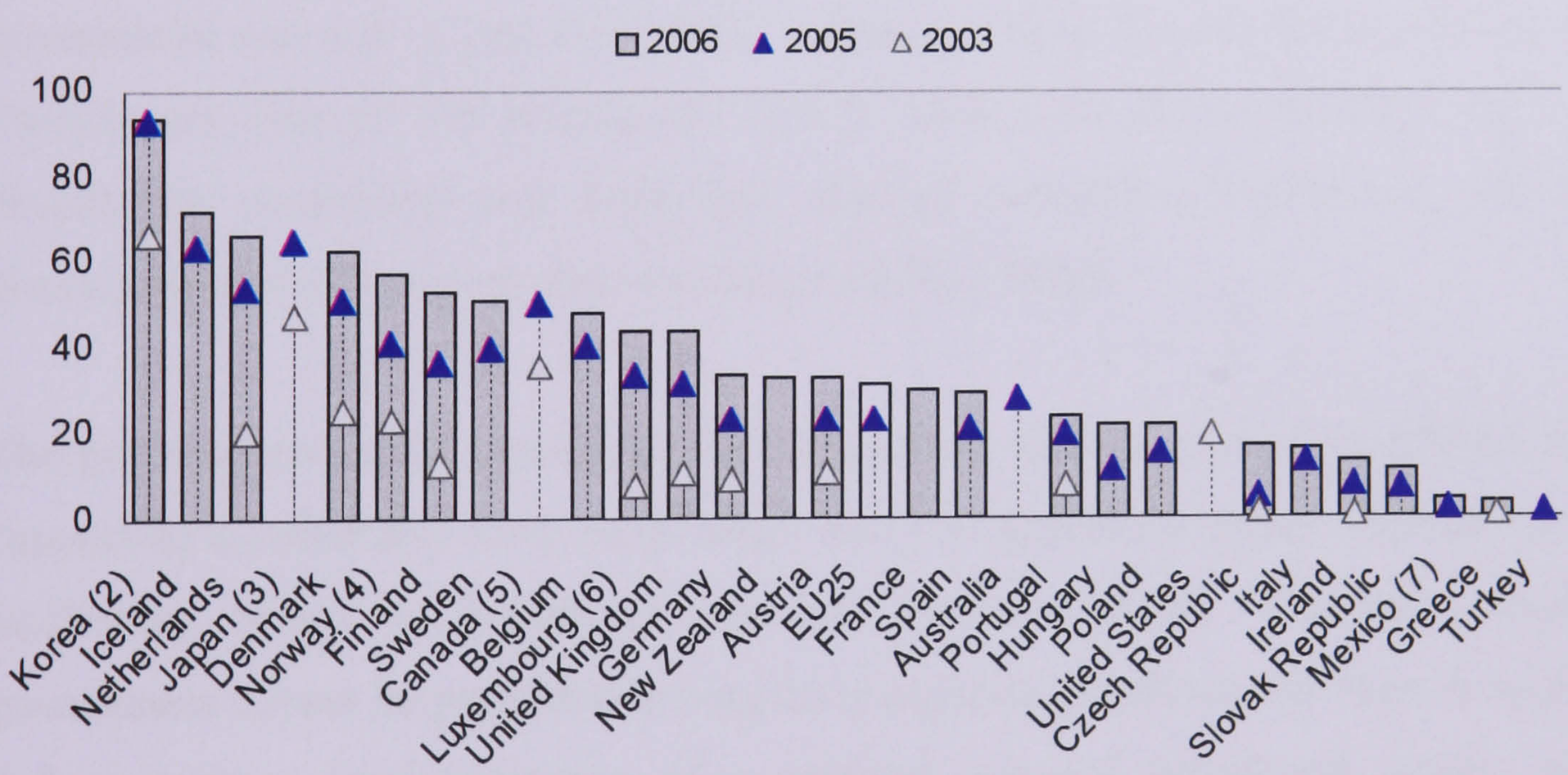
Broadband deployment has been slow worldwide due to economic uncertainty and regulatory complexity. Some other factors also responsible for the slow deployment include the absence of a competitive market, disagreement between traditionally regulated industry and new technology industries over terms of the entry to the market, investment in new infrastructure, and use of existing infrastructure and the legitimate need to ensure universal access to broadband service (Cisco, 2004).

There is a concern that broadband deployment will be incomplete, creating a geographical digital divide, because the provision of broadband access in rural areas may not be cost effective and thus market forces may be insufficient to provide national coverage in all countries (Umino, 2002). Another issue affecting this segment's growth is developing the network of telecommunications systems to deliver curb side access of fibre-optic transmission lines piping information, entertainment, and communications all in one line to living rooms across the United Kingdom. Moreover, as more enterprises and consumers subscribe to this new technology, the future of broadband is full of uncertainty as competing companies and industries try to anticipate technological advances, market conditions, consumer preferences, and even cultural and societal trends (Huber, 2002; CRS, 2003). For example Turner (2003) identifies that British Telecommunication's (BT) initial attempt to deploy broadband technology through its ISP failed due to key commercial and technological weaknesses. This issue was addressed by BT shifting to a more strategically defensive strategy

based on securing its position of dominance on the UK local access market. This strategy proved considerably more successful.

Based on the deployment of a mass-market broadband, it created an evident industrial/corporate strategy interface as BT's corporate objectives aligned with public policy objectives of creating a universally accessible broadband product. The result of this interface has been to place BT at the heart of the "Broadband Britain" programme - a position that contravenes the original intentions of the UK government (Turner, 2003). A further issue identified under this category is the scarcity of examples of market proven business models, unbundling of carrier/services that would set the pace for upcoming service providers. The data showed in Figure 2.10 ranks broadband subscribers in various countries. As can be seen, while Korea has the highest percentage of 94 percent on household with broadband access, the UK ranks low at 43.9 percent despite the UK government's effort to make the UK a top broadband country.

**Figure 2.10 Households with broadband access, 2000-06 (1). Percentage of all households.)**




***Source: OECD***

### 2.6.4 Congestion control

The volatile nature of voice, video and data traffic sometimes allows the amount of traffic to surpass the speed link of a broadband connection. The packet losses imposed by Internet Protocol (IP) networks can cause long and erratic recovery delays, since senders must often use conservative loss detection and retransmission mechanism (Morris, 2000). Congestion control can show chaotic

behaviour (Veres and Boda, 2000) whenever the input is more than the link capacity. Congestion control schemes usually entail adjusting the input rate to match the available link capacity or rate (Jain, 1996 and Rhee et al, 1999).

Congestion control is a key issue in broadband networks, (Cooper and Park, 1990; Eckberg et al, 1989; Guizani, 1998; Priscoli and Pietrabissa, 2003). Although Priscoli and Pietrabissa identify congestion as an issue in broadband, however they did not provide an absolute solution to address this but presented a closed loop control mechanism that limits the on board congestion probability in spite of the long propagation delay. Furthermore, pricing on broadband can also be employed to avoid over-utilization of network resources and as a mechanism for congestion control (DaSilva, 2000; Elmaghraby et al, 2003; Falkner et al, 2000; and Cao et al, 2002).

### 2.6.5 Complicated role of governments

The development of broadband networks and services is a key issue for governments around the world (WATIAC, 2003). Access to broadband is widely accepted as a prerequisite for a community's economic welfare and the delivery of government services (Clark et al, 2002). Canada, South Korea, Netherlands and Sweden are four of the leading broadband markets in the world (Wu, 2004) despite the uncertainty and delay that affected broadband regulations, which discourage both investment and innovation (Huber, 2002).

The potential economic importance of e-commerce and the role of broadband in supporting e-commerce have increasingly led governments to place emphasis on facilitating access to broadband networks (Umino, 2002). Therefore, local government cannot be permitted to singularly regulate broadband services in ways that undermine implementation of a uniform national broadband policy, as patchwork regulation creates a serious impediment to the development of broadband services. New players are therefore needed, both public and private.

Umino (2002) however argued that government should provide policies that would continue to emphasise the role of competition in stimulating broadband development and diffusion and should avoid direct intervention in the broadband market which risks distorting market mechanisms. He also clarified that

government's role should facilitate such development and only intervene in areas where it has become clear that there will be no private infrastructure. The UK government recognised the importance of broadband development, which is reflected in the ranges of government initiatives structured in different ways that directly and indirectly gave momentum to the development of broadband infrastructure and services in both the urban and rural areas (UK Online, 2002 and Umino, 2002).

For the UK government to achieve its vision on broadband, the government should provide leadership (Gillett et al, 2004) on broadband via setting the agenda as well as creating a strategic partnership with key players in the private and public sectors, and continue to drive forward competition in the supply of infrastructure and services. Measures such as investment incentives, government grant programs, and subsidies should be designed to bring services and knowledge to communities where broadband is slow in being taking up.

### 2.6.6 Integration and Interoperability

Interoperability and standards issues affect the entire broadband supply chain including standards, micro-payments, rights and management issues. Broadband interconnection issues needs to be discussed so as to find ways for the integration of broadband network with existing networks. The use and integration of computers with telecommunication have created a new era. In order to provide the much-needed broadband services, high capacity transport systems are widely adopted in the transmission network. While these systems offer great economic advantages through multiplexing and sharing of transmission facilities, they also increase the vulnerability of the telecommunication services dependent on them. If a failure occurs on a high speed facility of such a network, all the related services get affected and network survivability has therefore, become a major concern in broadband network planning (Shyur et al, 1999).

### 2.6.7 Affordability and Broadband Pricing

The availability of a broadband infrastructure, in itself, will not necessarily result in the take up of broadband; however, the price of broadband access plays an important part in stimulating its take-up and in turn this will depend to a large extent on the conditions of competition in the infrastructure market (Umino, 2002).

From the customers and service providers' perspective, it is assumed that customers, and potential customers, of broadband services are most concerned with:

- Clear information about the service offering, particularly concerning the speed of download and upload that can be expected in practice
- Clear pricing information
- An activation process that is predictable
- Availability performance of the service, including the failure rate, average availability, and both typical and worst-case restoration times

Growing consumer demand for data communications has forced telecommunication operators to greatly extend capabilities and capacity of their networks and to offer acceptable prices for all available information and communications services with high speed Internet connection for the small business and individual users (Kos et al, 2003). Moreover, customers of the computing and communications industries are getting increasingly irritated at ever more complex and confusing prices as services are sold both singly and in combinations on a great variety of different contracts (Anderson, 2003).

Pricing is an important issue that needs to be addressed in broadband and can be a crucial limit on the demand for broadband (Romero, 2002). This is especially more so since pricing in broadband can be used as an effective means to recover cost, to increase competition among different service providers (Choudrie and Lee, 2004), and also to reduce congestion or to control traffic intensity (Cao et al, 2002 and Xavier, 1997). High subscription price can lead to the slow acceptance of broadband. Without competition and lower subscription prices, broadband runs

the risk of becoming the Internet's limited access toll road of large corporation and affluent consumers.

Service providers set up a price they consider right, in order to induce a desirable demand from the users to achieve a profit as large as possible. Some service providers offer different tariffs with the stipulation that user will not pay more than the selected amount, which determines the type of service the network may guarantee. The choice of a user reflects the valuation based upon the budget for an amount of bandwidth beyond guaranteed rate and the service provider in turn offers a fair share of the bandwidth based on the user budgets and bandwidth requirements (Yaiche et al, 2000). Pricing strategy can thus be determined by many approaches, which includes the cost based approach, the optimisation-based approach and edged pricing approach (Shenker et al, 1996).

Broadband can seem confusing for consumers, with the huge amount of operators offering so many different products, some with capped bandwidth and different length contracts and set-up fees (Wakefield, 2004). A number of pricing schemes have been proposed that addresses the pricing issues in broadband, which include the flat pricing scheme (Edell and Varaiya, 1999). Flat pricing scheme means that the user is charged a fixed amount per time unit (month) irrespective of usage (Falkner et al, 2000). One of the success factors of broadband adaptability in South Korea was that the government aimed the price at an affordable level wherein the middle-income family can afford (Lee and Choudrie, 2002) and encouraged competition amongst service providers, which sequentially pushed prices lower.

### 2.6.8 Infrastructure Availability and Investment Possibilities

The European Commission pointed out that a widespread secure broadband infrastructure is essential for the development and delivery of services and applications such as eHealth, eBusiness, eGovernment and eLearning (Telecities, 2004). Although many countries are attempting to build an information infrastructure and accelerate the acceptance of broadband access technology, the results are not always satisfactory (Sangjo et al, 2003). What seems clear is that industry believes that providing broadband services to the home and offices offers

the potential of financial return worthy of significant investment and some level of risk.

However the issue of broadband availability gives way to content, access and use. Therefore the focus on this section will be on the value of content in broadband networks, the market forces that drive demand for content, the players positioning for new revenue opportunities – and the rising importance of content delivery over mobile networks.

Kabira (2004) identify some issues related to availability as follows:

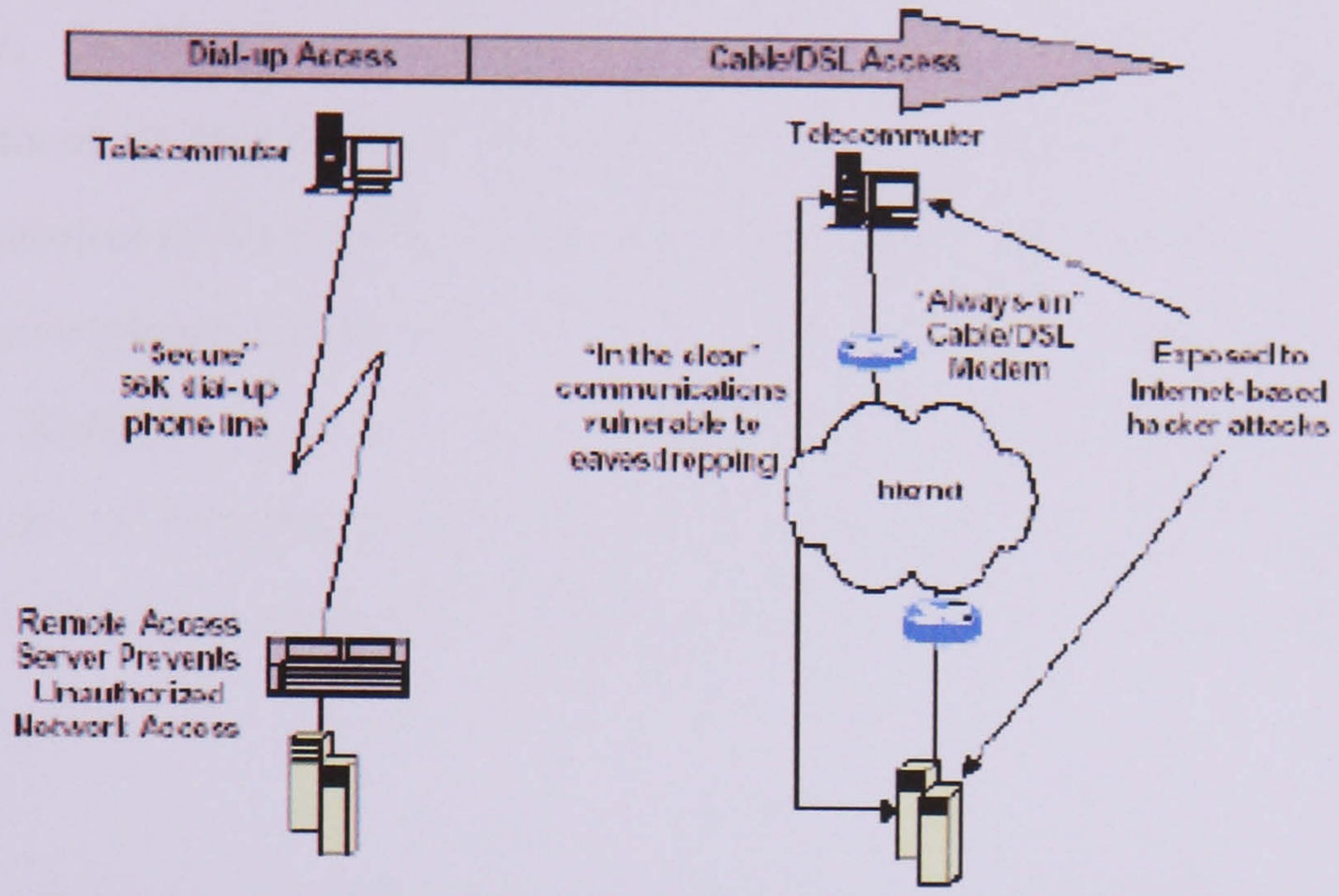
- The availability of cost-effective platforms for creating new services while leveraging existing heterogeneous infrastructure
- Operations Support Systems (OSS) and Business Support System (BSS) support for flow-through provisioning and activation. The term OSS refers to the systems that perform management, inventory, engineering, planning, and repair functions for telecommunications service networks.
- Flexible mediation capable of supporting new billing paradigms such as innovative rating and prepay
- Maintaining an accurate real-time inventory of network assets
- Inter-carrier dependencies and reconciliation
- Support for complex IP layered services
- Allocating wavelength capacity in real-time (Lambda provisioning on demand)
- QoS / SLA Support throughout the network value chain

### 2.6.9 Security

Security is a key concern with most broadband access (Fowler, 2000). There is a potential cost to broadband adoption, particularly the increased exposure to security incidents and vulnerabilities. Examples of these are viruses, worms, spyware and hackers so precautions are necessary. Moreover, the increase in the acceptance of broadband by non-tech savvy consumers and businesses has increased the demand for security solutions addressed for this growing market (Anderson, 2004). These security functions can take many forms, including hardware, software, or a service. The highest priorities for broadband users are

firewall, anti-virus and privacy control/content filtering capabilities (Bumback, 2002).

**Figure 2.11 Broadband Access Security Challenges (Nahar, 2001)**




Security breaches represent one of the most serious threats that Internet Service Providers, telephone companies, and cable companies rarely acknowledge (Glass, 2001). Microsoft bcentral (2004) advised that the users should research the security requirements and policy offered by a service provider and check whether the company's service delivery includes security and data filtering systems. It is important to also install own firewall and virus-scanning software as sending data across the Internet always means invoking appropriate security measures; moreover, different services also have inherent security concerns. Figure 2.11 shows broadband access security challenges.

Consumers of broadband risk getting their systems infected as the broadband nature of high speed and 'always on' allow unwanted intruders to get in and out of the user's system. This is made possible through the static IP address assigned to the broadband user's system. If hackers take over a system, they can turn it into an Internet server for sending malicious emails. They can also use it as an illicit meeting place, by setting it up as an Internet relay chat server, or use the hard disk as a repository for illegally copied software, movies or music (Glass, 2001).

### 2.6.10 Quality Issues in Broadband

The issue of broadband quality will be the core of this dissertation. Although sections 2.6.1 – 2.6.9 highlighted and addressed various other issues with broadband, quality is becoming an issue of increasing importance with this technology. Quality is determined by how well it meets and exceeds the expectations of its stakeholders (Lengnick-Hall, 1996). With this in mind it is now become essential to look at the issues of quality in broadband technology and how these issues has been handled by ISPs in order to provide broadband services to its customers. Besides, these issues on quality can also cause a pessimistic effect on the adoption of broadband technology. Furthermore quality is also customer driven, demanding continuous improvement, and total involvement (Firquin, 1992).

Most work done on broadband quality so far has been concentrated on QoS and this in most cases has been misrepresented as broadband quality. However quality has various facets to it and these facets need to be taken into consideration in other to provide a broadband quality that can be sustained in a very long run.

Below are various facets of broadband quality, which will be looked into in greater detail in the next chapter.

- **QoS** - A set of quality requirements on the collective behaviour of one or more objects (ITU/ISO, 1994).
- **Quality of Services (QoSs) -** These is the area where different management services are provided by content providers and telecommunication.
- **Cultural Quality** - Culture is depicted as mental programming, which particularly predetermines a person's behaviour and can be described and defined in many ways (Gong et al, 2007).
- **Functional Quality -** This relates to the standard product quality including satisfaction of needs and absence of defects
- **Quality of Perception (QoP) -** This measures perceptual quality as experienced by the user, including the level of information transfer to the user when users are presented with multimedia video clip at different quality levels using different display devices.

- **Quality of price** - This focuses on pricing and charging for the variety of different application services offered by a broadband network.
- **Reliability** – This focuses on the broadband connection which is never disrupted (Wang et al, 2007).
- **Security -** Quality of security is the level of protection provided by the ISP to broadband users.

## 2.7 Summary

In this chapter broadband was defined and various broadband access technologies have been described. Various broadband applications as well as the broadband transport protocol – ATM were also discussed. Following these, identification of broadband issues that may affect deployment and adaptation of broadband were examined and the quality issue was introduced as one of the central issues of broadband. In the next chapter, various facets of quality in broadband arena are explored closely.

# CHAPTER 3: Quality Issues

## 3.1 Introduction

In this chapter, broadband quality and its various facets are examined and discussed in detail. The aim of this chapter is to justify the research gap, and consequently develop the background to the provision of broadband quality framework by laying the foundations upon which this research will be developed. Quality as perceived by consumers, the service provider, telecommunication companies and the government are also examined. At the end of this chapter the reader will have gained an understanding of the different facets of broadband quality as perceived by various stakeholders.

## 3.2 Quality Defined

Quality in various forms has been investigated for many years because of its benefits to commercial applications and consumers. Quality can also be described as "fitness for purpose" or value for money as perceived by the customer. In this thesis, quality will be defined as the totality of features and characteristics of a product or service that bears on its ability to satisfy a given need, in other words, the degree to which the product or service meets its requirements.

The assessment of quality involves the use of information gathered from interested parties to identify differences between user expectations and experiences. Quality can be achieved by meeting the *Quality trilogy* (Juran, 1986). The Quality trilogy is a three-pronged approach to managing quality. The three parts are quality planning (developing the products and processes required to meet customer needs), quality control (meeting product and process goals) and quality improvement (achieving unprecedented levels of performance).

Juran (1989) definition of quality (see table 3.1) would enable us to appreciate how significant quality is to broadband and also allow us to choose in this research which quality facet to focus on. Can it be then said that quality and QoS in broadband are the same as perceived by various stakeholders? As described earlier, the word quality in broadband has many sides to it, while QoS in broadband is but one of its facets. A detailed description of the many facets of quality is provided later in this chapter. It is from this description that the issues of

quality are identified and a gap is established that would be addressed by this work.

**Table 3.1 Juran (1989) description of quality**

| Availability of Service/Production Features that meet Customer needs | Freedom from Deficiencies |
|---|---|
| Higher quality enables companies to:<br>▪ Increase customer satisfaction<br>▪ Make products sellable<br>▪ Meet competition<br>▪ Increase market share<br>▪ Provide sales income<br>▪ Secure premium prices<br><br>▪ Major effect is on sales<br>▪ Usually, higher quality costs more | Higher quality enables companies to:<br>▪ Reduce error rates<br>▪ Reduce rework, waste<br>▪ Reduce field failures, warranty charges<br>▪ Reduce customer dissatisfaction<br>▪ Reduce inspection, test<br>▪ Shorten time to put new products on the market<br>▪ Increase yields, capacity<br>▪ Improve delivery performance<br>▪ Major effect is on costs<br>▪ Usually, higher quality costs less |

In order to bridge the gap from the current disintegrated works on broadband quality, there is a need to create a logical framework that amalgamates all the many facets of broadband quality. The framework would serve two purposes: firstly, it will be a guide to the specification of quality parameters, and, secondly, it will serve as work plan for the study of quality and the development of new ideas. As quality is in the eye of the beholder, it is essential to initially unfold the identities of the stakeholders in the broadband arena before discussing their perceptions of broadband quality.

## 3.3 The identification of stakeholders

Broadband has revolutionised the way businesses as well as people connect to the world via the Internet and has the power to open up a whole new world of possibilities. Stakeholders' interest is of utmost important in the delivery of broadband and is intended for maintaining the viability of any organization's products and services, as they influence programs, products, and services. However there is a debate within the literature about how to define stakeholders (Papazafeiropoulou et al, 2001).

A stakeholder is any person, group or institution with an interest in a project or programme (ODA, 1995). This definition includes intended beneficiaries and intermediaries, winners and losers, including those involved or excluded from the

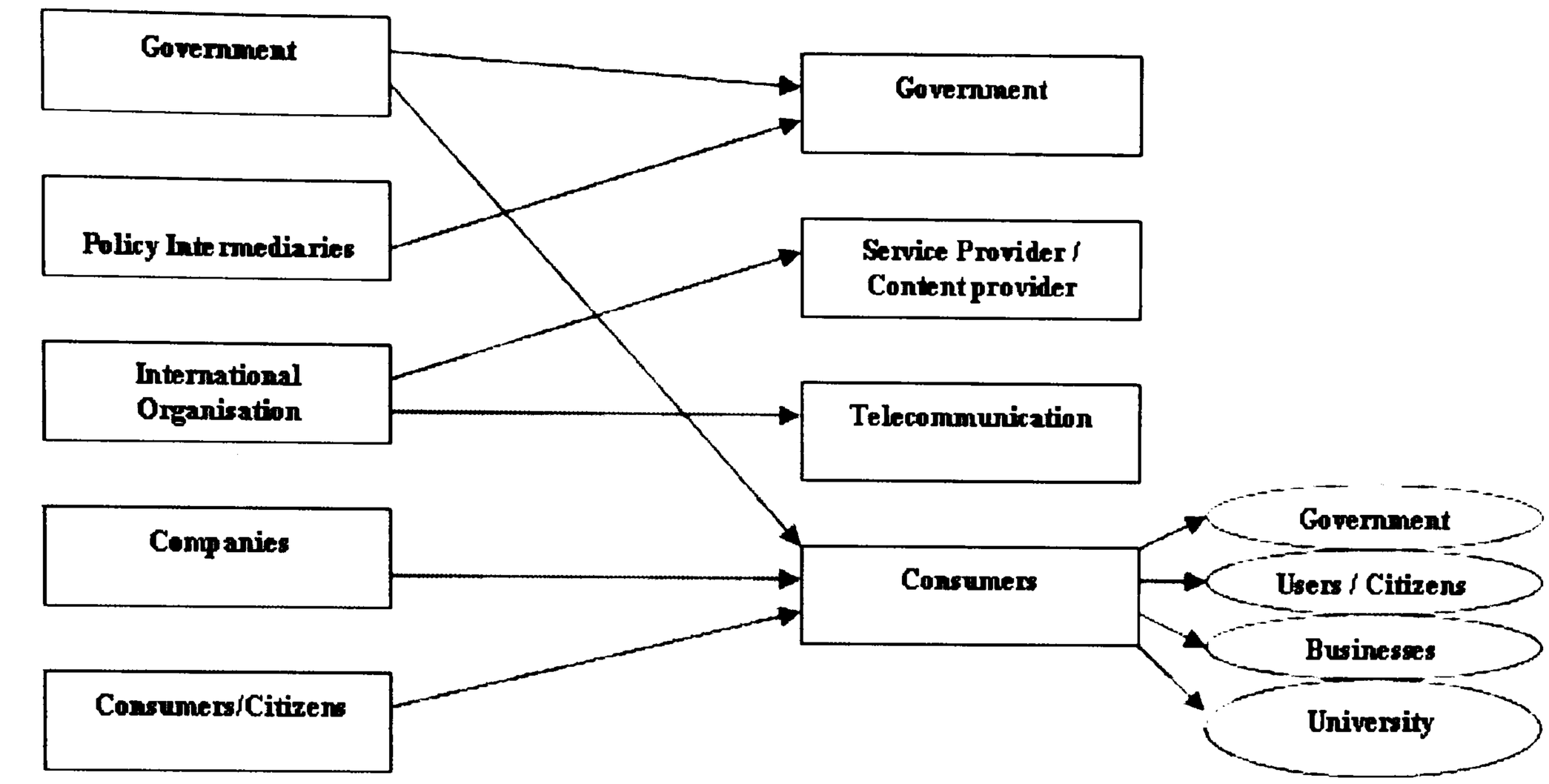
decision-making process (Freeman, 1984). In order to identify who the stakeholders are in this study, it is necessary to employ the use of a stakeholder analysis (SA). SA is a tool that is use to identify the respective interest and attitudes of various actors-individual and organisation towards a subject or situation (in this case the research) and their respective power to influence it (Fetscherin, 2004 and Varvasovszky and Ruairi, 2000).

In order to conduct a SA, three steps are involved, which will be applied to this study. The first step is to identify who the stakeholders are, the second is the assessment of their interests and attitudes towards the subject in question; and the third consists of estimating their influencing power to achieve their interest (Fetscherin, 2004). In this work, the stakeholders identified by Papazafeiropoulou and Pouloudi (2000) will be adopted. Although Papazafeiropoulou and Pouloudi identified five main groups of stakeholders, these will be merged into four groups (Figure. 3.1) as the focus of this research is on incorporated quality of broadband as perceived by users as a whole. Accordingly, the stakeholders that will be considered for the broadband quality perspective are the following:

- Government
- Consumers
- Internet Service provider /Content Provider
- Telecommunication

The above-mentioned stakeholders were selected on the basis of their position in the market as the main actors in the broadband arena. For instance, the government is responsible for the strong policy drive behind the uptake of broadband in the UK, while the telecommunication companies maintain the availability and provide reliability of connection between the service providers and the broadband users. However, in order to achieve broadband quality, all the stakeholders must encourage collaboration and commitment to quality. In the next four subsections the selected stakeholders' perceptions on broadband quality is examined.

**Figure 3.1 Adapted Stakeholders**




### 3.3.1 Broadband: The Government Perspective

Broadband is crucial to economic development and quality of life (Frieden, 2005). Countries that have thus developed and deployed broadband programs have seized an earlier lead in broadband penetration; promote domestic education, quality of life, productivity and new industries (Whitman, 2005). In this sense, the role of government will be to ensure equal access for all to a telecommunications infrastructure and the Internet and, moreover, provide an initiative to stimulate the take up of broadband amongst consumers, the public and businesses.

This can only be done through an effective collaboration between government and the telecommunications sector – such cooperation will be a necessary condition to guarantee the territorial balance of the broadband infrastructure as well as to set up affordable and high quality Internet access services. As telecommunications and computing technologies continue to evolve and shape the global business environment, the broadband Internet readiness of a country becomes an increasingly significant aspect in affecting its global competitiveness (Lee and Chan-Olmsted, 2004).

In the London Times (2002) the then UK Prime Minister Tony Blair and Swedish Premier Goeran Persson observed that broadband communication would be a key element of Europe's future competitiveness. Indeed, Tony Blair for years had been calling on Britain to be "*the most competitive and extensive broadband market*" among the G7 countries by 2005 (DTI, 2004a and Malone, 2005), while Canada, Japan, Korea, Australia, Italy, China and other leading nations also offered aggressive plans to boost broadband penetration (U.S Dept of Commerce, 2002).

Governments world-wide are thus, increasingly realising that broadband access to the Internet will be central to the economic development of their countries. Wide availability of broadband communication would have a significant impact on their economies, and several EU Member States have started reviewing the situation regarding broadband on their territory (Europa, 2004). Bodies pursuing broadband developments include central government departments and agencies, local authorities, educational and health establishments, the emergency services and voluntary and community organisations, as well as many organisations in the private sector.

In the UK, government has made available a wide range of funding to both public and private sector organisations for initiatives that could include the provision of broadband facilities (UK Broadband Task Force, 2003). In the public sector, for instance, many organisations are becoming increasingly interested in the benefit of broadband communication to support their current and future business operations. The UK government's objective is to secure the optimum broadband environment for UK businesses and consumers, and believes that rapid rollout and adoption of broadband across the UK is important to both its social and economic objectives (DTI, 2003 and Gunter et al, 2003).

Broadband take off in the UK was also fuelled by the Organisation for Economic Co-operation and Development (OECD) (2001) report which called for governments to promote competition, rather than use subsidies, to boost the growth of broadband in rural and remote areas, and for governments to do more to encourage the development of broadband, emphasising its importance for

economic, social and cultural development worldwide and warning about the risk of missed opportunities from failing to do so.

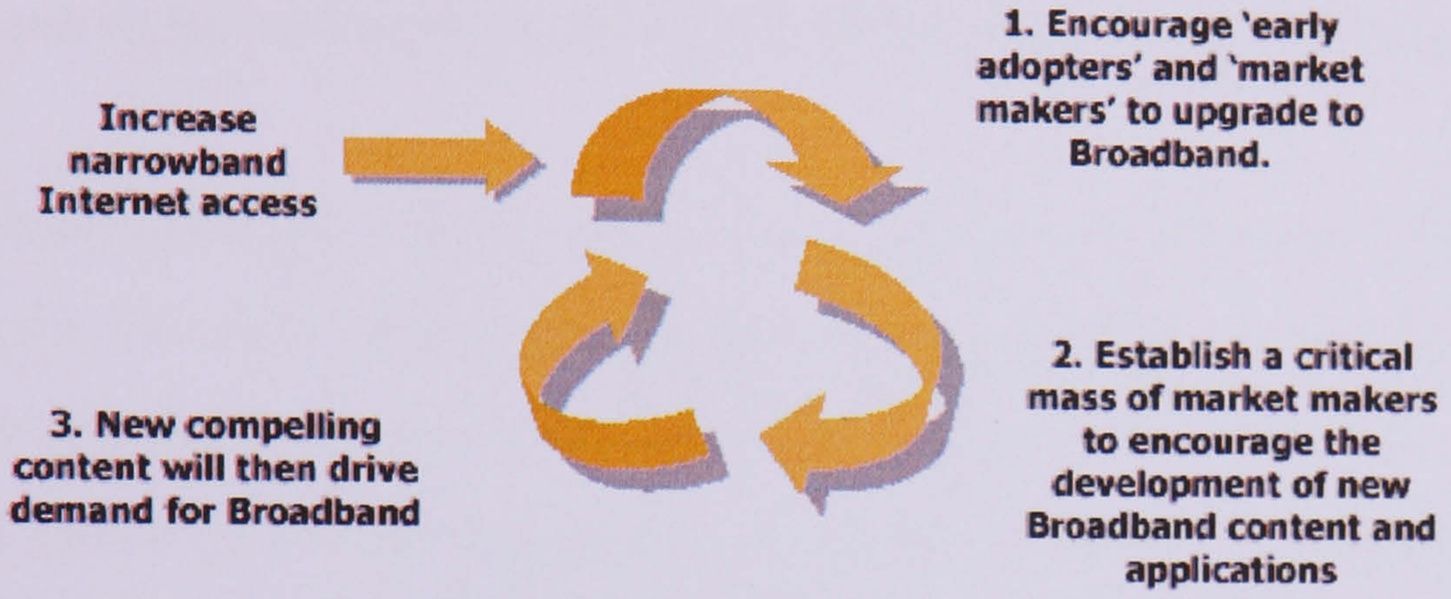
The OECD groups 30 member countries sharing a commitment to democratic government and the market economy. It helps governments to ensure the responsiveness of key economic areas with sectoral monitoring. The OECD believes that simply forcing operators to offer services in remote areas will reduce competition and innovation and could also mean users will end up paying more for an inferior service. From a UK perspective, the government must show more vision in its broadband strategy and provide more investment if Britain is to match the achievements of South Korea (Lee and Choudrie, 2002; Wearden, 2002). This is one of the key conclusions of an investigation into the success of broadband in South Korea, which was led by Brunel University and funded by the Department for Trade and Industry (DTI).

DTI was tasked in July 2002 with taking the broadband roll out across the UK initiatives forward. As a result the government made available a £30 million Broadband fund via the DTI to the Regional Development Agencies (RDAs) in England and the developed administrations to fund pilot projects and innovative schemes to help develop broadband networks (DTI, 2004c). UK progress in this respect is measured every six months by the DTI based on an index developed jointly by the UK government and the Broadband Stakeholders Group (BSG).

The UK government in November 2002 launched the UK Broadband Task Force, a team of consultants from the DTI and the Office of Government Commerce (OGC), to work with public sector bodies to increase the availability and take-up broadband, ensuring maximum impact on regional economic development. In April 2003, the Task Force developed into the Broadband Aggregation Programme (BAP), which created one national and nine regional aggregation bodies, now known as Adits, to help the public sector achieve the government's aims by procuring aggregated services on its behalf. BAP is a joint DTI and RDA initiative.

The UK government thus supported the need, as recommended by BSG, for a integrated approach to simulating the broadband *virtuous circle* (Figure 3.2) in which the demand and supply grow in parallel, each reinforcing each other, with market players as the main drivers and government working to support and accelerate the pace of change (DTI, 2004c).

**Figure 3.2 Broadband virtuous circle, Source DTI (2004c)**




In the newsletter released on the OGC website in May 2003, it was announced that six Internet providers which included BT (British Telecommunication) and Telewest were chosen by the government to help speed up broadband Internet access into local authorities and government departments (OGC, 2003). The OGC Chief Executive, Peter Gershon, said of the agreement:

> *"This new arrangement will be of major benefit to those government departments who are seeking to develop the use of Broadband. It reduces the time and effort required in sourcing Broadband products by offering quality goods and services at value for money prices without the need for separate tendering processes"* (DTI, 2004b).

Companies bidding for inclusion in the agreement were assessed on their ability to provide quality and value for money broadband services. At the end of December 2003, 85 % of the UK population had access to an affordable broadband offering (DTI, 2004b), however the take up of broadband was still slow, highlighting a lack of broadband penetration with penetration in the DTI report being measured using the following indices:

- *Extensiveness index*, combining coverage and the addressable market, have the UK moved up to third joining the USA

- *Competitiveness index*, measuring choice, price and regulation, where the UK ranked third
- *Take-up index*, where the UK was joint sixth in the G7 ranking for take-up, along with Italy.

Moreover, what must be remarked is that, as the UK economy and society are becoming more and more dependent on the Internet there is little sign of a legal and regulatory framework, and (in this case) a quality framework that assures the continued reliability and performance of broadband Internet for UK consumers.

The UK government, for example has experienced several incidents of widespread attacks on the Internet which includes parliament as well as government agencies. Businesses and individual users have also had their use of the Internet interrupted by viruses and other intrusive methods. Although the Internet as a whole shows a remarkable ability to survive attacks there is no focused regulator to provide a quality Internet access in spite of the fact that the Prime Minister and other ministers have consistently said that deployment and wide take up of broadband is vital to the UK's future.

A valuable lesson can be learned from South Korea, which was spurred by aggressive government policy to accelerate the nation's move into the information society (Kim et al, 2004; Lee and Lee, 2003). This in turn made the country the uncontested champion of the world in broadband Internet access. Thus for instance, in January 2004, the total number of Internet users that could access the web at ultra-speeds in Korea reached 28.6 million, which represented 62% of the total population (The Economist, 2004). Over half the country's 48 million citizens regularly logged onto the Net, and 85% of new subscribers purchasing a high-speed service (Bourdon, 2002). These made South Korea have the highest broadband penetration in the world at 23.17% population as at the end of December 2003 (Choudrie and Lee, 2004).

In order to achieve this, the Korean government built a nationwide fibre network to get students and others hooked on high-speed services. To keep prices low, it encouraged rivals to compete with the former state-run monopoly, KT (Korea Telecom), and it provided loans to software ventures. The UK broadband

environment currently stands at a crucial development crossroads. The effort to bring broadband to the UK resident is bogged down in the fight between rival telecommunication companies, which has resulted in over 60 Internet service providers.

It has been observed that the benefits of creative and disruptive innovation buoyed by strong competition at all levels benefiting from the right condition have made South Korea the world leader in terms of broadband use. The quality issue that the UK government needs to address in order to promote broadband use is that of price and culture, which would aid the UK government to achieve its vision of the UK being the number one in the use of broadband in Europe and the world as a whole.

The emergence of various broadband service providers in the UK has encouraged competition amongst service providers and driven fiercely high-priced broadband access down. This would encourage consumers to take on broadband as desired by the UK government. Additionally, if the UK is to succeed as a world-class place for e-business, public service delivery and online participation, the UK has to develop a world-class communications infrastructure and an explosion of new broadband content and application.

### 3.3.2 Broadband: The Consumers' Perspective

The deployment of broadband is shaping the nature of business for many industries involved in media, communications, entertainment, and numerous other forms of content and interactive services delivered via the Internet (Wolf and Zee, 2000). According to UK Online (2002) most people connect to the Internet over a phone line, typically using a modem with a speed of 28.8 or 56 kilobits per second (Kbit/s). This "narrowband" communication is slow – an estimated one third of user time online is spent waiting, reducing the convenience and ease of use of e-commerce.

Broadband services offer extensively faster data rates and "always on" connection to the Internet. As there is a push towards broadband economy, consumers can be expected to have (Papacharissi and Zaks, 2006):

- **Higher connectivity**: Consumers in the US spend nearly four times as long as their counterparts online, and engage more frequently in a wide range of e-commerce activities. Small businesses with a higher bandwidth connection are nearly twice as likely to trade online as their narrowband counterparts.
- **Entirely new sorts of value added services**: broadband makes possible new services not feasible over narrowband, both for consumers (e.g. video streaming, video conferencing, education), and for businesses (e.g. electronic trading communities/hubs and application service provision).

Given the increasing importance of broadband, especially within the business and corporate sector of the market, transparency in regard to customer service levels is important for ensuring further confidence and growth in the broadband services market. Additionally an increasing number of households, including home workers are also turning to broadband services for domestic use. Therefore, broadband technology has increasingly become entrenched in the everyday lives of people. The broadband industry has picked up speed as consumers in growing numbers are dropping dialup in favour of faster Internet access (Zanthus, 2003) and the value-added content delivery has become both economically and technologically feasible with the advent of last-mile broadband access.

