

M.Sc. in Web Technologies  
National College of Ireland, Dublin



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*"Can Progressive Enhanced Web Application  
Via Http Adaptive Technology Improve The  
User Experience?"*

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*A thesis submitted in fulfilment of the requirements for the degree of MSc in  
Web Technologies, in the School of Computing, at the  
National College of Ireland.  
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## **Declaration of Authorship**

I hereby certify, that this material which I now submit for assessment leading to the award of master of science in web technology is entirely my own work and has not been taken from the work of others save and to the extent that such work has been sited and acknowledged within the text of my work.

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## **ABSTRACT**

The purpose of this research is to examine the effect of Progressive Enhancement via Http adaptation on user experience. Quantitative research methodology has been used for the purpose of this project.

Two web applications were developed and different questionnaires for each web application were distributed. First web application employs the Progressive enhancement technology while the second doesn't. The web application pertaining to progressively enhanced via HTTP adaptation technology reacts according to the bandwidth of the user (i.e.) if the user's bandwidth is very high, then the user will see a web page with excellent quality/resolution images and vice versa. The bandwidth is calculated in the background and subsequently redirected to the right web page depending on the result of the bandwidth test. The second web application is an application with good quality images bigger in size/resolution, thereby allowing load time to be high for some users. The researcher distributed the survey link in order to get the information and 106 people participated in the survey. From the information received, the conclusion was drawn. We can see from the conclusion that Progressive enhancement technology via HTTP adaptation clearly reduces the load time and enhances the user experience. The second web application developed with good quality images made the user experience poor for the users with low bandwidth and hence it can be concluded that user experience is affected by load time.

## **Acknowledgement**

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## **1. Introduction**

## **1.1 Background**

This is an era of smart phones, tablets and laptop; we can access all the information we need by few clicks. We are always connected to the internet by some means. Nowadays internet is an important part of one's life as millions of users are highly dependent on the internet. Slow speed computers and slow speed internet makes the web experience worse for many users.

Recent surveys conducted by different organisations show that ninety-six percent of all internet users worldwide access internet at least once in a day. Ninety-eight per cent people agreed that internet is essential for accessing information and education. (Computerhope.com, 2014)

The research shows that global download speed increased to 3.3Mbps in 2013. The three most populated countries in the world (i.e.) China, India and USA are the top users of internet as well. China, USA and India have approximately 568, 254 and 151 million users respectively. China and India have a combined average download speed of 2.05 Mbps whereas for China it is 2.8Mbps and for India 1.3 Mbps. (Silicon-press.com, 2014)

Majority of users worldwide have slow speed internet. By slow speed internet, I mean that the user cannot view online videos smoothly without pauses and visit heavy size websites. So if my thesis proves that Progressive enhancement technologies can improve the load time and enhance user experience, then it can be a solution for majority of internet users worldwide experiencing slow internet speed.

There are certain web applications which are bigger in size (i.e.) they contain high resolution images and videos which increase their size thereby prolonging load time. For example photography, e-shopping and astronomy web applications; these web applications contain very high resolution images which makes the load time a lot higher as compared to any other web application.

The good quality images and high definition videos are huge in size and majority of the users over the internet cannot watch high definition videos without lag. So web developers before 2010 used to upload videos of low/medium resolution which used to affect high speed



internet users as they could view high resolution videos without lag. Sound quality as well as video quality is crisp and clear in high definition videos which definitely enhance the user experience. Subsequently, the concept of HTTP adaptive streamlining was standardised for video streaming over internet. This concept revolutionised the video communication and streaming over the internet as any user with high speed broadband can now watch HD videos and live streaming. HTTP adaptive streaming technology adapts to the change in bandwidth of the user by increasing or decreasing the resolution of the video.

The web application load time and performance is dependent on various factors like device, browser, bandwidth of internet and platform being used. Most of the web applications can be rendered without platform dependency if they use the same web browser on a Mac, Windows or Linux system. One of the major issues confronting web developers includes the recoding and recompilation of the websites for different web browsers and devices. The styling and formatting needs to be changed to make it compatible with web browsers like Internet Explorer while other major web browsers like Google Chrome, Mozilla and Safari works fine without major changes to the code. Different devices have different screen resolution and size which means the web application layout may overflow or underflow depending on the screen resolution. Images can be scattered or assembled at one place in the web application which affects the user experience. Progressive enhancement technology is the solution for these type of issues in which the web application adapts itself depending on the device and the browser. The coding is done in such a way from the start that the web application adapts itself after detecting the web browser used and the screen resolution of the device.

HTTP adaptive streaming solves the problem of slow load time and lags in video streaming. Progressive enhancement makes the web application more adaptive to other devices. If HTTP adaptive technology is merged with progressive enhancement, then it can produce a web application which can upgrade or downgrade itself to provide an optimal solution for the high load time issues with slow speed internet users. This solution can be most effective for the web applications where high resolution images are important. In this project, we will try to merge these two technologies to provide a better load time which will enhance the user experience.