Consumers have been attracted to this by the provision of broadband specific services such as online games, videoconferences, VoIP, video entertainment (e.g. Video-on-demand), breadth of content and location-independent storage. Furthermore, business users are offered radical improvements in success at operating a corporate website, communicating with suppliers, clients and peers the world over, transmitting larger files more frequently, and accessing multimedia applications via the Internet (Alahuhta et al, 2005). Business users can also take part in real-time international tenders for business contracts, operate stock trading and control across the supply chain, use foreign currency exchange and trading facilities, and receive complex video, sound and animation-based presentations all on the Internet. In turn, companies will be able to offer advanced online services to their customers and enjoy the benefits of effective e-customer relationship management (Pitta et al, 2006).

For home users, broadband opens the door to Internet gaming, video-conferencing and virtual shopping and a whole world of other exciting services yet to even be imagined. Krikke (2003) shows that broadband adoption is exceptionally high among online gamers and that gaming is the main drive for broadband adoption. Broadband also gives users a fast connection to the Internet, more bandwidth for email and data services and the world's information at their fingertips. With broadband, the Internet has become more interactive and online sessions can be conducted in real-time more speedily. Broadband also makes the Internet come alive and opens up a myriad of multimedia services that allows for learning and communicating. However the number of broadband users is very slow, as the attitude and response of consumer towards embracing broadband is not encouraged because some say the broadband prices are too high for the service quality that is offered by service providers (Craig, 1999; Richardson, 2001; UK-bug, 2004).

According to one of the eight quality management principles on which the quality management system standards of the revised ISO 9000:2000[1] series are based, organisations depend on their customers and therefore should understand current and future customer needs by meeting customer requirements and strive to exceed customer expectations. Moreover, they should also measure customer satisfaction and act on it. ACA (2002) believe that the customers and potential customers of broadband services are most concerned with:

- Clear information about the service offering, particularly concerning the speed of download and upload that can be expected in practice
- Clear pricing information
- Activation process that is predictable
- Availability performance of the service, including the failure rate, average availability, and both typical and worst-case restoration times

[1] The ISO 9000 standards are a set of international quality management system standards and guidelines ISO 9000 currently includes three quality standards: ISO 9000:2000, ISO 9001:2000, and ISO 9004:2000. ISO 9001:2000 presents requirements, while ISO 9000:2000 and ISO 9004:2000 present guidelines. All of these are process standards (not product standards). ISO is a network of the national standards institutes of 148 countries, on the basis of one member per country, with a Central Secretariat in Geneva, Switzerland, that coordinates the system. Extracted from www.ISO.org.

In order for the government, the telecommunication sector, and service providers to strategise and improve on the growth of broadband in the UK, these impediments need to be recognised and understood.

In related work, Dandolopartners (2003) presented consumers concern about broadband in the following categories:

- Awareness
- Quality of support
- Service levels.

These shall now be examined in greater detail:

### 3.3.2.1 Awareness

Consumers often are ignorant of restrictions offered by service providers until they encounter problems with their broadband connections. These limits come in different guises, such as the following:

- Inability to compare one service offering with another.
- Difficulties with technical language and jargon.
- Concerns about actual performance of a service compared to advertised characteristics – especially in relation to actual speeds and bandwidth availability.
- Lack of information about limitations or restrictions on services and what those limitations or restrictions mean in meaningful terms (e.g. 1 Gig = 700 annual reports).
- Problems in discovering which technologies are available in particular geographic locations.
- Potential for hidden costs, e.g. in relation to megabyte limits, installation costs or charges for uploading, which can occur with certain applications.
- Uncertainty about bills, especially where services are sold as part of a bundle.
- Issues relating to equipment or network compatibility, especially for small business users.

### 3.3.2.2 Quality of Support and Communication

Consumers have expressed concern about the level of service and support they receive from providers and the manner in which issues are communicated. Examples of the issues are:

- Poor experiences of installation: delays, lack of skills among installation technicians and 'buck passing'- for example, where the service is provided by a reseller who will blame the network provider for a problem or where an installer blames the consumer's equipment.
- Help desks – low skill levels, inadequate escalation processes and lack of incentives to properly solve problems the first time.
- Fault repair - these are times taken to repair and the quality of the technical support.
- Lack of communication regarding outages or other customer service issues.
- Inadequate billing information including, lack of itemisation, uncertainties around upload and download limits and excess charges, misalignment of usage periods and billing cycles and the use of direct debit payments where the charge may vary.

### 3.3.2.3 Service performance

Consumers are also concerned about reliability- that is, loss of service and service degradation, availability of bandwidth to support required speeds, authentication for log in difficulties and security of data and personal information. All these concerns need to be addressed in order to provide a quality broadband service, as the inability to address these issues would lead to a lack of broadband adaptability, which in turn could lead to broadband failure in the UK. Additionally, the consumer choice of quality provided by an ISP is determined by price, reliability, and service levels and also by the value added services ISPs can offer in the package. Indeed, customers can only buy the services they are offered (McGinity, 2003) and so users' expectations are clearly related to the selected services. At the same time, a service can have different characteristics however this depends on the type of user that can access this service (Francalanci and Pernici, 2004).

In general, the customer satisfaction experience is something that needs to be understood better by both the customers and service providers. Customers want to know that their unique needs and concerns reach open ears, whilst service providers want to be able to engender trust by not only listening, but also by acting on these concerns in real time. Customer satisfaction is a post-purchase attitude formed through a mental comparison of the service and product quality that a customer expects to receive from an exchange and the level of service and product quality the customer perceives as actually receiving from the exchange (Kim et al, 2003). When customers hold a positive perception of a service provider this leads to strong loyalty that translates into high customer retention rates and extended word-of-mouth recommendations. As a result, these customers would then have to understand the very high levels of service that can be achieved by a service provider and depend on them in terms of future quality experience.

A negative experience can have lingering ramifications for a service provider, even when quickly addressed and corrected, often requiring a long period of time before that service provider can restore customer confidence (TBR, 2004). Research has found that broadband users would be willing to pay more if providers guaranteed them a better quality of service. Four-fifths of those with broadband Internet connections are interested in guaranteed QoS from their providers while 68 percent would be willing to pay a premium for quality service. These findings came from a survey of 6,000 individuals registered with Broadand4Britain, commissioned by network platforms company net.com and reported at ITU Telecom World 2003 (Hallett, 2003).

### 3.3.3 Broadband: The Telecommunication Perspective

Telecommunication networks improve the quality and timeliness of decision making, permit internal operations to be streamlined, enhance customer service and reduce overall costs of doing business. Moreover, they can also help business to expand to new locations, rural areas and enter new markets. Broadband telecommunication networks based on ATM technology have emerged only recently and offer a variety of services based on the latest development and technology.

In South Korea, telecommunications providers have built the world's most comprehensive Internet network by supplying affordable and reliable access that far surpasses what is available elsewhere, even in those homes that had their own broadband already set-up. This, however, was achieved with a hefty push from the government (Belson and Richtel, 2003). In the UK, BT and the cable TV companies are the main players in the broadband market, along with a large number of Internet service providers who either sell the BT ADSL service or in some cases have started to install their own ADSL equipment in BT exchanges.

Since deregulation of the telecommunications' industry in Europe, quality labels have been increasingly necessary to differentiate between the services provided by companies active in telecommunications, which includes telecommunication companies in the UK. However, in South Korea, KT, one of the biggest telecommunication companies present, exerted continuous efforts to grow, especially in respect of service quality, to satisfy customers and launch of new services in response to customer various needs. This was subsequently identified as one of the key success factors behind KT (Xiangwan and Xiongjian 2003).

### 3.3.4 Broadband: The Internet Service Provider Perspective

The service provider industry is racing to deploy market broadband capabilities and services and also seeks to position their organisations to capture their share of mass-market growth. This will be fuelled by the ability to rapidly create and deploy new and novel solid business models for current and future services in response to market demands.

Service providers longing to deliver broadband capabilities, especially those offering business broadband services, are upgrading their existing network infrastructures and expanding their service offerings (Kabira, 2004). In addition they are developing robust, mature networks. Moreover, the service provider deals with multiple telecommunication and cable circuit providers to obtain wide geographic coverage for broadband facilities and take responsibility for integration of the circuits.

Service providers also handle the administrative activities for delivery of services to commercial and private sector users in order to generate additional revenue (UK Broadband Task Force, 2003). Furthermore, they are in the position to provide value added services to the public sector users e.g. schools, government agencies, businesses and individual users. Most service providers commit to guaranteed service levels but the sharing of broadband facilities can be problematic where it affects performance and capacity for individual user organisations. However, the rapid changes in technology and pricing for broadband can affect the consumer be it government agencies, business or individual so they must ensure that they are not locked into an inflexible contract and charging regime.

Indeed, the more service providers in the market place offering differentiated services, competing with one another, marketing with and against one another, the more the broadband market will grow and the more value for money consumers will experience (Lenton, 2002). The trick for broadband providers is to harness some of this growth for themselves. Future adoption is expected to rise and service providers need to provide unparalleled customer support, network reliability, and attractive pricing to capture market share and increase brand awareness (Tan-Wanklyn, 2004). Thus, a high quality service and support leading to more satisfied customers should be any service provider's focus.

In order for a service provider to achieve high levels of customer services satisfaction, six powering operating principles as identified by TBR (2004) should be taken into consideration.

1. **Commitment.** Consistent success in customer satisfaction does not happen by accident. It is the result of deep commitment and loyalty of purpose, guiding long-term decision-making and day-to-day actions.
2. **Leadership.** The service provider should aim to lead the industry by perfecting and continually improving on a service model that meets and exceeds the expectations of customers. TBR (2004) considers that this type of consistent leadership would give customers the confidence to expect more out of their service providers.

3. **Value Consistency.** The service provider should consistently set the standard for promoting the most positive customer perceptions, not only of pricing, but also of quality and overall value.
4. **Assurance.** The service provider needs to establish a strong sense of trust among its customers: this could be achieved through an understanding of customer expectations and how best to meet those commitments in a timely fashion.
5. **Adaptability.** Many new customers come in with different expectations, and this has led to service providers being faced with varying challenges of orienting large numbers of new customers, so the adaptability, flexibility and responsiveness approach to customers should be at the root of the service provider's ability to serve customers, both new and old.
6. **Resilience.** As is universal in technical products, service and support, the service provider is faced with a number of challenges along the way. A rapid response to problem solving implemented throughout all levels should be observed.

As far as quality aspects are concerned, service providers feel that when broadband access is stable, dependable and reliable, then they are assuring a high quality product (ACA, 2003). Unfortunately that notion is not necessarily true, as reliability is just one aspect of quality and there exist other facets of quality that the service provider needs to consider in the delivery of broadband services. Another way some service providers lure users to feel they offer quality is through value for money. This is done, for instance, by providing one month free broadband service or three months broadband service at very low rates which then goes up to their normal monthly rate at the end of the offer period (McGinity, 2002). This is evident in Table 3.2 which shows the monthly subscription price for various options with various UK service providers.

For example Eclipse Internet offers a month free Internet access and thereafter subscriber pay £14.99 a month. Some ISPs even offers half price for the duration of 6-12 months and thereafter subscribers pay the full monthly subscription price, for example Virgin Media and BT Total broadband.

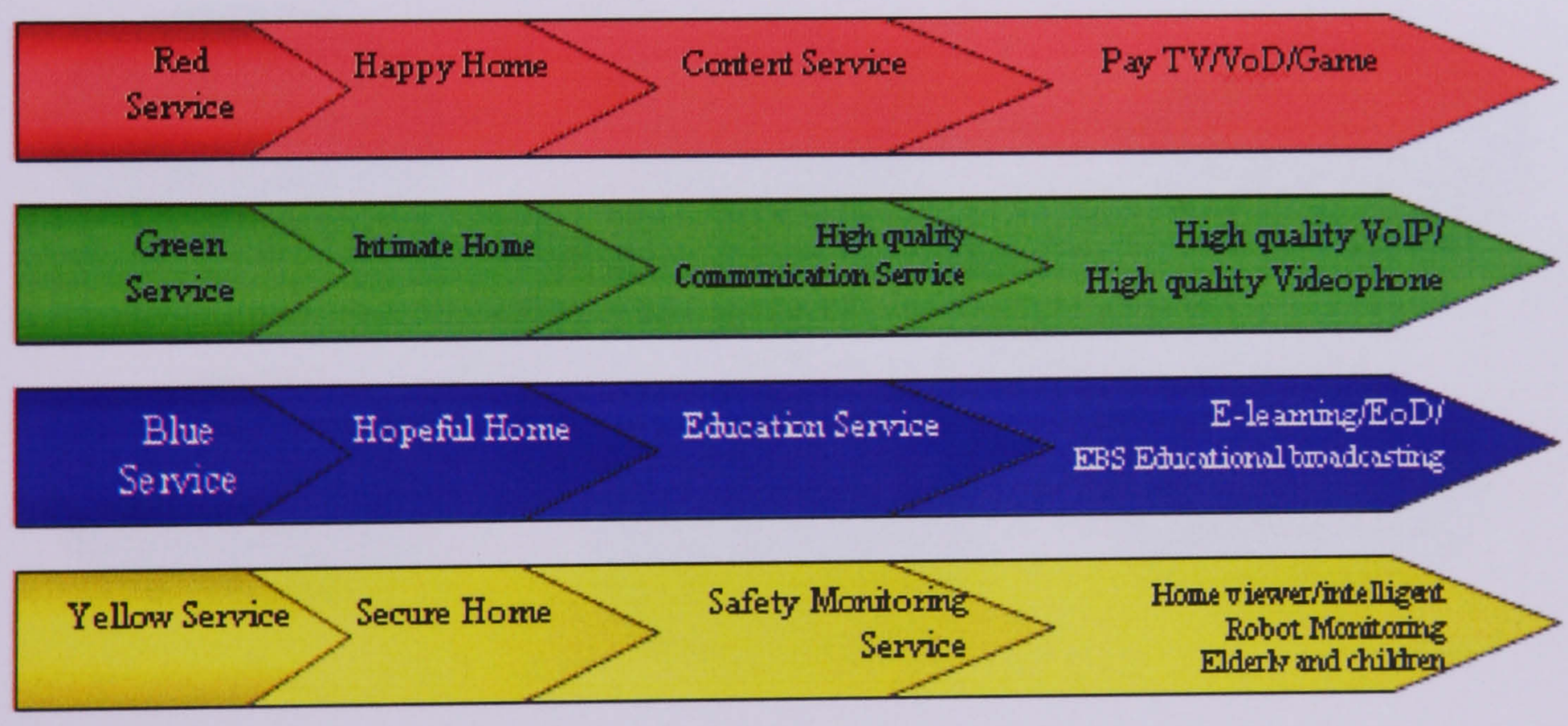
Furthermore in Table 3.2 it is evident that the ISPs are driving their prices down and providing more services for a fixed rate for short period which helps to promote vast competition amongst the service providers. In the UK there are over 50 service providers and, as such, a huge variety of broadband packages are made available, which can make it difficult for consumers to establish the differences between the offerings from different ISPs, let alone decide which the right package is good for them. Customers are therefore put in a position to make a choice of which broadband package is good value for money depending on how they and their household use the Internet. This however could lead to more confused consumers, as consumers are not yet enlightened to the level of what offer is relevant to their needs.

**Table 3.2 The selected service providers used for this research taken from http://www.aboutyourmoney.co.uk/broadband/all-packages.htm and http:/www.broadbandchecker.co.uk as at September, 2007**

| Provider | Package | Speed | Download limit | Minimum contract | Monthly cost | Set up cost |
|---|---|---|---|---|---|---|
| Fasthosts | Broadband 512 | 512kbps | Unlimited | 0 months | £17.99 | £50.00 |
| Toucan | 512K broadband | 512kbps | Unlimited | 12 months | £16.99 | Free |
| Fasthosts | Broadband 1024 | 1mbps | Unlimited | 0 months | £24.99 | £50.00 |
| UK Online | 1MB | 1mbps | Unlimited | 12 months | £9.99 | £25.00 |
| Namesco | Home | 2mbps | 5Gb | 1 month | £14.95 | Free |
| Tiscali | 2mb Unlimited broadband | 2mbps | Unlimited | 12 months | £14.99 | Free |
| AOL | Broadband silver | 2mbps | Unlimited | 18 months | £14.99 | Free |
| UK Online | 2MB | 2mbps | Unlimited | 12 months | £14.99 | £25.00 |
| Orange | Broadband Starter | 2mbps | 2Gb | 12 months | £14.99 | Free |
| Virgin media | Size M | 2mbps | Unlimited | 12 months | £10.00 for the first 12 months then £18.00 a month thereafter | Free |
| Fasthosts | Broadband 2048 | 2mbps | Unlimited | 0 months | £29.99 | £50.00 |
| Virgin media | Size L | 4mbps | Unlimited | 12 months | £17.00 for the first 12 months then £25.00 a month thereafter | Free |
| AOL | Broadband Platinum | 8mbps | Unlimited | 18 months | £29.99 | Free |
| BT total broadband | Option 1 | 8mbps | 5Gb | 18 months | £8.95 for the first 6 months then £17.99 a month thereafter | Free |
| Madasafish | Max Broadband | 8mbps | 5Gb | 12 months | £11.99 | Free |
| BT total broadband | Option 2 | 8mbps | 8Gb | 18 months | £13.99 for the first 6 months then £22.99 a month thereafter | Free |
| Seriously Internet | Pay-As-You-Go | 8mbps | 1Gb | 0 months | £14.99 | Free |
| Eclipse Internet | Evolution option 1 | 8mbps | 20Gb | 12 months | £14.99 first month free | Free |
| Plusnet | Broadband your way - Option 2 | 8mbps | 8Gb | 1 month | £14.99 | £40.00 |
| Tiscali | 8mb Unlimited broadband | 8mbps | Unlimited | 12 months | £17.99 | Free |
| Demon | Demon Home 8000 | 8mbps | Unlimited | 12 months | £17.99 | Free |
| Toucan | 8Mb broadband | 8mbps | Unlimited | 12 months | £17.99 | Free |
| BT total broadband | Option 3 | 8mbps | Unlimited | 18 months | £18.99 for the first 6 months then £24.99 a month thereafter | Free |
| Eclipse Internet | Evolution option 2 | 8mbps | 30Gb | 12 months | £18.99 | Free |
| Namesco | Homemax | 8mbps | 10Gb | 1 month | £19.95 | Free |
| UK Online | 8MB | 8mbps | Unlimited | 12 months | £19.99 | Free |
| Orange | Broadband Unlimited | 8mbps | Unlimited | 12 months | £19.99 | Free |
| Madasafish | MAX Plus Broadband | 8mbps | 20Gb | 12 months | £19.99 | Free |
| Plusnet | Broadband your way Option 3 | 8mbps | 20Gb | 12 months | £19.99 | £40.00 |
| Demon | Demon Home Office 8000 | 8mbps | Unlimited | 12 months | £22.99 | Free |
| Virgin media | Size XL | 20mbps | Unlimited | 12 months | £29.00 for the first 12 months then £37.00 a month thereafter | Free |
| Be Broadband | Be Lite | 24mbps | 4Gb | 12 months | £14.00 | £24.00 |
| Be Broadband | Be Unlimited | 24mbps | Unlimited | 0 months | £24.00 | £24.00 |

The value of service a provider gives to its consumer is not just about interconnect, but is also in the services that are delivered to the consumer and the content that can be addressed. In this respect, the UK could follow the example of South Korea, where KT is already making progress by moving from a single service provider (high speed Internet) to multiple services provider (application services and solutions), which is called the "Octave Project" (IEC, 2004b). The multiple services will sit on top of the already high speed Internet of which KT is a major provider in South Korea. The Octave project will thus become an avenue that will provide for a spectrum of services, labelled the red service –happy home, green service – intimate home, blue service – hopeful home and yellow service – secure home. These new services of KT will be provided by a home gateway installed in the living room and offices and provide more worth to the already present broadband quality they offer to their users (Figure 3.3). Although most of the service providers in the UK are single service providers, there exist a few service providers that offer multiple services on top of their high speed Internet service (for example the merging of NTL: Telewest to Virgin to make Virgin Media) and AOL.

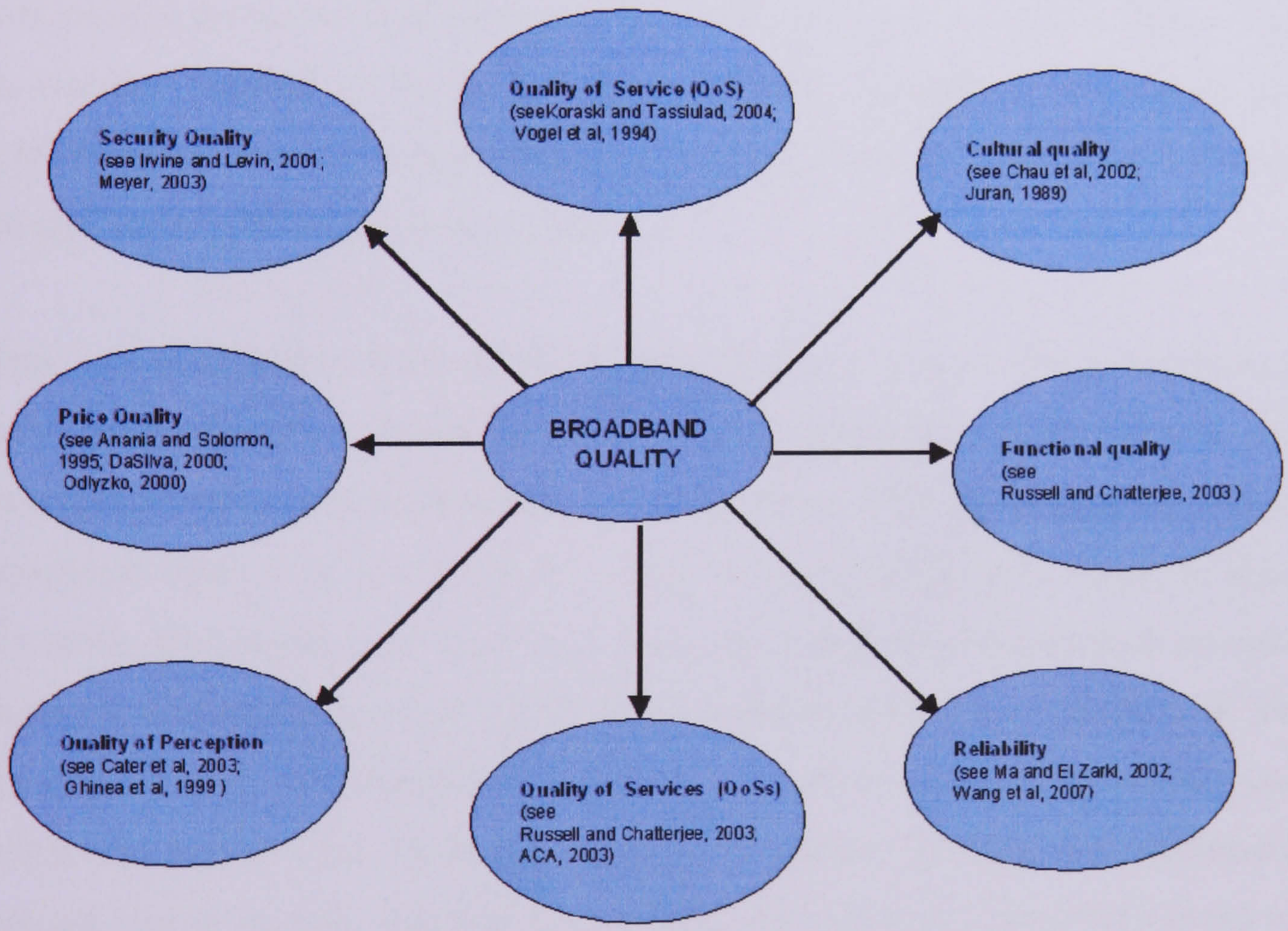
**Figure 3.3: KT Octave service overview**



## 3.4 The Many Facets of Quality

The rapid growth and acceptance of telecommunication has led to a variety of definitions and perceptions concerning the word 'quality'. Whilst quality depends on the perception of the party looking into it, Smart (2002) recommended that all quality efforts should be grounded in customer data and a user-centred design process. Smart also recommended that there should be a differentiation among quality dimensions, determining those dimensions that are essential to customer satisfaction and those that are merely attractive. A detailed description of the many facets of quality as it applies to broadband is explained below. This has been derived from secondary research sourced from academic papers, government and agency documents. Figure 3.4 shows an overview of the many facets of broadband quality.

**Figure 3.4: The many facets of broadband quality issues**




### 3.4.1 Quality of Service (QoS)

Although the term QoS has been used to designate certain technical parameters in the specification of communication protocols (Vogel et al, 1994), it has been proposed to capture the qualitatively or quantitatively defined performance needed of an application. QoS is thus a key attribute of a broadband communication system (Koraski and Tassiulad, 2004) and represents a set of methods and

processes that a service provider implements to maintain a specific level of quality.

QoS has been defined as a property measured between the physical and the application layer on the International Standards Organisation (ISO) seven layers model. Wang et al (1996) described QoS as having an essential service differentiator in two key respects: the management of and focus on customer expectations, and the efficient allocation of capital resources. Green et al (2001) defined QoS subjectively as the user's degree of satisfaction with the service, however from the network point of view it is the collective effect of performances that may be measured at a hierarchy of access points, while Manner et al (2002) identified that QoS is usually understood to mean fast, predictable and loss-free forwarding of data packets. Ghinea and Chen (2003) also explained that QoS illustrates the technical side of computer networking and represents the performance properties that the underlying network is able to provide. QoS is thus an essential element of the well-managed network, bringing predictability and availability as a service to applications and offers a practical solution for ensuring the guaranteed delivery of critical data.

There is a consensus that the primary goal of QoS is to provide priority including dedicated bandwidth, controlled jitter and latency (required by some real-time and interactive traffic), and improved loss characteristics. The motivation for a QoS broadband network is to provide customers with the capability to select the kind of service they require and, therefore, obtain more efficient allocation of network resources (Parthasarathy et al, 2003). The broadband network is defined as the physical network that consists of switching and communication equipment and multimedia end-devices. Upon this physical infrastructure resides the multimedia network whose primary function is to provide the middleware support needed to realize services with end-to-end QoS guarantees over the physical media-unaware network. This is achieved by building upon a set of QoS abstractions derived from the broadband network. This set of QoS abstractions jointly defines the resource management and control space. The process of service creation calls for resource reservation and distributed state manipulation algorithms.

Based on the above description, QoS can be safely defined as broad ranging, touching on many aspects of the construction management and use of telecommunications networks. QoS technologies provide the elemental building blocks that will be used for future business applications in campus, WAN and service provider networks. QoS is then referred to be the capability of a network to provide better services to selected network traffic over various technologies, including Frame Relay, ATM, Ethernet and 802.1 networks, SONET, and IP-routed networks, possibly using any or all of these underlying technologies. Accordingly, in the literature, QoS covers four broad areas, namely Management, Applications, Monitoring, Reporting and Cost, which shall now be explored in more detail.

#### 3.4.1.1 Management

Any network, regardless of available bandwidth, needs solid resource management to ensure that its most critical applications are given the resources they require. QoS provides a set of techniques designed to manage bandwidth, delay, jitter, and packet loss in a network (Krishnamoorthy, 2001). QoS has evolved rapidly over the past few years and it is the manner in which transmission rates, error rates, and other characteristics can be measured, improved, and, to some extent, guaranteed in advance. Recent years have seen great advances in the field of QoS research due mainly to the emergence of multimedia networking and computing.

#### 3.4.1.2 Application

Delivering real-time services such as Internet telephony, video conferencing, and streaming media, as well as business-critical data applications across the Internet requires end-to-end QoS guarantees. These need a hierarchy of standardized contracts, which are referred to as service level agreements (SLAs). SLAs provide a mechanism for service providers and customers to flexibly specify the service to be delivered (Lehr and McKnight, 2002; Subramanian and Lewis, 2003).

From this perspective, the multimedia network provides a programming model that allows service behaviour to be specified and executed. The power of this conceptual framework comes from its seamless integration of elements from the

domains of signalling (or connection management), transport and management. This synergy allows traditionally difficult QoS networking issues to be addressed in an elegant and natural way (Lazar, 1997). The rapid growth and coexistence of different application domains, such as multimedia and electronic commerce, present a significant challenge to the provision of their QoS.

#### 3.4.1.3 QoS Monitoring and Reporting

QoS monitoring is executed on two time scales. Fast time scale (or in-flow) monitoring allows flow control mechanisms to adapt to rapid network fluctuations. Slow time scale monitoring is used for renegotiation and network management. QoS monitoring ensures that the QoS associated with a service is obtained as guaranteed at admission time, collects data for management, and detects QoS violations including initiating renegotiation. Slow time scale monitoring is used for renegotiation and network management (Lazar, 1997). Monitoring and reporting requires consideration across a wide range of customer expectations and requirements.

According to the ACA (2003) customers have expressed requirements in terms of:

- Activation Process
- Service Availability
- Throughput
- Delay (mean and variation)
- Loss

As a general observation, monitoring and reporting on a range of QoS indicators will require expenditure on requirements analysis, system design, and then deployment and operation of systems. Given the costs involved, and the widely varying requirements in the market, it is believed that:

- Self-reporting is preferred to external independent monitoring in the majority of cases
- Market-determined standards are preferable to standard minimum requirements, as a general rule

Again, such service independent reporting should be tailored to individual customer needs to ensure the inherent costs are not imposed across all customers who may not value the extra information provided.

#### 3.4.1.4 Cost

By taking care of QoS at the IP service edge in connection with service provisioning, the cost of managing QoS for specific subscribers and its applications in the network is eliminated, as is the cost of having many sophisticated and expensive capabilities present in other devices elsewhere in the network. In this way, QoS equipment and support costs are more affordable for ISP with smaller staff and budgets and make QoS practical for larger incumbents that can not afford the complexity of supporting several distinct platforms and management environment (Forberg, 2000). Lorenz and Orda (2002) proposed a framework, partitioning an end-to-end QoS requirement into local requirements in order to minimise the overall cost, which comes in addition to a large body of research linking QoS and cost (Key and McAuley, 1999).

### 3.4.2 Cultural Quality

Cultural quality is an effort to improve the level of performance across an entire organisation to achieve higher levels of customer satisfaction. This is also referred to as Continuous Quality Improvement (CQI). CQI is the use of incremental and breakthrough quality management techniques to constantly improve processes, products, or services provided to internal and external customers and thus achieve enhanced levels of customer satisfaction. Individual consumer tastes and purchasing patterns are thus partly determined by the collective values of their local authority (Chau et al, 2002).

Cultural quality has six keys principles (Juran, 1989). They are:

- Quality first: - Quality is a moving target that is defined and/or judged by the customer.
- Customer Focus: - A strong knowledge by organisation or group of the external customer (for example BSG and Broadband task force (BTF)) and the customer's needs and quality definitions.
- Customer Identification: - Emphasis on identifying and understanding customer needs, requirements, aspirations, preferences and expectations.
- Preventive focus: - By listening to the "Voice of the Customer," organizations gain valuable information to drive improvement

initiatives, design/implement new services, support the improvement of outcomes for consumers and brand name recognition for the organization

- Database Decision Making: - Services must be designed to meet the needs/requirements of consumers and/or communities served.
- Continuous Rapid Improvement: - Customer-driven quality means anticipating, meeting, and exceeding customer requirements.

### 3.4.3 Functional quality

This relates to standard product quality, including satisfaction of needs and absence of defects (Russell and Chatterjee, 2003). This is the quality of software that runs the broadband connection from the user to the service provider and from the service provider to the telecommunication company and, in return, from the telecommunication company to the service provider and then to the user. In order to achieve this software quality it is expected that the necessary testing procedures and techniques have been utilised before deployment of such software to the users of broadband. The testing of the software would involve black box testing, which gives a functional testing of the software. The testing of the software also includes testing to make sure that broadband equipment works flawlessly with it, compatibility with various operating systems, and reliability.

### 3.4.4 Reliability

In the past several years, there has been an escalating demand for broadband digital video services, such as digital TV, pay-per-view, video conferencing, and video on demand (Ma and El Zarki, 2002). As a result reliability of broadband connection has become an important requirement of the Internet (Wang et al, 2007). Broadband users need a reliable connection to access their high-bandwidth video and audio content quickly (Ofcom, 2007) as well as for communication such as VoIP (UK Online, 2007). However the cost of bandwidth constitutes a major cost component for broadband services (Kumar, 2004). Therefore a feasible and future-safe technical solution must emphasize scalability, cost-effectiveness and a choice of vendors offering compatible equipment (ITU, 2005) for their broadband connection provided by their ISP is very vital. Moreover, the solution should provide adequate reliable connectivity capabilities for both voice and data.

### 3.4.5 Quality of Services (QoSs)

This refers to the management of the client relationship between service providers and their users (Russell and Chatterjee, 2003). Customers who are seeking broadband solutions should be able to clearly distinguish between services, which may be designed for residential applications that offer little if any guarantees in respect of availability and performance, and those designed for business purposes where guarantees of availability and performance are critical.

The industry has been more forthcoming in recent times with many suppliers beginning to offer Service Level Agreements (SLAs), which define the performance characteristics of services. However, the focus has been mainly on network 'uptime' rather than network throughput or performance. The greatest source of confusion in the marketplace at present is focused on the customers' expectation of the speed that can be achieved by switching from a dial-up service to broadband access. Merely quoting the top speed that can be achieved on an ADSL access line, for example, does not necessarily provide the customer with a good basis for comparison. It is of paramount importance that customers be given a more useful description of the service they are planning to purchase.

Further industry involvement is needed to ensure that all parties accept a common definition of the terminology and its use in communication with customers. The general style of the Consumer Information Guidelines for ISPs (ACA, 2003) is a very practical illustration of using an agreed framework for communicating with customers.

The service definition information can be well addressed by developing a similar framework that is specifically tailored for broadband, including "over subscription Ratio" and other items that are salient to broadband services. Responses are also broadly typified under two headings (ACA, 2003):

- Better communication, transparency and consumer education
- Improved service levels and support from carriers.

The main components of quality of services are quality customer service and network performance monitoring. These shall now be looked at in more detail.

### 3.4.5.1 Customer Service Quality

The emphasis on service quality has been most apparent since the growth of managed customer service. Service forms the basis for clear communication with the customer, with the objective of ensuring that customers are aware of what they are purchasing, and the degree to which the available products will meet their needs and expectations. By clearly defining the terms that are used, customers can have greater confidence that their expectations are realistic. In particular, if Service Level Targets, Agreements, or Guarantees are offered, customers will be able to evaluate those offerings prior to making a purchase.

Through the resource management enabled by QoS, service providers can offer better SLAs to customers and generate revenue based on these differential services. For example, a service provider may offer Premium, Gold, and Best-Effort services. So, for VoIP, Premium could offer assurances on delay and jitter, as well as bandwidth. Gold service may imply assured bandwidth with no tight bounds on delay and jitter, while best-effort service might be thought of as a simple and basic offering. Premium and Gold services are value-added offerings and thus generate revenue. From a customer standpoint, these differential services provide assurances for mission-critical voice, video, and data (Krishnamoorthy, 2001).

### 3.4.5.2 Network Performance Monitoring

Network performance monitoring relates to such parameters as:

- Infrastructure availability performance – including failure rates, restoration times and average uptime performance (Labovitz et al, 1999).
- Throughput and speed actually achieved through the network (Jin and Tierney, 2003).
- Packet Contention – delays and losses through the network (Hamadana and Rakocevic, 2005).

In general terms, these parameters include the engineering indicators that are related to network rather than individual service design and those customers have expressed an interest in. Again, further consideration by the industry is recommended to ensure agreement on a representative set of indicators.

### 3.4.6 Quality of Perception (QoP)

To understand and predict the performance users will experience when they use broadband, one needs a thorough understanding of the processes of human perception. However, perceptual quality is much more than just subjective opinion about audio-visual quality. The perceived quality of computer graphics imagery, for instance depends on the accuracy of the rendered frames, as well as the capabilities of the human visual system (Cater et al, 2003). In this respect QoP is a metric which encompasses not only users' satisfaction with the quality of multimedia presentations but the users' ability to analyse, synthesise and assimilate the informational content of a multimedia display (Ghinea et al, 1999). Therefore when perceptions exceed expectations, the stakeholders obtained more than what they bargained for (Chen et al, 2006; Jiang et al, 2003).

### 3.4.7 Quality of Price

The quality of price is the amount the government or the consumer pays for the delivery of agreed outputs. The price of broadband service depends on the type of broadband access modes; the amount a user downloads and uploads from the service provider. The price a consumer pays for broadband services varies according to the service provider and depends on the particular service plan with that ISP (National office for the Information Economy (NOIE), 2002).

Technologies supporting high-speed transmission of data have been available for years, but only at a substantial price. This has made possible the emergence of widely affordable broadband services along with a mass interest in and market for those services. Usually the cost incurred by the consumer includes a one-off connection fee or installation charge, however most service providers these days provide free connection and installation to attract customers to their network. A monthly access fee that is often dependent on the amount of data transferred is then charged per month. The cost of any additional hardware, software or service required is also charged.

The new market for broadband services is a result of an outgrowth of technological improvements, increased competition (Choudrie and Lee, 2004), and increased acceptance of and interest in the Internet (BAP, 2000). However the setting of prices for network services has always been primarily a marketing

strategic decision rather than an engineering concern (DaSilva, 2000). While cost plays an important part in the consideration of the final determination of prices offered by service providers, price certainty has been shown to be important to consumers in general (Anania and Solomon, 1995; Odlyzko, 2000) and for universal service.

Determining what price to charge consumers has led to varying price tags for the provision of broadband service by ISP. One solution to this problem is to price/charge for both resource usage and for guarantees offered for the service. According to Almay (1999), price setting contains the following six steps:

- Selecting the pricing objective
- Determining demand
- Estimating costs
- Analysing competitors prices and offers
- Selecting a price method
- Selecting the final price

Taking the above price setting into consideration, two price rates have been debated to be use to level on consumers; flat rates and usage-based pricing. Flat rates refer to a tariff that is independent of the amount of traffic produced as well as of grade of service. In contracts usage-based mean that prices are a function of the amount of traffic that actually flows through a connection. The advantages and disadvantages as briefly described by Almay (1999) and DaSilva (2000) are shown in Table 3.3.

**Table 3.3: Argument for and against flat rates and usage-sensitive pricing**

| | Pro | Con |
|---|---|---|
| **Flat Rate** | • Easy to implement<br>• Little overhead for billing | • Unfair to light users<br>• No recovery of congestion cost<br>• Server overgrazing<br>• Not appropriate for different QoS |
| **Usage-based pricing** | • Can play a role in congestion control<br>• Increased fairness | • Adverse response from customers<br>• Difficult to budget for<br>• Increased billing complexity<br>• May discourage usage |

The main measure of interest in such schemes is the amount of resource allocated for a connection, which is easy to compute. As modern networks cater for different applications by using the same resource and offering different service

qualities, pricing for such networks becomes complicated. Although there are several different pricing schemes for broadband networks, the general consensus is to move away from the flat-rate pricing structure used in telephony.

In South Korea, strong facilities-based competition has put downward pressure on prices and encouraged the aggressive rollout of services, forcing service providers to compete on quality of service. The Korean government recognised that broadband access would need to be priced at affordable levels for middle-income households in order to be successful (Choudrie and Lee, 2002) but competition amongst the service providers pushed the prices down even further so consumers could have better value for money for what is being offered.

### 3.4.8 Quality of Security

Quality of security is the level of protection provided by the ISP to broadband users (Irvine and Levin, 2001) and security has become one of the most significant problems of broadband technology that is being accessed and researched on. Therefore it is not possible to discuss broadband quality without considering the importance of security as one the major facet of quality in the provision of broadband services.

According to Meyer (2003), an unprotected computer system that is hooked to a broadband connection is a sitting duck waiting to be victimised. This is as a result of the 'always on' high bandwidth broadband connection the service provider offers their users, which makes them attractive targets for the unscrupulous attacker. Every computer that connects to the Internet is given its own unique IP address and the ISP is responsible for 'leasing' this IP address out to a consumer when connected to the Internet using broadband. When a broadband connection is made it does not give up its IP address easily, as the always-on nature of broadband must maintain an IP address or the connection to the Internet would be lost. It is as a result of this prolonged connection that a user can become vulnerable to the attacker if proper security measures are not put in place to safeguard the consumer. Therefore, in order to provide broadband quality the ISP must provide a selection of security options to the consumers.

## 3.5 Research Problem and Motivation

From the literature review and discussions in both chapters 2 and 3 above, it was noted that broadband offers several advantages to both the public and private sectors in terms of cost savings, efficiency and competitiveness. The shift to broadband requires massive investments in terms of new networks and infrastructures, along with the development of new content, services, applications and business models. However several issues such as reliability, security, and of course quality amongst many could hinder the adoption and the long-term use of broadband. Therefore, both discussions on the aforementioned research problem on broadband quality (Section 2.6.10) and the lack of research studies on the subject in an integrated manner provided the motivations for conducting this research and its impact on users. This problem and motivation aided in formulating the aims and objectives highlighted in section 1.3.

## 3.6 Summary

In this chapter it was shown that quality is not just QoS but that QoS is one of the many facets of quality. Quality was defined and various facets of broadband quality were discussed. Broadband as perceived by different stakeholders was also discussed. Furthermore, it was identified that previous work has treated broadband quality in a disjoint manner and that there is a need to collate all the aspects of broadband quality in order to provide quality broadband service to its consumers. The collated broadband quality would be presented in a unified broadband quality framework. In the next chapter the methodologies used to carry out this research will be described and justified.

# CHAPTER 4: Research Approach and Methodology

## 4.1 Introduction

The preceding two chapters introduced the foundational concept for this work. In this chapter, the nature of the research approach and method that will be used for this work is discussed. The chapter begins by discussing the nature of the research and the rationale behind the choice of the research method used. Subsequent sections describe the design of the investigation, the data collection process, and the data analysis technique.

## 4.2 Research Strategy, Approach and Methods

A research strategy is a means of going about one's research using a particular style with various research methods (Galliers and Land, 1987). The term 'research approach' describes the general style of a research endeavour, while 'research method' is an application of a set of distinct technique (Galliers, 1991). However in the research world there exist many methods and approaches (Galliards, 1994), therefore selecting the appropriate research method can be a daunting and difficult task during the research process (Walsham, 1995).

**Figure 4.1 Overview of the research approach after Tiwana and Bush, 2005**

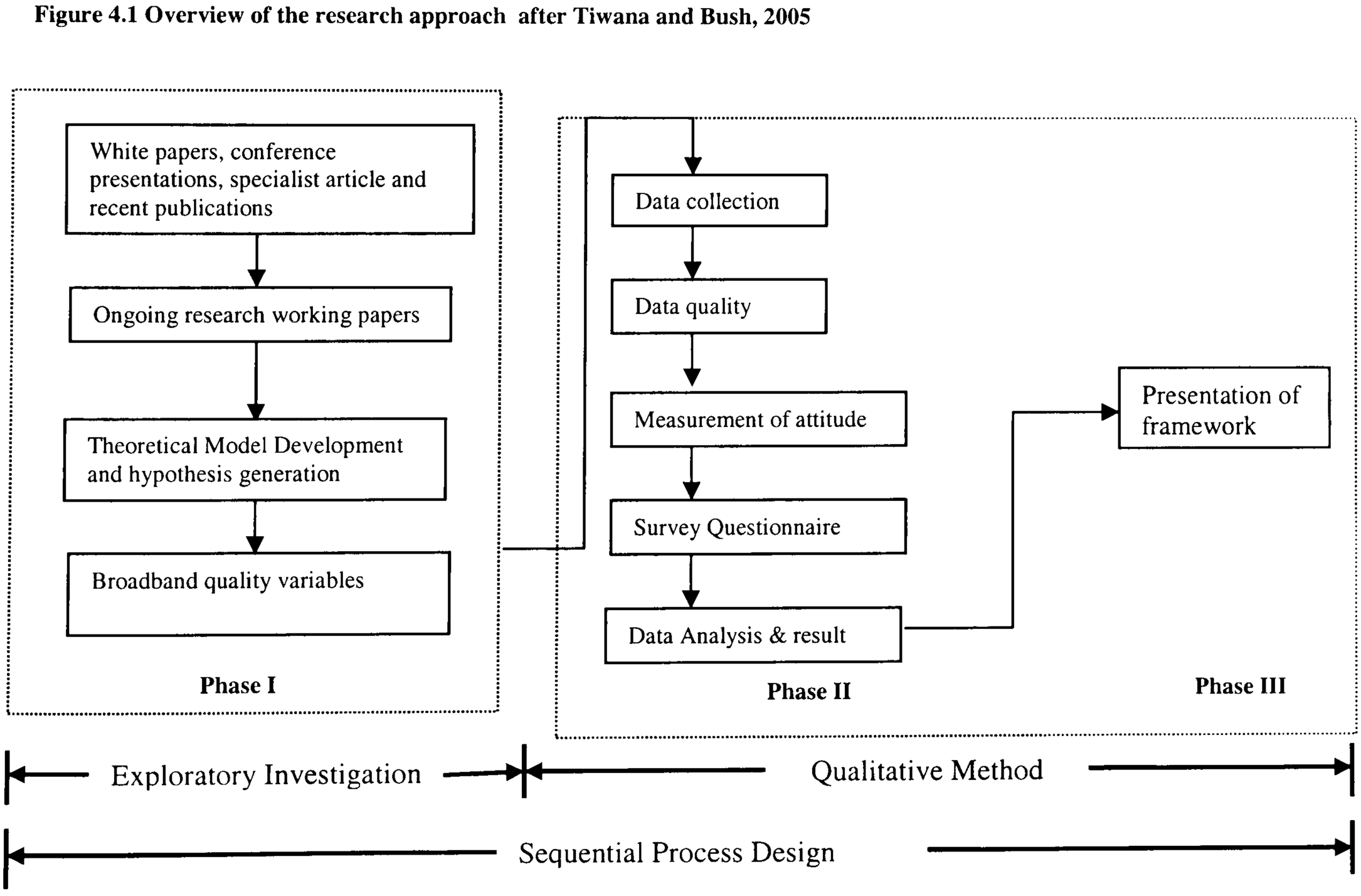


Figure 4.1 depicts the sequential progression used for this research. The sequential progression from exploratory investigation (Phase I) to qualitative methods (Phase II and III) across different phases of a study allows for a much richer and grounded understanding of the research phenomenon. The strength of this route comes from its ability to draw on existing theoretical perspectives, while remaining open to new ideas that emerge from a grounded approach and theoretical development (Tiwana and Bush, 2005). Moreover this process provides benefits in terms of more robust conclusions, development and investigation of the research hypotheses in an evolutionary manner, and increased an understanding of the research results (Wood et al, 1999). A description of the processes used in each of the 3 phases shown in figure 4.1 and how they were employed is detailed in the following subsection below.

### 4.2.1 Exploratory Investigation (Phase I)

The exploratory investigation research method will be partly used for Phase 1 of the research. An exploratory study is undertaken when little is known about the situation at hand or when no information is available on how similar problems or research issues have been resolved in the past. This method allows for the synthesising of data gathered from secondary sources and other drawn inferences from the data in order to make own analysis, as the nature of the subject of this project area is dynamic and is relatively new and still evolving. Gavana et al (2001) suggests the use of an exploratory investigation when there is relatively little information about particular situations or when there are no precedents available to extrapolate from.

Furthermore, Ives and Jarvenpaa (1991) and Neuman (1997) endorse the use of synthesising and analysing data that has been collected for other purposes with a view to drawing inferences for exploratory research in information systems research. Additionally, the lack of synthesised empirical documentation of the study of broadband quality in a consolidated form has driven the choice of this methodology. Insufficient information about the particular situations being investigated, lack of available precedents to extrapolate from and the fact that an exploratory study of this kind may provide further insight into this relatively new subject area also form the basis for the selection of this methodology.

The dynamic nature of the subject area means that the research material will be collected from ongoing research working papers, white papers, conference presentations, specialist articles and recent publications. Inferences can be drawn from all of these according to Yin (1994). As stated earlier in the literature review chapters, each broadband quality in past work has been treated in a fragmented fashion. Thus, applying the exploratory method will enable us to bring together all previous work on broadband quality that has so far been treated in isolation. It is the gathering of this preliminary information that helped in identifying the broadband issues as well as establishing priorities which formed the taxonomy of broadband quality issues. Furthermore, the information gathered using this method suggested the hypotheses for this research.

Although the use of exploratory method in Phase 1 help to increase the familiarity with the analysis of broadband quality issues, there are however disadvantages in using this method. Such disadvantages can be in the form of providing an extensive preliminary work which may lead to possibly loss of direction due to limited knowledge and the evolving nature of broadband and broadband quality. However, the findings derived from exploratory method become the antecedent for further studies (in this case, this research). The shortcoming of the use of exploratory method is compensated for by using a qualitative method to provide an empirical data to support our findings.

### 4.2.2 Qualitative research Method (Phase II and Phase III)

The use of a qualitative research method is designed to help researchers understand people's interpretations and the social and cultural contexts within which they live (Burns, 2000 and Myers, 1999). A qualitative method gives a better understanding of processes and provides high quality results; however investigation can be so all-encompassing that it is difficult to focus (Patton, 1990). Although Miles and Huberman (1994) took a positivist approach to qualitative research, however they offer some helpful advice on how to explore and manage large volumes of qualitative data, which will become relevant for this study.

The advantages of using a qualitative method include producing more in-depth, comprehensive information. It also uses subjective information and participant

observation to describe the context, or natural setting of the variables under consideration, as well as the interactions of the different variables in the context (Patton, 1990). Moreover it seeks a wide understanding of the entire situation. However the very subjectivity of the investigation leads to difficulties in establishing the reliability and validity of the approaches and information. The scope of this research method is limited due to the in-depth, comprehensive data gathering approaches required.

The methods of qualitative research include action research, case study research, grounded theory, life histories, hermeneutics, or general narrative enquiry or participant observer research (O'Neil, 2006). The qualitative methods has imbedded in it a variety of techniques (Miles and Huberman, 1994) which includes historical analysis, focus groups, interviews, surveys questionnaires, and diaries used to capture detailed data through close and open-ended questions (O'Neil, 2006).

The use of a survey technique is applied to Phase II of this research which uses an interpretative approach using a qualitative research method. According to Neuman (2000) the interpretative approach is defined as "*the systematic analysis of socially meaningful action through the direct detailed observation of people in natural settings in order to arrive at an understanding and interpretation of how people create and maintain their social world*". Interpretative context in this research is entirely appropriate as a survey of users' understanding of broadband quality is taken. It is also less expensive than other methods, which will be beneficial to this small-scale project.

#### 4.2.2.1 Survey Research Method

Survey is a term used as an approach within which a number of data collection techniques, such as mail, telephone and interviews are available and can be utilised for data collection purposes (Galliers and Land, 1987). The survey research method was considered most appropriate for the phase II of this research as the survey approach is most widely employed for examining technology perceptions related issues. Moreover this method can used to gather data from respondents thought to be representative of some population (in this case,

broadband users), using an instrument composed of closed structure or open-ended items (questionnaire). The studies related to individual users and consumers have been dealt with using survey approach and can be attributed to issues such as convenience, cost, time and accessibility (Gilbert, 2001). In addition survey approach facilitates data collection from a wide geographical area within a limited time and resources (Fowler, 2002).

The disadvantage of using a survey method is that it relies on standardisation which forces the researcher to develop questions general enough to be minimally appropriate for all respondents, and may possibly miss what is most appropriate to many respondents. The surveys method are can be inflexible in that it require the initial study design (the tool and administration of the tool) to remain unchanged throughout the data collection. A follow-up may be necessary in order to ensure that a large number of the selected sample will reply to the survey questionnaire. Further the participants may find it hard to recall certain information asked about in the questionnaire or tell the truth about a controversial question. However he advantages the survey method has outweighs the disadvantage in that it provides a structured way to collect information using questionnaires. Furthermore the survey will allow us to evaluate the users' perception on broadband quality, since user satisfaction is measured by customer feedback (Krishnan, 1993). The result of this survey will provide a valuable guide as to what users of broadband consider is quality.

#### 4.2.2.2 Survey Implementation

There are three essential process of the survey research approach, which are sampling, data collection and instrument development (Fowler, 2002). Fowler (2002) recommended that in order to have a good survey design it is essential merge all the three process. The first process, sampling, discussed in section 4.2.2.3 below involves the selection of a small subset of a population that is representative of the whole population. The most important thing to consider in a good sample is applying a technique that gives all or nearly all the population members the same chance of being selected (Fowler, 2002). The data collection can be conducted employing techniques such telephone, mail and the Internet; however, the selection should be made after evaluating the advantages and

disadvantages from the perspective of a particular research context (Fowler, 2002).

#### 4.2.2.3 Selection of Respondents - Sampling

Using Fowler (2002) suggestion on sampling, broadband users, mostly home users that are residence in Hillingdon, Greenwich, Lewisham and Havering boroughs were targeted. These four London boroughs were targeted as there were more broadband users in London than other part of the UK (Point Topic, 2006). The users from Hillingdon were taken from the Hillingdon electoral register while other users from other boroughs were given the questionnaire randomly. Interestingly, Choudrie and Dwivedi (2005) have explored the use of the Hillingdon electoral register. Although the design of the questionnaire targeted only broadband users there was a section that was also addressed dial-up and why those users had not taken up broadband. Of the 500 participants targeted for the survey, 133 respondents completed the survey questionnaire successfully.

#### 4.2.2.4 Data Collection

Empirical assessment of the consumers' perception of broadband quality is based on data collected mainly through a nationwide survey in the UK. The data collection from the survey questionnaire was as a result of information gathered using the exploratory investigation including supplemented and verified with published materials such as consortium papers, journals, researchers, and government statistics to highlight the variables used for the development of the questionnaire. Emphasis is placed on the importance of looking at the variables in the natural setting in which they are located. These variables were required to determine if the selected underlying constructs significantly explained the consumers' perception regarding broadband quality and constitute empirical material for the researcher to interpret. Furthermore, the responses were used as material to develop a thick description and rich understanding of broadband quality as perceived by the users.

There are many ways of obtaining information; the most common methods are literature searches, talking with people, focus groups, personal interviews, telephone surveys, mail surveys, email surveys, and Internet surveys. However

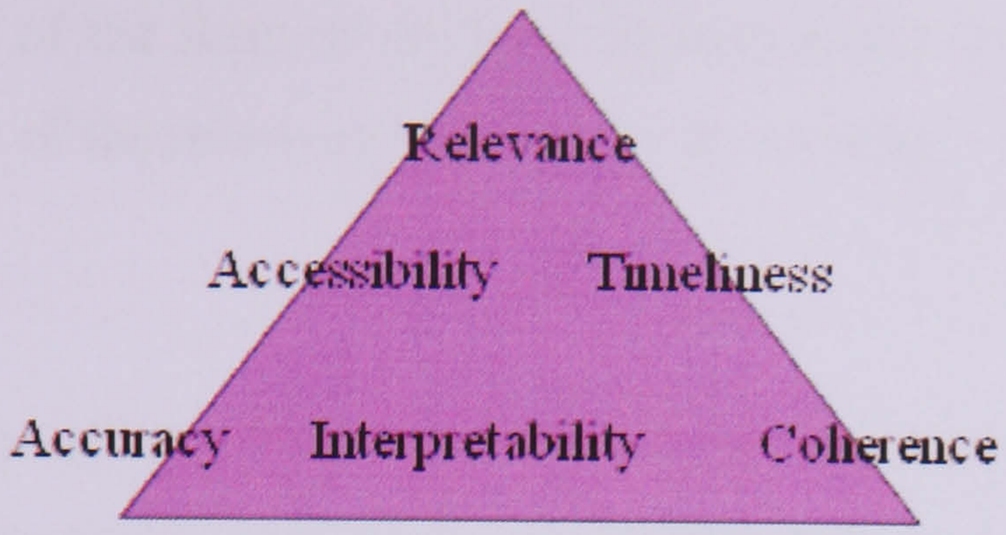
Cornford and Smithson (1996) identified three major ways of collecting data, which are interviews, reviews and survey/questionnaires as the primary mechanism for ensuring quality requirements and specification. The mail and email surveys as employed by Savage and Waldman (2004) was utilised in this research:

- **Mail surveys**- are a cost effective method of gathering information. They are ideal for a large sample size, or when the sample comes from a wide geographical area. It costs less than a telephone interview however it may take over twice as long to complete. Moreover because there is no interview, there is no possibility of interviewer bias. The main disadvantage is the inability to probe respondents more detailed information. The use of the mail survey was mostly used for the broadband users living in the four London boroughs used in this research
- **Email survey**- is clearly the most cost effective and fastest method of distributing a survey. Although the demographic profile of the Internet user does not represent the general population, this is changing. Some broadband uses were also targeted by email, however within the four London boroughs.

### 4.2.2.5 Data quality

Data quality is a major preoccupation since it will have major consequences on the values obtained for the outcome/impact indicators and poor quality data will translate into wrong indicator values, providing a false vision of reality and possibly leading to wrong policy recommendations (Lariviere, 2003). In order to produce a comprehensive and authenticated quality data, the data quality framework (Brackstone, 1999) will be used to develop the questionnaire. The use of the data quality framework was subsequently also endorsed by Kalton (2001) and Kasprzyk (2001).

**Figure 4.2: Data Quality Framework**




This framework, (Figure 4.2) was also used by the Department of Health and Ageing, Australia to gather information on how computer and the Internet are being used in general practices and the attitudes towards the use of broadband technology in the delivery of clinical services. The information gathered from the survey was used to inform development of an implementation strategy and project plan (Australian Government, 2003). The selection criteria of how the questionnaires follow the data quality framework is as follows:

**Relevance:** The relevance of statistical information reflects the degree to which it meets the real needs of clients. It is connected with whether the available information sheds light on the issues most important to users. Relevance is generally described in terms of key user needs, key concepts and classifications used and the scope of the collection (including the reference period). These components are then compared against specific user needs to assess relevance.

**Accuracy:** The accuracy of statistical information is the degree to which the information correctly describes the phenomenon it was designed to measure. It is usually characterised in terms of error in statistical estimates and is traditionally decomposed into bias (systematic error) and variance (random error) components. It may also be described in terms of major sources of error that potentially cause inaccuracy (e.g. sampling, non response).

**Timeliness:** This refers to the delay between the reference point (the end of the reference period) to which the information pertains, and the date on which the information becomes available.

**Accessibility**: This refers to the ease with which users can reference it. This includes the ease with which the existence of information can be ascertained, as well as the suitability of the form or medium through which the information can be accessed. The cost of the information may also be an aspect of accessibility for some users.

**Interpretability**: This reflects the availability of the supplementary information and metadata necessary to interpret and utilise it appropriately. This information normally covers the availability and clarity of metadata, including concepts, classifications and measures of accuracy. In addition, interpretability includes the appropriate presentations of data such that it aids in the correct interpretation of the data.

**Coherence**: This reflects the degree to which it can be successfully brought together with other statistical information within a broad analytic framework and over time. Coherence encompasses the internal consistency of a collection as well as its comparability both over time and with other data sources. The use of standard concepts, classifications and target populations promotes coherence, as does the use of a common methodology across surveys.

#### 4.2.2.6 Measurement of attitudes

There exist various methods for measuring attitudes for the survey questionnaire part of this research, such as the Thurstone method and Likert technique. While the Thurstone method is a differential scaling technique which uses a stimulus-centred approach in locating the positions of stimuli or items on the psychological continuum, the Likert technique is a summative scale which is considered to be a subject-centred approach because its purpose is to scale subjects rather than dimensions. The scale was developed by Rensis Likert in 1920 in an attempt to improve the level of measurement in social research through the use of standardised response categories in survey questionnaires (Hitchcock and Porter, 2004). The technique presents a set of attitude statement. Subjects are asked to express agreement or disagreement of a seven-point scale. Each degree of agreement is given a numerical value from one to seven. Hence, a total numerical value can be calculated from all the responses. Often the scale will be presented as

| | | | | | | |
|---|---|---|---|---|---|---|
| *1=strongly disagree* | *2=quite disagree* | *3=slightly disagree* | *4=neutral* | *5=slightly agree* | *6=quite agree* | *7=strongly agree* |

For the purpose of this research and the relevance of technique, the Likert technique will be use to measure participants' attitude in response to the survey questionnaire. This is because this method allows the participant to choose one of several feelings about a statement from strong approval to strong disapproval. The intensity of the response to the questions is used to measure the strength of the participant's attitude as this allows the researcher to obtain more quantitative information about the survey.

#### 4.2.2.7 Design of Survey questionnaire

Understanding the nature and characteristic of user behaviour is a vital step to improve on broadband service offered by service providers (Marques et al, 2004), which in turn influences the increase of service quality. Consequently the survey questionnaire was designed to focus on users' perceptions and experience on broadband service as delivered by service providers in the UK. The survey questionnaire was divided into three parts; the first part described the nature of the study, while the second part requested demographic and "technological" information. Demographic details included the respondents' gender, age, professions and annual income of the household. This information made it possible to establish the persona of the sample to the whole population. The questionnaire includes 34 multiple-choice questions, open and closed ended questions (Hall and Hall, 1996), which focused on the users' profession, and their salary, the type of broadband access, what problems they had encountered with the broadband access and their interactions with their service providers as a result of the problem. Respondents were encouraged to comment or elaborate on their responses when it was relevant.

Finally the third part focused on users' perception using a Likert-scale. Participants were asked to indicate the degree to which they perceived broadband quality based on ten variables (Table 4.1) using a 7-point scale ranging from strongly disagree to strongly agree (see 4.2.2.7). In order to cater for the fact that respondents tend to agree more than disagree when asked their opinion to a statement, half of the questions were phrased in a positive way and half in a

negative way. In doing this, it was intended that the tendency to agree would be negated and a realistic measure of perception attained (Fowler, 2002). The variables used were as a result of in-depth analysis of literature review in Chapter two and three. The reason why these variables were selected is because they cover all the aspect of services rendered by service provider to their customers. The data generated will be the primary data for this work.

**Table 4.1: Summary of broadband quality variables used for the measurement of users' perception**

| | Variables |
|---|---|
| 1. | Price |
| 2. | Speed |
| 3. | Quality of Service (QoS) |
| 4. | Security |
| 5. | Quality of Perception (QoP) |
| 6. | Customer Service Response |
| 7. | Reliability |
| 8. | Connectivity |
| 9. | Policy |
| 10. | Availability |

Price is the fixed monthly fee paid for access and unlimited usage. Speed describes the time it takes to receive and send information to and from the Personal Computer (PC). QoS refers to certain level of network service performance to a data flow from an ISP to a customer PC in order to provide the streaming multimedia applications such as VoIP, online games and VOD. Security is the provision security service as rendered by the ISP to broadband users. QoP is the measurement of users' satisfaction with the quality of multimedia presentation and also user's ability to analyse, synthesise and assimilate the informational content of multimedia displays. Customer service response measures the attitude of ISP customer service representative (CSR) towards their customers; this attitude includes technical knowledge of problems experience by broadband users, time and speed of response and friendliness of CSR. Reliability is that broadband connection which is never disrupted that is no service outages. Connectivity is the type of access users have with their ISP, whether DSL, Cable or wireless connection. Policy measures the users' perception

on government involvement on broadband. Finally availability measures the instant connection by the broadband users to the Internet via their ISP.

Questions about participant employment status and wages were also asked. The rationale of employing a questionnaire for this study was to present a large number of respondents with questions in a similar way using a systematic approach and recording their responses in a methodological manner (Hall and Hall, 1996). A self-completion approach to collect a significant amount of data within a short period of time and at a lowest cost was adopted.

The developed survey questionnaire was initially piloted among 25 people, comprising of academicians, as well as broadband and non-broadband users in order to have a feel of the questionnaire on how appropriate the questions were in relation to the study. Feedback from the pilot study was collected and collated. Appropriate adjustments were made to improve the survey questionnaire to reflect changes based on the feedback including removal of some questions. The final survey questionnaires were then sent out to larger users of broadband users in UK. The final survey questionnaire can be found in Appendix 2 of this thesis

## 4.3 Limitation of the chosen research methods

Despite the fact that this research was conducted in accordance with best practice guidelines, there are nevertheless limitations on the success of the research methods adopted for this work. The results of the use of an exploratory investigation in phase 1 of the research are not usually useful for decision-making by themselves, but they can provide significant insight into a given situation to form a foundational concept. However the shortcoming of the exploratory research method used in this research is compensated by the qualitative research method (phase II) in the form of a survey questionnaire which produced an undiluted data feedback of respondents' perception on broadband quality investigated in this research.

Furthermore the use of a Likert scale in the qualitative research method in phase II allows responses to be gathered in a quick standard manner and also allows participants a wide range of choices, making them feel more comfortable. However, the participant may not be honest, which may be intentional or

unintentional. Additionally, participants may base answers on feelings toward the survey and may answer according to what they feel is expected of the as participant.

## 4.4 Ethical Issues impacting Data Collection

The data collection, analysis and usage processes involved the consideration of both ethical and legislative issues such as those specified in the Data Protection Act (1998) which are relevant to research of this nature. In particular, the Brunel University guidelines in respect of personal data used in research was strictly adhered to. For example, data collected was not used to support decisions or measures relating to any individual. Moreover, data were not used in a way which could cause substantial damage or distress to an individual (Brunel University, 2008). The data results were anonymised that is, the results do not identify individuals. Participants were under no pressure to complete survey questionnaire as this was stated in the covering letter sent out with the questionnaire. This approach helped assure respondents of the confidentiality and integrity of their responses. Furthermore all data collected was destroyed at the end of the research.

## 4.5 Summary

In this chapter, an exploratory investigation and an interpretative approach using qualitative research methods in a sequential progression design were identified as suitable for this work. The application of the qualitative method for this research was described and justified. The research strategy of these methodologies into the research was also analysed in detail. Chapter five will provide the analysis of the data and results gathered from the survey questionnaires sent to the participants.

# CHAPTER 5: Data Analysis and Results

## 5.1 Introduction

This chapter presents an analysis of data gathered through the survey questionnaire and discusses the outcomes of findings based on the survey conducted on users' perception of broadband quality. Data collected is analysed using SSPS.

## 5.2 Data Analysis

Using SPSS and Excel, a statistical analysis is conducted which help to identify key parameters identified from the responses of the survey participants. The data collected is of numerical and statistical data which makes the data a quantitative data. The result of the analysis of the data collected from the survey is depicted in tables, charts, and graphs.

## 5.3 Research Findings and Analysis

The analysis initially presents the profile of the respondents, so as to give a picture of broadband consumers in the UK (Table 5.1a and Table 5.1b). A total of 500 questionnaires (see Appendix A) were sent out to users. 152 users responded of which 135 were usable for the analysis and the remaining 17 were wrongly completed. Of those found usable, 133 (98.5%) represented individuals, while 2 (1.5%) represented organisations. 80 (60.2%) of individual respondents were male, 53 (39.8%) female.

From the data gathered, most (42.9%) of the individual respondents belonged to the 35 - 44 years age group; this was followed by the 24 – 34 years age group (38.3%) and 17 – 23 years (8.3%) group. The rest of the respondents belonged to the 45 – 55 age group (6.8%), the 56 – 70 age group (2.3%) while 1.5% belonged to the under 16 years age group (Table 5.1a). Table 5.1b depicts the profile of the organisations that took part in the survey.

**Table 5.1a: Profiles of Individual respondents**

| Variable | Category | Frequency | Percentage |
|---|---|---|---|
| **Borough** | Respondents live in various London boroughs | | |
| | | | |
| **Sex** | Male | 80 | 60.2% |
| | Female | 53 | 39.8% |
| | | | |
| **Age** | Under 16 | 2 | 1.5 |
| | 17 – 23 | 11 | 8.3 |
| | 24 – 34 | 51 | 38.3 |
| | 35 – 44 | 57 | 42.9 |
| | 45 – 55 | 9 | 6.8 |
| | 56 – 70 | 3 | 2.3 |
| | Over 70 | 0 | 0 |
| | | | |
| **Occupation** | Directors, doctors, lawyers, professors | 14 | 10.5 |
| | Electricians, mechanics, plumbers and other craft) | 5 | 3.8 |
| | Managers, teachers, computer Programmers | 49 | 36.8 |
| | Machine operators, assembly, cleaning | 5 | 3.8 |
| | Foremen, shop assistants, office workers | 16 | 12 |
| | Pensioners, casual workers | 1 | 0.8 |
| | Unemployed | 2 | 1.5 |
| | Student | 24 | 18 |
| | Others | 14 | 10.5 |
| | Unanswered (UA) | 3 | 23 |
| | | | |
| **Annual Income (£)** | < 10,000 | 18 | 13.5 |
| | 10,000 – 19,999 | 23 | 17.3 |
| | 20,000 – 29,999 | 22 | 16.5 |
| | 30,000 – 39,999 | 13 | 9.8 |
| | 40,000 – 49,999 | 13 | 9.8 |
| | 50,000 – 59,999 | 16 | 12 |
| | 60,000 – 69,999 | 2 | 1.5 |
| | 70,000 – 79,999 | 5 | 3.8 |
| | 80,000 – 89,999 | 3 | 2.3 |
| | 90,000 – 99,999 | 4 | 3 |
| | > 100,000 | 4 | 3 |
| | Unanswered (UA) | 10 | 7.5 |

**Table 5.1b: Profile of organisation respondents**

| | | |
|---|---|---|
| **Organisation type** | Government agency | |
| | Gaming Company | |
| | Education | |
| | Agriculture, Mining, Oil | |
| | University or college | |
| | Communications | |
| | Transportation | |
| | Finance, Banking, Accounting, Insurance, Real Estate | 2 |
| | Research / Development | |
| | Engineering / Architecture | |
| | Health, Medical Services, Legal | |
| | Internet / e-commerce | |
| | Other | |
| **Location** | Greenwich | |
| **Age of organisation** | Less than 5 years | 1 |
| | 6 – 10 years | 1 |
| | 11 – 25 years | |
| | Over 26 years | |
| **How many people in organisation** | Less than 100 | 2 |
| | 100 – 499 | |
| | 500 – 1000 | |
| | More than 1000 | |

**Figure 5.1: Income profiles of the respondents**

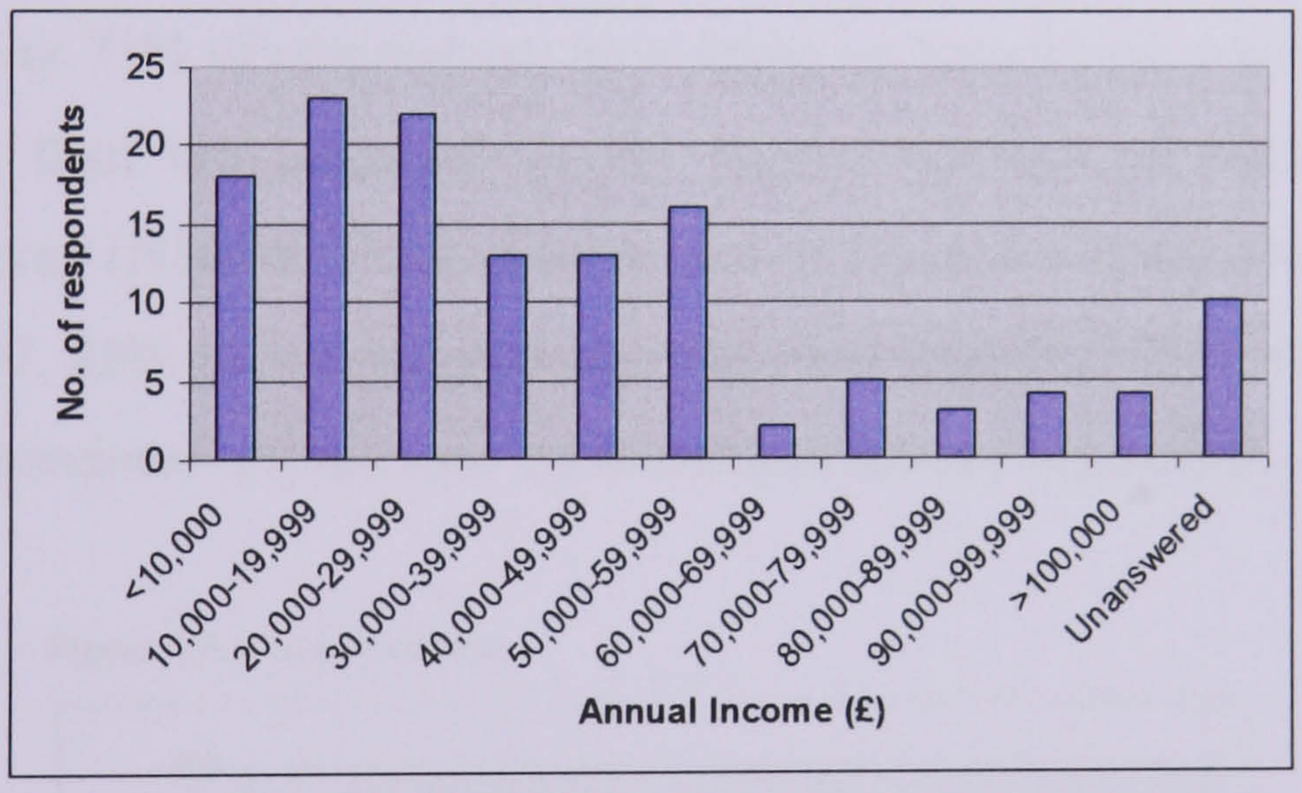
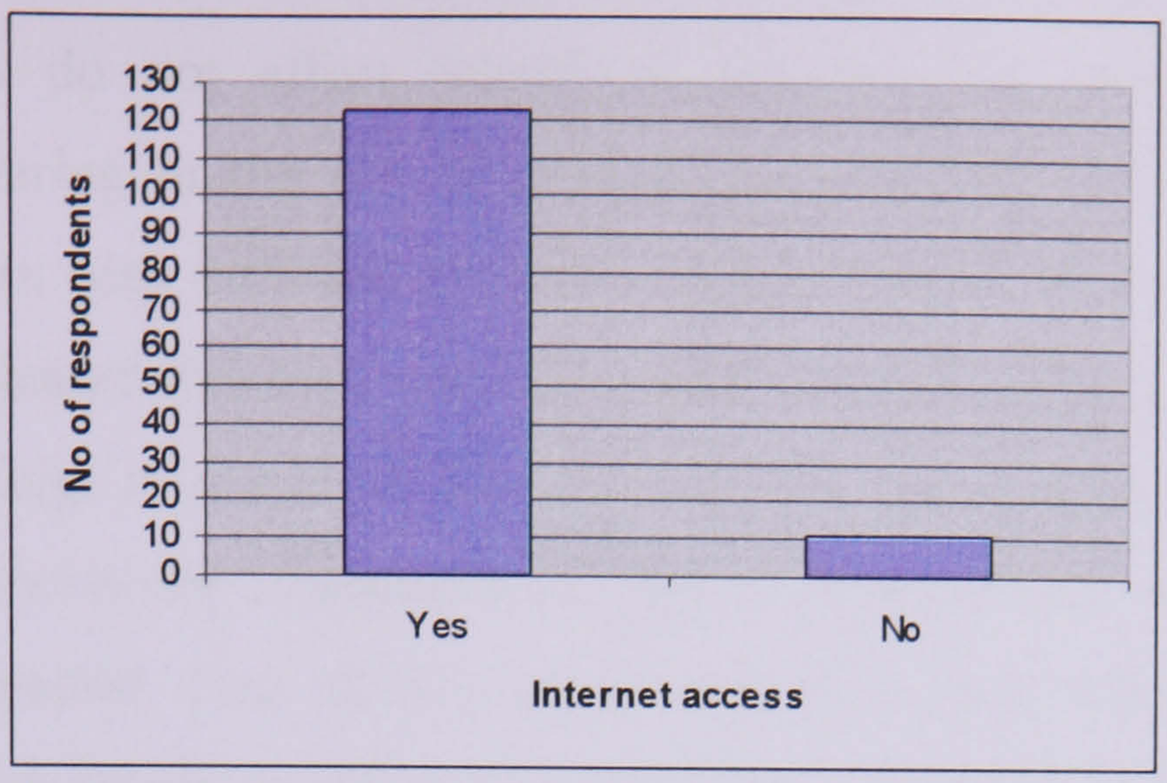


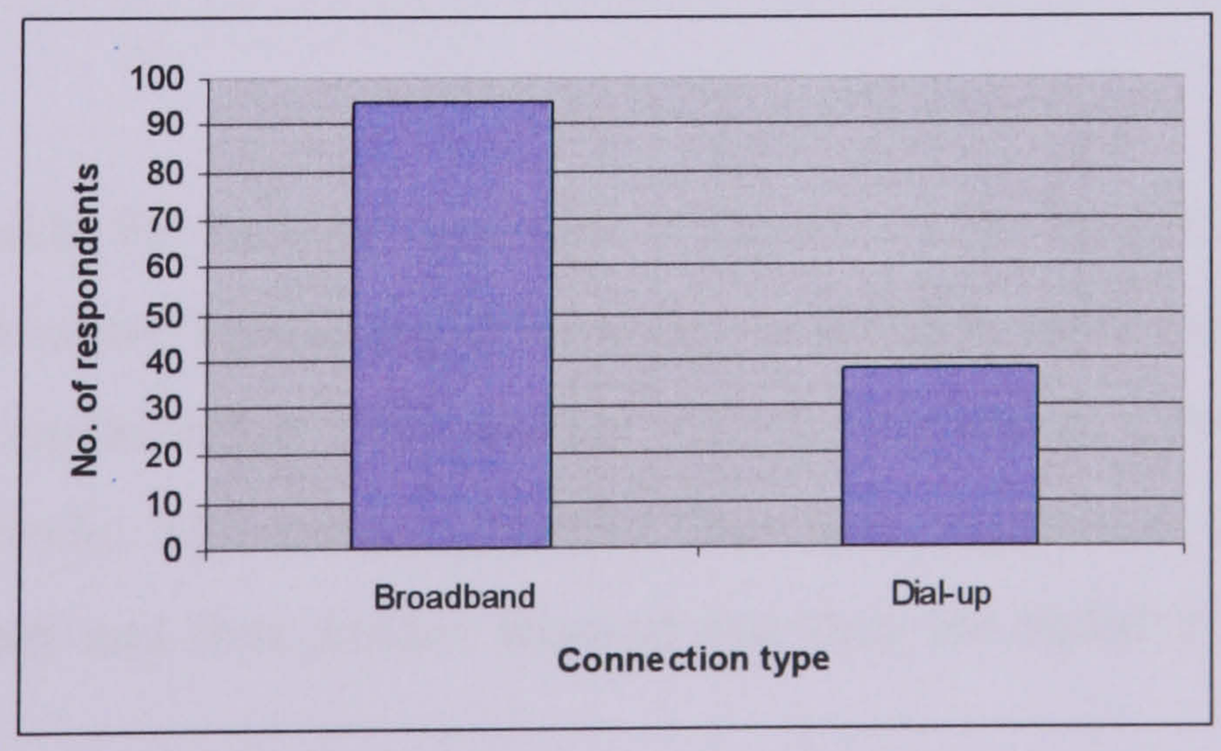

Figure 5.1 shows that the income profile of the individual respondents spanned a wide range, with most of the sample (53.4% of respondents) being bunched in the medium income bracket (£10,000-49,999). At both ends of the spectrum the student participants in the survey held part-time jobs and indicated income levels of below £10,000, while white-collared professionals (doctors, IT consultants) and entrepreneurs indicated high income levels of above £70,000. However 10 respondents (7.5%) did not declare what their annual income was.

**Figure 5.2: Internet Access**




As Figure 5.2 illustrates, 122 individual respondents indicated that they have access to the Internet at home while 11 respondents claimed not to have access to the Internet from home; however they professed to have access to the Internet from other sources, for example Internet cafés, the office or the library. Of those respondents that claimed to access the Internet from home, 27 of the respondents confessed to still using dial-up to access the Internet at home, while 95 respondents accessed the Internet using a broadband connection (Figure 5.3). This shows that over 71% of respondents have taken up broadband, which is a slightly lower figure than that obtained in the survey findings of National Statistic Omnibus Survey (NSOS) which claimed that of London households with Internet access in 2007, 88% have a broadband connection (NSOS, 2007). Thus, the study using the respondents' perspective on broadband quality is justified.

**Figure 5.3: Connection type**



Interestingly, an Analysis of Variance (ANOVA) run on the data has revealed that income levels do not affect broadband take-up; this reflects the fact that broadband offering in the UK is competitively priced, and thus encourages a variety of users with different earning profiles. Indeed, of the 27 people in the study who indicated that they were still using dial-up to access the Internet, 13 of them had earnings in excess of £40,000 with the rest earning below £30,000 per annum. This shows the remarkable popularity of broadband with people from a mid-income bracket. Few of the respondents who used dial-up claimed not to know if they could get broadband in their home, while some indicated that they had access to the Internet in the office and that their need to access the Internet at home was minimal; it was thus more cost effective to access the Internet via dial-up at home. Moreover, most of the respondents with dial-up access fell into the same *computer programmer, manager and teacher* category (see Table 5.1a); supporting their claim that they access the Internet more in the office than at home.