The core purpose of this research is to find out if progressive enhanced web applications via HTTP adaptation technology affect the user's experience. Our second objective will be to discover how the user experience is affected when the user accesses a web application with high load time.

## **1.2 Research Objectives**

The fundamental aim of this research is to invent a new concept by which the user experience can be enhanced on the web. In order to fulfil this aim, further sub-objectives were developed. These objectives are as follows:

1. To explore how progressive enhancement via HTTP adaptive streaming affects the user experience.
2. To explore how a normal website with high load time affects the user experience.
3. To survey people on the web and see which is more effective.

## **1.3 Research Question**

"Can progressive enhanced web application via Http adaptive technology improve the user experience?"

## **1.4 Significance of Research**

This study has immense significance and importance. It is beneficial both academically as well as from the perspective of practical implications. Academically, this study can contribute its part by adding to the availability of literature. There is a lot of research currently undertaken about user experience and its concomitant enhancement. Many researchers have introduced new technologies like HTTP adaptive streaming which is the major video streaming protocol nowadays but none of them combined HTTP adaptive method with progressive enhancement.

So, this study would fill the gap in literature about the user experience with progressive enhancement technology.

This study is also significant from the aspect of practical implications as it would provide an easy way to reduce the load time of websites without deteriorating the quality of the website. The user will be redirected to the website appropriate for the bandwidth and page load time will be reduced, thereby enhancing the overall user experience. Moreover, it will provide an efficient solution in the field of web development to design websites for users with respect to their internet speed. High speed internet users can utilise their speed by viewing large websites with good graphics, HD videos and high quality images, whereas low speed internet users will be able to access websites with very less load time but average quality images or videos.

### **1.5 Research Approach**

To complete this project, first literature review needs to be completed to analyse and retrieve information about the topics to be used in the development process of the web application followed by the characteristics and working of various technologies. The knowledge gained from the literature review will offer an overview of the features which should be included in the web application. After the literature review, the requirement specifications would be completed followed by the development of the application. The application has been designed to fulfil all the requirements and further tested on the local server. When the application passed the test, it was subsequently deployed to the Amazon EC2. Then two questionnaires were made for both applications and distributed in the college via email.

The survey was put up on Survey Monkey, responses were collected and then analysed. The conclusion was drawn from the responses and discussed in the result chapter.

### **1.6 Thesis Road Map**

The document is divided into following sections.

The thesis is divided into following sections.

Chapter 1: Introduction – This chapter contains the research background, objective, question, approach and significance of the research.

Chapter 2: Literature Review – This chapter provides an overview of the different literature on HTTP adaptive Streaming, Progressive enhancement and user experience.

Chapter 3: Technical Overview and Evaluation: This chapter provides the overview of the web application and technologies used to facilitate the purpose of this project.

Chapter 4: Analysis and Findings: This chapter presents data collected from the surveys using the quantitative research method. The conclusion was drawn from the results.

Chapter 5: Conclusion: This chapter offers the overview, contribution and conclusion of the thesis and future work.

## **1.7 Conclusion**

The conclusions derived from reviewing and analysing the different literature is documented in this section. The research is focused on Progressive enhancement technologies, HTTP adaptive streaming and user experience, which constituted the main topics. The knowledge gained after reviewing and analysing the literature helped in the development process of the web application and the features to be included in the web application. User and customer experience provided an overview on how to make the web application more accessible and easy to use.

To start the review of HTTP Adaptive streaming, first HTTP was analysed to derive deep knowledge of the concept.

*"HTTP is hypertext transfer protocol, as clear from its name it transfers files and data on the web."( Computerhope.com, 2014)*

The four stages of HTTP are Connection, Request, Response and Close as discussed. Furthermore, HTTP adaptive streaming, being one of the most important concepts for this research is also discussed.

*"Adaptive streaming aims to optimize and adapt the video configurations in order to provide the best quality video to the end users." (Michalos, Kessanidis and Nalmpantis, 2012)*

Adaptive streaming can improve the user experience while watching a video over the internet. It adapts with the change in bandwidth of the user. This concept is very important for this research because this will constitute the base technology to develop progressive enhanced web application.

*"The DASH takes over by chopping the video file into smaller pieces, the segments and downloading them in a dynamic way thus the streaming is in a continuous, without interruption playback mode no matter which part of the stream is being watched while the rest is being downloaded"* (Bitsearch.blogspot.ie, 2014). This explains the working of the DASH. HTTP adaptive streaming setup contains three main components -Server, Distribution and Client. Short summary of all the components is discussed in that section.

*"User experience is regarded as a holistic approach including the context of use, emotions, meaningfulness of a product, consumer-product attachment and how a product is understood to work. Furthermore, prior experience and user values have an impact on user experience."* (Tokkonen and Saariluoma, 2013) User experience is what the research is all about. So proper understanding of this concept is required. An in-depth review was done on this topic and few techniques to improve the user experience were discussed.