**Figure 5.4: Respondents Internet access from outside their home**

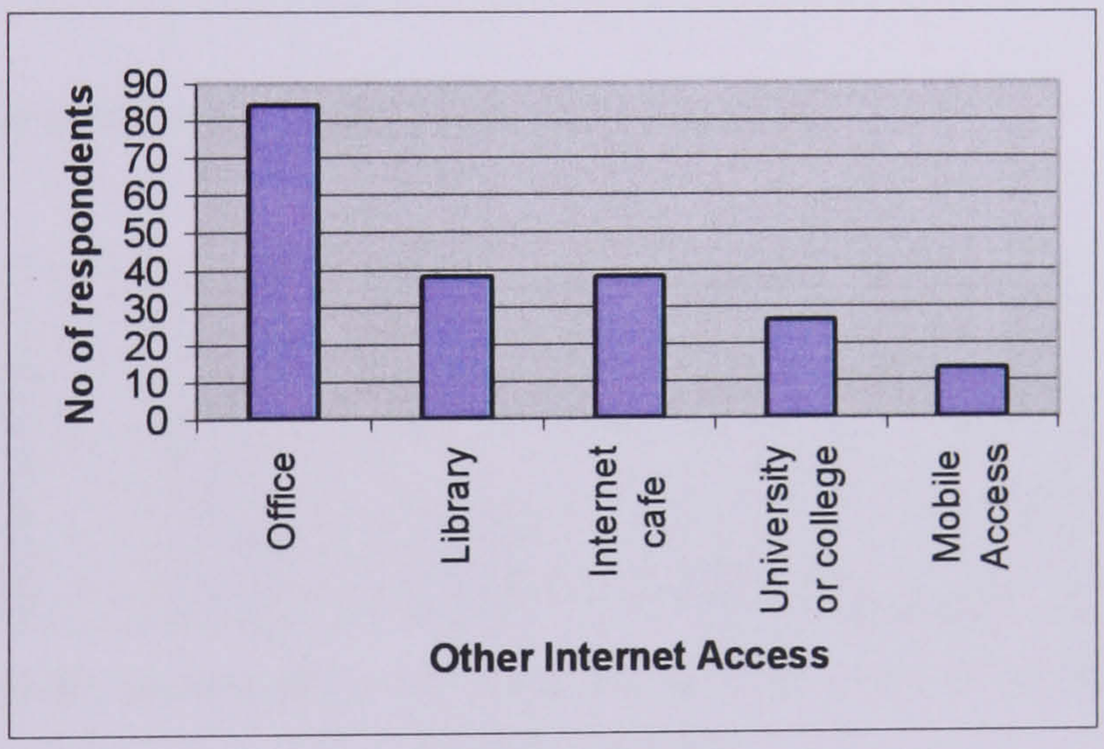


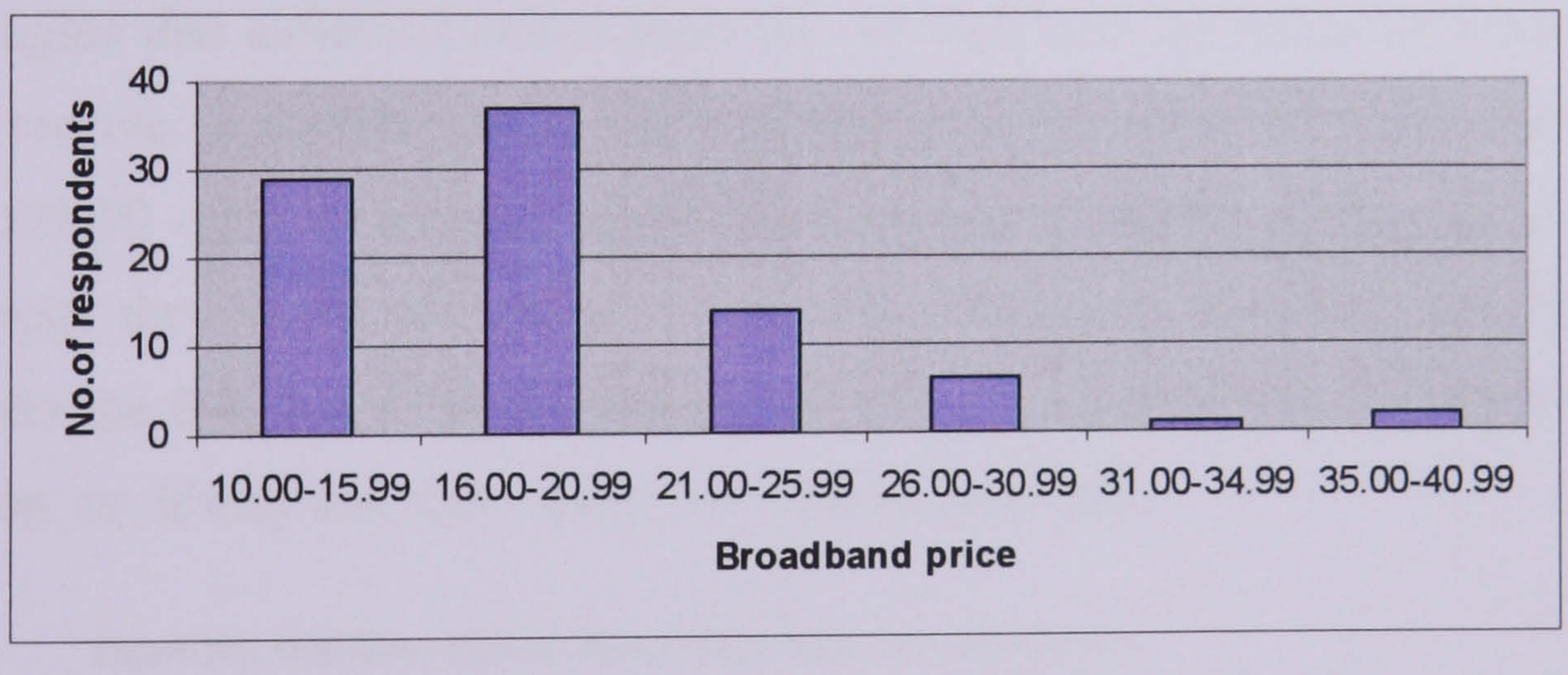

Figure 5.4 depicts the varying respondents' access to the Internet from locations other than their home. From here, it becomes evident that most respondents access the Internet from the office, followed by access from the Internet cafe and local library respectively. This reflects the fact that most respondents are comfortable with the Internet and thus further showed that they are suitable participants for this study.

**Table 5.2: Types of broadband connection**

| Variable | Category | Frequency | Percentage |
|---|---|---|---|
| Type of broadband access | Broadband with DSL/ADSL | 66 | 69% |
| | Broadband with Cable modem | 21 | 22% |
| | Wireless | 3 | 3% |
| | Other | 1 | 1% |
| | Unanswered (UA) | 4 | 4% |

The survey also revealed that 69% (n=66) of the respondents use broadband with a DSL/ADSL connection to access the Internet compared to 22% (n=21) who use broadband with cable modem (Table 5.2). This finding reflects that DSL/ADSL is widely utilised by consumers compared to cable modem users, however the choice of broadband type does not affect the broadband price paid by the respondents. While 39% of the respondents pay £16.00 – £20.99 monthly for their broadband connection, it was found that those who paid either £10 - £15.99 or £21 - £25.99 respectively represent 31% and 15% of broadband users (Figure 5.5). Only 3 respondents paid over £31 for their broadband connection (Table 5.3).

**Figure 5.5: Broadband monthly subscriptions paid by the respondents**




Interestingly, it was observed that the earnings of those that pay £16 – £20.99 monthly for their broadband connection cover the spectrum of the various income categories included in the study, reflecting the fact that this is the most popular broadband segment across all income categories (Table 5.3).

**Table 5.3: Broadband price paid by the respondents**

| | | Broadband monthly price | | | | | |
|---|---|---|---|---|---|---|---|
| | | 10.00-15.99 | 16.00-20.99 | 21.00-25.99 | 26.00-30.99 | 31.00-34.99 | 35.00-40.99 |
| **Annual Income** | <10,000 | 4 | 6 | 1 | 1 | | |
| | 10,000-19,999 | 6 | 3 | 2 | 2 | | 1 |
| | 20,000-29,999 | 5 | 9 | | | | |
| | 30,000-39,999 | 4 | 6 | 1 | | | |
| | 40,000-49,999 | 1 | 2 | 4 | 1 | | |
| | 50,000-59,999 | 3 | 5 | 3 | | | |
| | 60,000-69,999 | | 2 | | | | |
| | 70,000-79,999 | | 2 | | | 1 | |
| | 80,000-89,999 | 1 | 1 | | | | 1 |
| | 90,000-99,999 | 3 | | 1 | | | |
| | >100,000 | | 1 | 1 | 1 | | |

Not surprisingly, an ANOVA revealed that the particular income level of an individual does not influence the individual's choice of broadband subscription cost. This payment is for speeds varying from 512Kb – 10Mbps, and again an ANOVA highlights that income levels do not affect the choice of broadband connection speed. Indeed, those respondents paying £16 - £20.99 monthly for broadband connection do so for a wide variety of connection speeds; this highlights that either the respondents are satisfied with the value for money that they receive, or that they do not shop around for better rates. Moreover, those who pay £21.00 - £25.99 monthly make this payment mostly for 1Mbps speeds only, although they could get 2Mbps broadband connection for under £20.99. This reflects the fact that some consumers are still not aware of the best deals on the market, or, if they are, they cannot be bothered to switch.

**Figure 5.6: Subscriber loyalty: Respondents time with current ISP**

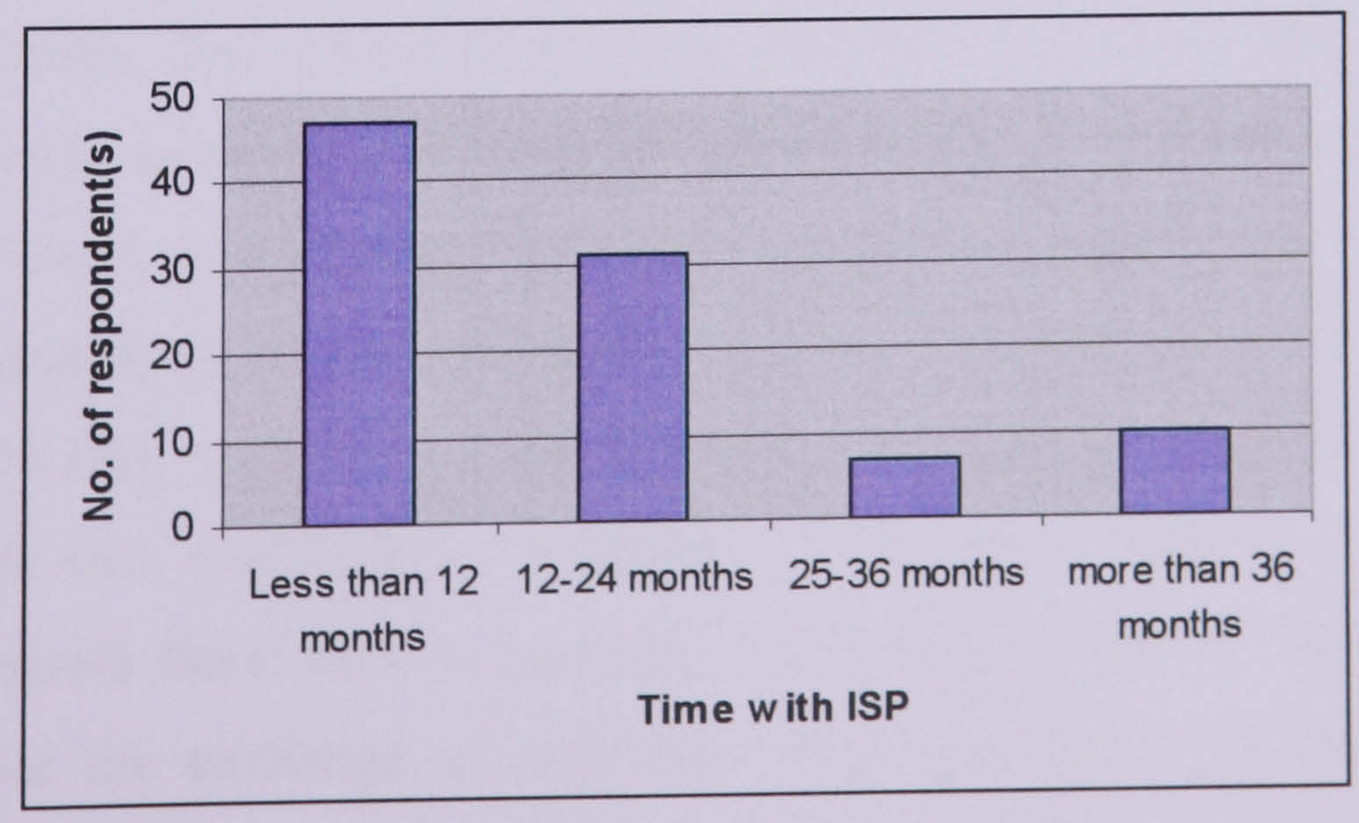


Figure 5.6 depicts that 49% (n=47) of broadband users surveyed had joined their ISP less than 12 months before, followed by 33% (n=31) who joined their ISP between 12 – 24 months and 7% (n=7) and 11% (n=10) who joined their ISP between 25 – 36 months and over 36 months respectively, thus illustrating the strong dynamics of broadband take-up in the UK. Analysis of the results also revealed that there was no correlation between the monthly broadband subscription cost paid by users and the length of time or the frequency with which users accessed the Internet. As broadband is an "always on" connection and the flat rate price does not depend on factors such as length of access, time of day, frequency, it is of no surprise that users confessed to having these usage patterns, which contrast starkly with other pricing models (traditionally associated with dial-up) which encourage users, for instance, to be much more aware of the amount of time spent online.

**Figure 5.7: User online activities using broadband**

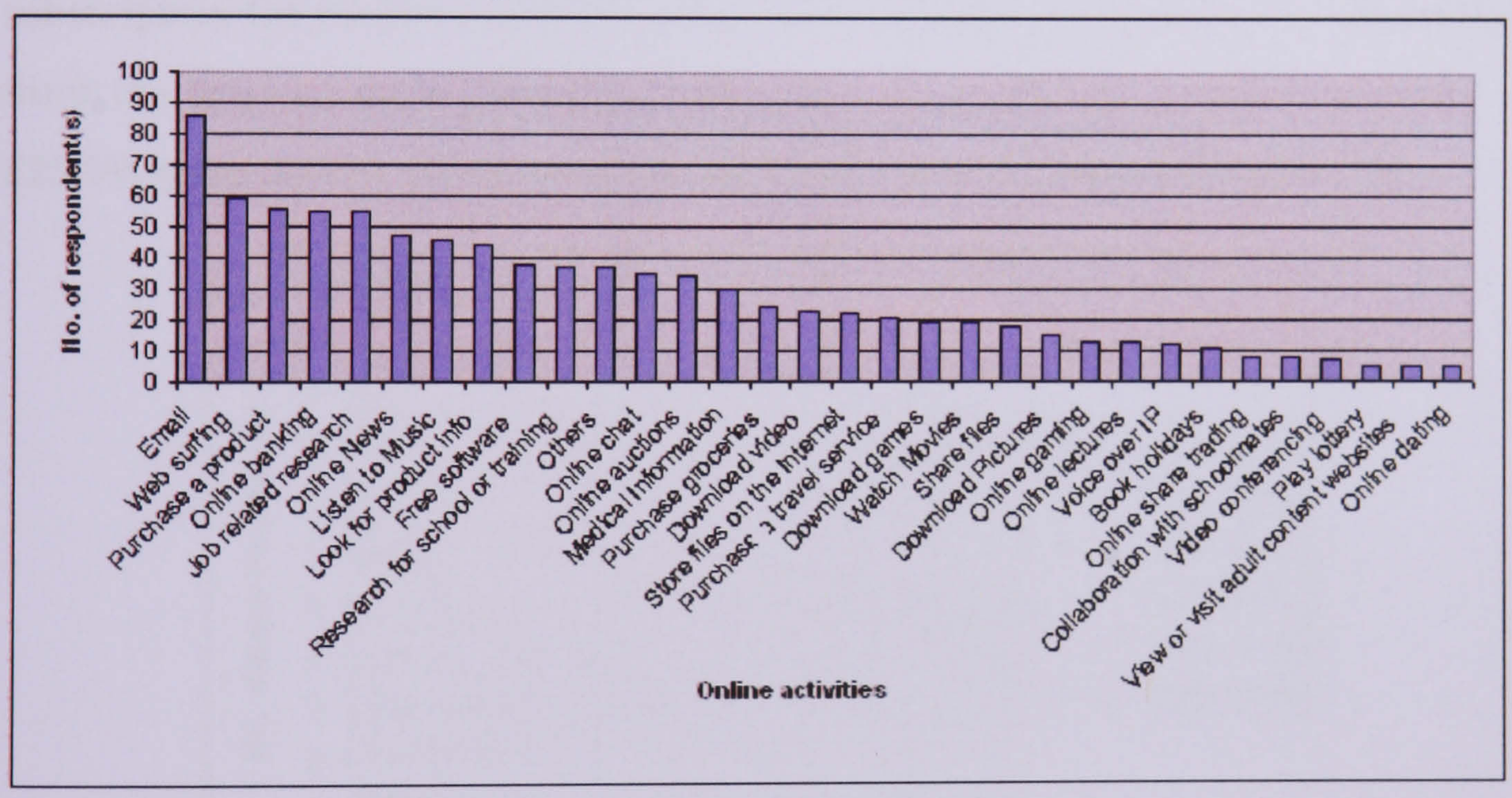



Figure 5.7 shows that an overwhelming majority of users (n=86, or 90% of broadband users surveyed in the sample) utilise their broadband connection to access their Email; other popular activities using broadband include web surfing, product purchasing, job related-research, online banking and listening to music. It is remarkable that, with the exception of the last activity, none of these more popular ones are traditionally regarded as bandwidth intensive, for which broadband would have been a necessity rather than a luxury. However, it is suspected that the exchange of relatively large messages via e-mail (such as

attachments containing digital photo snaps) goes someway towards justifying broadband use for e-mail.

**Figure 5.8: Download frequencies**

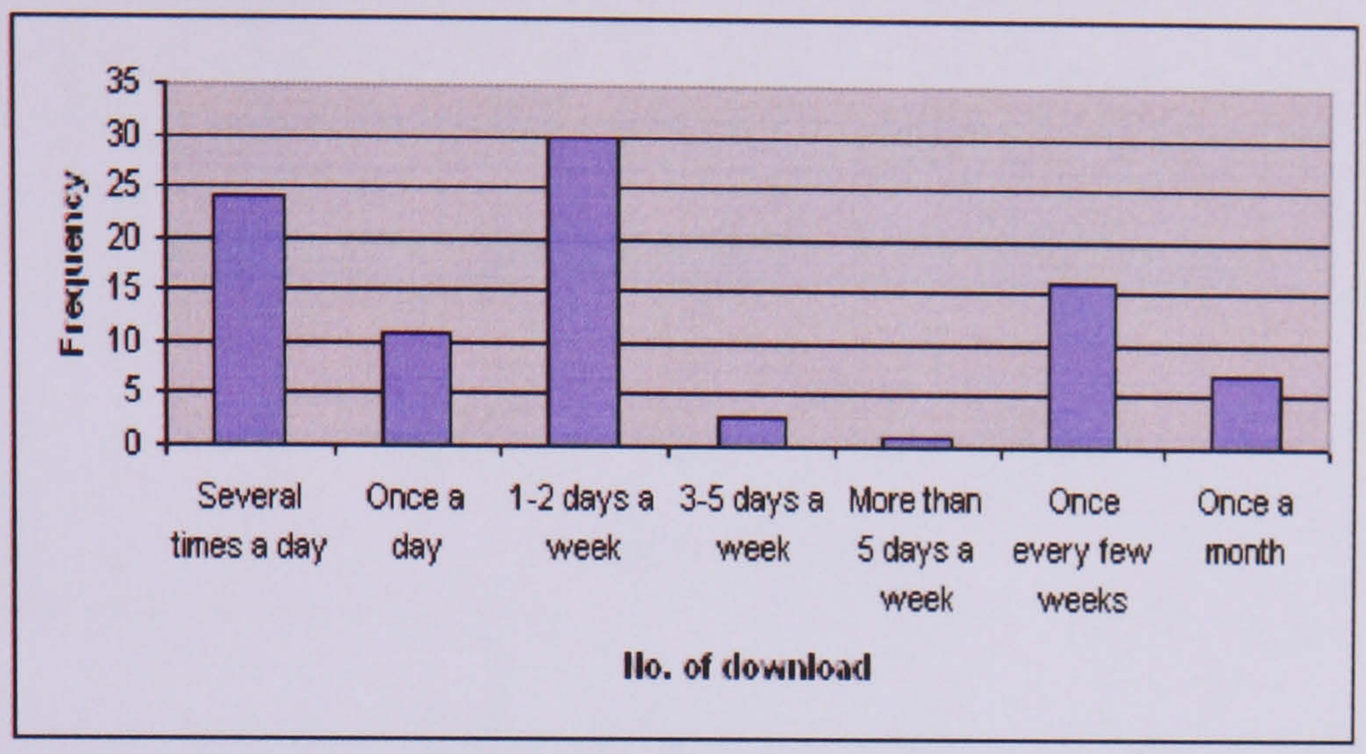
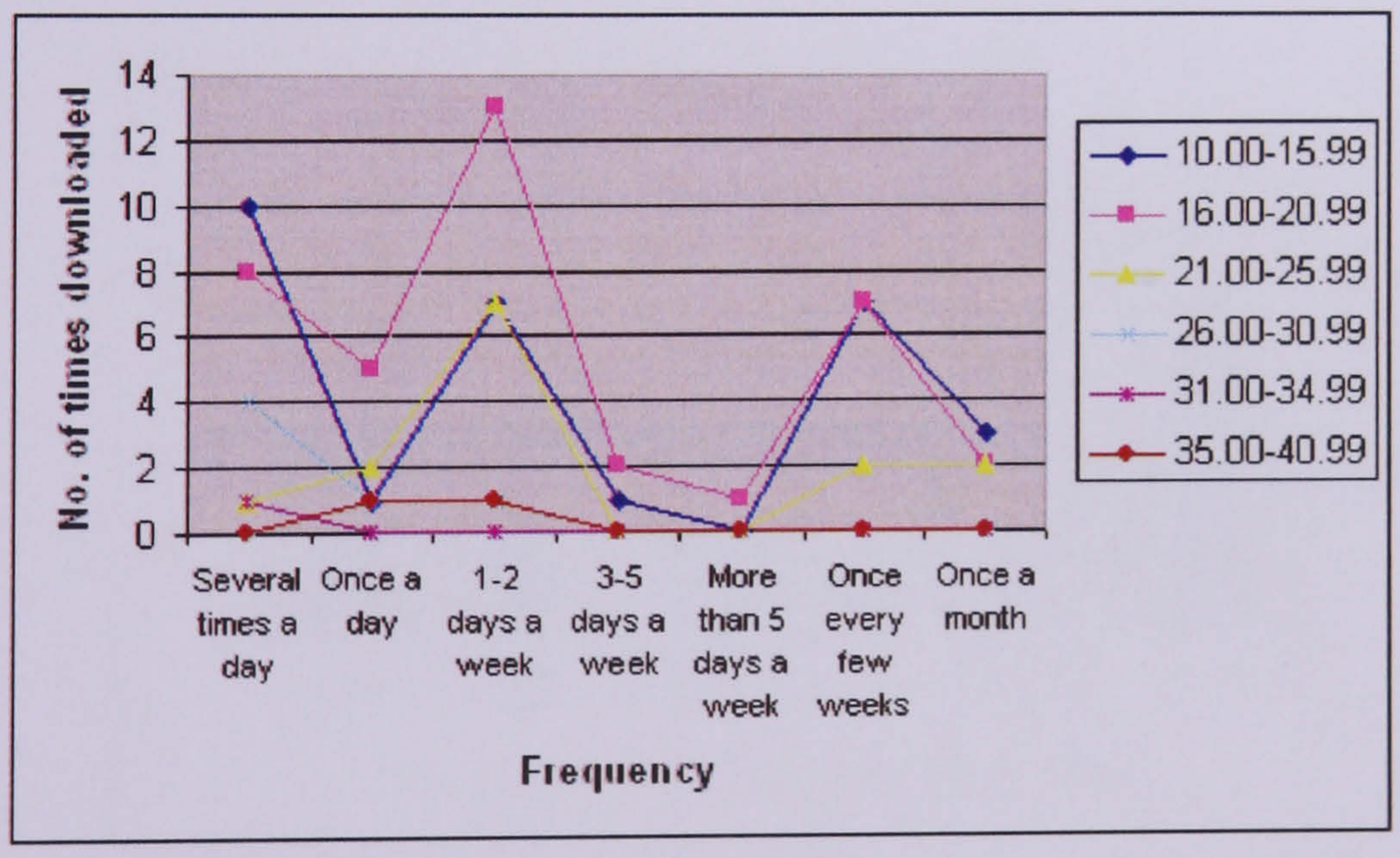


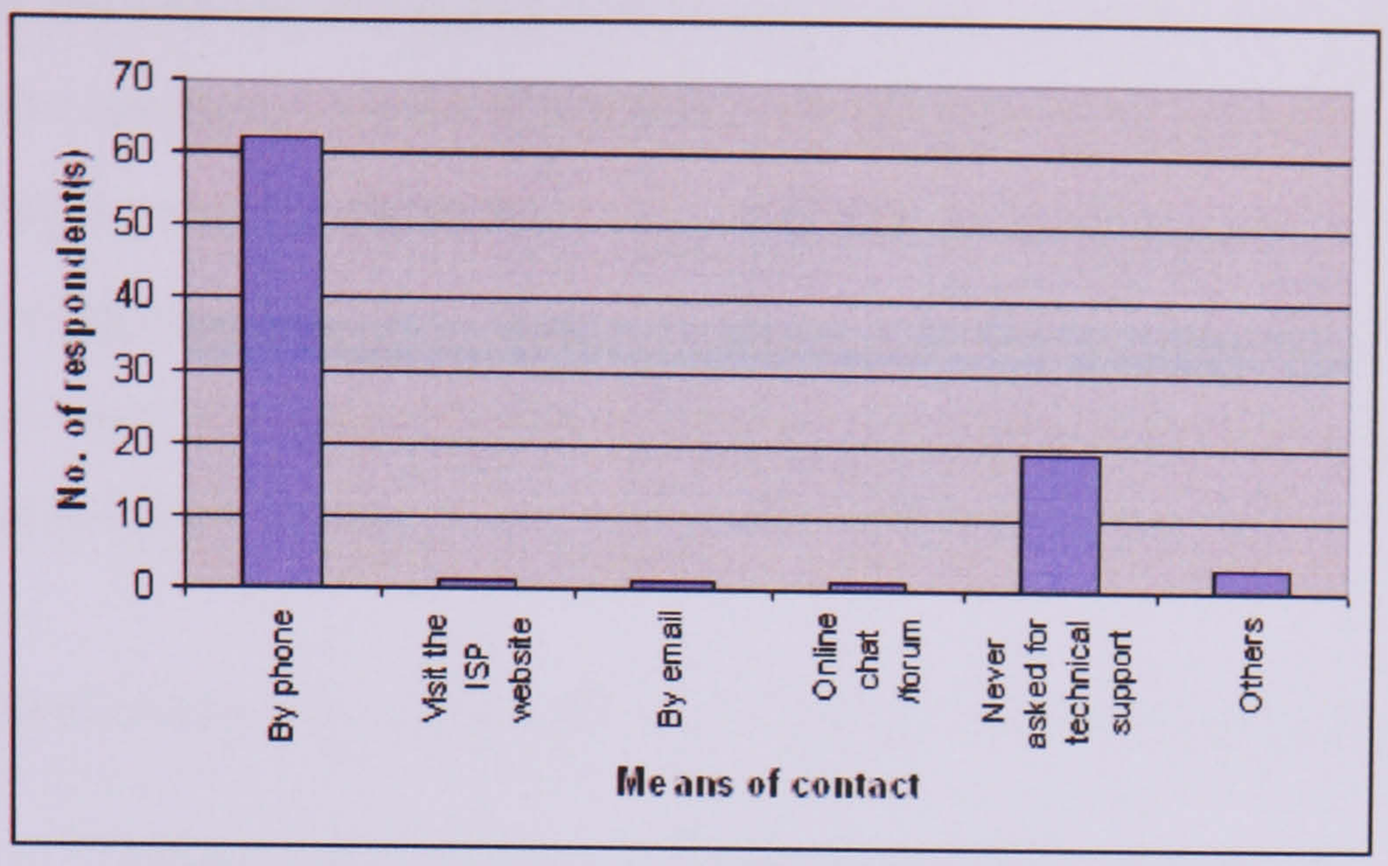

Figure 5.8 depicts respondents' download frequency using their broadband connection. The survey also highlighted that users who pay a monthly subscription fee of £16 – £20.99 utilize their broadband connection to download from the Internet more frequently than those that pay £10 - £15.99 and £21 – £25.99, respectively, thus providing users with value for money (Figure 5.9).

**Figure 5.9: No. of download times**



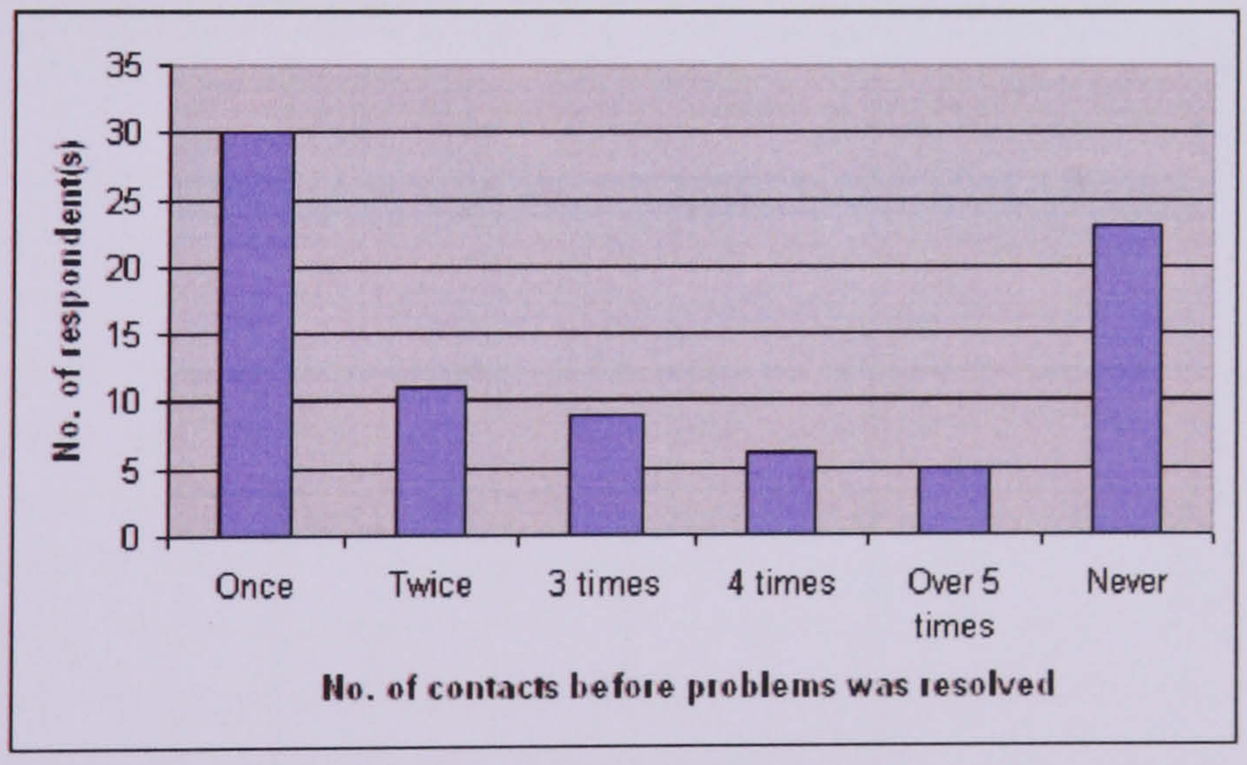

The majority of users contacted in the survey (n=62, or 65% of respondents) stated that they use the phone to contact their ISP for problems that they had encountered using broadband (Figure 5.10).

**Figure 5.10 Means of contact to ISP support**




32% (n=30) of the respondents who had had problems with their ISP stated that one phone call had been enough to solve the problem, although there were five respondents who had to contact their ISP over 5 times in order to get their broadband problem solved (Figure 5.11). This finding highlights that the majority of the ISP technical support team are perceived to be efficient and as such provide value to their customers, since good customer services and support are the key factors that attract customers.

**Figure 5.11 Number of times before problem was resolved**




If the question of whether the number of times that a customer contacts their ISP support in order to get his/her problem solved depends on the subscription fee that the customer pays is asked, Figure 5.12 shows that the five respondents who had to contact their ISP more than five times paid a relatively low monthly fee (below £15.99), whereas customers who paid more than £26 for their broadband had contacted their ISP once or twice. In between these extremes, a mixed picture

arises highlighting no clear dependency between the broadband monthly subscription fee and the efficiency with which technical problems are solved. The only obvious correlation with the monthly subscription is the fact that respondents that pay a high monthly price may experience more stability and reliability than the lower paying respondents. This is because respondents that pay high monthly subscriptions tend to contact their service provider less often than those that pay very low subscription rates.

**Figure 5.12 No of contact before problem was resolved against broadband price paid monthly**

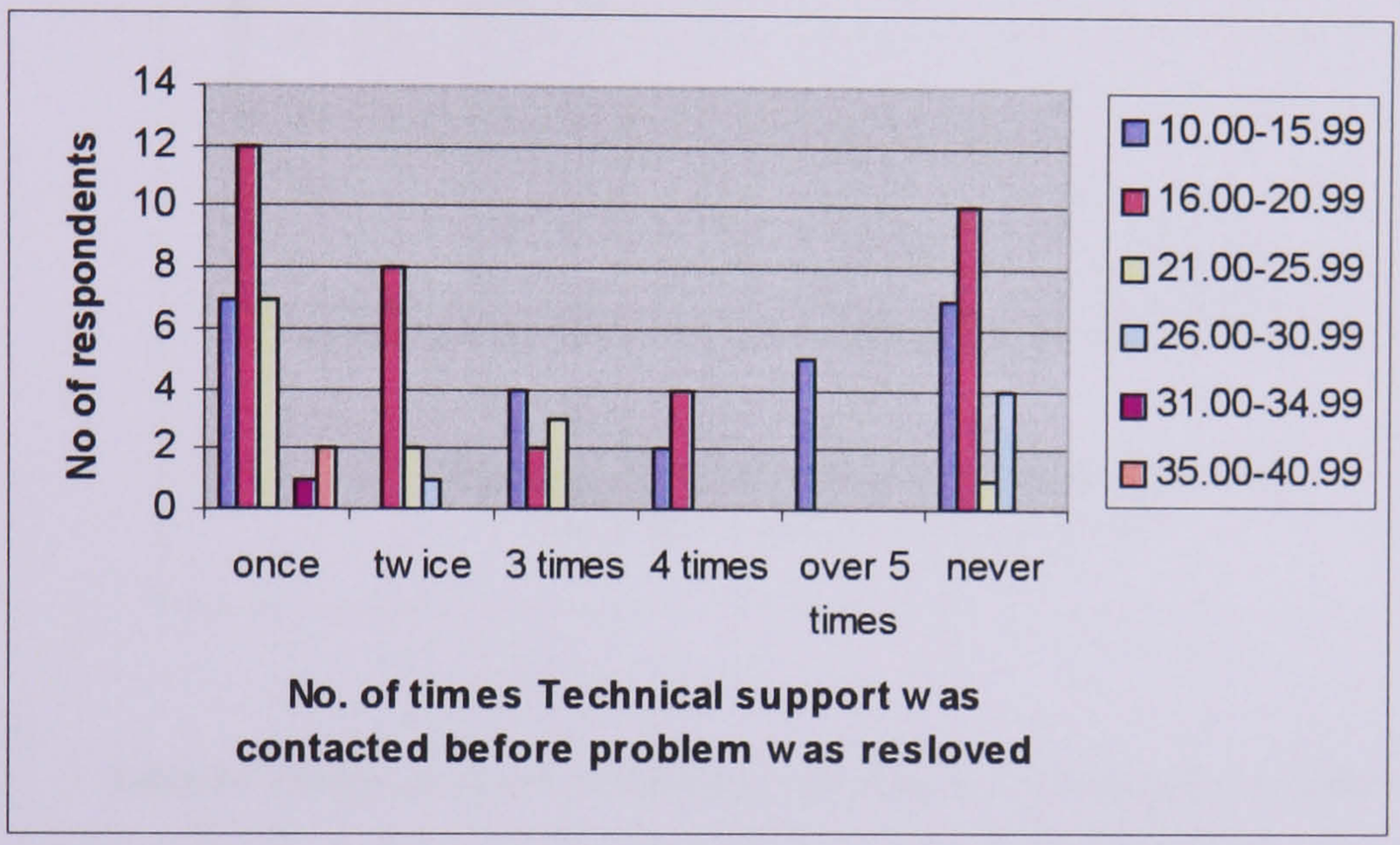



**Table 5.4 Waiting period for technical support before problem technical was resolved against monthly subscription**

| Monthly Subscription | 10.00-15.99 | | | | | 16.00-20.99 | | | | | 21.00-25.99 | | | 26.00-30.99 | | 31.00-34.99 | 35.00-40.99 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Once | 3 times | 4 times | Over 5 times | Never | Once | Twice | 3 times | 4 times | Never | Once | Twice | 3 times | Twice | Never | Once | Once |
| <5 minutes | | 3 | | | | 2 | | | | | 2 | | | | | | |
| 10 minutes | | | | | | 4 | 1 | | 2 | | 2 | 1 | | | | | |
| 10-30 minutes | 2 | 2 | | | | 3 | 4 | 1 | | 2 | 1 | | | | 1 | | 1 |
| 31 – 59 minutes | | | | | | | 1 | | | | 2 | 1 | 2 | | | 1 | |
| 1 hour - 2 hours | 2 | | | | | 2 | | | | | | | | 1 | | | |
| 4 - 8 hours | | | | | | | 1 | | | | | | | | | | |
| 24 hours | 1 | | 1 | | | | 1 | | 2 | | | | | | | | 1 |
| 1 week | 2 | | | | | | | 1 | | | | | | | | | |
| 2 weeks | | | | 5 | | | | | | 1 | | | | | | | |
| Others | | | | | 3 | | | | | 2 | | | | | | | |

It was also observed that those respondents that paid a monthly subscription fee of less than £21 and who contacted their ISP technical support team had to wait for periods of time ranging from roughly less than 5 minutes to up to 2 weeks to have their problem solved (Table 5.4). These contrasts with the case of those who pay over £21.00, all of whom claimed that their problem had been solved in less than 24 hours. This shows that those that pay more for their broadband connection tend

to ring fewer times to get their broadband problem solved than those that pay less, as in the case of those that pay less than £16.00 for their broadband connection. Indeed, this might also be as a result of the Service Level Agreement (SLA) of the ISPs with the respondents. The response to this question shows how significant this is to the participant when a t-test was carried out (p=0.00; t= 18.05).

**Figure 5.13 Number of respondents happy with the support of their ISP**

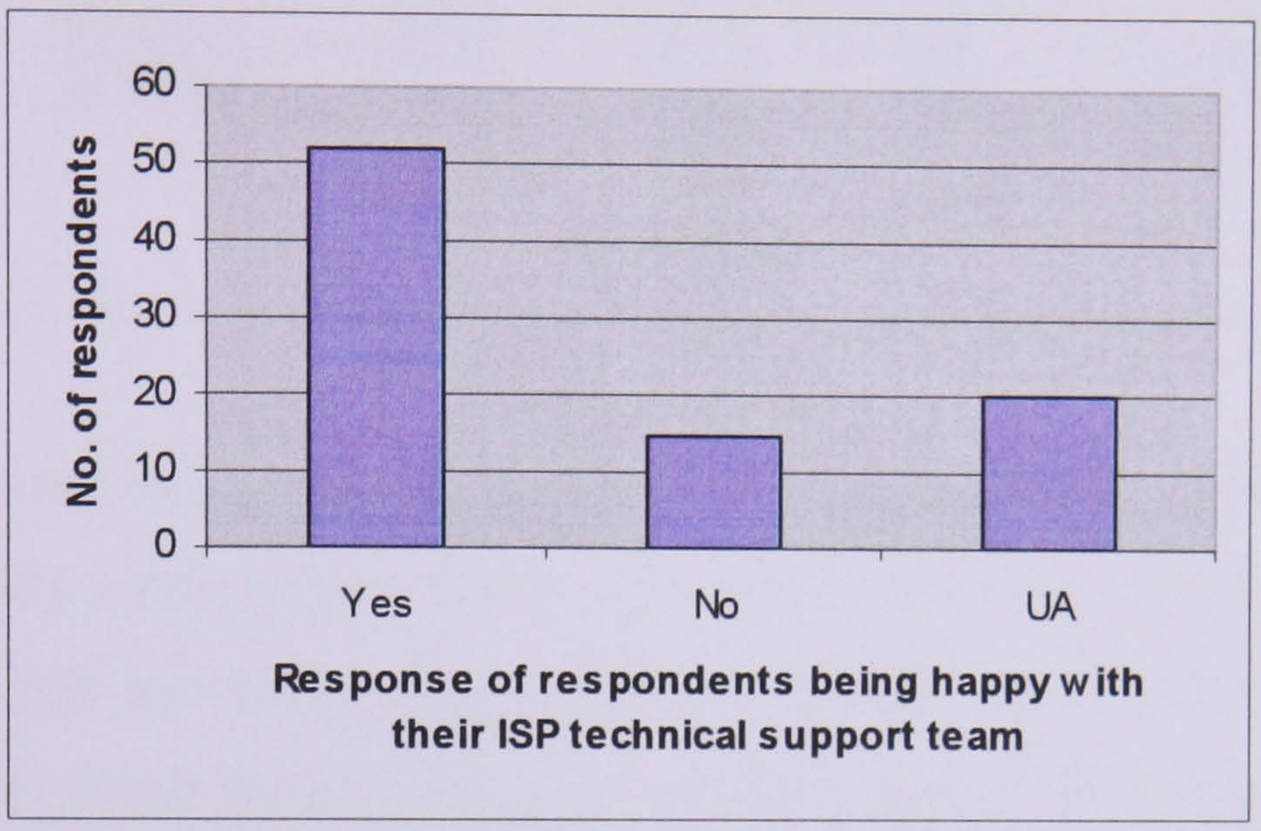


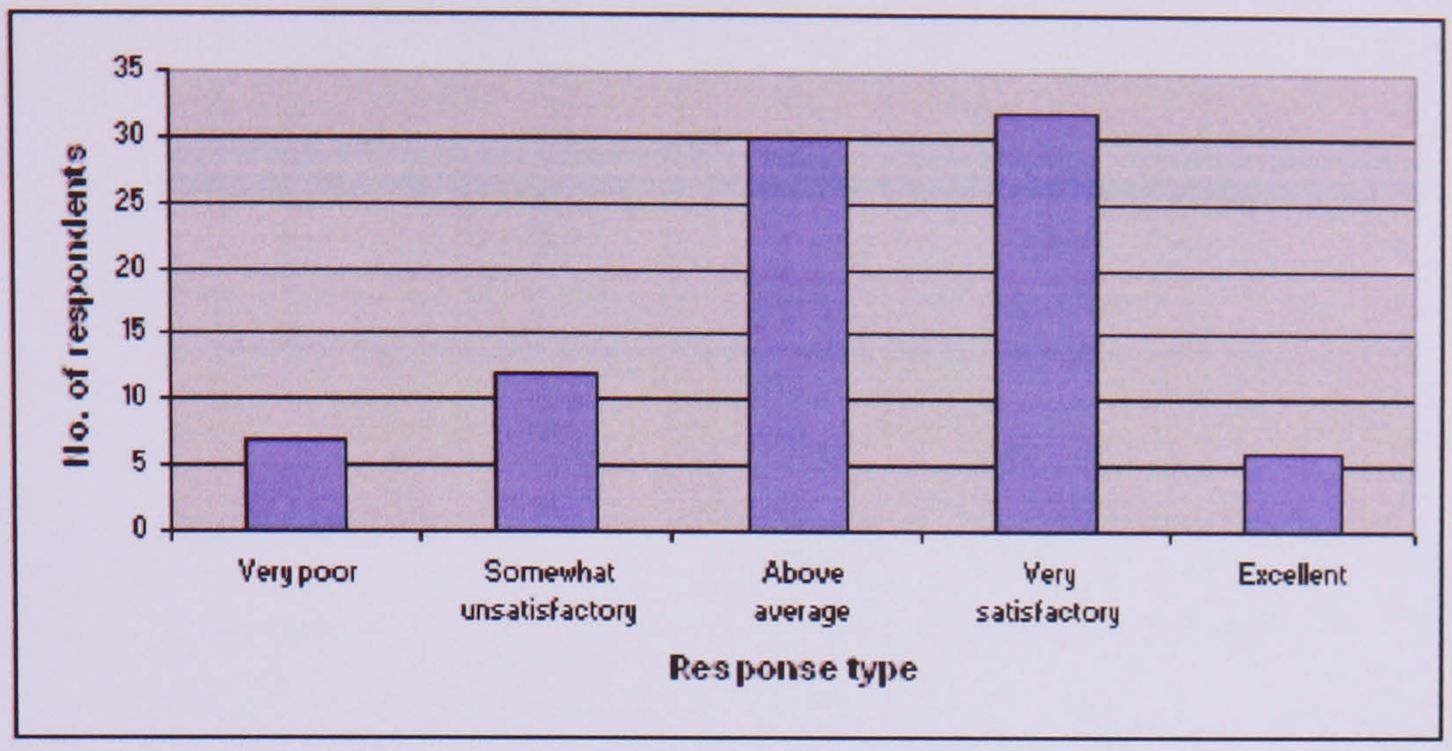

**Table 5.5 Clarity of offered information with respect to broadband connection**

| Category | Frequency | Percentage |
|---|---|---|
| Yes | 73 | 77% |
| No | 12 | 13% |
| Unanswered | 10 | 10% |

Respondents were also asked if they were happy with the way their technical issues were resolved. To this question, 55% said they were happy, while 15% indicated that they were not (Figure 5.13). Furthermore, the respondents were asked if they were given clear information about their broadband connection. Here, 77% responded yes, while 13% said no (Table 5.5). This shows that most ISPs present their users with clear instructions about their connections. A t-test carried out on the survey data to see the respondents' reaction to the overall quality received from their ISP customer service revealed that the majority of users were in strong agreement (mean = 3.21; p = 0.000) to their ISP providing an overall quality customer service. 87 participants responded to this question, of which 79% respondents claimed that the overall quality received from their service provider was between satisfactory and excellent. Indeed, only 20% of the

respondents were not happy about the overall quality of their ISP customer service (Figure 5.14).

**Figure 5.14 Quality of the customer services received**

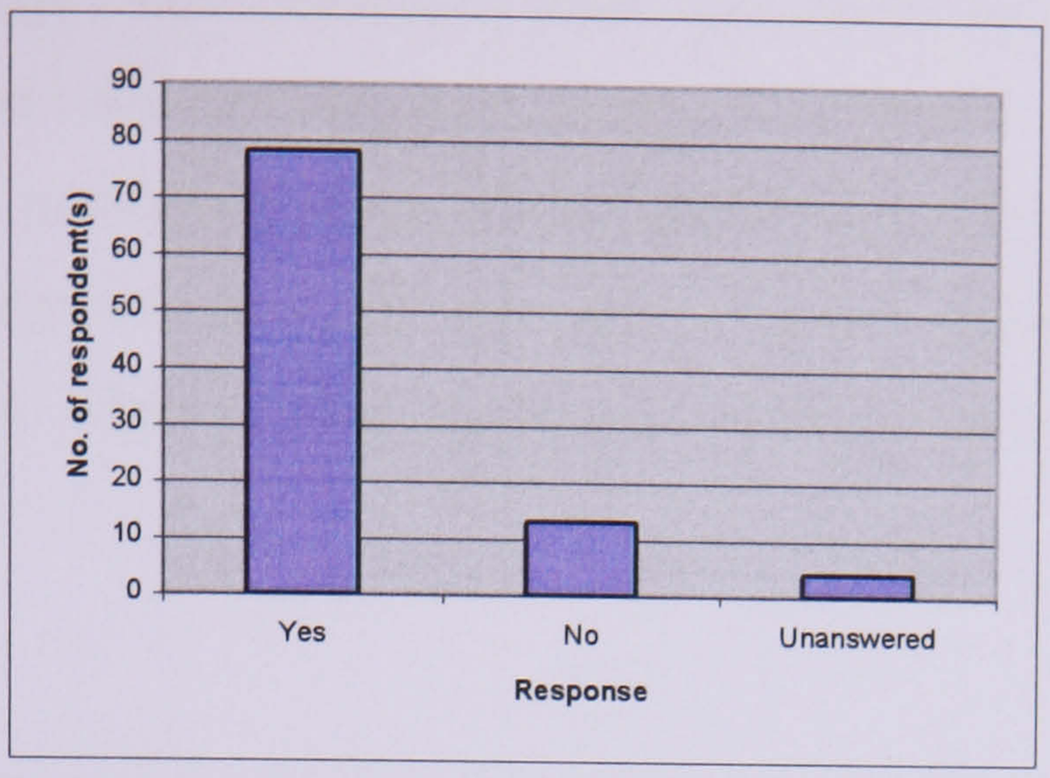



A t-test carried out on the overall value of services provided by the ISP compared with the monthly subscriptions shows respondents reaction to an agreement with the broadband ISP providing value for money (mean = 2.91; p=0.000), with over 50% of the surveyed sample having a positive bias in this respect; this may perhaps be because of their unwillingness to shop around, as specified earlier. This is measured by '*good to excellent*' representing an acceptance to the fact that their service providers offer value for money. However in contrast, only 27% of the surveyed sample did not think that their broadband was value for money, a measure of a lukewarm response to the question (Table 5.6).

**Table 5.6 Response to the overall value of services provided by the ISP compared with monthly subscription**

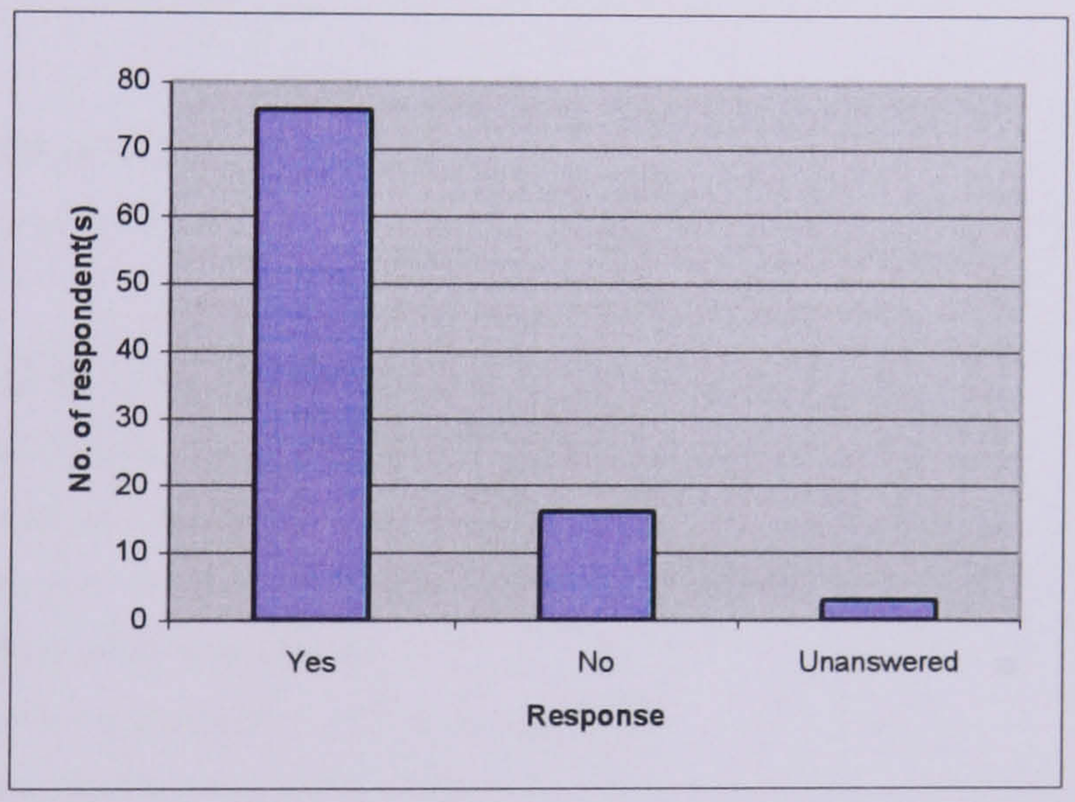
| Category | Frequency | Percentage |
|---|---|---|
| Excellent | 10 | 11% |
| Very good | 14 | 15% |
| Good | 41 | 43% |
| Fair | 26 | 27% |
| Unanswered | 4 | 4% |

**Figure 5.15 Number of respondents happy with ISP**




On a related matter, 82% of users surveyed claimed they were happy with their ISP compared with 17% that were not happy (Figure 5.15). Moreover, 72% of the respondents would recommend their ISP to their friends and family (Figure 5.16).

**Figure 5.16 Recommendation of ISP**




## 5.4 Summary statistics: Analysis of level of agreement based on perceived broadband quality

In this study, participants' responses were coded by awarding a numerical score of 1 to 7 to each of the expressed opinions on the Likert scale, with 1 representing an opinion of "strongly disagree" and 7 of "strongly agree". An initial reliability analysis test was conducted on the data collected. The reliability method used was the Alpha method, which is the most popular method of examining reliability (Hinton et al, 2004). The Alpha reliability measure ranges from zero for a completely unreliable test to one for a completely reliable test (Hinton et al, 2004).

In the case of the survey, both the Alpha and standardized Alpha are 0.7413 and 0.7528 respectively. This indicates that the responses received on the questionnaires sent out to the participants are reliable. Thus, from this information, a fair perception on broadband quality from the respondents can be comfortably extracted. A t-test was then applied to the collected survey data in order to establish whether the expressed opinions were also statistically significant.

### 5.4.1 Services

The survey revealed that the vast majority of users were in strong agreement (mean = 5.62; p = 0.000) with respect to broadband being reliable (Table 5.7). This perhaps comes as a result of the satisfaction with the broadband speed connection received from their ISP (mean = 5.45; p = 0.000), again reflected by positive user opinions of users continuing their broadband subscription (mean = 5.38; p = 0.000).

**Table 5.7 Indicators for ISP services**

| Quality factors | Mean | Significant level (p) |
|---|---|---|
| Service: Satisfactory technical support from ISP | 5.13 | 0.000 |
| Service: Satisfied with the speed of broadband from ISP | 5.45 | 0.000 |
| Service: Not satisfied with the design of my current ISP web page | 3.10 | 0.017 |
| Service: It takes a long time to download from my broadband connection | 3.02 | 0.027 |
| Service: Satisfied with security measures from ISP | 4.57 | 0.003 |
| Service: Customer service representative handle my call quickly | 4.64 | 0.000 |
| Service: Customer representative was knowledgeable | 4.88 | 0.000 |
| Service: Customer service representative was courteous | 5.14 | 0.000 |
| Service: Waiting for query answered is satisfying | 4.53 | 0.000 |
| Service: Automated phone system made customer service more satisfying | 4.05 | 0.004 |
| Service: Happy with overall customer satisfaction ISP | 4.52 | 0.000 |
| Service: Call was transfer to best person able to answer request | 4.66 | 0.000 |
| Service: Happy with speed of response | 4.62 | 0.000 |
| Service: Intend to continue broadband subscription | 5.38 | 0.000 |
| Service: Considered moving subscription to another ISP | 3.61 | 0.062 |
| Service: Not happy with my service provider | 3.27 | 0.320 |
| Service: Would recommend my service provider to my friends | 5.14 | 0.000 |
| Service: Broadband connection is reliable | 5.62 | 0.000 |
| Service: Overall service quality of my current Internet connection is satisfactory | 5.23 | 0.000 |

The results also highlighted that respondents would recommend their service provider to friends, with participants indicating relatively strong agreement in this area (mean = 5.14; p= 0.000). This is as a result of the overall strong agreement of the respondents of satisfactory technical support received from their ISP (mean = 5.13; p= 0.000) and the overall service quality from their broadband connection (mean 5.23; p= 0.000), including the courteous behaviour of their ISP customer service representative (mean 5.14; p= 0.000).

### 5.4.2 Usage

**Table 5.8 Indicators for Broadband usage**

| Quality factors | Mean | Significant level (p) |
|---|---|---|
| Usage: Use broadband to listen to and download music | 5.08 | 0.000 |
| Usage: Enjoy using broadband to watch and download movies | 4.02 | 0.024 |
| Usage: Enjoy using broadband to play online games | 3.26 | 0.297 |
| Usage: Use broadband connection for video conferencing | 3.18 | 0.159 |
| Usage: Satisfied with the quality of multimedia presentation | 4.67 | 0.000 |
| Usage: Happy with the informational content delivered by multimedia application | 5.12 | 0.000 |
| Usage: Found broadband connection is always breaking | 2.62 | 0.000 |

From the survey, most respondents indicated a relative strong agreement that they are happy with the informational content delivered by multimedia application via their broadband connection with a mean = 5.12; p = 0.000 (Table 5.8). This is followed by broadband connection being used to listen and download music (mean = 5.08; p= 0.000) and watching and downloading movies (mean = 4.02; p=0.024). This could be as a result of the reliability of their broadband connection which the participants responded by strong disagreement to broadband connection always breaking (mean = 2.62; p= 0.000). This finding further supports the results presented in the preceding section, which revealed that participants thought that their broadband connection was reliable.

### 5.4.3 Price

Table 5.9 reflects a strong agreement (mean =4.70; p= 0.000) between respondents as regards the fact that the service provider offers good value for money. However respondents indicated their agreement with respect to the statement that the current price they pay for their broadband subscription is costly (mean =3.27 and p=0.000) and that it is costly to subscribe to broadband at its current price. Interestingly, while the majority of the respondents strongly agree

that their service provider is expensive, their monthly subscription is less than £26.00 (Table 5.3) and most of them are still with the same ISP (Figure 5.6). The reason for still being with the same ISP despite wanting to change their ISP to another as reflected in table 5.7 could be that the respondents could not be bothered with the hassle of changing, as long as their basic needs for broadband connectivity are met. This could also be influenced by the lack of respondents being exposed to broadband's potential.

**Table 5.9 Indicator for price**

| Quality factors | Mean | Significant level (p) |
|---|---|---|
| Price: It is costly to subscribe to broadband at its current price | 3.27 | 0.000 |
| Price: Service provider offers good value for money | 4.70 | 0.000 |
| Price: Broadband price offered by service provider is expensive | 3.99 | 0.006 |

### 5.4.4 Government

Table 5.10 indicates the survey respondents' strong agreement to the fact that the UK government should promote broadband more (mean = 6.07; p= 0.000) and that the UK government should subsidise broadband prices (mean = 5.36; p= 0.000). However broadband uptake in the UK has continued to remain strong. Nonetheless it is important that the UK government promotes broadband more by making available additional funds towards broadband technology especially in respect of providing higher data speeds and a wider variety of services. In this respect, it is believed that the UK government could follow the lead of their South Korean counterparts, who promoted broadband by making subsidies available to broadband ISPs (Choudrie and Lee, 2004).

**Table 5.10 Indicators for government**

| Quality factors | Mean | Significant level (p) |
|---|---|---|
| Government: UK government should promote broadband more | 6.07 | 0.000 |
| Government: Government should subsidise broadband prices | 5.36 | 0.000 |

## 5.5 Discussion

Despite the fact that broadband uptake has risen in the past years and is growing strongly, there still seems to be a lack of understanding amongst users and indeed service providers as to the potential and quality aspect of broadband as a whole. In the survey described in this chapter, it was found that some respondents were paying a high monthly fee for limited use of their broadband connection. This, because most respondents use the service for emails (which, if one abstracts out messages with large attachments, hardly warrant broadband speeds), followed by activities such as web surfing, job-related searches as well as e-banking and e-commerce. Despite this, users tend to stay with their service providers because they might think that switching to another service provider could be complicated and time-consuming.

It was discovered that household income does not influence the monthly subscription that respondents pay for their broadband connection, which further stresses the point that users do not necessary bother to shop around for the most appropriate deal for them. Superficially, this is a surprising result – for the study shows that most service providers charged based on the added services, such as Video on Demand and Voice over IP as well as the increase in broadband bandwidth made available to users.

Furthermore, it was also discovered that most users are generally satisfied with the technical support service received from their service provider. This may, however, be because most of the respondents are technically knowledgeable and are able to communicate issues encountered during their broadband connection to the support team of their ISP easier. Moreover, it was discovered that most respondents would like the UK government to show more support by providing additional funds and subsides in order to promote the penetration of broadband technology. Combining all the findings from this chapter with the various quality aspects discovered in the literature review chapters of broadband quality issues, the broadband quality framework can now be developed and presented in the next chapter.

## 5.6 Summary

In this chapter the data collected from the survey was analysed and the outcome of the findings discussed. The outcomes of these findings will be used to extract what quality aspects are important to users based on their perspective on broadband. In the next chapter, the need for a broadband quality framework will be discussed and a framework put forward.

# CHAPTER 6: Proposed Multi-dimensional Model of Broadband Quality

## 6.1 Introduction

This chapter proposes and describes a broadband quality framework. It starts by extracting the various broadband quality facets identified in the literature review (Chapter 2 and 3) and thereafter combines them with the quality perceived by respondents to the survey questionnaire (Chapter 5) as being important for broadband. These broadband quality dimensions are then merged to make up the proposed integrated framework for broadband quality.

## 6.2 Identification of Broadband Quality attributes

The proposed broadband quality framework is based on four phases: extraction of quality dimensions from the broadband literature review - which includes the UK government perspective as regards to how the government wants the UK to be one of the top broadband users in the world; a user perspective on broadband quality based on the survey questionnaire; and broadband quality as perceived from an Internet Service Provider perspective.

### 6.2.1 Extraction of broadband qualities from literature review

In Chapter 3, eight major attributes of broadband quality were discovered. These attributes included QoS, Cultural quality, Functional quality, Reliability, Quality of Services, QoP, Price, and Security. The literature review also highlighted that it was important that the ISP provides reliability and maintains the accessibility of the broadband connection between the service providers and the broadband users/consumers (Tan-Wanklyn, 2004).

Furthermore, it was recognised that price pays an important role in gaining more customer base and so service providers were forced to beat down their broadband subscription pricing rates (Anania and Solomon, 1995; DaSilva, 2000; Odlyzko, 2000) or offer additional services. These additional services include providing anti-virus, anti-spam and other security services such as parental control and anti-theft facilities.

The customer services responses of an ISP to the consumer also play a vital role in the broadband arena. This, as it is the consumer who will judge whether or not the service provided is fit for their use and therefore quality of the service cannot be assessed independently of the consumers who use the service (Strong et al,

1997). With most ISPs now offering similar packages in terms of price and connection speeds, the quality of customer service is an increasingly important factor in consumers' choice of service provider (Charlton, 2006). However, security was also discovered to be a main concern with broadband access (Fowler, 2000).

UK government policy also helps in giving guidance as to how service providers should deliver broadband connection to their customers. Moreover, this policy is being worked on and improved on by the UK government by setting up regulatory bodies and agency in order to provide this policy.

### 6.2.2 Responses from participants survey questionnaire

User/consumer perceptions play a vital role in broadband technology because broadband has become an integral part of many people's lives. Therefore, the perception of users was needed to form a part of the proposed framework. In order to extract the perception of users, the broadband quality attributes discovered from the literature review were then used to form the foundation of the survey questionnaires sent to participants. The users' responses were then measured to find which aspects of broadband quality were deemed important to them. From the research survey carried out it was observed that the majority of consumers would like the government to be involved in the promotion of broadband in the UK. Accordingly, the UK government must do more to ensure consumers get broadband well in excess of the speeds offered by today's packages, according to a telecommunications advisory group (Andrews, 2007).

It was also observed that if a reliable broadband connection is provided and the consumers were happy with various broadband services such as customer service support, they would recommend their service provider to friends and family. This, in turn provides for a powerful marketing strategy to a service provider. Although most respondents believe their monthly subscription is value for money, the majority still believe that the UK government should subsidise their broadband monthly subscription. Therefore, pricing plays an important role as an aspect of broadband quality.

### 6.2.3 Broadband quality from service provider perspective

Considering the ongoing development of technology for providing multiple services over the Internet, the growth of the industry, and the division of the broadband market into customer segments with widely varying expectations and requirements, there is only a finite availability of network resources. Consequently, service providers are faced with the dilemma of having to cope with the growing awareness and demand for broadband provision but at the same time having to provide a good service quality at a reasonable monthly subscription. Most, however, concentrate on the delivery of broadband technology to the consumers and the benefit of the services it offers. Furthermore, from the literature review of chapter 3 it has been highlighted that the perspective of an ISP on broadband quality is different from that of the consumers.

Drawing on the idea of Ferreira and Pithan (2005) on human computer interaction, three characteristics can be deemed as important from an ISP perspective from the literature, which are:

Effectiveness: - This is the accuracy and completeness with which specified users can achieve specified goals in particular environments, and is based on providing users with a reliable access to the Internet. This also includes providing users with add-on services such as VOIP, and virus protection software that the user will not feel pressured in to buying as part of a pricey broadband bundle.

Efficiency: - This is given by amount of resources expended in relation to the accuracy and completeness of goals achieved; this is when the ISP has provided the agreed download/upload capacity within the agreed contract between the ISP and users.

Satisfaction: - This is the degree to which users are able to have access to Internet via broadband hassle free and effortlessly.

## 6.3 Need for a Broadband Quality framework

As there is only a finite availability of network resources, computer scientists and engineers are faced with the dilemma of having to cope with a growing user demand but at the same time having to provide a good service quality. Although there are numerous articles on broadband, most have concentrated on the delivery of broadband technology to the consumers and the benefit of the services it offers. Few if any address broadband quality from the users' perspective, considering at the same time the ongoing development of this technology for providing multiple services over the Internet, the growth of the industry, and the division of the broadband market into customer segments with widely varying expectations and requirements. The industry and the marketplace should re-examine and develop the prospect of independent monitoring in order to solve this challenge, and it is now very important to develop a unified quality framework without delay, which allows for flexibility and improvement. A framework is a basic conceptual structure used to solve or address complex issues, in this case the broadband quality issues.

From the research survey carried out it was observed that the demand for broadband is very sensitive to price, reliability and service quality. The development of broadband quality framework will thus clarify communications and expectations, and will lay the groundwork for further monitoring and reporting. Clearly, different customer segments focus on different aspects of quality, and have quite distinct needs beginning with a framework of definitions which allows us to accommodate all sections of the market. As monitoring and reporting develop, a clearly defined framework will allow specific segments of the market to be monitored differently, without any confusion arising due to the use of inconsistent terminology.

## 6.4 The Proposed Broadband Framework

The proposed broadband quality framework aims to include compliance of ISPs to provide competitive prices for broadband services; quality assurance, ease of use, reliability, connectivity and value for money broadband services of assured quality through simple, quick and effective technical support without having to negotiate separate terms and conditions for the service. These were chosen as result of issues identified both in the literature review and feedback from the survey questionnaire. This framework has been designed to conform to the OGCbuying.solutions Broadband solutions framework agreement (OGCbuying Solution, 2004) which is one of the policies introduced by the UK government for the deployment of broadband. This policy could in turn be adapted in other countries that are yet to fully take on broadband. Furthermore this framework will ensure that proper incentives and rewards for investment on broadband services are provided to the consumer by ISPs.

### 6.4.1 Construction of the proposed framework

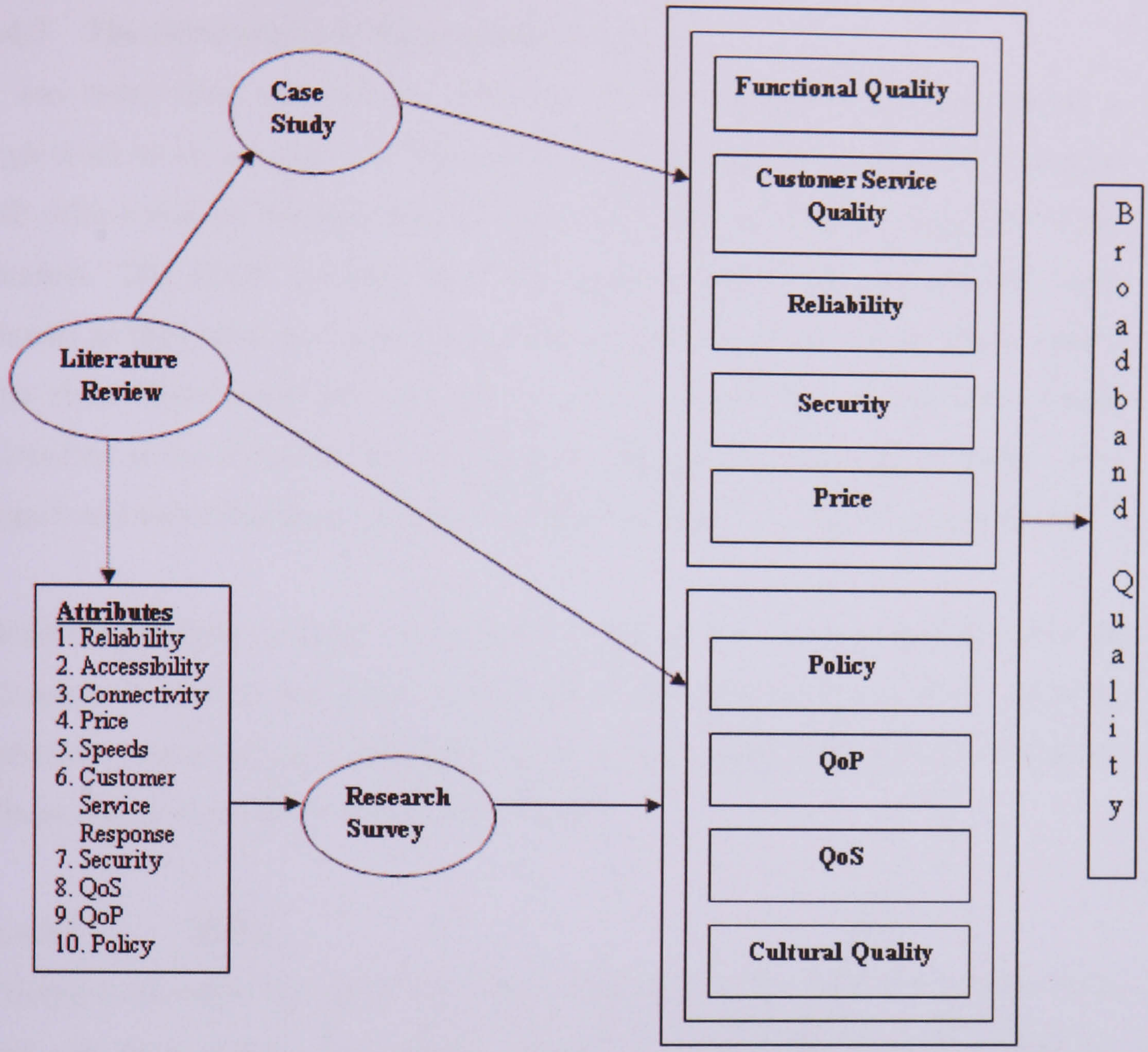
In order to construct a generalised broadband quality framework, it is vital to state a specification, which captures application quality requirements and map these quality requirement to resources. This is inline with ACA (2002), which suggested that three quality aspects should be included in the design of a full framework, namely:

Service Definition – with the objective of ensuring that customers are aware of what they are purchasing, and the degree to which the available products will meet their needs and expectations.

Network Performance Reporting – with the objective of delivering information to customers regarding the performance of the infrastructure used to provide their services.

Monitoring and Reporting – with the objective being to define and then monitor and report indicators that yield a statistically useful predictor of Mean Opinion Scores of customers on the utility of individual services provided over a broadband infrastructure.

**Figure 6.1 The Proposed Broadband integrated Quality Framework**




### 6.4.2 The Broadband integrated Quality Framework (BiQF)

Figure 6.1 provides the proposed integrated broadband quality framework. The word 'integrated' has also been used as a label to describe a group of separate dimensions of broadband quality that are able to cooperate with each other effectively to achieve interoperability. The framework that the researcher has proposed on the basis of the literature review (see Chapter 2 and Chapter 3) is consistent with findings of this research (Chapter 5). Using the consumer's perspective together with the extraction of broadband quality from the literature review, a framework conceptualising the underlying aspects of broadband quality that are important is thus developed. This broadband quality framework combines a number of ideas from existing frameworks (Yoshida et al, 2005; Lu et al, 2007) as well as a novel idea to produce an efficient multi-issue broadband quality

framework. This novel idea is in the form of presenting the broadband quality facets in an incorporated manner as none currently exist.

### 6.4.3 The Dimensions of the proposed BiQF

It was noted from this research that most of the respondents generally report a high level of satisfaction with their broadband subscription price, claim that there ISP offer value for money, and they have a reliable broadband connection to the Internet. The BiQF includes nine major dimensions; these dimensions were chosen as they receive a high response and a high significant value which shows that these dimensions are very important to the participants. However issues identified in the literature that was asked in the questionnaire but received a low significant value based on participants' response was not added to the framework.

Besides QoS have and QoP already been identified as essential quality facets in Chapters 2 and 3, the BiQF also contains the dimension of price, security, reliability, customer service quality, policy, cultural quality and functional quality. These dimensions are, however, inter-related.

#### 6.4.3.1 Price

Pricing is an important aspect of quality that needs to be looked at in broadband and can be a crucial limit on the demand for broadband (Romero, 2002). In broadband, pricing can be used as an effective means to recover cost, and to increase competition among different service providers (Choudrie and Lee, 2004).

**Table 6.1: Responses to broadband being costly to subscribe at its current subscription fee**

| Response | No of respondents | Percentage of respondents |
|---|---|---|
| Strongly disagree | 16 | 16.84 |
| Quite disagree | 15 | 15.79 |
| Slightly disagree | 14 | 14.74 |
| Neutral | 20 | 21.05 |
| Slightly Agree | 14 | 14.74 |
| Quite agree | 6 | 6.32 |
| Strongly Agree | 1 | 1.05 |
| Unanswered | 9 | 9.47 |
| **Total** | **95** | **100%** |

From the data contained in Table 5.9, Table 6.1 and Table 6.3, it was notice that even though respondents in the survey claim that it was costly to subscribe to

broadband, 49% (n=47) they do recognise that the service provider offers good value for money (Table 6.2).

**Table 6.2: Responses to service provider offers good value for money**

| Response | No of respondents | Percentage of respondents |
|---|---|---|
| Strongly disagree | 2 | 2.11 |
| Quite disagree | 5 | 5.26 |
| Slightly disagree | 3 | 3.16 |
| Neutral | 29 | 30.53 |
| Slightly Agree | 22 | 23.16 |
| Quite agree | 18 | 18.95 |
| Strongly Agree | 7 | 7.37 |
| Unanswered | 9 | 9.47 |
| **Total** | **95** | **100%** |

**Table 6.3: Responses to broadband prices offered by service providers is expensive**

| Response | No of respondents | Percentage of respondents |
|---|---|---|
| Strongly disagree | 9 | 9.47 |
| Quite disagree | 7 | 7.37 |
| Slightly disagree | 11 | 11.58 |
| Neutral | 26 | 27.37 |
| Slightly Agree | 19 | 20 |
| Quite agree | 10 | 10.53 |
| Strongly Agree | 4 | 4.21 |
| Unanswered | 9 | 9.47 |
| **Total** | **95** | **100%** |

**Table 6.4: Responses to expect that the government should subsidise broadband prices**

| Response | No of respondents | Percentage of respondents |
|---|---|---|
| Strongly disagree | 7 | 7.37 |
| Quite disagree | 5 | 5.26 |
| Slightly disagree | 1 | 1.05 |
| Neutral | 14 | 14.74 |
| Slightly Agree | 8 | 8.42 |
| Quite agree | 14 | 14.74 |
| Strongly Agree | 38 | 40 |
| Unanswered | 9 | 9.47 |
| **Total** | **95** | **100%** |

Furthermore, 63% of respondents (n=60) expect that the government should subsidise broadband prices (Table 6.4). From the responses of the survey it is clear that price plays a vital role, and so is rightly part of the proposed framework. Interestingly, in a recent publication by the Broadband Stakeholder Group (2007), it is observed that subscription prices are falling at the same time as there being a rise in broadband connection speeds. This would have impacted on consumers benefiting from a wide choice of service providers.

### 6.4.3.2 Security

An increased exposure to security incidents and vulnerabilities is a potential cost of broadband usage. This is particularly the case with the increased traffic associated with broadband networks and applications such as peer-to-peer networking, and can be exacerbated by users' computers being insufficiently protected with firewall, antivirus and content-filtering software.

**Table 6.5 Responses of respondents to being satisfied with the security measures provided with broadband access obtained from their current service providers**

| Response | No of respondents | Percentage of respondents |
|---|---|---|
| Strongly disagree | 6 | 6.32 |
| Quite disagree | 9 | 9.47 |
| Slightly disagree | 6 | 6.32 |
| Neutral | 21 | 22.11 |
| Slightly Agree | 10 | 10.53 |
| Quite agree | 26 | 27.37 |
| Strongly Agree | 10 | 10.53 |
| Unanswered | 7 | 7.37 |
| **Total** | **95** | **100%** |

Most ISPs now provide basic security protection. However, they encourage users to take up a full security protection as having a broadband connection leads to users becoming very vulnerable to attackers. Interestingly, from the survey results, it was noted that when the respondents were asked if they were satisfied with their ISP security measures, the response to this was positive (mean=4.57; p=0.003), which signifies its importance to the users (Table 6.5).

### 6.4.3.3 Reliability

As Table 5.7 shows in chapter 5, having a reliable connection provides users with a sense of quality that their broadband connection is stable. Service providers are thus expected to take appropriate steps for making the required bandwidth available in a time bound manner within their licence framework. From the literature review it was observed that the cost of bandwidth constitutes a major cost component for broadband services (Kumar, 2004). Even though this is a major cost, it is necessary for the ISP to provide a reliable connection for their customers.

**Table 6.6: Responses to broadband connection is very reliable**

| Response | No of respondents | Percentage of respondents |
|---|---|---|
| Strongly disagree | 1 | 1.05 |
| Quite disagree | 3 | 3.16 |
| Slightly disagree | 5 | 5.26 |
| Neutral | 7 | 7.37 |
| Slightly Agree | 12 | 12.63 |
| Quite agree | 33 | 34.74 |
| Strongly Agree | 25 | 26.32 |
| Unanswered | 9 | 9.47 |
| **Total** | **95** | **100%** |

**Table 6.7: Responses to I find that my broadband connection is always breaking**

| Response | No of respondents | Percentage of respondents |
|---|---|---|
| Strongly disagree | 28 | 29.47 |
| Quite disagree | 24 | 25.26 |
| Slightly disagree | 11 | 11.58 |
| Neutral | 7 | 7.37 |
| Slightly Agree | 4 | 4.21 |
| Quite agree | 7 | 7.37 |
| Strongly Agree | 3 | 3.16 |
| Unanswered | 11 | 11.58 |
| **Total** | **95** | **100%** |

However, the majority of the respondents (n=70) agree that their broadband connection is reliable (Table 6.6) and evidence in their responses show they disagree (n=63) that their connection always is breaking (Table 6.7). The strongly agree response of the users to their broadband connections being reliable shows that reliability is important to users, the absence of without which could cause an adverse effect to the use of broadband, hence its place in the framework.

### 6.4.3.4 Customer Service Quality

The emphasis on customer service quality has been amply apparent since the growth of managed customer service. Service forms the basis for a clear communication with the customer, with the objective of ensuring that customers are aware of what they are purchasing, and the degree to which the available products will meet their needs and expectations. By clearly defining the terms that are used, customers can have greater confidence that their expectations are realistic.

**Table 6.8: Responses to the customer service representative handled my call quickly**

| Response | No of respondents | Percentage of respondents |
|---|---|---|
| Strongly disagree | 4 | 4.21 |
| Quite disagree | 4 | 4.21 |
| Slightly disagree | 6 | 6.32 |
| Neutral | 30 | 31.58 |
| Slightly Agree | 13 | 13.68 |
| Quite agree | 19 | 20 |
| Strongly Agree | 10 | 10.53 |
| Unanswered | 9 | 9.47 |
| **Total** | **95** | **100%** |

**Table 6.9: Responses to the customer service representative was very knowledgeable**

| Response | No of respondents | Percentage of respondents |
|---|---|---|
| Strongly disagree | 1 | 1.05 |
| Quite disagree | 4 | 4.21 |
| Slightly disagree | 8 | 8.42 |
| Neutral | 22 | 23.16 |
| Slightly Agree | 12 | 12.63 |
| Quite agree | 28 | 29.47 |
| Strongly Agree | 8 | 8.42 |
| Unanswered | 12 | 12.63 |
| **Total** | **95** | **100%** |

In the survey, this is reflected in the strong agreement of the respondents admitting that their calls were handled quickly and the customer service representatives were courteous (Table 5.7; Table 6.8; Table 6.9; Table 6.10). This is also further emphasised by the respondents from the survey, 82% of those using broadband being happy with their ISP (Figure 5.14; Table 6.11; Table 6.12; Table 6.13), with 72% recommending their ISP to their friends and family (Figure 5.15; Table 6.14).