There are two quality attributes of user experience - Pragmatic and Hedonic quality. Pragmatic quality refers to the product's ability to achieve goals while Hedonic quality refers to the product's ability to support the achievement of goals.

Furthermore, some facets of user experience are discussed in detail and give the overview to develop the web application in a way which makes it more usable and easy to learn.

Another important topic to mention is Progressive enhancement.

*"Progressive enhancement is a philosophy aimed at crafting experiences that serve your users by giving them access to content without technological restrictions."* (Gustafson and Zeldman, 2011)

Progressive enhanced web applications are more user friendly and platform independent which is very important, since many diverse ranges of devices are used like tablets, smart phones, laptops etc. Graceful degradation which is opposite of progressive enhancement is also discussed to know how web applications were designed exclusively for the latest browsers and machines.

## 2. Literature Review

### 2.1 Introduction

The next section of the thesis will provide an overview of the different literature on HTTP adaptive Streaming, Progressive enhancement and user experience. The importance of user experience in web development is highlighted to enunciate the objectives of this paper.

A state of the art review on recent papers about progressive enhancement and user experience is covered in this chapter. I will also cover the effectiveness of HTTP adaptive streaming because this technology is integral to my project's functioning. There are very few papers published on Progressive enhancement and graceful degradation, so I will try to explain these topics as much as I can.

### 2.2 What is HTTP (Hyper Text Transfer Protocol)?

HTTP is hypertext transfer protocol, as clear from its name it transfers files and data on the web. It has various sets of rules by which information or data can be transferred from server to browser and vice versa.

It was introduced in 1991 as http/0.9 and was firstly coined by Ted Nelson. The ports used by http are: 80, 8008 or 8080. (Computerhope.com, 2014)

HTTP standardises the communication between the user and server over internet.

*"HTTP is behind every request for a web document or graphic, every click of a hypertext link, and every submission of a form." (Wong, 2000)*

Another protocol used in transferring files through web more secure than http is https (hypertext transfer protocol over secure) as the files here are encrypted before those files

are sent across the server. This is usually slower than http as it has encryption and is generally used during login procedure in various websites. The port used here is 443. (Silicon-press.com, 2014)

HTTP is the most widely used protocol in current internet traffic and to understand the nature of the internet traffic we need to analyse and characterise HTTP traffic.

### How HTTP works?

This section will explain the working of HTTP protocol. The client initiates a transaction from the browser via HTTP Request and the Server gives a response with the data.

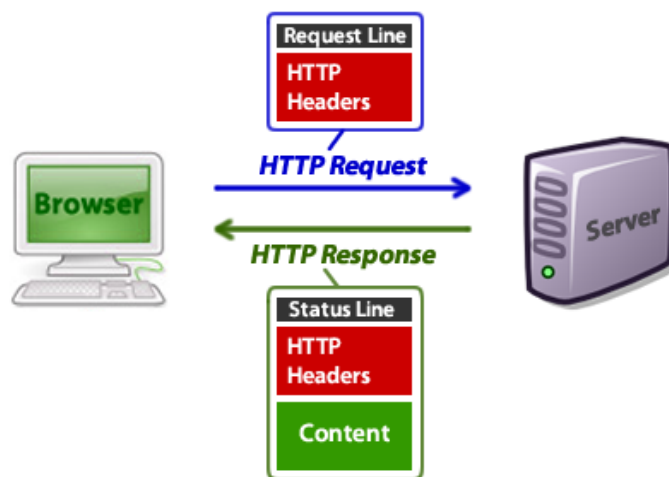


Figure 1: HTTP Working (Code Tuts+, 2014)

The HTTP protocol contains following states:



## **Connection**

The connection is established from the client to the server. Port 80 is used to initiate the transaction.

## **Request**

A request message is sent by the client when the connection is established. The request message contains the details about what the client is looking for from the server. It can be a webpage or submission of a form.

## **Response**

Server responds to the client with the data or the error code. Error codes are explained later in this section.

## **Close**

The connection is closed by either both parties when that transaction is done.

(W3.org, 2014) When a client requests a service from a web server, an error might occur.

This is a list of HTTP status messages that might be returned from the server during the transaction:

They are divided into five categories. (W3schools.com, 2014)

- 1xx: Information
- 2xx: Successful
- 3xx: Redirection
- 4xx: Client Error
- 5xx: Server Error

### **1xx: Information**

*The 1xx class of status codes gives a provisional response which contains Status-Line and optional headers, and is terminated by an empty line.*

### **2xx: Successful**

*The 2xx class of status codes indicates that the client's request was successfully received, understood, and accepted.*

### **3xx: Redirection**

*The 3xx class of status codes indicates that further action needs to be taken by the user agent in order to fulfil the request.*

### **4xx: Client Error**

The 4xx class of status codes is intended for cases in which the client seems to have erred.

### **5xx: Server Error**

The 5xx class of status codes indicate cases in which the server is aware that it has erred or is incapable of performing the request.

## **2.3 What is HTTP Adaptive Streaming?**

Adaptive streaming aims to optimize and adapt the video configurations in order to provide the best quality video to the end users. Adaptive streaming service provides different variants of the same video content, each variant is further split into small segments and encoded at different bit-rates. The streaming clients can dynamically choose different bit-

rate variants to fit the changing network conditions (Michalos, Kessanidis and Nalmpantis, 2012).

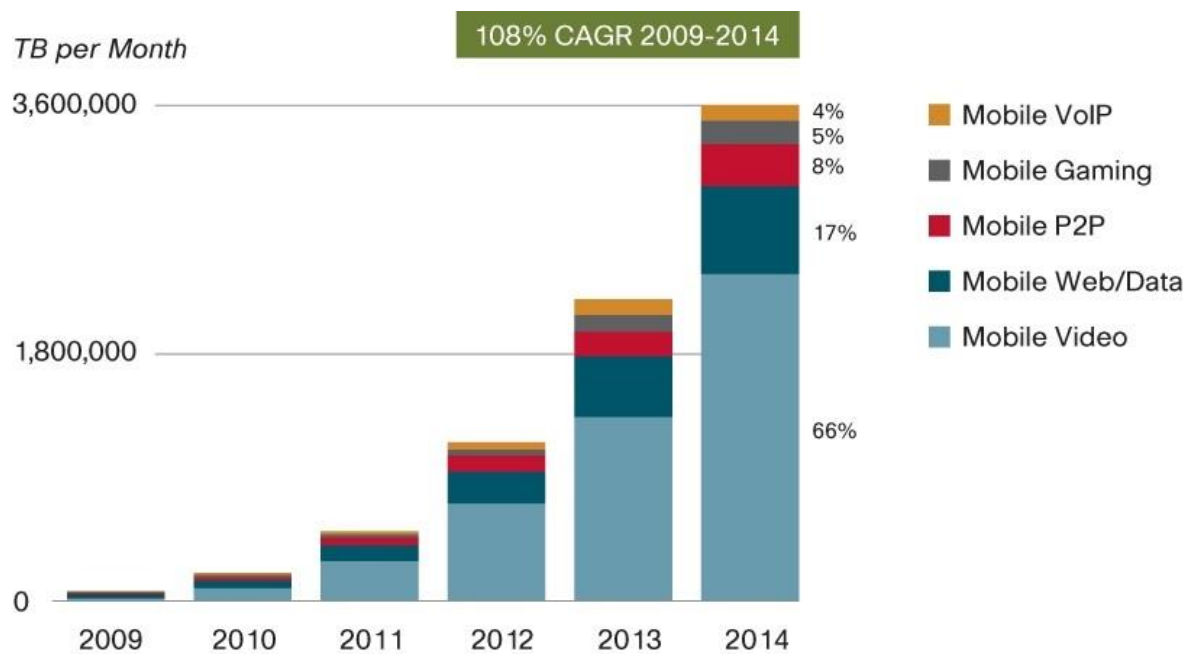
Adaptive streaming is required for IP networks, because the needed bandwidths for high definition and high bitrate streaming is not in place for all different access networks. Furthermore, since some network links are often shared resources, the available bandwidth may change at any time during a session.

The DASH standard is composed of two main parts. One part defines the Media Presentation Description (MPD) that is used by the client to find the links to access the content.

The other part defines the format of the content in terms of media segments as extensions to the 3GP and MP4 file formats. (Cisco, 2014)

### **Importance of HTTP Adaptive Streaming**

The growing demand of users to watch movies or videos online anytime and anywhere has propelled the improvement of video streaming technology. Video streaming these days is considered as a necessity than a feature which is embraced by all websites worldwide. Keeping in mind its importance, Adaptive Streaming over HTTP was developed and was being standardized all over recently in late 2011. Despite its incomplete development, it became more popular and demanding as it was initiated by YouTube. Its main feature is that it works on various lines as most of the users do not possess fixed speed on their lines, (i.e.) they do not have fixed bandwidths.



**Figure 2: Mobile data traffic analysis (Adams, 2014)**

According to the recent studies conducted by Cisco, it is expected that between 2009 and 2014, the mobile data traffic will grow by a factor of 40. It will be more than double every year. (Michalos, Kessanidis and Nalmpantis, 2012) It is clear that the mobile video traffic will account for 66% of the total amount of mobile data. A good user experience while video streaming is one of the most important factors to be considered in the mobile eco system. User experience is badly affected when there is a lag, high load time and pauses while streaming a video. There are many factors which can cause these issues like network bandwidth, mobile display resolution and mobile processor. The use of HTTP adaptive streaming technologies can solve these major issues with video streaming because it dynamically reacts with the bandwidth, (i.e.) if the internet bandwidth becomes low, it will start streaming a low bit rate video and it will provide a smooth playback experience with best achievable video quality. Quality of service is drastically improved with smooth playback and best achievable bit rate.