**Table 6.10: Responses to being happy with speed of response in handling request**

| Response | No of respondents | Percentage of respondents |
|---|---|---|
| Strongly disagree | 3 | 3.16 |
| Quite disagree | 5 | 5.26 |
| Slightly disagree | 9 | 9.47 |
| Neutral | 20 | 21.05 |
| Slightly Agree | 19 | 20 |
| Quite agree | 16 | 16.84 |
| Strongly Agree | 9 | 9.47 |
| Unanswered | 14 | 14.74 |
| **Total** | **95** | **100%** |

**Table 6.11: Response to being happy with the overall customer satisfaction with ISP Technical Support**

| Response | No of respondents | Percentage of respondents |
|---|---|---|
| Strongly disagree | 2 | 2.11 |
| Quite disagree | 7 | 7.37 |
| Slightly disagree | 6 | 6.32 |
| Neutral | 25 | 26.32 |
| Slightly Agree | 18 | 18.95 |
| Quite agree | 21 | 22.11 |
| Strongly Agree | 3 | 3.16 |
| Unanswered | 13 | 13.68 |
| **Total** | **95** | **100%** |

**Table 6.12: Response to overall service quality of my current Internet connection is satisfactory**

| Response | No of respondents | Percentage of respondents |
|---|---|---|
| Very dissatisfied | 2 | 2.11 |
| Fairly dissatisfied | 7 | 7.37 |
| Slightly dissatisfied | 3 | 3.16 |
| Neutral | 8 | 8.42 |
| Slightly satisfied | 15 | 15.79 |
| Fairly satisfied | 31 | 32.63 |
| Very satisfied | 16 | 16.84 |
| Unanswered | 13 | 13.68 |
| **Total** | **95** | **100%** |

**Table 6.13: Response to am not happy with my service provider**

| Response | No of respondents | Percentage of respondents |
|---|---|---|
| Strongly disagree | 22 | 23.16 |
| Quite disagree | 19 | 20 |
| Slightly disagree | 8 | 8.42 |
| Neutral | 10 | 10.53 |
| Slightly Agree | 7 | 7.37 |
| Quite agree | 10 | 10.53 |
| Strongly Agree | 8 | 8.42 |
| Unanswered | 11 | 11.58 |
| **Total** | **95** | **100%** |

**Table 6.14: Response to recommending service to friends and family**

| Response | No of respondents | Percentage of respondents |
|---|---|---|
| Strongly disagree | 3 | 3.16 |
| Quite disagree | 7 | 7.37 |
| Slightly disagree | 4 | 4.21 |
| Neutral | 16 | 16.84 |
| Slightly Agree | 8 | 8.42 |
| Quite agree | 23 | 24.21 |
| Strongly Agree | 23 | 24.21 |
| Unanswered | 11 | 11.58 |
| **Total** | **95** | **100%** |

### 6.4.3.5 Policy

The UK telecommunication Act of 1996 established a regulatory policy that promoted competition, innovation, and investment in broadband services and facilities (Grubesic, 2004). Effective protection of content is essential to the long-term development of broadband networks. The best long-term protection for providers of content therefore lies in robust competition among providers of broadband connectivity and helps in providing a good foundation for the provision of broadband services (Huber, 2002). In this sense, it is remarkable that respondents of the survey strongly agreed that the UK government should encourage the service providers by promoting broadband more and subsidising broadband prices for consumer in other to encourage the use of broadband (Table 5.10 and Table 6.15). Given the critical importance of broadband as the key enabling infrastructure of the knowledge economy, a failure of broadband supply to meet demand could stifle the pace of innovation in the UK economy compared to the global competitors. This risk should be recognised and addressed by government (Broadband Stakeholder Group, 2007).

**Table 6.15: Response to the UK government should promote broadband more**

| Response | No of respondents | Percentage of respondents |
|---|---|---|
| Strongly disagree | 2 | 2.11 |
| Quite disagree | 1 | 1.05 |
| Slightly disagree | 1 | 1.05 |
| Neutral | 8 | 8.42 |
| Slightly Agree | 9 | 9.47 |
| Quite agree | 18 | 18.95 |
| Strongly Agree | 48 | 50.53 |
| Unanswered | 8 | 8.42 |
| **Total** | **95** | **100%** |

### 6.4.3.6 Cultural Quality

Culture has been identified as an underlying determinant of consumer behaviour (El Said and Hone, 2005) and this also extends to broadband. Cultural quality is an effort to improve the level of performance across an entire organisation to achieve higher levels of customer satisfaction. This is also referred to as Continuous Quality Improvement (CQI). CQI is the use of incremental and breakthrough quality management techniques to constantly improve processes, products, or services provided to internal and external customers and thus achieve higher level of customer satisfaction. As Table 5.8 shows, there is a wide

spectrum of broadband usage, which demands CQI initiatives to be in place for effective customer satisfaction.

#### 6.4.3.7 Functional Quality

This relates to the standard product quality, including satisfaction of needs and absence of defects (Russell and Chatterjee, 2003). Functional quality reflects the ease of installation, complexity of ordering and running a broadband connection. It is given by the quality of software that manages the broadband connection from the user to the service provider and from the service provider to the telecommunication company, and in return from the telecommunication company to the service provider and then to the user. In order to achieve this software quality it is expected that the necessary testing procedures have been carried out before deployment of such software to the users of broadband.

Testing of the software would include examining broadband equipment to ensure it works flawlessly with it and compatibility with various operating systems. This is reflected in the strong agreement between respondents to the survey, admitting that their broadband connection is reliable (Table 5.7) and they are satisfied with the quality of multimedia presentations on their broadband connection (Table 5.8). This shows that their ISP is able to deliver a broadband connection that can accommodate the multimedia content for the delivery of enriched digital media and entertainment services. From the customers and service providers' perspective, it is assumed that customers and potential customers of broadband services are most concerned with clear information about the service offering, particularly concerning the speed of download and upload that can be expected in practice (Table 5.7).

## 6.5 Measurement of Broadband Quality

There is currently no metric for measuring the overall broadband quality, this is due to its subjective nature. The perceived quality depends on the context and expectations of the different stakeholders assessing broadband quality. For example, the ISP might think that providing a good QoS to its customers and offering reduced subscription prices bestow good quality, while the broadband users may perceive reliability of their broadband connection to the Internet and an excellent customer service from their ISP is good quality. Each of these subjective viewpoints of broadband quality facets is important and should be considered. Furthermore, an integrated assessment of broadband quality facets based on the participants' perspective has proved that the lack of any of these in the BiQF can result in consumer dissatisfaction and may lead to negative impact on quality.

## 6.6 Interplay of Broadband Quality facets

The interplay between the various facets of broadband quality identified in the framework is discussed in this section. This also emphasises their importance as well as the inter-relationships between them:

- If the government encourages and promotes broadband usage by way of developing new favourable policies which also enhances competition between ISPs, this will help push down price and enable more consumers to take up broadband.
- If the ISPs provides a set of methods with associated processes that aid in implementing and maintaining specific level of broadband networks - this set of methods also known as QoS invariably gives reliability in broadband connectivity.
- A reliable broadband connection is needed to run high bandwidth broadband applications such as VoIP, online games, VOD and other multimedia applications - this reliability provides a positive QoP to the users.
- Most broadband users will consider a low subscription price favourably. However, if users are satisfied with the overall customer services including their ISP's after sales services, users are most likely to stay longer with their ISP irrespective of their subscription price.

- When an ISP improves the level of performance across their entire organisation it rubs off on providing a good customer service relations, the functional testing of the equipment as well as the software sent out to their customers. This level of performance across the organisation is the cultural quality attitude of the ISP.
- The security requirements and policy offered by a service provider can be checked to ensure that broadband users' service delivery includes security and data filtering systems. Finally, customers are most likely to be satisfied and remain loyal to their ISP if they provide secured broadband connectivity as a standard service.

A summary of how the identified broadband quality facets interact with each other is presented in table 6.16.

**Table 6.16: Interaction between the broadband quality facets presented in the BiQF**

| Stakeholders | Broadband Facets | Influence |
|---|---|---|
| Government | Policy | Prices<br>Cultural quality |
| ISP | Cultural Quality | Functional quality<br>Reliability<br>Security<br>Price<br>QoS<br>QoP<br>Customer Service |
| Customers/Broadband users/Government agencies as well | Price<br>Customer Service (after sale services)<br>Reliability<br>QoP | Customer service<br>Cultural quality |

Although the previous work on broadband quality facets has been treated individually; however, with the interplay described above, it has become essential to fuse all the identified broadband quality facets together to form an integrated framework for quality. This will in turn provide a clear picture to all stakeholders, of the compliance of ISPs to provide competitive prices for broadband services; quality assurance, ease of use, reliability, connectivity and value for money

broadband services of assured quality through simple, quick and effective technical support without having to negotiate separate terms and conditions for the service.

## 6.7 Summary

This chapter proposed a broadband quality framework based on the findings of the research. Most of the findings of this research have been consistent with the literature review except on few occasions. This research and previous work collectively validate and support each other, with minor exceptions. Clearly, different customer segments focus on different aspects of quality, and have quite distinct needs, beginning with a framework of definitions which allows us to accommodate all sections of the market. As monitoring and reporting develop, a clearly defined framework will allow specific segments of the market to be monitored differently, without any confusion arising due to the use of inconsistent terminology.

The next chapter, which is the last mile of this thesis, will provide the essence of all the chapters. Furthermore, it will also discuss briefly the research limitations, contributions, conclusions and future developments of this research.

# CHAPTER 7: Conclusions

## 7.1 Introduction

This chapter draws conclusions from the findings of this research, and highlights the implications of the findings for governments, ISP and consumers. The chapter begins with an overview of the research being provided in Section 7.2. The contributions of this thesis to the topical literature and implications of this research in terms of the theory, policy and practice are then identified and discussed in Section 7.3. This is followed by the research limitations in Section 7.4, while section 7.5 identifies the research conclusions of this thesis. Finally the chapter ends by recommending areas for future research in Section 7.6.

## 7.2 Research Overview

### 7.2.1 Chapter 1

This chapter defined the research problem and outlined the research motivation for conducting this research. Previous literature was reviewed and organised into a synopsis of research affecting the topic of the thesis, highlighting agreements, contradictions, and areas which require further research, and went on to direct the studies of the thesis. The current large-scale investments in the development and upgrading of the telecommunication infrastructures delivered by telecommunication and service providers with the increasing uptake of broadband in the UK has made it necessary to look at broadband quality delivered to the users by ISPs in the UK, which was the motivation for this research. The literature analysis indicated earlier research efforts on broadband all approached the issue of quality in a fragmented manner. For example, QoS in broadband has until now been assumed by many to be the same as quality in broadband. Quality, nonetheless is made up of many facets, of which QoS is but one of them.

This research differs from previous work and offers an alternative perspective to previous research by providing an integrated approach towards broadband quality. Moreover, it is one that integrates the essential perspective of the user/consumer. Consequently, this research aimed to create a framework for the structuring of quality monitoring concepts in broadband service that would ensure that the standard of quality are met and maintained in order to ensure confidence and growth in the broadband services arena. The objectives to achieve the overall aim include: providing a taxonomy of broadband quality issues; conducting data

collection and analysis in order to validate the users' perspective of broadband quality; finally, outlining implications for theory, practice and policy. Chapter 1 also furnished brief information on potential research approaches, outlined the research contribution to theory, practice and policy and finally provided an overview of the dissertation.

Chapters 2 and 3 provided the literature review and gave a conjectural perspective of this research.

### 7.2.2 Chapter 2

This chapter begins by offering a more detailed insight into broadband, its technologies and the various issues that surrounds broadband. The identification of broadband issues that may affect deployment and adoption of broadband were examined. These were then linked with quality issues of provision and services of broadband, which resulted in the provision of taxonomy of broadband quality issues, the first objective of this research.

### 7.2.3 Chapter 3

Here, quality was defined and the many facets of quality in regards to broadband, from the perspective of various stakeholders, were detailed. Moreover, Chapter 3 identified that even though quality in the IT field is usually measured by product failure (Krishnan, 1993) or QoS (Koraski and Tassiulad, 2004; Krishnamoorthy, 2001), it however relates to the characteristics by which customers or stakeholders judge an organisation, product or service. Unsurprisingly then the concept of quality is a multi-faceted one, as there are as many quality perspectives as there are stakeholder groups (Choudrie et al, 2005). Although the aforementioned types of studies in the literature review chapter were helpful to prepare and promote the broadband market, they offered limited implications on broadband quality which can affect all stakeholders in the industry such as the UK Government, ISP and in particular the consumers.

### 7.2.4 Chapter 4

This provided an overview of the research approaches utilised within the research. A sequential progression from exploratory investigation (Phase I) to qualitative methods (Phase II and III) across different phases of a study allows for a much richer and grounded understanding of the research phenomenon. The exploratory investigation approach was utilised as little is known about the situation at hand, since broadband is still evolving and no information is available on the integration of broadband quality as perceived by the users in the past. This method allows for the synthesizing of data gathered from secondary sources of materials and other drawn inferences from the data in order to make some analysis, since the nature of the subject of this project area is dynamic, being relatively new and still evolving.

The second phase of the research method involved using a quantitative method, which made use of the survey approach. The data collected from the survey questionnaire was as a result of information gathered using the exploratory investigation to highlight the variables used for the questionnaire. However as the theme of this research is on quality, it is important that the type of data collected be of good quality. In order to achieve this, the data quality framework (Brackstone, 1999) was used.

This survey questionnaire was used to investigate users' perception on broadband quality as provided by their service providers. The questionnaire was divided into two parts, the first focusing on general and background information regarding each respondent including the users' profession and their salary, organisations' field of activity, and the type of their respective access to broadband, as well as questions soliciting information with respect to any problems that they might have had with broadband access and their interactions with their service providers as a result of the problem. Respondents were also encouraged to comment or elaborate on their responses where it was relevant.

The second part focused on users' perception of ten issues dealing with broadband quality based on ratings given using a 7-point Likert scale. These issues were identified as relevant from the related literature (Jungck and Shim, 2004; Ghinea et al, 1999; Gillett and Lehr, 1999; Lakshminarayanan and Padmanabhan, 2003; Orda, 1999; Romero, 2002; Sansò et al, 2005; Savage and Waldman, 2005) and

included price, speed, QoS, security, QoP, cultural quality, reliability, ease of installation and use, performance, availability.

UK consumers living in four local authorities' boroughs comprising Greenwich, Lewisham, Havering and Hillingdon were targeted for this research. These consumers consist of academicians, students, home users and professionals and data were collected within a six month window. 500 respondents were targeted and mailed the survey questionnaire. Chapter 4 partly addresses the objective of conducting data collection and analysis in order to validate users' perspective of broadband quality.

### 7.2.5 Chapter 5

The findings obtained from the data analysis of the conducted survey that examined users' perception of broadband quality in the UK were presented. It was observed that a vast majority of the respondents were in strong agreement to having a reliable broadband connection from their ISP, which could be influenced, by the satisfaction of their broadband speed. This in turn reflects their strong positive opinions of users continuing with their broadband subscription. Therefore it will be fair to establish that reliability and speed play an important role in the perceptions of broadband users. Furthermore, it was also observed that as a result of the strong agreement of the respondents receiving a satisfactory technical support from their ISP, as well as receiving an overall service quality, which includes the courteous behaviour of their ISP customer service representative, users, would recommend their ISP to their friends and family. It will then be fair to establish also that customer service plays an important role in the respondents' perception to broadband quality.

Additionally, it was revealed that most respondents indicated a relative strong agreement that they are pleased with the informational content of multimedia applications via their broadband connection; they also use their broadband connection to listen and download music, watch and download movies. This however, depends on the reliability of their broadband connection, an issue which the participants responded to by indicating strong disagreement to broadband connection always breaking.

Although the research revealed that respondents agree that they receive value for their broadband subscription, they still indicated that the current price they pay for their broadband subscription is costly. Price therefore plays an important aspect of quality that needs to be looked at in broadband and can be a crucial limit on the demand for broadband (Romero, 2002). Moreover, users who agree that their subscription is costly are still with the same ISP despite wanting to change to another. This could be because the respondents could not be bothered with the hassle of changing, as long as their basic needs for broadband connectivity are met. The survey respondents showed strong agreement to the fact that the UK government should promote broadband more and that the UK government should subsidise broadband prices, an indication again confirming that price is very important in broadband quality. Interestingly, an indication that broadband should be promoted more by the UK government received the highest level of agreement; this shows that the involvement of the UK government is highly desired in this country. Involvement of the UK government, however, requires providing policies that would stand as guidelines for ISPs.

### 7.2.6 Chapter 6

In chapter 6, a novel broadband framework was elaborated on in order to address the quality requirement in broadband deployment and adoption. Inevitably, the research suggested that the quality of broadband service offered by ISP does not only depend on QoS, but on other aspects of quality such as price, perception, customer service, reliability, QoP and security. This was also confirmed from the participants' responses in the survey questionnaire. Furthermore from the survey, other aspects of broadband quality were also discovered to be important; these included functional quality, cultural quality and policy. All these quality aspects were then fused together to provide an integrated quality framework for stakeholders, including users, service providers and the government. The framework can be potentially used as a tool to provide broadband quality to consumers in the UK and indeed other countries.

## 7.3 Research Contributions

This research presents one of the initial efforts towards understanding broadband quality in an integrated format; furthermore, it is also one of only a few studies that address the issue of broadband quality in a combined design in both the industry as well as in the academic world. The contribution of this research should then benefit several groups:-

### 7.3.1 Academic Contribution

- The research conducted in this thesis provided an offering towards theory in that it integrated various dimensions of broadband quality abstracted from the appropriate literature, combined with consumer perspectives in order to enhance the knowledge of technology.
- This research provides taxonomy of broadband quality issues which was extracted from previous work done in isolation on broadband quality.
    - Quality of service (QoS)
    - Quality of Services (QoSs)
    - Cultural Quality
    - Functional Quality
    - Quality of Perception (QoP)
    - Price Quality
    - Security

  This taxonomy of broadband quality issue then became the foundation for the provision of an integrated broadband quality framework.
- The integrated broadband quality framework formed by the findings of this thesis can be exploited by both academician and students to pursue further research in broadband quality issues.

### 7.3.2 Industrial Contribution

- ISPs will now be offered an argument that demonstrates how broadband quality should be encouraged in the provision of broadband connection to consumers.
- The framework can be potentially used as a tool to provide broadband quality to consumers in the UK and indeed other countries. This is important since factors such as price, speed, QoP, QoS, customer services,

reliability, security and even policy play a vital role in the users' perception of broadband quality.

- For government, it brings awareness of what the users expect from them as part of their involvement, by providing policies that would stand as guidelines and code of practice for ISPs. Therefore, this research provides an incremental contribution towards theory development in the area of the impact of deployment of broadband to consumers.

## 7.4 Research Limitations

In retrospect, increasing the numbers of participants could have improved the studies of this thesis. The use of a small number of users from a specific part of the UK for this research is a limitation of this study as the willingness of potential participants and the resources available to recruit them limited the number of participants. Therefore the statistical power of empirical results, and the depth of information gathered in the qualitative studies were also limited. It is always desirable to have a larger sample size to further validate results; a larger dataset would have strengthened the findings. Although the study offers a snapshot of user opinions – which might change when users are exposed to the full potential of broadband technology – it nevertheless offers a picture of the intricacies that quality issues raise in broadband. The survey questionnaire findings would have been strengthened if it had been possible to also supplement the findings using interviews. However, recruiting participants in this way could prove to be very challenging and could have resulted in prolonging the research unnecessarily.

## 7.5 Research Conclusions

The following main conclusions are drawn from this research and are based on underlying research questions proposed in Chapter 2:

- QoS in broadband has until now been assumed by many to be the same as quality in broadband, however, quality is made up of many facets, of which QoS is but one of them.
- It was observed that if the consumer perceived that they are receiving quality in terms of reliability and ease of use of broadband, it will influence their staying with an ISP for a very long time irrespective of how much their broadband subscription cost. Thus, although the action of

staying with a particular ISP could be counteracted with the fact that they are just not bothered about the hassle of changing their ISP.

- Additionally, it was observed that various facets of broadband quality interplay with each other. For example a policy by the government to increase competition amongst ISPs will force broadband subscription price down which will increase broadband take up. Furthermore an ISP with a cultural quality attitude to improve the level of performance across an entire organisation in order to achieve higher levels of customer satisfaction provides a secured and reliable broadband connection, good customer services as well as providing an ease of use equipment for customers' broadband connection to the Internet.
- Reliability of their broadband connection plays a vital role in quality, as lack of this from their ISPs tends to frustrate users, motivating them to change their ISPs irrespective of how much the broadband subscription cost.
- The use of broadband quality framework provides a baseline for all the ISPs in the UK to work towards providing good quality broadband service to its consumers.
- Furthermore, the framework would enable the UK government to achieve its desired place in broadband adoption in the world. This takes into consideration the UK government's stated intention and vision to make the UK one of the top broadband users in the world (Choudrie and Papazafeiropoulou, 2006).
- The taxonomy of broadband quality issues can be further adjusted for future use of broadband quality research.

## 7.6 Future Work

An interesting avenue for future research would be to examine whether the findings obtained from this study are specific to the UK users or whether the results will be the same across other countries of the world. This would require a cross-cultural approach when understanding broadband quality. The data for this research has been collected over a short period of time and provides a snapshot. However, it could be expanded over a longer period of time to offer a longitudinal and qualitative study. Thus, a longitudinal, qualitative study seems to be an

appropriate future direction to overcome the limitation of this work. This will allow an in-depth understanding of the impact of broadband quality and will provide a clearer and more complete picture of broadband quality as perceived by users and will certainly be helpful in developing a further understanding of the critical segments for subject areas related to the marketing of broadband by ISPs. On this basis, the broadband quality framework can be refined in future endeavours.

Furthermore the evaluation of the BiQF can be carried out and confirm whether the solution can be generically applied to all service providers of broadband communication.

# References

## Books

Burns, R. B. (2000) Introduction into research methods, Sage Publications Limited, London.

Cornford, T. and Smithson, S. (1996) Project Research in Information Systems: A Student Guide, Great Britain, MacMillian Press Limited.

Freeman, R. (1984) Strategic Management: A stakeholder approach, Boston, Pitman Publication

Foster, W.A (2000) Quality Reviews and Risk Management, Chapter 8, pp. 348 of Case Management: A practical guide in Managed Care, Lippincott Williams & Wilkins,US; 2Rev Ed edition.

Fowler, F.J. (2002) Survey research methods, Thousand Oaks, USA: Sage Publications

Gavana, R.Y, Delahaye, B.L, and Sekaran, U. (2001) Applied business research, Wiley, Australia, pp.108

Gilbert, G.N (2001) Researching Social Life: Second Edition, Sage Publications

Hall, D. and Hall, I. (1996) Practical social research: Project work in the community, Macmillan Press Limited, London

Juran, J.M. (1989) Juran on Leadership for Quality. The Free Press, New York

Juran, J.M. (1986) The Quality Trilogy, http://pages.stern.nyu.edu/~djuran/trilogy1.doc, Accessed 3 June, 2008

Laudon, K.C. and Laudon, J.P. (2002) Management information systems: Managing the digital firm, Seventh edition, Prentice Hall International Inc, New Jersey

Maxwell, K. Residential Broadband: An Insider's Guide to the Battle for the Last Mile, John Wiley & Sons, 1999

Miles, M.B. and Huberman, A.M. (1994) Qualitative data analysis: An expanded source book, Thousand Oaks, CA, 2nd ed. Sage

Neuman, L. (2000) Social research methods: Qualitative and quantitative approaches. 4th Edition. USA: Allyn & Bacon

Neuman, L. (1997) Social research methods: Qualitative and quantitative approaches. Needham Heights, MA: Allyn & Bacon, pp. 20

Nuaymi, L. (2007) WiMax: Technology for Broadband Wireless Access, Wiley

Patton, M.Q (1990) Qualitative Evaluation and Research Methods, 2nd Ed. Newbury Park, CA: Sage

Wolf, M. and Zee, N. (2000) The Last mile: Broadband and the next Internet revolution, New York, McGraw Hill.

Yang, K. and El-Haik, B. (2003) Design for six sigma: A Roadmap for product Development, Mc Graw Hill Professional.

Yin, R. (1994) Case study research: Design and Methods, CA: Stage Publishing, Beverly Hills

Young Kyun, K. and Prasad R. (2001) 4G Roadmap and Emerging Communication Technologies, pp 12-13

## Journal and Papers

Alahuhta, P., Ahola, J. and Hakala, H. (2005) Mobilizing Business Applications: A survey about the opportunities and challenges of mobile business applications and services in Finland, Technology Review, Tekes http://www.tekes.fi/ohjelmat/vamos/Finland.pdf , Accessed 14 April, 2008.

Albizuri, F., Graña, M. and Raducanu, B. (2003) Statistical transmission delay guarantee for non real-time traffic multiplexed with real-time traffic Computer Communications, Volume 26, Issue 12, pp. 1365-1375.

Almay H. (1999) Pricing in the Internet, http://keskus.hut.fi/opetus, Accessed 16 February 2005

Anania, L. and Solomon, R. (1995) Flat-The Minimalist Price, Internet Economics eds, McKnight and Bailey, MIT Press, Cambridge, MA, pp.91 – 120.

Anderson, R. (2003) Cryptography and Competition Policy- Issues with 'Trusted Computing' PODC, Boston, Massachusetts, USA, ACM.

Anderson, J. (2004) Broadband Security: Securing the Masses, http://techlibrary.networkcomputing.com/detail/RES/1078534809_110.html, Accessed 21 June 2004

Andrews, R. (2007) Govt 'must act' to ensure super-fast broadband, E-Consultancy, http://www.e-consultancy.com/news-blog/363075/govt-must-act-to-ensure-super--fast-broadband.html, Accessed 29th October, 2007

Arkenbout, E., Van Dijk, F., and Van Wijck, P. (2004) Copyright in the Information Society: Scenario's and Strategies, European Journal of Law and Economic, Volume 17, Issue 2, pp. 237 – 249.

Arts, F., Barri, P., Clemminck, I., Niemegeers, A., Pauwels, B., Taildeman G. and Vrana, M. (2004) Network processor requirements and benchmarking, Computer Networks, Volume 41, Issue 5, pp. 549-562.

Australian Communication Authority (ACA) (2003) Broadband Quality of service issues: Consumer Perspectives, http://www.acma.gov.au/webwr/consumer_info/publications/reviews_investigations/index/broadband_quality_of_svce_issues.pdf Accessed 20 April 2005

ACA (2002) Quality of Service for Broadband, Broadband Pty Limited http://www.aca.gov.au/consumer_info/publications/reviews_investigations/index/request.rtf Accessed 10 May 2004

Australian Government (2003) Access to broadband technology for GPs, An Australian Government initiatives, Statistical-clearing house.

BAP (Broadband Access Project) (2000) Broadband Backgrounder: Public Policy issues raised by Broadband technology. The Centre for Democracy & Technology http://www.cdt.org/digi_infra/broadband/backgrounder.shtml#IIB, Accessed 30 April 2004.

Belson, K. and Richtel, M. (2003) U.S. broadband dream is alive in Korea. The New York Times, http://news.com.com/2100-1034_3-999695.html, Accessed 7 June 2004

Berger, A.W. Naldi, M., De Giovanni, L. and Villén-Altamirano, M. (1998) Standardization of traffic measurements and models for broadband networks: open issues, Computer Networks and ISDN Systems, Volume 30, Issue 14. pp. 1327-1340.

BIG (Broadband Industry Group) (2004) Broadband Explained, pp. 256-275, http://www.bigfuture.org, Accessed 29 December 2007

Bolotin, E., Cidon, I., Ginosar, R., and Kolodny, A. (2004) Cost considerations in network on chip, Integration, the VLSI Journal, Volume 38, Issue 1, pp. 19-42.

Bostoen, T., Jan Verlinden, J., Van den Bogaert, E., Suciu, R. (2004) Dynamic Spectrum Management in Practice: Increasing DSL Rate/reach Performance by Avoiding or Mitigating Crosstalk Interference. Alcatel http://www.bitpipe.com Accessed 27 August 2004

Bourdon, T. (2002) South Korea: Broadband Queen. Alcatel, Newlink http://www.alcatel.com/newslink/0202/cover_art1.htm. Accessed 7 May 2004

Brackstone, G. (1999) Managing data quality in a statistical agency, Survey methodology, Volume 25, No.2, pp. 139 - 149

Broadband Wireless Exchange (2006) 802.11g Wireless Internet Access, http://www.bbwexchange.com/wireless_internet_access/802.11g_wireless_internet_access.asp Accessed 12 December 2007

Brunel University (2008) Use of Personal Data in Research, Policies and Guide line http://www.brunel.ac.uk/4495/data%20protection1/persdataresearch.doc, Accessed 3 June, 2008

Broadband Stakeholder Group (2007) Pipe Dreams? Prospects for Next Generation Broadband deployment in the UK, http://www.broadbanduk.org/content/view/236/7/ Accessed 15 December 2007

Bumback, J. (2002) Broadband Security: The Pit Bull for Your Home and Small Business Network, http://techlibrary.networkcomputing.com/detail/RES/1042074016_489.html, Accessed 21 June 2004

Cao, X., Shen, H., Milito, R., Wirth, P. (2002) Internet Pricing with a game theoretical approach: concepts and examples, IEEE/ACM Transaction on networking, Volume 10, No.2, pp.208 – 216.

Cater K., Chalmers, A., and Ward, G. (2003) Detail to attention: exploiting visual tasks for selective render, ACM International Conference Proceeding Series, Proceedings of the 14th Euro graphics workshop on Rendering, Session: Refinement, Visibility and selective rendering, pp. 270 – 280.

Cava-Ferreruela and Alabau-Munoz, A. (2006) Broadband policy assessment: A cross-national empirical analysis, Telecommunications Policy, Volume 30, Issue 8–9, pp. 445–463

Chang, C. and Hsu, K. (2003) Design and implementation of MP3-music on demand system using streaming technology, Journal of Network and Computer Applications, Volume 26, Issue 4, pp. 291-321.

Charlton, G. (2006) Customers unhappy with broadband customer service, E-Consultancy, http://www.e-consultancy.com/news-blog/361904/customers-unhappy-with-broadband-customer-service.html Accessed 29th October 2007

Chau, P.Y.K, Cole, M., Massey, A.P., Montoya-Weiss, M., and O'Keefe, R.M (2002) Cultural differences in the online behaviour of consumers, Communication of the ACM, Volume 45, No. 10, pp.138 – 143.

Chen, Y. and Lee, S.Y. (2000) Bounded tag fair queuing for broadband packet switching networks, Computer Communications, Volume 23, Issue 1, pp. 45-61.

Chen, S.Y, Ghinea, G. and Macredie, D. (2006) A cognitive approach to user perception of multimedia quality: An empirical investigation, International Journal of Human-Computer Studies, Volume 64, Issue 12, pp.1200 – 1213.

Chirinos, L., Losavio, F. and Bøegh, J. (2005) Characterizing a data model for software measurement, Journal of Systems and Software, Volume 74, Issue 2, pp. 207-226.

Chotikapong, Y., Cruickshank, H., Sun, Z., Evans, B.G. (2000) Network Architecture and Performance Evaluation of Broadband Satellite System, IEEE International Conference on Networks (ICON'00), pp. 488 – 490.

Choudrie, J., Papazafeiropoulou, A. and Lee, H. (2003) A web stakeholders and strategies: a case of broadband diffusion in South Korea. Journal of Information Technology, Vol. 18, pp. 281- 290

Choudrie, J. and Lee, H. (2004) Broadband development in South Korea: Institutional and Cultural factors, European Journal of Information Systems. Volume 13, No.2 pp. 103 – 114.

Choudrie, J. and Dwivedi, Y.K (2006) A comparative study to examine the socio-economic characteristics of broadband adopters and non-adopters, Electronic government, an International Journal, Volume 3, Number 3, pp. 272 - 288

Choudrie, J. and Papazafeiropoulou, A. (2006) Lessons learnt from the broadband diffusion in South Korea and the UK: implications for future government intervention in technology diffusion, Electronic Government, an International Journal, Volume 3, Number 4, pp. 373 - 385.

Cisco (2004) Accelerating Broadband, http://www.cisco.com/gov/networks/broadband.html Accessed 27 November 2004

Clark, D., Gillett, S., Lehr, W., Sirbu, M. and Fountain, J. (2002) Local Government Stimulation of Broadband: Effectiveness, E-Government and Economic Development, John F.Kennedy School of Government, Harvard University, Faculty research series, http://itc.mit.edu/itel/docs/2002/White_Paper_NSF_DigGov.pdf, Accessed 21 March 2003

Congressional Research Service (CRS) (2003) Broadband Internet Access: Background and Issues. Congressional Research Service, The library of Congress USA, pp. 1 – 14.

Cooper, C.A and Park, K.I. (1990) Toward a broadband congestion control strategy, Network, IEEE, Volume 4, Issue 3, pp. 18 – 23.

Correa, D. (2007) Assessing Broadband in America: OECD and ITIF Broadband Rankings, The Information Technology and Innovation Foundation, http://www.itif.org/files/BroadbandRankings.pdf, Accessed 23 January 2008

Craig, A. (1999) BT broadband too expensive for the masses http://www.vnunet.com/analysis/87872 Accessed 21 March 2004

Cuffie, D., Biesecker, K., Cain, C., Charleston, G. and Ma, J. (1999) Emerging High-Speed Access Technologies, IT Professional, volume 1, No. 2, pp. 20-28

D'Antonio, S., D'Arienzo, M., Esposito, M., Romano S.P., and Ventre, G. (2004) Managing service level agreements in Premium IP networks: a business-oriented approach, Computer Networks, Volume 46, Issue 6, pp. 853-866.

Dandolopartners (2003) Broadband Quality of Service Issues: Consumer Perspectives, A report for the Australian Communications Authority. pp. 1 – 19. http://www.dandolo.com.au, Accessed 21 January 2005

Data Protection Act (1998) (http://www.opsi.gov.uk/acts/acts1998/19980029.htm) Accessed 2 June, 2008

DaSilva, L. (2000) Pricing for QoS enabled networks: A survey. IEEE Communications surveys and Tutorials, Volume 3, No. 2, pp. 14-20

Donahue, H.C and Ferrigno-Stack, J. (2001) Quality of Service Monitoring: A Timely Idea Standardization and Innovation in Information Technology, 2nd IEEE Conference, pp. 176 – 182.

Doyle, J.K. (2001) Introduction to Survey Methodology and Design, Chapter 10 of Handbook for IQP Advisors and Students, Interdisciplinary & Global Studies Division, Worcester Polytechnic Institute.

DSL Forum (2001a) General Introduction to Copper Access Technologies, http://www.dslforum.org/aboutdsl/general_tutorial.html, Accessed 29 April 2004

DSL forum (2001b) Learning about DSL, http://www.dslforum.org/about_dsl.htm, Accessed 15 June 2004

DSL forum (2004) SHDSL FAQ, http://www.dslforum.org, Accessed 15 April 2004

DTI (2003) Broadband, http://www.broadband.gov.uk/, Accessed 20 April 2004

DTI (2004a) International broadband market comparison http://www.dti.gov.uk/industry_files/pdf/broadband_international_MCR_Dec_2004.pdf, Accessed 21 January 2005

DTI (2004b) The Government and Ofcom Response to the BSG Third Annual Report and Strategic Recommendation http://www.dti.gov.uk/industry_files/pdf/third_annual_rep_strategic_recommendationsp.pdf, Accessed 21 January 2005

DTI (2004c) Broadband, http://www.dti.gov.uk/industry_files/pdf/BROADBAND_GOVERNMENT_POLICY_APR_2004.pdf, Accessed 2 August 2004

Dwivedi, Y. and Choudrie, J. (2004), Broadband Adoption: A UK Residential Consumers Perspective, In the proceedings of the American Conference on Information Systems (AMCIS-2004), New York City, USA, pp 2622-2627.

Eckberg, A.E, Luan, D.T. and Lucantoni, D.M (1989) Meeting the challenge: congestion and flow control strategies for broadband information transport, Global Telecommunications conference, and Exhibition, Communications Technology for the 1990 and Beyond, IEEE, Volume 3, pp. 1769 – 1773.

Edell, R. and Varaiya, P. (1999) Providing Internet Access: What we learn from INDEX, IEEE Network, Volume 13, Issue 5, pp. 18 – 25.

Ekenberg, L. and Johanneson, P. (2004) A framework for determining design correctness, Knowledge-Based Systems, Volume 17, Issue 7 – 8, pp. 249 - 262.

Elmaghraby, A.G., Mostafa, M.G., Kumar, A. and Kantardzic, M.M (2003) Research direction in dynamic polices for broadband services, http://128.164.157.92/workshop/proceedings/ae.pdf, Accessed 21 January 2005

El Said, G., R. and Hone, K., S. (2005). Culture and E-Commerce: An Exploration of the Perceptions and Attitudes of Egyptian Internet Users. Journal of Computing and

Information Technology: Special Issue on Information Systems, Simulation Modelling and Knowledge Management, Volume 13, Issue 2, pp. 107-122.

Europa (2004) National Strategies, European Targets, http://europa.eu.int/information_society/eeurope/2005/all_about/broadband/index_en.htm, Accessed 21 October 2004

Falkner, M., Devetsikiotis, M. and Lambadaris, I. (2000) An overview of pricing concepts for Broadband IP Networks, IEEE Communications Survey, http://www.comsoc.org/pubs/survey, Accessed 21 January 2005

FCC (2004) Broadband http://www.fcc.gov/broadband , Accessed 18 December, 2004

Ferreira, S.M. and Pithan, D.N (2005) Usability of digital libraries: a study based on the areas of information science and human-computer-interaction, World Library and Information congress: 71st IFLA General Conference and Council, Norway, http://www.ifla.org/IV/ifla71/papers/165e-Ferreira_Pithan.pdfAccessed on 2 June 2008

Fetscherin, M. (2004) Digital Rights management and technology bill evaluation using stakeholder analysis: A Case study of the music industry, http://userpage.fu-berlin.de Accessed 13 May 2005

Firquin, B.L. (1992) Quality is free—But how do you implement total quality and restructure information technology at the same time? ACM SIGUCCS xx, pp. 93– 95.

Firth, L. and Kelly T. (2001) Broadband briefing paper, ITU, Geneva, www.itu.int./broadband, Accessed 16 June 2004

First Release (2006) Internet Access: Household and Individuals, National Statistics, http://www.statistics.gov.uk/pdfdir/inta0806.pdf Access 31 December 2007

Fischer, S. and Leue, S. (1998) Formal methods for broadband and multimedia systems, Computer Networks and ISDN Systems, Volume 30, Issues 9-10, pp. 865-899.

Forberg, R. (2000) The changing costs of QoS Intelligence for the Broadband Economy, GlobalXtra.

Foros, O., Hansen, B. (2001) Competition and compatibility among Internet service providers, Information Economics and Policy, Volume 13, Issue 4, pp. 411 – 425

Fowler, D. (2000) The last mile: making the broadband connection, netWorker, Volume 4, issue 1, pp. 26 – 32.

Francalanci, C. and Pernici, B. (2004) Information quality assessment: Data quality assessment from user's perspective, Proceedings of the 2004 international workshop on Information quality in information systems, pp. 68 – 73.

Frieden, R. (2005) Lessons from development in Canada, Japan, Korea and the United States, Telecommunications policy, Volume 29, Issue 8, pp. 595-613

Galliers, R.D. (1994) Point in Understanding Information System Research approaches, Systemist, Volume 16, Issue 1, pp. 32 – 40

Galliers, R.D., 1991, Choosing Appropriate Information Research Approaches: a Revised Taxonomy, in Nissen, Klein and Hirscheim, (Eds) Information Systems Research: Contemporary Approaches and Emergent Traditions Elsevier, Amsterdam.

Galliers, R.D. and Land, F.F (1987) Viewpoint: Choosing appropriate information systems research methodologies, Communication of ACM, Volume 30, Issue 11, pp. 901-902.

Gao, K., Gao, W., He, S. and Zhang, Y. (2004) Real-time scheduling based on imprecise computation for scalable streaming media system over the Internet Real-Time Imaging, Volume 10, Issue 5, pp. 307-313.

Ghinea, G., Thomas, J.P and Fish, R.S (1999) Multimedia, network protocol and users – bridging the gap, International Multimedia Conference, Proceedings of the seventh ACM international conference on Multimedia (Part 1), pp. 473 – 476.

Ghinea, G. and Chen, S.Y (2003) The impact of cognitive styles on perceptual distributed multimedia quality, British Journal of Educational Technology, Volume 34 No. 4, pp.393 – 406.

Gillett, S. and Lehr, W. (1999) Availability of Broadband Internet Access: Empirical Evidence, 27th Annual telecommunication policy research conference

Gillett, S., Lehr, W.H., Osorio, C. (2004) Local government broadband initiatives Telecommunications Policy, Volume 28, pp. 537 – 558.

Gilroy, A. and Kruger, L.G. (2006) Broadband Internet Access: Background and Issues. Issues Brief for Congress, Congressional Research Service, The Library of Congress, http://usinfo.state.gov/infousa/economy/technology/docs/60574.pdf Accessed 12 December 2006

Glass, B. (2001) Got Broadband? You're Under Attack http://www.extremetech.com/article2/0,1558,828154,00.asp Accessed 21 June 2004

Gong, W., Li, Zhan G. and Stump, Rodney L. (2007) Global internet use and access: Cultural considerations, Asia Pacific Journal of Marketing and Logistics; Volume 19, Issue 1, pp. 57 - 74

Green, R.J., Wooley, N., Garnham, N.W. and Jones, K.P. (2001) Quality-of-Service management for broadband residential video services, Electronics & Communication Engineering Journal, Volume 13, Issue 6, pp. 265 – 275.

Grimm, C., Vöckler, J.S, and Pralle, H. (1998) Request routing in cache meshes, Computer Networks and ISDN Systems, Volume 30, Issues 22-23, pp. 2269-2278.

Grubesic, T.H. (2004) The geodemographic correlates of broadband access and availability in the United States, Telematics and Informatics, Volume 21, Issue 4, pp. 335 - 358.

Guizani, M.H (1998) An effective congestion control scheme for ATM networks, International Journal of Network Management, Volume 8, Issue 2, pp. 75 – 86.

Gunter, B., Russell, C., Withey, R. and Nicholas, D. (2003) Broadband in Britain: how does it compare with narrowband? Aslib Proceedings, Volume 56, No. 2, pp. 89 – 98.

Gyires, T., and Wen, H.J (2005) Extension of Multi-protocol Label Switching for long-range dependent traffic: QoS routing and performance in IP networks, Computer Standards & Interfaces, Volume 27, Issue 2, pp. 117-132.

Hallett, T. (2003) Broadband users 'would pay more for quality', Zdnet, UK http://news.zdnet.co.uk/communications/broadband/0,39020342,39117081,00.htm, Accessed 27 August, 2004

Hamadana, E. and Rakocevic, V. (2005) Evaluating and Improving TCP Performance against Contention Losses in Multihop, Ad Hoc Networks, IFIP International Conference on Mobile and Wireless Communication Networks, Marrakech, Morocco

Hitchcock, A. and Porter, K. (2004) Methodology recipe, The Likert Scale, http://arches.uga.edu/~porterk/likertscale.html, Accessed 29 November, 2004

Hotch, R. (1999) How much ATM is in your future? – Technology Information, Communication News, http://findarticles.com/p/articles/mi_m0CMN/is_1_36/ai_53654167/pg_2 Accessed 2 January 2006

Howard, D. (2002) Reinventing broadband: improved technologies, sober business plans, and tiered pricing may soothe an ailing industry. netWorker, ACM press, Volume 6, Issue 2, pp.20 – 25.

Huang, C. and Chang, C. (2004) An adaptive flow control with the re-transmission policy over the server–proxy–client networking environment, Journal of Systems and Software, Volume 69, Issues 1-2, pp. 15-27.

Huber, P.W (2002) The Government's role in promoting the future of the Telecommunications Industry and Broadband Deployment, Manhattan Institute for Policy research. http://www.manhattan-institute.org Accessed 13 January 2005.

Humphrey, M. and Freeman, J. (1997) How xDSL Supports Broadband Services to the Home, IEEE Network, Volume 11, Issue 1, pp. 14 – 23.

Ichiko, T., Yamamoto, M., Kawamura, Y. and Hanano, M. (2001) Advanced multimedia telecommunications using a high speed broadband backbone network beyond all

aspects of the current Internet (revised), Computers & Education, Volume 37, Issues 3-4, pp. 211-224.

International Engineering Consortium (IEC) (2004a) Asymmetric Digital Subscriber Line (ADSL). http://www.iec.org/online/tutorials/acrobat/adsl.pdf

International Engineering Consortium (IEC) (2004b) Achieving the broadband vision: service provider perspective, http://www.iec.org/online/iforums/cisco

Irvine, C. and Levin, T. (2001) Quality of security service, New security paradigms, Proceedings of the 2000 workshop on New security paradigms, pp. 91 – 99.

ITU (2005) Promoting Broadband: Broadband Issues in Private Sector, Promoting ICT Technologies & Broadband Applications, ITU Forum of the Regional Working Group (RWG) on Private Sector Issues – Asia & Pacific Region, Bangkok

ITU (2001) Report on xDSL, Fourth Meeting of Study Group 1:Geneva, Caracas (Venezuela), http://www.itu.int/ITU-D/study_groups/SGP_1998-2002/SG2/Documents/2001/082R2V2E.doc, Accessed 14 December, 2005

ITU (1994) Reference Model of open Distributed processing – Part2: Descriptive model, Draft International standard 10746-2, Draft ITU-T Recommendation X.902.

Ives and Jarvenpaa (1991) Executive involvement and participation in the management of information technology, MIS Quarterly, Volume 15, Issue 2, pp. 205 -227

Jain, R. (1996) Congestion control and Traffic Management in ATM Networks: Recent Advances and A Survey, Department of Computer science, The Ohio University, Collumbus, OH ACM, Computer Networks and ISDN System, Volume 28, Issue 13, pp. 1723-1738.

Jamalipour, A. (2001) Broadband Satellite Networks – The Global IT Bridge. Proceedings of the IEE, Vol. 89, No. 1 pp. 88 – 104.

Jarrett, K.W and Goleniewski, L. (2007) Traditional transmission media for Networking and telecommunication, InformIT Network, http://www.informit.com/articles/article.aspx?p=683070&rl=1, Accessed 2 January 2008.

Jiang, J.J., Klein, G., Tesch, D., and Chen, H. (2003) Closing the user and provider service quality gap, Communication of the ACM, Vol. 46, No.2, pp. 72–76.

Jin, G. and Tierney, B. (2003) Netest: a tool to measure the maximum burst size, available bandwidth and achievable throughput, Information Technology: Research and Education, Proceedings. ITRE2003. International Conference on, pp. 578- 582

Kabira (2004) Kabira Technology Inc. is powering a software revolution in telecommunications and real-time financial services. Kabira Technologies is the leader in high-speed Switching Software and Service Platforms for

telecommunications, real-time financial services and government systems. http://www.kabira.com

Kalton, G. (2001) How important is accuracy? Proceedings of Statistics Canada Symposium, Achieving Data Quality in a Statistical Agency: A Methodological Perspective, http://www.statcan.ca/english/freepub/11-522-XIE/2001001/session24/ckalt.pdf Accessed 5th November 2007

Karthigeyan, I., Manoj, B.S., and Siva Ram Murthy, C. (2005) A distributed laxity-based priority scheduling scheme for time-sensitive traffic in mobile ad hoc networks, Ad Hoc Networks, Volume 3, Issue 1, pp. 27-50.

Kasprzyk, D. (2001) Accuracy-an important and visible aspect of quality of concern to statisticians and survey http://www.fcsm.gov/01papers/Kasprzyk.pdf Accessed 22 November 2006

Key, P.B and McAuley, D.R (1999) Differential QoS and Pricing in Networks: where flow-control meets game theory, IEE Proceedings software, http://research.microsoft.com/network/publications/ieeproc.pdf Accessed 23 December 2007.

Kim, D.J., Ferrin, D.L., and Rao, H.R. (2003) A study of the effect of consumer trusts on consumer expectation and satisfaction: the Korean experience. ICEC 2003, Pittsburgh, PA, ACM, pp. 310 – 315.

Kim, H.H, Moon, J.Y and Yang, S. (2004) Broadband penetration and participatory politics: South Korea Case, Proceedings of the 37th Hawaii International conference on system sciences, Track 5, Volume 5, pp. 50117.2.

Klerer, M. (2003) Introduction to IEEE 802.20, Technical and procedural Orientation, http://ieee802.org/20/P_Docs/IEEE%20802.20%20PD-04.pdf, Accessed 3 June, 2008

Kondo, T., Nishimura, K. and Aibara, R. (2004) Implementation and Evaluation of the Robust high-quality video transfer system on the broadband Internet, Proceedings of the 2004 International Symposium Application and the Internet, IEEE, pp. 1 – 7.

Krishnan, M.S. (1993) Cost, quality and user satisfaction of software products: an empirical analysis. IBM Centre for Advanced Studies Conference, Proceedings of the 1993 conference of the Centre for Advanced studies on collaborative research: software engineering, Volume 1, pp. 400- 411.

Kos, T., Sprljan, N., Zovko-Cihlar, B. (2003) Comparison of broadband network technologies, IEEE Region 8 EUROCON 2003, Proceedings, Volume 1, pp.178 - 182.

Krikke, J. (2003) South Korea beats the world in Broadband Gaming, IEEE Multimedia, IEEE Computer Society, Volume 10, No. 2, pp. 12 – 14.

Krishnamoorthy, V. (2001) The Importance Of QoS In Broadband Networks For Mission Critical Content, Internet Telephony, http://www.tmcnet.com/it/0101/0101cisco.htm Accessed 27 August 2004

Kumar (2004) Broadband Policy, Government of India, Ministry of communications and IT, Department of Telecommunications, http://www.dotindia.com/ntp/broadbandpolicy2004.htm Accessed 21 January. 2005

Labovitz, C., Ahuja, A. Jahanian, F. (1999) Experimental study of Internet stability and backbone failures, Fault-Tolerant Computing, Digest of Papers, Twenty-Ninth Annual International Symposium on, pp. 278-285

Lazar, A. A. (1997) Project X, http://comet.ctr.columbia.edu/xbind/overview.html. Accessed 26 August 2004

Lee, H. and Choudrie, J. (2002) Investigating Broadband Deployment in South Korea, DTI / Brunel University, www.broadbanduk.org/reports/SKorea_report.pdf Accessed 09 April 2004

Lee, C. and Chan-Olmsted, S. M. (2004) Competitive advantage of broadband Internet: a comparative study between South Korea and the United States, Telecommunications Policy, Volume 28, Issues 9-10, pp. 649 – 677.

Lee, Y. and Lee, D. (2003) Broadband Access in Korea: Experience and future Perspectives, Communication magazine, IEEE, Volume 41, Issue 12, pp. 30-36.

Lehr, W. and McKnight, L.W. (2002) Show me the money: contracts and agents in service level agreement markets, The journal of policy, regulation and strategy for telecommunications, Volume 4, No. 1, pp. 24 – 36.

Lengnick-Hall, C.A (1996) Customer Contribution to Quality: A different view of the Customer-oriented firm, The Academy of Management Review, Volume 21, No. 3, pp. 791-824.

Lenton, D. (2002) A broad Place Broadband communication, IEE Review Vol. 48, Issue 5, pp. 11 – 13.

Leung, K.K. (2002) Load-dependent service queues with application to congestion control in broadband networks, Performance Evaluation, (Netherlands), Volume 50, No. 1, pp. 27-39.

Liikanen, E. (2002) The European Broadband Strategy, http://europa.eu.int, Accessed 21 October 2004.

Liu, W., Lou, W., and Fang, F. (2005) An efficient quality of service routing algorithm for delay-sensitive applications, Computer Networks, Volume 47, Issue 1, pp. 87-104.

London Times (2002) Broadband communication as a key element of Europe's future competitiveness, March 2002

Lorenz, D.H. and Orda, A. (2002) Optimal partition of QoS requirements on unicast paths and multicast trees, IEEE/ACM Transactions on Networking (TON), Volume 10. Issue 1, pp. 102 – 114.

Lu, K., Qian Y. and Chen, H. (2007) A Secure and Service-Oriented Network Control Framework for WiMAX Networks, WiMAX and Beyond, IEEE Communications Magazine, Volume 45, Issue 5, pp. 124–130

McDonald, J.C. (1989) The Regulatory Challenge of Broadband Technologies, IEEE Communication Magazine, Volume 27, Issue 1, pp. 71 – 74.

McGinity, M. (2002) Broadband to go, Communications of the ACM, Volume 45, No. 6, pp. 21 – 24.

McGinity, M. (2003) Getting Real, Provider have a new boss: The customer, Communication of the ACM, Volume 46, No. 4, pp. 23 – 26.

Ma, H and El Zarki, M (2002) A new transport for Broadcasting/ Multicasting MPEG2 Video over wireless ATM Access Networks, Kluwer Academic Publisher, Wireless Networks, Volume 8, Issue 4, pp. 371 – 380.

Malone, S. (2005) Britain has most extensive broadband coverage in G7, http://www.computerbuyer.co.uk Accessed 13 May 2005

Manner, J. Toledo, A.L., Mihailovic, A., Munoz, V. M., Hepworth, E. and Khouaja, A. (2002) Evaluation of mobility and quality of service interaction. Computer Networks, Elsevier Science B.V., Volume 38, pp. 136 –168

Manvi, S. S. and Venkataram P. (2004) Applications of agent technology in communications: a review, Computer Communications, Volume 27, Issue 15, pp. 1493-1508

Marçal de Oliveira, K., Rocha, A.R. and Weber, K.C. (2002) Workshop on software quality, International Conference on Software Engineering, Proceedings of the 24th International Conference on Software Engineering, Orlando, Florida, WORKSHOP SESSION: Workshops, pp. 671 – 672.

Marchetti, C., Pernici, B. and Plebani, P. (2004) Quality of service: A quality model for multichannel adaptive information, Proceedings of the 13th international World Wide Web conference on alternate track papers & posters. pp. 48 – 54.

Markopoulou A.P., Tobaji, F.A. and Karam, M.J. (2003) Assessing the quality of voice communication over Internet backbones, IEEE/ACM Transactions on Networking (TON), Volume 11, Issue 5, pp. 747 – 760.

Marques H.T., Rocha, L.C.D., Almeida, J.M., Meira Jr., W. and Almeida, V.A.F. (2004) Characterising broadband user behaviour, International Multimedia Conference, Proceedings of the 2004 ACM workshop on Next-generation residential broadband challenges, pp. 11- 18.

Meyer, D. (2003) PC broadband Security, Volume 22, Issue 4, IEEE potential, pp. 41 – 43.

Microsoft bcentral (2004) Broadband Security, http://www.bcentral.co.uk/issues/technology/broadband/security.mspx?pf=true Accessed 21 June 2004.

Mitra, D., Morrison, J.A. and Ramakrishnan K.G. (1999) Optimization and design of network routing using refined asymptotic approximations, Performance Evaluation, Volumes 36-37, pp. 267-288.

Morris, R. (2000) Scalable TCP congestion control, Proceedings of IEEE INFOCOMM, Volume 3, pp.1176–1183.

Myers, M. (1999) Qualitative Research in Information systems, MIS Quarterly Volume 21, Issue 2, pp. 241 – 242

Nahar, S. (2001) Securing the Broadband Network, http://www.sans.org/rr/papers/26/612.pdf, Accessed 21 June 2004

National office for the Information Economy (NOIE) (2002) Broadband for small Business, Canberra, Commonwealth of Austrialia.

NSOS (2007) Internet Access http://www.statistics.gov.uk/CCI/nugget.asp?ID=8&Pos=1&ColRank=2&Rank=960 Accessed 24th October, 2007

O'Neil, R. (2006) The advantages and disadvantages of qualitative and quantitative research methods, http://www.roboneill.co.uk/papers/research_methods.htm Accessed 2 June 2008

Odlyzko, M. (2000) Should flat-rate rate pricing continue? IT Professional, Volume 2, Issue 5, pp. 48 – 51.

OECD (2001) The development of broadband access in OECD countries, SourceOCDE Science et technologies de l'information, (Fr. à paraître), pp. 1-63(64).

Office of Communication (Ofcom) (2006) The International communication Market 2006, http://www.ofcom.org.uk/research/cm/icmr06/, Accessed July 2007.

Ofcom (2004) The Ofcom Internet and Broadband Update, http://www.ofcom.org.uk/research/telecoms/reports/bbresearch/int_bband_updt/may2004/, Accessed 22 March 2005

Ofcom (2007) Review of the wholesale broadband access markets 2006/07, Identification of relevant markets, assessment of market power and proposed remedies. http://www.ofcom.org.uk/consult/condocs/wbamr/wbamr.pdf Accessed 2 June, 2008

Office of Government and Commerce (OGC) (2003) Peter Gershon Announces New Broadband Service,

http://www.ogc.gov.uk/application.asp?app=press_release.asp&process=full_record&id=1000020 Accessed 19 April 2004

Okumus, I. T., Mantar, H. A., Hwang, J. and Chapin, S. J. (2004) Inter-domain QoS routing on Diffserv networks: a region-based approach, Computer Communications, Volume 22, Issue 2, pp. 174 – 188.

Orda, A. (1999) Routing with end-to-end QoS guarantees in broadband networks, IEEE/ACM Transactions on Networking (TON) Volume 7, Issue 3, pp. 365-374.

Overseas Development Administration (ODA) (1995) Guidance note on how to do stakeholder analysis of aid project an programmes http://eurofic.org/gb/stake1.htm Accessed 13 May 2005.

Papacharissi, Z. and Zaks, A. (2006) Is broadband the future? An analysis of broadband technology potential and diffusion, Telecommunication Policy, Volume 31, Issue 1, pp. 64 – 75.

Papazafeiropoulou, A. and Pouloudi, A. (2000) The Government role in improving Electronic commerce adoption, Proceedings of European conference on information systems, Vienna, Austria, pp. 709 – 716.

Papazafeiropoulou, A. Currie W. and Pouloudi, A. (2001) Applying the stakeholder concept to Electronic Commerce: Extending previous research to guide government bill makers, 34th Annual Hawaii International Conference on system Sciences (HICSS-34)

Parthasarathy, R., Bostian, C.W., DaSilva, L.A., Midkiff, S.F and Callahan, T.M. (2003) A Framework for policy-based Quality of service in an LMDS Wireless Network. Centre for Wireless Telecommunication, Virginia Polytechnic Institute and State University Blacksburg, http://www.ee.vt.edu/~prangapr/Documents/rangaprabhuQoSpaper.pdf, Accessed 26 April 2004

Pechiar, J., Perera, G. and Simon, M. (2002) Effective bandwidth estimation and testing for Markov sources, Performance Evaluation, Volume 48, Issues 1- 4, pp. 157-175.

Peslak, A.R (2004) Improving software quality: an ethnics based approach, Special Interest Group on Computer Personnel Research Annual Conference, Proceedings of the 2004 SIGMIS conference on Computer personnel research: careers, culture, and ethnics in a networked environment. pp. 144 – 150.

Picot, A. and Wernick, C. (2007) The role of government in broadband access, Telecommunication policy, Volume 31, Issue 10-11, pp. 660 – 674

Pitta, D., Franzak, F. and Fowler, D. (2006) A Strategic approach to building online customer loyalty: integrating customer profitability tiers, Journal of Consumer Marketing, Volume 23, Issue 7, pp. 421 – 429.

Point Topic (2006) Broadband Britain divided over Local Loop Unbundling, http://point-topic.com/content/ukplus/stats/balluest3006061026.htm, Accessed 22 November. 2006.

Priscoli, F.D. and Pietrabissa, A. (2003) Closed-loop congestion control in a GEO satellite system, Control Engineering Practice, Volume 11, Issue 4, pp. 387-401.

Raatikainen, P., Martikainen, O. and Naoumov, V. (2003) Media switch for multimedia services. Network Control and Engineering for QOS, Security and Mobility. International Federation for Information Processing 107, pp.317-328.

Räisänen, V. (2004) Service quality support—an overview, Computer Communications, Volume 27, Issue 15, pp. 1539-1546.

Rath, K. (2000) Broadband Networks, IEEE Multimedia, Volume 7, Issue, 4, pp. 10 – 13.

Rayes, A. (2003) Operation management of IP broadband access networks, Computer Communications, Volume 26, Issue 7, pp. 679-690.

Reininger, D., Raychaudhuri, D. and Ott, M. (1998a) A Dynamic Quality of service framework for video in Broadband Networks, IEEE Network, pp.22- 34.

Reininger, D., Raychaudhuri, D. and Ott, M. (1998b) Market based Bandwidth Allocation Policies for QoS Control in Broadband Networks, ICE'98 Charleston SC USA. pp. 101 – 110.

Rhee, I., Balaguru, N. and Rouskas, G. (1999) MTCP: Scalable TCP-Like Congestion Control for reliable Multicast, Proceedings of IEEE INFOCOM, Volume 3, Issue, pp.1265-1273

Richardson, T. (2001) UK broadband prices 'too high' says BT Retail boss http://www.theregister.co.uk/2001/10/10/uk_broadband_prices_too_high/ Accessed 21 March 2004

Romero, S. (2002) Price is limiting demand for broadband, New York Times, http://www.nytimes.com, Accessed 30 October 2004

Rowe, L.A. and Larson, R.R. (1993) A video-on-demand System, Technical Report of UCB, University of California at Berkeley.

Russell, B. and Chatterjee, S. (2003) Relationship quality: the undervalued dimension of software quality. Communication of the ACM, Volume 46, Issue8, pp. 85 – 89.

Samueli, H. (2000) The Broadband Revolution. IEEE Micro. Volume 20, Issue 2, pp. 16 – 26.

Sandy and Dave (2003) Broadband Anywhere: The extended broadband home, The broadband home, System dynamics Inc, http://broadbandhomecentral.com/report/backissues/Report0308_4.html, Accessed 28 May 2005

Sangjo, O., Joongho, A. and Beomsoo, K. (2003) Adoption of broadband Internet in Korea: the role of experience in building attitudes, Journal of Information Technology, Routledge, Taylor and Francis, Volume 18, No. 4, pp. 267 – 280.

Sansò, B., Girard, A. and Mobiot, F. (2005) Integrating reliability and quality of service in networks with switched virtual circuits, Computers & Operations Research, Volume 32, Issue 1, pp. 35-58.

Savage, S.J and Waldman, D.M (2004) United States demand for Internet, Review of network economics, Volume 3, Issue 3, pp. 228 – 247.

Sawyer, S., Allen, J.P. and Lee, H. (2003) Broadband and Mobile opportunities: a socio-technical perspective, Journal of Information Technology, Volume 18, Number 2, pp.121 - 136.

Seibert, C.H. and Tobaji, F.A. (2003) Assessing the user-perceived quality of packet voice in networks with mobile users, Proceedings of the 6th ACM International workshop on modelling analysis and simulation of wireless and mobile systems, pp. 20 – 27.

Shan, T., Zhang, G. and Yang, O. (2003) A traffic scheduling framework in broadband wireless access systems, Computer Communications, (Netherlands), Volume 26, No 14, pp. 1602 – 1612.

Sharpe, L. (2003) Rooted in reality, IEE Review, Special report Telecommunication, pp. 40 – 43.

Shelanski, H.A (1999) The speed gap: broadband infrastructure and the economic commerce, Berkeley technology law journal, Volume 14, issue 2, pp. 721-744.

Shenker, S., Clark, D., Estrin, D. and Herzog, S. (1996) Pricing in computer networks: Reshaping the research agenda, Telecommunication Policy, Volume 20, No.3, pp.183 -201.

Shinohara, H. (2005) Broadband access in Japan: rapidly growing FTTH market, IEEE Communication Magazine, Volume 43, Issue 9, pp 72 – 78.

Shyur, C., Lu, T. and Wen, U. (1999) Applying tabu search to capacity planning for network restoration, Computers and Operations Research, Volume 26, Issue 12, pp. 1175 – 1194.

Smart, K.L. (2002) Assessing quality documents, ACM Journal of computer documentation (JCD), Volume 26, Issue 3, pp. 130 - 140.

Smith, M.S., Moteff, J.D., Kruger, L.G., McLoughlin, G.J. and Seifert, J.W. (2001) Internet: an overview of key technology policy issues affecting its use and growth, Internet policies and issues, Nova Science Publishers, Inc. Commack, NY, USA, pp. 41– 72.

Spero, I. and Stone, M. (2004) How young consumers are changing the world of marketing, Qualitative Market Research: An International Journal, Emerald Group Publishing Limited, Volume 7, Issue 2, pp.153-159.

Spurge, V. and Almond, N. (2004) Broadband technology: How developers are responding to office occupiers' needs. Property Management, Emerald Group Publishing Limited, Volume 22, pp. 108 – 126.

Sriram, K. (1993) Methodologies for bandwidth allocation, transmission scheduling, and congestion avoidance in broadband ATM networks, Computer Networks and ISDN Systems, (Netherlands), Volume 26, No 1, pp. 43 – 58.

Strong, D.M, Lee, Y.W and Wang R.Y. (1997) 10 Potholes in the Road to Information Quality, Computer Volume 8, Issue30, pp. 38 – 46.

Su, P., and Gellman, M. (2004) Using adaptive routing to achieve Quality of Service, Performance Evaluation, Volume 57, Issue 2, pp. 105-119.

Subramanian, M. and Lewis, L. (2003) QoS and bandwidth management in broadband cable access network, Computer Networks, Volume 43, Issue 1, pp. 59-73.

Tan-Wanklyn, C. (2004) New Zealand Enterprise Broadband and IP Usage and Preferences. Doc #NZ203101Lsurvey, pp. 1-42. http://www.idc.com/getdoc.jsp;jsessionid=D4SDMNAIPGGSICQJAFICFGAKBEAUMIWD?containerId=NZ203101L&pageType=SYNOPSIS Accessed 28 July, 2004

TBR (Technology Business Research) (2004) Setting the Standard for Customer Satisfaction, Executive Summary, An Analysis of Dell's Customer Satisfaction Track record and Approach, http://www.tbri.com/whitepapers/dellwhitepaper.htm, Accessed 26 August 2004

Telecities (2004) WP 1 – Overcome the barriers to the development of Information Society, Broadband infrastructure. http://www.ictcenter.nl/upload/WP1_thehague_broadband.doc Accessed 21 October, 2004

The Economist (2004) South Korea: Broadband Blues. Economist Intelligence Unit, Ebusinessforum, http://www.ebusinessforum.com/index.asp?doc_id=7048&layout=rich_story Accessed 21October 2004

Thiara, B. 2004 An investigation into Broadband technology in relation to security issues. http://www.scit.wlv.ac.uk/~c9705859/home.htm Accessed 1 September 2004

Tiwana, A. and Bush, A. (2005) Continuance in Expertise-sharing networks: A social Perspective, IEEE transactions on engineering management, Volume 52, No. 1, pp. 85 – 101

Trifu, A and Dragos I. (2003) Strategy based Elimination of design flaws in Object-oriented systems, Proceeding of the fourth workshop on object-oriented Re-engineering, http://loose.upt.ro/download/papers/TrifuEtAl.pdf Accessed 31 December 2007

Turner, C. (2003) Issues in the mass-market deployment of broadband: An analysis of British Telecommunications' (BT) strategy, the journal of policy, regulation and strategy for telecommunications, Emerald Group Publishing Limited. Volume 5, No. 2, pp. 3 – 6.

Turner, M., Traynor, M. and Smith, H. (2003) UK E-commerce liability: Ignorance is bliss. Computer Law & Security Report, Volume 19, Issue 2, pp. 112-120.

UK-bug (2004) Broadband Prices Still Too High http://www.uk-bug.net/Article461.html Accessed 21 March 2004

UK Broadband Task Force (2003) Public Sector Funding: A Guide. http://www.telematicseast.org.uk/eetdt/documents/BTF_Funding_Guidance.pdf Accessed 21 December 2007

UK Online (2002) The broadband future: An action plan to facilitate rollout of higher bandwidth and broadband services, http://www.e-envoy.gov.uk/publications/reports/broadband/finalrep.doc Accessed 15 May 2004

UK Online (2007) Broadband reliability 'preferred over speed' http://www.broadband-finder.co.uk/news/uk-online/broadband-reliability-preferred-over-speed_18387525.html Accessed 1 June 2008

Umino, A. (2002) Broadband Infrastructure deployment: The role of Government Assistance, http://www.olis.oecd.org Accessed 14 January 2005

Varghese Panicker, K.K, Siva Ram Murthy, C. and Mittal, R. (1999) An improved scheme for self-healing in ATM networks. Computer Communication, Volume 22, Issues 15-16, pp.1400-1414.

Varvasovszky, Z and Ruairi, B. (2000) A stakeholder analysis, how to do (not to do), Oxford University Press, Volume 15, Issue 3, pp. 338-345.

Velez, J., Lourenco, A., Pechirra, C. and Almeida, L. (2001) Broadband Access Technologies. Workshop on Universal Accessibility of Ubiquitous Computing (WUACAC), Proceedings of the 2001 EC/NSF workshop on Universal accessibility of ubiquitous computing: providing for the elderly, Alcacer do Sal, Portugal, ACM 1-58113-424-X/01/005, pp. 56–61.

Veres, A. and Boda, M. (2000) The chaotic nature of TCP congestion control. Proceeding of IEEE INFOCOM, Volume 3, pp. 1715 – 1723.

Vicomsoft (2000) DSL Q&A , http://www.vicomsoft.com/knowledge/reference/xdsl1.html, Accessed 15 June 2004

Vicomsoft (2002) DSL Q&A Part 2 http://www.vicomsoft.com/knowledge/pdfs/dsl2_qa.pdf Accessed 15 June 2004

Vogel, A., Kerherve, B., Bochmann, G.A, S. V., and Gecsei, J. (1994) Distributed multimedia applications and quality of service –A survey, IBM Centre for Advanced Studies Conference Proceedings of the 1994 conference of the Centre for Advanced Studies on Collaborative research, pp. 71

Wada, M., Hashimoto, T., Matsumura, Y., Takeda, H., Matsuda, T., Komori, M., Takahashi, T., Minato, K. and Tokutomi, Y. (2003) Teleconference system composed of super-high-definition image system and B-ISDN, Systems and Computers in Japan, (USA), Volume 34, No 1, pp. 98 – 109.

Wakefield, J. (2004) Broadband soars in 2004. BBC News, UK Edition, http://www.news.bbc.co.uk/1/hi/technology/4099457, Accessed 2 February 2005

Walsham, G. (1995) The Emergence of Interpretivism in IS research, Information systems research, Volume 6, Issue 4, pp. 376 – 394.

Wang, H., Yang, Y.R., Liu, P.H., Wang, J., Gerber, A. and Greenberg (2007) Reliability as an interdomain service, ACM SIGCOMM Computer Communication Review, Volume 37, Issue 4, pp. 229 - 240

Wang, S.Y., Meyer, S.E., Ming Yee Lai (1996) Quality of Service (QoS) for Residential Broadband Video Service, Global Telecommunications Conference. GLOBECOM '96, Communications: The Key to Global Prosperity, Volume 3, 18-22, pp. 1949 – 1953.

WATIAC (Western Australian Technology & Industry Advisory Council) (2003) Enabling a Connected Community: Developing broadband Infrastructure and Services in Western Australia, http://www.wa.gov.au/tiac , Accessed 22 October, 2004

Wearden, G. (2002) Broadband Britain 'must follow Korea path. ZDNet UK. http://news.zdnet.co.uk/Internet/0,39020369,2123734,00.htm Accessed 09 April 2004

Website Optimization (2006) China to Pass US in Total Broadband Lines - UK Broadband to Double by 2008 - US Broadband Penetration Jumps to 76.3% Among Active Internet Users - October 2006 Bandwidth Report, http://www.websiteoptimization.com/bw/0610/ Accessed June, 2007

Wheeler, S. and Duggins, S. (1998) Improving software quality, ACM southeast Regional Conference, Proceedings of the 36th annual southeast regional conference, pp. 300 – 309.

Whitman, B. (2005) Global FTTH Risks and Reward, Corning, http://www.corning.com/docs/opticalfiber/cm6325.pdf Accessed 4 June 2008

Witowsky, B. (2004) A vision for the broadband Network, Proceedings of the 17th International Conference on VLSI Design, pp. 373

Wood, M., Daly, J., Miller, J. and Roper, M. (1999) Multi-method research: An empirical investigation of object-oriented technology, Journal of systems and software, Elsevier, Volume 48, issue 1, pp. 13 - 26

Wu, I. (2004) Canada, South Korea, Netherlands and Sweden: regulatory implications of the convergence of telecommunications, broadcasting and Internet, Telecommunications policy, Volume 28, pp. 79 – 96.

Xavier, P. (1997) Price setting and regulation for telecommunication in the absence of reliable and detailed cost information, Telecommunication Policy, Volume 21, Issue 3, pp. 213 – 233.

Xiangwan, L. and Xiongjian, L. (2003) KT's Broadband Business Experience and Key Success Factor, Proceeding of ICCT 2003, Volume 1, Issue 9-11, pp. 118 – 122.

Xin, Y., Tian, Z. and Liu, X. (2002) Capture the future of the Internet: broadband development in China pp. 216 – 226 http://www.mmd.eng.cam.ac.uk Accessed 24 February 2005

Yaiche, H., Mazumbar, R.R. and Rosenberg, C. (2000) A game theoretic framework for bandwidth allocation and pricing in broadband networks, IEEE/ACM Transactions on networking, Volume 8, No. 5, pp. 667 – 678.

Yiannakos, A.E. (1984) Quality assurance and quality control in the software development process, ACM SIGSOFT Software Engineering Notes, Volume 9, Issue 2, pp. 130 – 132.

Yoshida, N., Hayashi, Y. Tamagaki, Y., Urashita, S., Kakuta, M. Watanabe, M., Garrigue, J. and Nakajima, R. (2005) SOBA Framework: An Application Framework for Broadband Network Environment, Proceedings of the 2005 Symposium on Applications and the Internet (SAINT'05), IEEE Computer society, Volume 00, Pages: 296 – 303.

Yun, K., Lee, H. and Lim, S. (2002) The Growth of Broadband Internet Connections in South Korea: Contributing Factors, Asia-Pacific Center , Stanford Institute for International studies, http://aparc.stanford.edu/publications/20032/yun.pdf, Accessed 15 December, 2005

Zahariadis, T., Pramataris, K. and Zervos, N. (2002) A comparison of competing broadband in-home technology, Electronic and Communication Engineering Journal, Volume 14, Issue 4, pp. 133 – 142.

Zanthus (2003) Broadband Service Delivery: Is Speed killing Customer Satisfaction. Micro-report,

http://wp.bitpipe.com/resource/org_1021653349_762/SupportSoft__BitPipe_BroadbandWhitePaper_bpx.pdf, Accessed 11 May 2004

Zhu, A. (2004) Analysis of queuing policies in QoS switches", Journal of Algorithms, Volume 53, Issue 2, pp. 137-168.

Zulkernine, M. and Seviora, R. (2005) Towards automatic monitoring of component-based software systems, Journal of Systems and Software, Volume 74, Issue 1, pp. 15-24.

# Appendix 1: The Survey questionnaire

**School of Information Systems, Computing & Mathematics**
**Brunel University**
**Uxbridge. Middlesex. UB8 3PH**

Brunel UNIVERSITY WEST LONDON

Dear Sir/Madam,

You are kindly requested to participate in this nationwide survey being conducted by Mrs Elizabeth Enabulele, a PhD candidate under the supervision of Dr. George Ghinea of School of Information Systems, Computing and Mathematics, Brunel University.
The aim of this research is to investigate broadband quality from your broadband service provider based on users' perception in the UK". The questionnaire consists of a number of questions that should take approximately 20 minutes to complete. Please tick all appropriate answers. If your answer is not displayed, then please state your answer in the "other" option category. Participation is voluntary. You may omit any questions that you do not wish to answer. Data will be kept with the investigator and supervisor and will be destroyed after completion of this dissertation. Included in this package is a self addressed returned envelope. I would encourage you to process this questionnaire at your earliest convenience.

If you have any questions about this study, please contact the investigators on the following address: **Mrs. Elizabeth Enabulele**, **PhD Student**, School of Information Systems, Computing and Mathematics, Brunel University, Uxbridge, Middlesex UB8 3PH, United Kingdom, email: Elizabeth.Enabulele@brunel.ac.uk, phone: 07956970202. To confirm the validity of this research, you may contact Dr. Ghinea at the following address: **Dr. George Ghinea**, School of Information Systems, Computing and Mathematics, Brunel University, Uxbridge, Middlesex, UB8 3PH, UK. Email: George.Ghinea@brunel.ac.uk

Thank you, for participating, I understand that your time is extremely precious.

Yours Faithfully,

Elizabeth Enabulele

**Note: Broadband** refers to a high speed, always on and un-metered Internet connection. The offered speed is above 256 Kilobits per second. **The term un-metered** refers to a fixed subscription fee and **metered** means cost per usage.

## Broadband quality Survey

**The following questionnaire is designed to gather information regarding the perceptive of users on broadband quality from their various service providers. Please note that all information collected is used for this research purpose only.**

**SECTION A**

**1. Borough**

**SECTION B**

**2. Age Range** *(Please select relevant answer)*

☐ Under 16 years ☐ 17-23 years ☐ 24 – 34 years ☐ 35 – 44 years ☐ 45 -55 years
☐ 56 – 70 years ☐ Over 70 years

**3. Sex** *(Please select one relevant answer)*

☐ Male ☐ Female

**4. What is your occupation?**

☐ Directors, doctors, lawyers, professors ☐ Electricians, mechanics, plumbers and other craft)

☐ Managers, teachers, computer Programmers ☐ Machine operators, assembly, cleaning

☐ Foremen, shop assistants, office workers ☐ Pensioners, casual workers,

☐ Unemployed ☐ Student

☐ Others (Please specify)…

**5. What is your household's annual income?**

☐ <10, 000 (£) ☐ 10,000-19,999(£) ☐ 20,000-29,999 (£) ☐ 30,000-39,999 (£) ☐ 40,000-49,999(£)

☐ 50,000-59,999(£) ☐ 60,000-69,999 (£) ☐ 70,000-79,999 (£) ☐ 80,000-89,999 (£) ☐ 90,000-99,999(£)

☐ > 100,000 (£)

**6. Do you have access to the Internet at home?**

☐ Yes ☐ No ***(If no would you like to have access to the Internet)***

**7. Where else do you access the Internet?**

☐ Office ☐ Library ☐ Internet café ☐ University or college ☐ Mobile Access

**8. How do you connect to the Internet at home?**

☐ Broadband ***(Please proceed to section D)***

☐ Dial-up modem ***(Please go to question 10)***

**9. Are you able to receive broadband at home?**

☐ Yes
☐ No If No, why? ***(Please list 3 main reasons why you haven't taken up broadband)***

☐ Don't Know

**(Thank you for completing this questionnaire)**

**SECTION C**

**10. What is your organisation's primary business activity?**

- ☐ Government agency
- ☐ Agriculture, Mining, Oil
- ☐ Transportation
- ☐ Engineering / Architecture
- ☐ Other *(Please specify)*
- ☐ Gaming Company
- ☐ University or college
- ☐ Finance, Banking, Accounting, Insurance, Real Estate
- ☐ Health, Medical Services, Legal
- ☐ Education
- ☐ Communications
- ☐ Research / Development
- ☐ Internet / e-commerce

**11. How old is your organisation?**

- ☐ Less than 5 years
- ☐ 6 – 10 years
- ☐ 11 – 25 years
- ☐ Over 26 years

**12. Approximately how many people are in your organisation?**

- ☐ Less than 100
- ☐ 100 – 499
- ☐ 500 – 1000
- ☐ More than 1000

**SECTION D**

**13. Who is your service provider?**

**14. How much do you pay for your broadband connection per month?**

- ☐ £10.00 - £15.99
- ☐ £16.00 - £20.99
- ☐ £21.00 - £25.99
- ☐ £26.00 – £30.99
- ☐ £31.00 - £34.99
- ☐ £35.00 - £40.99
- ☐ £41.00 - £50.99
- ☐ £51.00 - £99.99
- ☐ £100.00 - £199.99
- ☐ Over £200.00

**15. How would you describe the type of broadband access to the Internet you have?**

- ☐ Broadband with **DSL/ADSL**
- ☐ Broadband with **CABLE MODEM**
- ☐ Wireless
- ☐ Other (Please specify)

**16. How do you describe your broadband connection speed?**

- ☐ <256Kbps
- ☐ 512Kbps
- ☐ 1Mbps
- ☐ 2Mbps
- ☐ 2Mbps – 4Mbps
- ☐ Other (Please specify)

**17. How long have you had broadband?**

- ☐ Less than 12 months
- ☐ 12 – 24 months
- ☐ 25 – 36 months
- ☐ More than 36 months
- ☐ Others ***(Please specify)***

**18. How often do you access the Internet using broadband?**

- ☐ Once a day
- ☐ Several times a day
- ☐ 1-2 days a week
- ☐ 3 – 5 days a week
- ☐ More than 5 days a week
- ☐ Once every few weeks
- ☐ Once a month

**19. How long does you/your organisation spends on the Internet at any session?**

- ☐ Less than ½ hour
- ☐ ½-1 hour
- ☐ 1- 2 hours
- ☐ 3- 4 hours
- ☐ 4 -5 hours
- ☐ 6- 7 hours
- ☐ 7- 8 hours
- ☐ Over 8 hours

**20. What do you do when you go on the Internet?** ***(Select as many that applies)***

- ☐ Download games
- ☐ Video (Download/ streaming)
- ☐ Watch movies (downloading/streaming)
- ☐ Purchase a product
- ☐ Online lectures
- ☐ Online Chat
- ☐ Research for school or training
- ☐ Store files on the Internet
- ☐ Online gaming
- ☐ Video conferencing
- ☐ Free software
- ☐ Play lottery
- ☐ Download Pictures
- ☐ Online News
- ☐ Look for product info
- ☐ Listen to music (streaming/MP3)
- ☐ Voice over IP
- ☐ Online banking
- ☐ Online share trading
- ☐ Web surfing
- ☐ Email
- ☐ Job related research
- ☐ Medical information
- ☐ Purchase a travel service

☐ Purchase groceries (household goods) ☐ Online auctions e.g. e-bay ☐ View or visit Adult content Websites
☐ Collaboration with schoolmates ☐ Online dating ☐ Share files
☐ Others ☐ Book Holidays

**21. How often do you download from the Internet?**
☐ Once a day ☐ Several times a day ☐ 1-2 days a week
☐ 3 – 5 days a week ☐ More than 5 days a week ☐ Once every few weeks
☐ Once a month

**22. How many times a year, do you seek technical support on your broadband connection from your service provider?**
☐ Once a week ☐ More than once a week ☐ Once a month ☐ More than Once a month
☐ Every Quarter ☐ More than once a year ☐ Once a year ☐ Never

**23. By which means do you call for technical support from your service provider?**
☐ By phone ☐ Visit the ISP Website ☐ By Email
☐ Online chat/Forum ☐ Never asked for technical support ☐ Others ***(Please specify)***

**24. How many times did you contact your service provider to get a particular problem resolved?**
☐ Once ☐ Twice ☐ 3 times ☐ 4 times ☐ Over 5 times ☐ Never

**25. How long did you have to wait for in order to get your ISP customer service technical representative to resolve the problem?**
☐ <5 minutes ☐ 10 minutes ☐ 10-30 minutes ☐ 31 – 59 minutes
☐ 1 hour – 2 hours ☐ 2 – 4 hours ☐ 4 – 8 hours ☐ 24 hours
☐ 2 - 3days ☐ 3 – 5 days ☐ 1 week ☐ 2 weeks
☐ Others ***(Please specify*** .....