### **Advantages of HTTP adaptive streaming (Michalos, Kessanidis and Nalmpantis, 2012)**

These are the key advantages of HTTP Adaptive streaming:

- The ability to dynamically change the video bit-rate based on the network throughput, which can be indirectly measured by monitoring the receive buffer.
- The content which is actually watched by the user traverses the network.
- It secures the content using DRM (Digital Rights Management) technologies rather than secure HTTP.
- It provides a seamless mechanism to insert real time advertisements.
- It starts with low bit-rate stream first so that it can start the playback instantly.
- Dynamic conditions and device capabilities: It adapts to any dynamic condition on web through internet, to display resolution, CPU and memory resources of client.

### **How Dynamic HTTP Adaptive Streaming (DASH) works?**

(Stockhammer, 2011)

DASH is a technology used to deliver the video content in an adaptive manner over internet. DASH reacts by recognizing and adapting to network's bandwidth. Hence, it delivers smooth and best achievable bit-rate video.

Most of the internet users do not have stable bandwidth internet and it can cause disruption while watching a video.

*"The DASH takes over by chopping the video file into smaller pieces, the segments and downloading them in a dynamic way thus the streaming is in a continuous, without interruption playback mode no matter which part of the stream is being watched while the rest is being downloaded"* (Bitsearch.blogspot.ie, 2014).

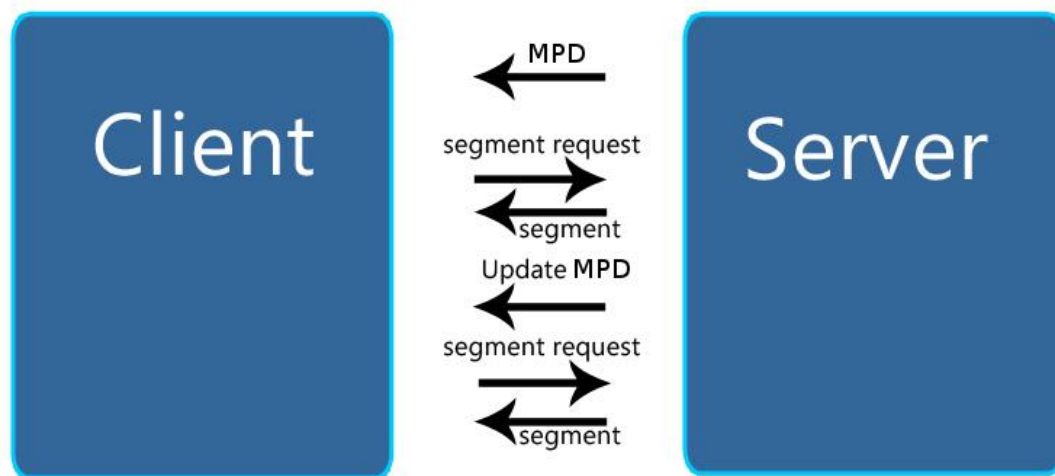
An HTTP streaming system consists of the following components:

- Server Components
- Distribution Components
- Clients Components

During live streaming, an encoder is required at server to encode media to be subsequently encapsulated for transfer (Hartung, Kesici and Catrein, 2011).

Then the Segmenter which is part of HTTP pseudo streaming prepares the media file by dividing it into multiple files based on the file's duration.

DASH also includes the Media Preparation Description (MPD) and file format definition (Lohmar et al., 2011).



**Figure 3: Client Server Transaction - DASH (Siraj Fahd, 2011)**

An operation which divides the file to be delivered in segments is included in MPD. MPD allocates a particular server address, which will be called by the client using the specific URL address (Stockhammer, 2011).

DASH process was standardised by 3<sup>rd</sup> Generation Partnership Project (3GPP). 3GPP undertook the naming for segment definition which is required in MDP process. Thus, all the segments receive 3GP file format (.3gp) defined in the preparation process and to retrieve the video a specific URL is allocated (Hassenzahl, 2008). Different file formats and implementation were invented for the segment files after 3GP.

The location of the media is being declared and all MPD information is contained in a manifest file after cropping the file into segments and defining them through 3GPP standards. Manifest file is a XML file and is considered as an encoder of multiple files.

Then, Distribution component which is a simple HTTP web based server retrieves all files required for initialisation of the stream. Server stores the stream and transfers the appropriate XML manifest file which is created by the segmenter to the client.

Last, but not least, XML manifest file is being referred by the client component which identifies the URL of the Stream. Manifest file contains all the information related to the segments as well as their bit-rate and other playback information. Then the client considering the potentials of the internet can call for specific segments regarding the bit range and other adaptive data without downloading the whole segment (Hartung, Kesici and Catrein, 2011).