**26. Were you happy with the way problem was resolved**
☐ Yes ☐ No, If No, Give reason ☐ N/A

**27. Were you provided with clear information about your connection before you signed a contract with your service provider?**
☐ Yes ☐ No, If No, explain

**28. How do you rate the clarity of information?**
☐ Very poor ☐ Somewhat Unsatisfactory ☐ Above Average ☐ Very Satisfactory
☐ Excellent

**29. In thinking about the most recent experience with your ISP, how was the quality of the customer service you receive?**
☐ Very poor ☐ Somewhat Unsatisfactory ☐ Above Average ☐ Very Satisfactory
☐ Excellent
*If you selected unsatisfactory, please describe what happen.*

**30. Overall, the value of the ISP services compared with the price paid is**
***(Please select one that applies)***
☐ Excellent ☐ Very Good ☐ Good ☐ Fair ☐ Poor

**31. Are you happy with your service provider?**
☐ Yes ☐ No, If no why ***(please list three main reasons)***

**32. Would you recommend your ISP services to colleagues or contacts within your industry?**
☐ Yes ☐ No

## SECTION E

**The following statements represent your perception of broadband quality based on number variables so it is all right to rate them accurately as much as you can.**

| **Awareness** | **Strongly disagree** | **Quite disagree** | **Slightly disagree** | **Neutral** | **Slightly Agree** | **Quite agree** | **Strongly Agree** |
|---|---|---|---|---|---|---|---|
| I am computer literate | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| I am not good at using computers | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| I find reading technical instructions difficult | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| I prefer instructions with illustrations easier | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| I have installed computer software before | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| I find it difficult to install software even with instructions | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| I found the installation of my broadband software easy | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| I would feel comfortable using the broadband to access the Internet on my own | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| I obtained satisfactory customer/technical support from my current service providers | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

| **Services 1** | **Strongly disagree** | **Quite disagree** | **Slightly disagree** | **Neutral** | **Slightly Agree** | **Quite agree** | **Strongly Agree** |
|---|---|---|---|---|---|---|---|
| I am satisfied with the speed of broadband obtained from my current service provider | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| I am not satisfied with the design of my current service provider web page | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| It takes along time to download from my broadband connection | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| I am satisfied with the security measures provided with broadband access obtained from my current service providers | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| The customer service representative handled my call quickly | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| The customer representative was very knowledgeable | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| The customer service representative was courteous | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| The waiting time for having my questions addressed was satisfactory | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| The automated phone system made the customer service experience more satisfying | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| I am happy with the overall customer satisfaction with ISP Technical Support | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| My phone call was quickly transferred to the person who best could answer my question | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| I am happy with the speed of response in handling request | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

| **Service 2** | **Strongly disagree** | **Quite disagree** | **Slightly disagree** | **Neutral** | **Slightly agree** | **Quite agree** | **Strongly Agree** |
|---|---|---|---|---|---|---|---|
| I intend to continue my current broadband subscription | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| I have considered moving my subscription to another service provider | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| I am not happy with my service provider | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| I would recommend my service provider to my friends | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

| | **Very dissatisfied** | **Fairly dissatisfied** | **Slightly dissatisfied** | **Neutral** | **Slightly satisfied** | **Fairly satisfied** | **Very satisfied** |
|---|---|---|---|---|---|---|---|
| The overall service quality of my current Internet connection is satisfactory | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

| **Usability** | **Strongly disagree** | **Quite disagree** | **Slightly disagree** | **Neutral** | **Slightly agree** | **Quite agree** | **Strongly Agree** |
|---|---|---|---|---|---|---|---|
| I use broadband to listen to and download music | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| I enjoy using broadband to watch and download movies | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| I enjoy using broadband to play online games | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| I use broadband connection for video conferencing | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| I am satisfied with the quality of multimedia presentation | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| I am able to understand the information content of multimedia display on my broadband connection | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| My broadband connection is very reliable | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| I find that my broadband connection is always breaking | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

| **Price** | | | | | | | |
|---|---|---|---|---|---|---|---|
| It is costly for me to subscribe to broadband at its current subscription fee | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| My service provider offers good value for money | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| The broadband prices offered by service providers is expensive | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

| **Government** | | | | | | | |
|---|---|---|---|---|---|---|---|
| I believe the UK government should promote broadband more | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| I expect that the government should subsidise broadband prices | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

**Thank you once again for your valuable time and patience for completing this questionnaire!**

# Appendix 2: The Survey results Analysed

**Survey questionnaire**

| | | |
|---|---|---|
| Survey questionaires received | 133 | 66.5 |
| Survey questionnaires not received | 67 | 33.5 |
| Total of number of questionnaires | 200 | 100% |

**Age Range of respondents**

| Age range | No. of respondents | Percentage of respondents (%) |
|---|---|---|
| Under 16 years | 2 | 1.50 |
| 17-23 years | 11 | 8.27 |
| 24 – 34 years | 51 | 38.35 |
| 35 – 44 years | 57 | 42.86 |
| 45 -55 years | 9 | 6.77 |
| 56 – 70 years | 3 | 2.26 |
| Over 70 years | | |
| **Total** | **133** | **100%** |

**Sex of respondents**

| Sex | No. of respondents | Percentage of respondents (%) |
|---|---|---|
| Male | 80 | 60.15 |
| Female | 53 | 39.85 |
| **Total** | **133** | **100%** |

**What is your occupation?**

| Occupation | No. of respondents | Percentage of respondents (%) |
|---|---|---|
| Directors, doctors, lawyers, professors | 14 | 10.53 |
| Electricians, mechanics, plumbers and other craft) | 5 | 3.76 |
| Managers, teachers, computer Programmers | 49 | 36.84 |
| Machine operators, assembly, cleaning | 5 | 3.76 |
| Foremen, shop assistants, office workers | 16 | 12.03 |
| Pensioners, casual workers | 1 | 0.75 |
| Unemployed | 2 | 1.50 |
| Student | 24 | 18.05 |
| Others (Please specify)… | 14 | 10.53 |
| Unanswered | 3 | 2.26 |
| **Total** | **133** | **100%** |

**What is your household's annual income?**

| Income | No. of respondents | Percentage of respondents (%) |
|---|---|---|
| <10, 000 (£) | 18 | 13.53 |
| 10,000-19,999(£) | 23 | 17.29 |
| 20,000-29,999 (£) | 22 | 16.54 |
| 30,000-39,999 (£) | 13 | 9.77 |
| 40,000-49,999(£) | 13 | 9.77 |
| 50,000-59,999(£) | 16 | 12.03 |
| 60,000-69,999 (£) | 2 | 1.51 |
| 70,000-79,999 (£) | 5 | 3.76 |
| 80,000-89,999 (£) | 3 | 2.26 |
| 90,000-99,999(£) | 4 | 3.01 |
| > 100,000 (£) | 4 | 3.01 |
| Unanswered | 10 | 7.52 |
| **Total** | **133** | **100%** |

**Do you have access to the Internet at home?**

| Responses | No. of respondents | Percentage of respondents (%) |
|---|---|---|
| Yes | 122 | 91.73 |
| No | 11 | 8.27 |
| **Total** | **133** | **100%** |

**Where else do you access the Internet?**

| Location | Office | Library | Internet café | University or college | Mobile Access |
|---|---|---|---|---|---|
| **No. of respondents** | 84 | 38 | 38 | 26 | 13 |

**How do you connect to the Internet at home?**

| Connection type | No. of respondents | Percentage of respondents (%) |
|---|---|---|
| Broadband | 95 | 71.4 |
| Dial-up modem | 38 | 28.6 |
| **Total** | **133** | **100%** |

**Are you able to receive broadband at home? (Response from those who use dial-up)**

| Responses | No. of respondents | Percentage of respondents (%) |
|---|---|---|
| Yes | 23 | 60.53 |
| No | 6 | 15.79 |
| Don't Know | 9 | 23.68 |
| **Total number of those who use dial-up** | **38** | **100%** |

**Who is your service provider?**

| Name of service provider | No. of respondents | Percentage of respondents (%) |
|---|---|---|
| AOL | 15 | 11.28 |
| BT broadband | 36 | 27.07 |
| Bull dog | 4 | 3.01 |
| Firefly | 1 | 0.75 |
| Freedom | 4 | 3.01 |
| Freeline.net | 1 | 0.75 |
| NILDRAM | 2 | 1.50 |
| Virgin Media | 17 | 12.78 |
| PIPEX | 1 | 0.75 |
| PLUSNET | 2 | 1.50 |
| TALK TALK | 1 | 0.75 |
| Tiscali | 6 | 4.51 |
| Orange | 2 | 1.50 |
| Others | 41 | 30.83 |
| **Total** | **133** | **100%** |

**How much do you pay for your broadband connection per month?**

| Broadband Subscription price paid | No. of respondents | Percentage of respondents (%) |
|---|---|---|
| £10.00 - £15.99 | 29 | 30.53 |
| £16.00 - £20.99 | 38 | 40 |
| £21.00 - £25.99 | 14 | 14.74 |
| £26.00 – £30.99 | 6 | 6.32 |
| £31.00 - £34.99 | 1 | 1.05 |
| £35.00 - £40.99 | 2 | 2.10 |
| £41.00 - £50.99 | - | - |
| £51.00 - £99.99 | - | - |
| £100.00 - £199.99 | - | - |
| Over £200.00 | - | - |
| Unanswered | 5 | 5.26 |
| **Total** | **95** | **100%** |

**How would you describe the type of broadband access to the Internet you have?**

| | | |
|---|---|---|
| Broadband with **DSL/ADSL** | 66 | 69 |
| Broadband with **CABLE MODEM** | 21 | 22 |
| Wireless | 3 | 3 |
| Other | 1 | 2 |
| Unanswered | 4 | 4 |
| **Total** | **95** | **100%** |

**How do you describe your broadband connection speed?**

| | | |
|---|---|---|
| <256Kbps | 6 | 6.32 |
| 512Kbps | 23 | 24.21 |
| 1Mbps | 29 | 30.53 |
| 2Mbps | 12 | 12.63 |
| 2Mbps – 4Mbps | 7 | 7.37 |
| 5Mbps – 10Mbps | 9 | 9.47 |
| Other | 1 | 1.05 |
| Unanswered | 8 | 8.42 |
| **Total** | **95** | **100%** |

**How long have you had broadband?**

| | | |
|---|---|---|
| Less than 12 months | 47 | 49.47 |
| 12 – 24 months | 31 | 32.63 |
| 25 – 36 months | 4 | 4.21 |
| More than 36 months | 10 | 10.53 |
| Unanswered (UA) | 3 | 3.16 |
| **Total** | **95** | **100%** |

**How often do you access the Internet using broadband?**

| | | |
|---|---|---|
| Once a day | 12 | 12.63 |
| Several times a day | 66 | 69.47 |
| 1-2 days a week | 6 | 6.32 |
| 3 – 5 days a week | 2 | 2.11 |
| More than 5 days a week | 6 | 6.32 |
| Once every few weeks | | |
| Once a month | | |
| Unanswered (UA) | 3 | 3.16 |
| **Total** | **95** | **100%** |

**How long do you/your organisations spend on the Internet at any session?**

| | | |
|---|---|---|
| Less than ½ hour | 2 | 2.11 |
| ½-1 hour | 20 | 21.05 |
| 1- 2 hours | 28 | 29.47 |
| 3- 4 hours | 18 | 18.95 |
| 4 -5 hours | 6 | 6.32 |
| 6- 7 hours | 2 | 2.11 |
| 7- 8 hours | 5 | 5.26 |
| Over 8 hours | 8 | 8.42 |
| Unanswered (UA) | 6 | 6.32 |
| **Total** | **95** | **100%** |

**What do you do when you go on the Internet?** ***(Select as many that applies)***

| **Activity on the Internet** | **Number of respondents** |
|---|---|
| Download games | 21 |
| Online gaming | 13 |
| Voice over IP | 12 |
| Video (Download/ streaming) | 23 |
| Video conferencing | 7 |
| Online banking | 55 |
| Watch movies (downloading/streaming) | 19 |
| Free software | 38 |
| Online share trading | 8 |
| Purchase a product | 56 |
| Play lottery | 5 |
| Web surfing | 59 |
| Online lectures | 13 |
| Download Pictures | 15 |
| Email | 86 |
| Online Chat | 35 |
| Online News | 47 |
| Job related research | 55 |
| Research for school or training | 37 |
| Look for product info | 44 |
| Medical information | 30 |
| Store files on the Internet | 22 |
| Listen to music (streaming/MP3) | 46 |
| Purchase a travel service | 21 |
| Purchase groceries (household goods) | 24 |
| Online auctions e.g. e-bay | 34 |
| View or visit Adult content Websites | 5 |
| Collaboration with schoolmates | 8 |
| Online dating | 5 |
| Share files | 18 |
| Book Holidays | 11 |
| Others | 35 |
| UA | 8 |

**How often do you download from the Internet?**

| | | |
|---|---|---|
| Once a day | 11 | 11.58 |
| Several times a day | 24 | 25.26 |
| 1-2 days a week | 30 | 31.58 |
| 3 – 5 days a week | 3 | 3.16 |
| More than 5 days a week | 1 | 1.05 |
| Once every few weeks | 16 | 16.84 |
| Once a month | 7 | 7.37 |
| UA | 3 | 3.16 |
| **Total** | **95** | **100%** |

**How many times a year, do you seek technical support on your broadband connection from your service provider?**

| | | |
|---|---|---|
| Once a week | 3 | 3.16 |
| More than once a week | 2 | 2.11 |
| Once a month | 6 | 6.32 |
| More than Once a month | 3 | 3.16 |
| Every Quarter | 7 | 7.37 |
| More than once a year | 21 | 22.11 |
| Once a year | 10 | 10.53 |
| Never | 38 | 40 |
| Unanswered | 5 | 5.26 |
| **Total** | **95** | **100%** |

**By which means do you call for technical support from your service provider?**

| | | |
|---|---|---|
| By phone | 62 | 65.26 |
| Visit the ISP Website | 1 | 1.05 |
| By Email | 1 | 1.05 |
| Online chat/Forum | 1 | 1.05 |
| Never asked for technical support | 19 | 20 |
| Others | 2 | 2.11 |
| Unanswered | 9 | 9.47 |
| **Total** | **95** | **100%** |

**How many times did you contact your service provider to get a particular problem resolved?**

| | | |
|---|---|---|
| Once | 30 | 31.58 |
| Twice | 11 | 11.58 |
| 3 times | 9 | 9.47 |
| 4 times | 6 | 6.32 |
| Over 5 times | 5 | 5.26 |
| Never | 22 | 23.16 |
| Unanswered | 12 | 12.63 |
| **Total** | **95** | **100%** |

**How long did you have to wait for in order to get your ISP customer service technical representative to resolve the problem?**

| | | |
|---|---|---|
| <5 minutes | 8 | 8.42 |
| 10 minutes | 12 | 12.63 |
| 10-30 minutes | 17 | 17.89 |
| 31 – 59 minutes | 7 | 7.37 |
| 1 hour – 2 hours | 5 | 5.26 |
| 2 – 4 hours | | |
| 4 – 8 hours | 1 | 1.05 |
| 24 hours | 6 | 6.32 |
| 2 - 3days | | |
| 3 – 5 days | | |
| 1 week | 3 | 3.16 |
| 2 weeks | 7 | 7.37 |
| Others | 5 | 5.26 |
| Unanswered | 24 | 25.26 |
| **Total** | **95** | **100%** |

**Were you happy with the way problem was resolved**

| | | |
|---|---|---|
| Yes | 52 | 54.74 |
| No | 15 | 15.79 |
| N/A | 20 | 21.05 |
| Unanswered | 8 | 8.42 |
| **Total** | **95** | **100%** |

**Were you provided with clear information about your connection before you signed a contract with your service provider?**

| | | |
|---|---|---|
| Yes | 72 | 75.79 |
| No | 12 | 12.63 |
| Unanswered | 11 | 11.58 |
| **Total** | **95** | **100%** |

**How do you rate the clarity of information?**

| Response | No of respondents | Percentage of respondents |
|---|---|---|
| Very poor | 6 | 6.32 |
| Somewhat Unsatisfactory | 10 | 10.53 |
| Above Average | 39 | 41.05 |
| Very Satisfactory | 34 | 35.79 |
| Excellent | 1 | 1.05 |
| Unanswered | 5 | 5.26 |
| **Total** | **95** | **100%** |

**In thinking about the most recent experience with your ISP, how was the quality of the customer service you receive?**

| Response | No of respondents | Percentage of respondents |
|---|---|---|
| Very poor | 7 | 7.37 |
| Somewhat Unsatisfactory | 12 | 12.63 |
| Above Average | 30 | 31.58 |
| Very Satisfactory | 32 | 33.68 |
| Excellent | 6 | 6.32 |
| Unanswered | 8 | 8.42 |
| **Total** | **95** | **100%** |

**Overall, the value of the ISP services compared with the price paid is**

| | | |
|---|---|---|
| Excellent | 10 | 10.53 |
| Very Good | 14 | 14.74 |
| Good | 41 | 43.16 |
| Fair | 26 | 27.37 |
| Poor | | |
| Unanswered | 4 | 4.21 |
| **Total** | **95** | **100%** |

**Are you happy with your service provider?**

| | | |
|---|---|---|
| Yes | 78 | 82.11 |
| No | 13 | 13.68 |
| Unanswered | 4 | 4.21 |
| **Total** | **95** | **100%** |

**Would you recommend your ISP services to colleagues or contacts within your industry?**

| | | |
|---|---|---|
| Yes | 76 | 80 |
| No | 16 | 16.84 |
| Unanswered | 3 | 3.16 |
| **Total** | **95** | **100%** |

## Awareness

**I am computer literate**

| Response | No of respondents | Percentage of respondents |
|---|---|---|
| Strongly disagree | 2 | 2.11 |
| Quite disagree | | |
| Slightly disagree | 3 | 3.16 |
| Neutral | 2 | 2.11 |
| Slightly Agree | 6 | 6.32 |
| Quite agree | 13 | 13.68 |
| Strongly Agree | 58 | 61.05 |
| Unanswered | 11 | 11.58 |
| **Total** | **95** | **100%** |

**I am not good at using computers**

| Response | No of respondents | Percentage of respondents |
|---|---|---|
| Strongly disagree | 56 | 58.95 |
| Quite disagree | 19 | 20 |
| Slightly disagree | 4 | 4.21 |
| Neutral | | |
| Slightly Agree | | |
| Quite agree | 4 | 4.21 |
| Strongly Agree | 5 | 5.26 |
| Unanswered | 7 | 7.37 |
| **Total** | **95** | **100%** |

**I find reading technical instructions difficult**

| Response | No of respondents | Percentage of respondents |
|---|---|---|
| Strongly disagree | 47 | 49.47 |
| Quite disagree | 15 | 15.79 |
| Slightly disagree | 7 | 7.37 |
| Neutral | 11 | 11.58 |
| Slightly Agree | 3 | 3.16 |
| Quite agree | 1 | 1.05 |
| Strongly Agree | 4 | 4.21 |
| Unanswered | 7 | 7.37 |
| **Total** | **95** | **100%** |

**I prefer instructions with illustrations easier**

| Response | No of respondents | Percentage of respondents |
|---|---|---|
| Strongly disagree | 4 | 4.21 |
| Quite disagree | 6 | 6.32 |
| Slightly disagree | 6 | 6.32 |
| Neutral | 15 | 15.79 |
| Slightly Agree | 12 | 12.63 |
| Quite agree | 14 | 14.74 |
| Strongly Agree | 29 | 30.53 |
| Unanswered | 9 | 9.47 |
| **Total** | **95** | **100%** |

**I have installed computer software before**

| Response | No of respondents | Percentage of respondents |
|---|---|---|
| Strongly disagree | 4 | 4.21 |
| Quite disagree | 1 | 1.05 |
| Slightly disagree | 1 | 1.05 |
| Neutral | 3 | 3.16 |
| Slightly Agree | 5 | 5.26 |
| Quite agree | 12 | 12.63 |
| Strongly Agree | 60 | 63.16 |
| Unanswered | 9 | 9.47 |
| **Total** | **95** | **100%** |

## Awareness contd.

**I find it difficult to install software even with instructions**

| Response | No of respondents | Percentage of respondents |
|---|---|---|
| Strongly disagree | 43 | 45.26 |
| Quite disagree | 17 | 17.89 |
| Slightly disagree | 4 | 4.21 |
| Neutral | 4 | 4.21 |
| Slightly Agree | 3 | 3.16 |
| Quite agree | 2 | 2.11 |
| Strongly Agree | 11 | 11.58 |
| Unanswered | 11 | 11.58 |
| **Total** | **95** | **100%** |

**I found the installation of my broadband software easy**

| Response | No of respondents | Percentage of respondents |
|---|---|---|
| Strongly disagree | 2 | 2.11 |
| Quite disagree | 2 | 2.11 |
| Slightly disagree | 2 | 2.11 |
| Neutral | 9 | 9.47 |
| Slightly Agree | 9 | 9.47 |
| Quite agree | 17 | 17.89 |
| Strongly Agree | 44 | 46.32 |
| Unanswered | 11 | 11.58 |
| **Total** | **95** | **100%** |

**I would feel comfortable using the broadband to access the Internet on my own**

| Response | No of respondents | Percentage of respondents |
|---|---|---|
| Strongly disagree | | |
| Quite disagree | 4 | 4.21 |
| Slightly disagree | | |
| Neutral | 1 | 1.05 |
| Slightly Agree | 2 | 2.11 |
| Quite agree | 14 | 14.74 |
| Strongly Agree | 66 | 69.47 |
| Unanswered | 8 | 8.42 |
| **Total** | **95** | **100%** |

**I obtained satisfactory customer/technical support from my current service providers**

| Response | No of respondents | Percentage of respondents |
|---|---|---|
| Strongly disagree | 4 | 4.21 |
| Quite disagree | 5 | 5.26 |
| Slightly disagree | 6 | 6.32 |
| Neutral | 16 | 16.84 |
| Slightly Agree | 7 | 7.37 |
| Quite agree | 26 | 27.37 |
| Strongly Agree | 22 | 23.16 |
| Unanswered | 9 | 9.47 |
| **Total** | **95** | **100%** |

**I am satisfied with the speed of broadband obtained from my current service provider**

| Response | No of respondents | Percentage of respondents |
|---|---|---|
| Strongly disagree | 3 | 3.16 |
| Quite disagree | 4 | 4.21 |
| Slightly disagree | 6 | 6.32 |
| Neutral | 8 | 8.42 |
| Slightly Agree | 9 | 9.47 |
| Quite agree | 32 | 33.68 |
| Strongly Agree | 26 | 27.37 |
| Unanswered | 7 | 7.37 |
| **Total** | **95** | **100%** |

## Awareness contd.

**I am not satisfied with the design of my current service provider web page**

| Response | No of respondents | Percentage of respondents |
|---|---|---|
| Strongly disagree | 17 | 17.89 |
| Quite disagree | 21 | 22.11 |
| Slightly disagree | 7 | 7.37 |
| Neutral | 27 | 28.42 |
| Slightly Agree | 11 | 11.58 |
| Quite agree | 5 | 5.26 |
| Strongly Agree | | |
| Unanswered | 7 | 7.37 |
| **Total** | **95** | **100%** |

**It takes along time to download from my broadband connection**

| Response | No of respondents | Percentage of respondents |
|---|---|---|
| Strongly disagree | 29 | 30.53 |
| Quite disagree | 14 | 14.74 |
| Slightly disagree | 16 | 16.84 |
| Neutral | 3 | 3.16 |
| Slightly Agree | 13 | 13.68 |
| Quite agree | 7 | 7.37 |
| Strongly Agree | 8 | 8.42 |
| Unanswered | 5 | 5.26 |
| **Total** | **95** | **100%** |

**I am satisfied with the security measures provided with broadband access obtained from my current service providers**

| Response | No of respondents | Percentage of respondents |
|---|---|---|
| Strongly disagree | 6 | 6.32 |
| Quite disagree | 9 | 9.47 |
| Slightly disagree | 6 | 6.32 |
| Neutral | 21 | 22.11 |
| Slightly Agree | 10 | 10.53 |
| Quite agree | 26 | 27.37 |
| Strongly Agree | 10 | 10.53 |
| Unanswered | 7 | 7.37 |
| **Total** | **95** | **100%** |

**The customer service representative handled my call quickly**

| Response | No of respondents | Percentage of respondents |
|---|---|---|
| Strongly disagree | 4 | 4.21 |
| Quite disagree | 4 | 4.21 |
| Slightly disagree | 6 | 6.32 |
| Neutral | 30 | 31.58 |
| Slightly Agree | 13 | 13.68 |
| Quite agree | 19 | 20 |
| Strongly Agree | 10 | 10.53 |
| Unanswered | 9 | 9.47 |
| **Total** | **95** | **100%** |

**The customer representative was very knowledgeable**

| Response | No of respondents | Percentage of respondents |
|---|---|---|
| Strongly disagree | 1 | 1.05 |
| Quite disagree | 4 | 4.21 |
| Slightly disagree | 8 | 8.42 |
| Neutral | 22 | 23.16 |
| Slightly Agree | 12 | 12.63 |
| Quite agree | 28 | 29.47 |
| Strongly Agree | 8 | 8.42 |
| Unanswered | 12 | 12.63 |
| **Total** | **95** | **100%** |

## Awareness contd.

**The customer service representative was courteous**

| Response | No of respondents | Percentage of respondents |
|---|---|---|
| Strongly disagree | | |
| Quite disagree | 1 | 1.05 |
| Slightly disagree | 4 | 4.21 |
| Neutral | 24 | 25.26 |
| Slightly Agree | 14 | 14.74 |
| Quite agree | 33 | 34.74 |
| Strongly Agree | 7 | 7.37 |
| Unanswered | 12 | 12.63 |
| **Total** | **95** | **100%** |

**The waiting time for having my questions addressed was satisfactory**

| Response | No of respondents | Percentage of respondents |
|---|---|---|
| Strongly disagree | 8 | 8.42 |
| Quite disagree | 3 | 3.16 |
| Slightly disagree | 9 | 9.47 |
| Neutral | 15 | 15.79 |
| Slightly Agree | 17 | 17.89 |
| Quite agree | 27 | 28.42 |
| Strongly Agree | 4 | 4.21 |
| Unanswered | 12 | 12.63 |
| **Total** | **95** | **100%** |

**The automated phone system made the customer service experience more satisfying**

| Response | No of respondents | Percentage of respondents |
|---|---|---|
| Strongly disagree | 10 | 10.53 |
| Quite disagree | 4 | 4.21 |
| Slightly disagree | 11 | 11.58 |
| Neutral | 26 | 27.37 |
| Slightly Agree | 10 | 10.53 |
| Quite agree | 17 | 17.89 |
| Strongly Agree | 3 | 3.16 |
| Unanswered | 14 | 14.74 |
| **Total** | **95** | **100%** |

**I am happy with the overall customer satisfaction with ISP Technical Support**

| Response | No of respondents | Percentage of respondents |
|---|---|---|
| Strongly disagree | 2 | 2.11 |
| Quite disagree | 7 | 7.37 |
| Slightly disagree | 6 | 6.32 |
| Neutral | 25 | 26.32 |
| Slightly Agree | 18 | 18.95 |
| Quite agree | 21 | 22.11 |
| Strongly Agree | 3 | 3.16 |
| Unanswered | 13 | 13.68 |
| **Total** | **95** | **100%** |

**My phone call was quickly transferred to the person who best could answer my question**

| Response | No of respondents | Percentage of respondents |
|---|---|---|
| Strongly disagree | 3 | 3.16 |
| Quite disagree | 4 | 4.21 |
| Slightly disagree | 3 | 3.16 |
| Neutral | 24 | 25.26 |
| Slightly Agree | 22 | 23.16 |
| Quite agree | 21 | 22.11 |
| Strongly Agree | 3 | 3.16 |
| Unanswered | 15 | 15.79 |
| **Total** | **95** | **100%** |

## Awareness contd.

**I am happy with the speed of response in handling request**

| Response | No of respondents | Percentage of respondents |
|---|---|---|
| Strongly disagree | 3 | 3.16 |
| Quite disagree | 5 | 5.26 |
| Slightly disagree | 9 | 9.47 |
| Neutral | 20 | 21.05 |
| Slightly Agree | 19 | 20 |
| Quite agree | 16 | 16.84 |
| Strongly Agree | 9 | 9.47 |
| Unanswered | 14 | 14.74 |
| **Total** | **95** | **100%** |

**I intend to continue my current broadband subscription**

| Response | No of respondents | Percentage of respondents |
|---|---|---|
| Strongly disagree | 5 | 5.26 |
| Quite disagree | 1 | 1.05 |
| Slightly disagree | 3 | 3.16 |
| Neutral | 12 | 12.63 |
| Slightly Agree | 11 | 11.58 |
| Quite agree | 31 | 32.63 |
| Strongly Agree | 21 | 22.11 |
| Unanswered | 11 | 11.58 |
| **Total** | **95** | **100%** |

**I have considered moving my subscription to another service provider**

| Response | No of respondents | Percentage of respondents |
|---|---|---|
| Strongly disagree | 15 | 15.79 |
| Quite disagree | 15 | 15.79 |
| Slightly disagree | 9 | 9.47 |
| Neutral | 16 | 16.84 |
| Slightly Agree | 14 | 14.74 |
| Quite agree | 8 | 8.42 |
| Strongly Agree | 7 | 7.37 |
| Unanswered | 11 | 11.58 |
| **Total** | **95** | **100%** |

**I am not happy with my service provider**

| Response | No of respondents | Percentage of respondents |
|---|---|---|
| Strongly disagree | 22 | 23.16 |
| Quite disagree | 19 | 20 |
| Slightly disagree | 8 | 8.42 |
| Neutral | 10 | 10.53 |
| Slightly Agree | 7 | 7.37 |
| Quite agree | 10 | 10.53 |
| Strongly Agree | 8 | 8.42 |
| Unanswered | 11 | 11.58 |
| **Total** | **95** | **100%** |

**I would recommend my service provider to my friends**

| Response | No of respondents | Percentage of respondents |
|---|---|---|
| Strongly disagree | 3 | 3.16 |
| Quite disagree | 7 | 7.37 |
| Slightly disagree | 4 | 4.21 |
| Neutral | 16 | 16.84 |
| Slightly Agree | 8 | 8.42 |
| Quite agree | 23 | 24.21 |
| Strongly Agree | 23 | 24.21 |
| Unanswered | 11 | 11.58 |
| **Total** | **95** | **100%** |

Awareness contd.

**The overall service quality of my current Internet connection is satisfactory**

| Response | No of respondents | Percentage of respondents |
|---|---|---|
| Very dissatisfied | 2 | 2.11 |
| Fairly dissatisfied | 7 | 7.37 |
| Slightly dissatisfied | 3 | 3.16 |
| Neutral | 8 | 8.42 |
| Slightly satisfied | 15 | 15.79 |
| Fairly satisfied | 31 | 32.63 |
| Very satisfied | 16 | 16.84 |
| Unanswered | 13 | 13.68 |
| **Total** | **95** | **100%** |

## Usability

**I use broadband to listen to and download music**

| Response | No of respondents | Percentage of respondents |
|---|---|---|
| Strongly disagree | 10 | 10.53 |
| Quite disagree | 9 | 9.47 |
| Slightly disagree | 2 | 2.11 |
| Neutral | 5 | 5.26 |
| Slightly Agree | 9 | 9.47 |
| Quite agree | 17 | 17.89 |
| Strongly Agree | 33 | 34.74 |
| Unanswered | 10 | 10.53 |
| **Total** | **95** | **100%** |

**I enjoy using broadband to watch and download movies**

| Response | No of respondents | Percentage of respondents |
|---|---|---|
| Strongly disagree | 17 | 17.89 |
| Quite disagree | 9 | 9.47 |
| Slightly disagree | 4 | 4.21 |
| Neutral | 17 | 17.89 |
| Slightly Agree | 16 | 16.84 |
| Quite agree | 7 | 7.37 |
| Strongly Agree | 15 | 15.79 |
| Unanswered | 10 | 10.53 |
| **Total** | **95** | **100%** |

**I enjoy using broadband to play online games**

| Response | No of respondents | Percentage of respondents |
|---|---|---|
| Strongly disagree | 27 | 28.42 |
| Quite disagree | 12 | 12.63 |
| Slightly disagree | 3 | 3.16 |
| Neutral | 19 | 20 |
| Slightly Agree | 9 | 9.47 |
| Quite agree | 5 | 5.26 |
| Strongly Agree | 9 | 9.47 |
| Unanswered | 11 | 11.58 |
| **Total** | **95** | **100%** |

**I use broadband connection for video conferencing**

| Response | No of respondents | Percentage of respondents |
|---|---|---|
| Strongly disagree | 27 | 28.42 |
| Quite disagree | 10 | 10.53 |
| Slightly disagree | 14 | 14.74 |
| Neutral | 13 | 13.68 |
| Slightly Agree | 3 | 3.16 |
| Quite agree | 8 | 8.42 |
| Strongly Agree | 9 | 9.47 |
| Unanswered | 11 | 11.58 |
| **Total** | **95** | **100%** |

## Usability contd.

**I am satisfied with the quality of multimedia presentation**

| Response | No of respondents | Percentage of respondents |
|---|---|---|
| Strongly disagree | 2 | 2.11 |
| Quite disagree | 9 | 9.47 |
| Slightly disagree | 1 | 1.05 |
| Neutral | 22 | 23.16 |
| Slightly Agree | 26 | 27.37 |
| Quite agree | 12 | 12.63 |
| Strongly Agree | 10 | 10.53 |
| Unanswered | 13 | 13.68 |
| **Total** | **95** | **100%** |

**I am able to understand the information content of multimedia display on my broadband connection**

| Response | No of respondents | Percentage of respondents |
|---|---|---|
| Strongly disagree | 3 | 3.16 |
| Quite disagree | 6 | 6.32 |
| Slightly disagree | 1 | 1.05 |
| Neutral | 17 | 17.89 |
| Slightly Agree | 17 | 17.89 |
| Quite agree | 19 | 20 |
| Strongly Agree | 20 | 21.05 |
| Unanswered | 12 | 12.63 |
| **Total** | **95** | **100%** |

**My broadband connection is very reliable**

| Response | No of respondents | Percentage of respondents |
|---|---|---|
| Strongly disagree | 1 | 1.05 |
| Quite disagree | 3 | 3.16 |
| Slightly disagree | 5 | 5.26 |
| Neutral | 7 | 7.37 |
| Slightly Agree | 12 | 12.63 |
| Quite agree | 33 | 34.74 |
| Strongly Agree | 25 | 26.32 |
| Unanswered | 9 | 9.47 |
| **Total** | **95** | **100%** |

**I find that my broadband connection is always breaking**

| Response | No of respondents | Percentage of respondents |
|---|---|---|
| Strongly disagree | 28 | 29.47 |
| Quite disagree | 24 | 25.26 |
| Slightly disagree | 11 | 11.58 |
| Neutral | 7 | 7.37 |
| Slightly Agree | 4 | 4.21 |
| Quite agree | 7 | 7.37 |
| Strongly Agree | 3 | 3.16 |
| Unanswered | 11 | 11.58 |
| **Total** | **95** | **100%** |

## Price

**It is costly for me to subscribe to broadband at its current subscription fee**

| Response | No of respondents | Percentage of respondents |
|---|---|---|
| Strongly disagree | 16 | 16.84 |
| Quite disagree | 15 | 15.79 |
| Slightly disagree | 14 | 14.74 |
| Neutral | 20 | 21.05 |
| Slightly Agree | 14 | 14.74 |
| Quite agree | 6 | 6.32 |
| Strongly Agree | 1 | 1.05 |
| Unanswered | 9 | 9.47 |
| **Total** | **95** | **100%** |

**My service provider offers good value for money**

| Response | No of respondents | Percentage of respondents |
|---|---|---|
| Strongly disagree | 2 | 2.11 |
| Quite disagree | 5 | 5.26 |
| Slightly disagree | 3 | 3.16 |
| Neutral | 29 | 30.53 |
| Slightly Agree | 22 | 23.16 |
| Quite agree | 18 | 18.95 |
| Strongly Agree | 7 | 7.37 |
| Unanswered | 9 | 9.47 |
| **Total** | **95** | **100%** |

**The broadband prices offered by service providers is expensive**

| Response | No of respondents | Percentage of respondents |
|---|---|---|
| Strongly disagree | 9 | 9.47 |
| Quite disagree | 7 | 7.37 |
| Slightly disagree | 11 | 11.58 |
| Neutral | 26 | 27.37 |
| Slightly Agree | 19 | 20 |
| Quite agree | 10 | 10.53 |
| Strongly Agree | 4 | 4.21 |
| Unanswered | 9 | 9.47 |
| **Total** | **95** | **100%** |

## Government

**I believe the UK government should promote broadband more**

| Response | No of respondents | Percentage of respondents |
|---|---|---|
| Strongly disagree | 2 | 2.11 |
| Quite disagree | 1 | 1.05 |
| Slightly disagree | 1 | 1.05 |
| Neutral | 8 | 8.42 |
| Slightly Agree | 9 | 9.47 |
| Quite agree | 18 | 18.95 |
| Strongly Agree | 48 | 50.53 |
| Unanswered | 8 | 8.42 |
| **Total** | **95** | **100%** |

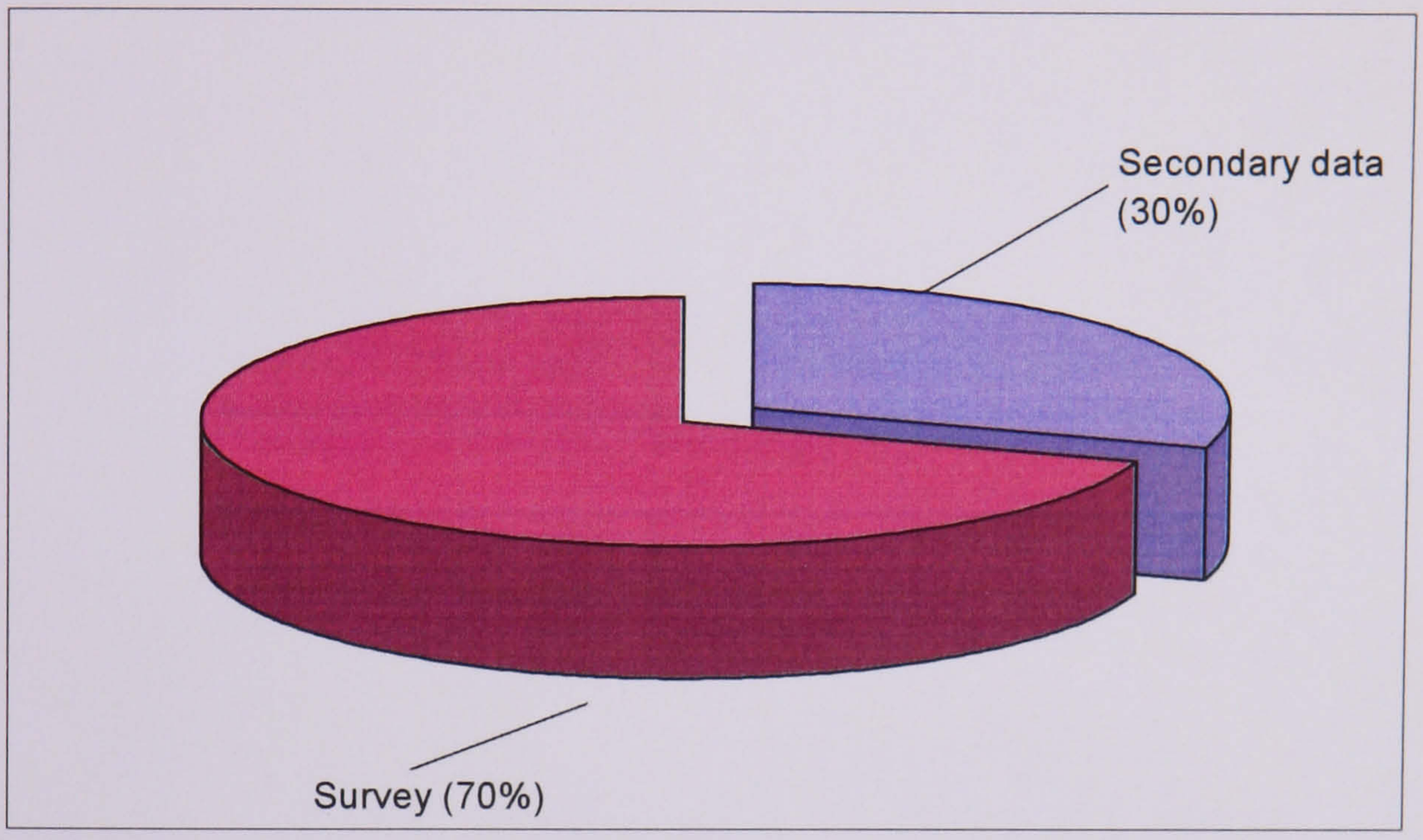
**I expect that the government should subsidise broadband prices**

| Response | No of respondents | Percentage of respondents |
|---|---|---|
| Strongly disagree | 7 | 7.37 |
| Quite disagree | 5 | 5.26 |
| Slightly disagree | 1 | 1.05 |
| Neutral | 14 | 14.74 |
| Slightly Agree | 8 | 8.42 |
| Quite agree | 14 | 14.74 |
| Strongly Agree | 38 | 40 |
| Unanswered | 9 | 9.47 |
| **Total** | **95** | **100%** |

# Appendix 3: Research Approach Analysed

The research was conducted using a sequential process from an exploratory investigation to a qualitative method whereby a combination of survey and secondary data analysis was employed (Figure A). The survey was use to measure user perception on broadband quality, and the secondary data analysis was use to analyse usage of broadband and quality taxonomy from the literature review.

**Figure A. Methods used for the research**




The range of tools employed to conduct the survey included postal service and email questionnaires.