## **2.4 What is User Experience?**

User experience is related to the quality of experience. *“User experience is regarded as a holistic approach including the context of use, emotions, meaningfulness of a product, consumer-product attachment and how a product is understood to work. Furthermore, prior experience and user values have an impact on user experience.”* (Tokkonen and Saariluoma, 2013)

User experience can also be defined in many different ways (Arhippainen 2009, 43–54; User experience definitions 2011). Recently, this concept has been clarified in the User Experience White Paper (Roto, Law, Vermeeren & Hoonhout 2011). User experience can be viewed as a particular case of an even broader term—experience, which can be loosely defined as feelings, knowledge and skills that a person acquires from his/her interactions with environment—natural, technological, social. One of the shortest definitions of user experience is, again, given by the International Organization for Standardization (2010):

*“Person’s perceptions and responses resulting from the use and/or anticipated use of a product, system or service”.* (Ergonomics of human system interaction, 2009)

### **Quality attributes of User experience**

Two quality attributes can be distinguished:

- Pragmatic quality.
- Hedonic quality.

Pragmatic quality refers to the utility and usability in relation to potential task of a product. (Hassenzahl, 2008) It is the product’s ability to perform task or “do goals”. For example: to search for a book in an online-bookstore.

In contrast, *“hedonic quality refers to the product’s perceived ability to support the achievement of ‘be-goals’, such as ‘being competent’, ‘being relate to other’, ‘being special’”* (Hassenzahl, 2008)

Hedonic quality focuses on the user attributes, why the user wants to use the product or own the product? It focuses on the personal taste and personality of the user. *“In turn, perceived hedonic quality indicated the potential fulfilment of be-goals through interaction with product.”* (Hassenzahl, 2008)



Positive experience is directly affected by the hedonic qualities and indirectly by Pragmatic qualities via making goal fulfilment more easy and likely. Usability facilitates pursuit of meaning be-goals and that's what makes it important.

#### **Facets of the User Experience** (Semanticstudios.com, 2014)

Peter Morville of Semantic Studios introduced this concept of the UX Honeycomb back in 2004. It represents a solid 7 aspects of the user experience that marketers, developers, and designers must implement to make the user experience better. This UX Honeycomb contains 7 hexagons, each of them representing the aspects of the UX.



**Figure 4: The User Experience Honeycomb** (Semanticstudios.com, 2014)

Following are the 7 aspects of the user experience with its short description.

- **Useful:** As web developers, we need to make our products and systems more useful. We need to alter the content and system to make it more useful.

- **Usable:** The product should be usable as well. We should not put all the things together in our product and align them in the right way.



**Figure 5: Example of Poor Design (Blog.veloviewer.com, 2013)**

For Example: The above image shows us an example of poor design. The watering can handle is not in the right place but has all the components required in a watering can. But it's still not usable because of the poor design. In the same way, we need to design our websites which can be used by the customers.

- **Desirable:** Our product should be more efficient. The content on the website should be more valuable to create a demand for the website among users. The value of images, brand, identity and elements of emotional design makes the website more valuable.
- **Findable:** Our web sites should be easy to navigate through. Users should easily find the objects and links they are looking for while on the page.
- **Accessible:** Our website should be accessible to people with disabilities. The website should contain tags which can be read or listened by people with disabilities using

specific tools. The text size should be adjustable by the user which makes it more accessible.

- **Credible.** Web credibility project explains the features and design elements which can influence whether users trust and believe what we tell them.
- **Valuable.** The site should deliver value to our sponsors. For non-profit websites, the user experience should be good.

It's a great tool overall to understand the features of usability and help web developers design their website in a way that can meet these facets of user experience.

Secondly, it's a great tool to redesign and enhance the existing websites to make them more credible and user friendly. Moreover, each facet of the honeycomb model enables us to explore beyond the conventional boundaries.

## Customer Experience

*"A customer experience is an interaction between an organization and a customer as perceived through a customer's conscious and subconscious mind. It is a blend of an organization's rational performance, the senses stimulated and the emotions evoked and intuitively measured against customer expectations across all moments of contact."* (Beyond Philosophy | Customer Experience Consultancy | CEM Consultants, 2008)

Customer experience for me is meeting the expectations prevalent in the user's subconscious mind and hence to deliver a good customer experience requires surpassing one's initial expectations.



**Figure 6: Ultimate Customer Experience (Appitive, 2014)**

The above image shows an example of ultimate customer experience. If you go to a restaurant, you expect hygienic environment, clean table, comfortable seats and tasty food. The above image shows that the customer gets all the expected things but what makes it an ultimate experience is the big size of the burger, coke, knife and fork. The user was not expecting such a great service and value for money in terms of the served food.

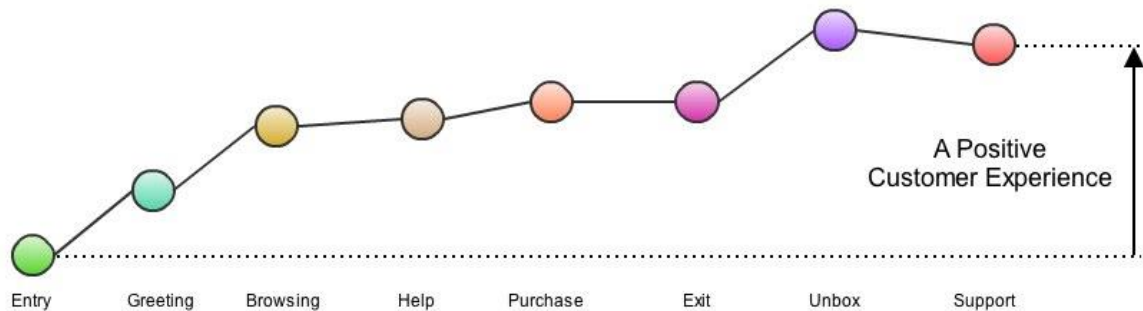
*“A customer experience is not just about a rational experience”.* (Beyond Philosophy | Customer Experience Consultancy | CEM Consultants, 2008)

A customer experience is more of personal expectation with the company or the product.

Let's take an example of how to deliver positive customer experience and that the concomitant stages involved in the process.

Let's imagine a customer who went to the local shop to buy a new laptop.

We divided the whole process in following stages.



**Figure 7: Stages of Positive Customer Experience (Sanchez, 2014)**

- Entry
- Greeting
- Browsing
- Help
- Purchase
- Exit
- Unbox
- Support

### **Entry**

A customer enters the laptop shop; the cleanliness and the whole environment of the shop make a huge impact on the customer experience. Shop is nice and clean with well-dressed staff, which makes it a pleasant experience.

### **Greeting**

The way the sales representative greets you when you enter the shop make a huge difference and influences the eventual experience – good/bad.

### **Browsing**

The way the catalogue or kiosk is designed can affect the experience of the customer. There should be proper index and the product should be easy to find to make the experience good.

### **Help**

The staff should have good knowledge of the product and some information of the company. The staff should be capable enough to answer all the major queries of the customer and make suggestions according to the needs of the customer.

### **Purchase**

The billing experience should be good as well. They should accept all the major Debit and Credit cards. If the sales representative can introduce some special offer or discount that will further enhance the customer experience.

### **Exit**

When you leave the shop the shopkeeper should greet again and should provide all the relevant information about the product.

### **Unbox**

Unboxing the product should be easy. The build quality of the box should be good as well. There should be all the manuals and warranty cards in the box.

## **Support**

There should be a good after-sales support to setup the whole laptop and help the customer in case of any issues with the laptop.

If the above stages in the process are properly handled by the sales representative and support staff then the experience will be very good for the customer. But again, it depends on the customer's expectations. If the experience is good, the customer will come again and recommend that shop to everyone which will assist in the increase of the number of sales. One customer can bring a lot more customers if the experience is good. If the experience is not good, the customer will not recommend the shop and this in turn can tarnish the company's reputation, thereby affecting or decreasing the sale which may bring about loss for the company. So in conclusion, the customer's experience is one of the most important things to take care of. One customer can affect many people; those many people can further affect more people. It is very hard to get rid of bad reputation in the market for a company. Sales are vastly affected by reputation.

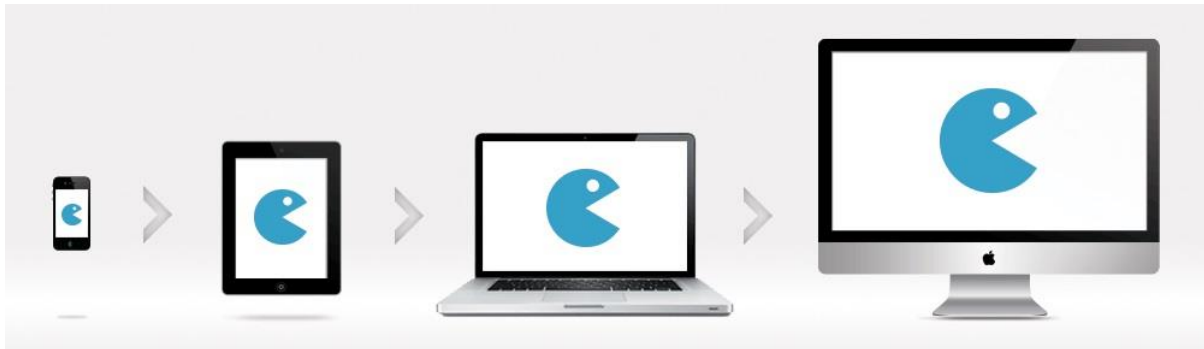
Same applies for the e-commerce websites. If the customer is not satisfied with the whole process, it will lead to a bad experience. Companies these days need to match the expectations of the customer, both in-store and website. Customers should easily find information and product on the website. The process to pay online should be safe and secure. The format of the website should be easy to understand and navigate.

## **2.5 What is Progressive enhancement?**

Progressive enhancement is a concept which came into existence after 2008 when web developers started optimising their websites for smart phones and tablets.

“Progressive enhancement is a philosophy aimed at crafting experiences that serve your users by giving them access to content without technological restrictions.” (Gustafson and Zeldman, 2011)

As the author mentioned, we should not worry about the browser, platform or language used to make the website. The most important is the user; if the user experience is poor then they will not visit again. (Gustafson and Zeldman, 2011)



**Figure 8: Progressive Enhancement (Zurb.com, 2014)**

Progressive enhancement is a web design technique where we only focus on our user, not the browser or the platform. We design the website in a fashion that it changes according to the capability of the user web browser and the platform. As we can see in Figure XYZ, the size of the image changes in correspondence to the device the user is using. This is a good example of Progressive enhancement.

The author of the book only focused on the language, mark ups, CSS and accessibility of the website but he totally ignored the fact that the website will be accessed over internet. We cannot ignore a very important factor which is “user’s connection speed”. Which language did you use? Which style did you adopt? How attractive is your website? Which browser does the user use to access the website? These questions are important but one of the most important questions relate to how fast the page will open on user’s screen, because a long page load time leads to poor user experience.

There are multiple options which we need to consider before we think about Progressive enhancement. (W3.org, 2014)

Following are the issues which we need to consider while using progressive enhancement. We need to consider all of the following options: (W3.org, 2014)



- HTML5 vs. HTML 4.01
- CSS3 vs. CSS 2.1 (and older)
- JavaScript enabled vs. disabled
- HD display vs. low-res display
- Touch device vs. mouse/keyboard device

### **Progressive Enhancement – Three Layered Approach**

We can divide the web development technologies in the following layers to make it progressively enhanced:

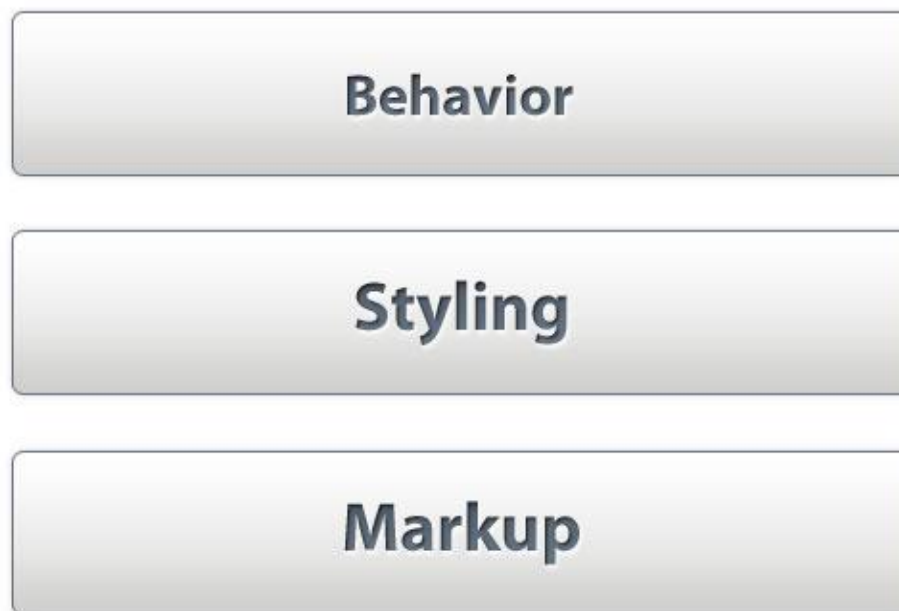
- HTML
- CSS
- Client-side Scripts



**Figure 9: Progressive Enhancement – Layered approach (Six Revisions, 2014)**

By dividing these website components in layers, we can easily make changes to make the website browser independent in terms of capability. We can pragmatically carry out progressive enhancement by enhancing the following areas of development:

- **Mark-up:** Well-Structured HTML and semantics can enhance the inter-operability and make it more flexible to change.
- **Styling:** The look-feel should be browser independent and there should be a support for all the major browsers.
- **Behaviour:** The site should be interactive and rich with the use of JavaScript.



**Figure 10 – Progressive Enhancement – Areas of Development (Zurb.com, 2014)**

**Benefit of using progressive enhancement. (Six Revisions, 2014)**

- **Accessibility:** Content can be reached by all the visitors.
- **Portability:** Browser and device independence can be achieved.
- **Modularity:** It can be debugged and is more faults tolerant because of the broken layers.

- **Performance of site:** Usability is increased and page load time is decreased which enhances the user experience.

### **Why Progressive enhancement**

Performance boost: This ensures that the content of webpage is loaded first, then styles and then behaviour. This improves load time as pages are displayed.

Improved accessibility: There are many users unable to read from screen; for such users it allows accessibility of various websites with enhanced usability by text readers and screen readers. This is the sole reason to boost user engagement.

Expand transferability: Despite all browsers, platform and their different compatibility, websites always remain effective.

It aims to give users a best possible user experience. It can be through iPhone, a kindle or a high-end desktop system. This experience should be fully functional and featured as possible. (Filamentgroup.com, 2014)

### **2.6 What is Graceful Degradation?**

*“Graceful Degradation is the practice of building your web functionality so that it provides a certain level of user experience in more modern browsers, but it will also degrade gracefully to a lower level of user in experience in older browsers. This lower level is not as nice to use for your site visitors, but it does still provide them with the basic functionality that they came to your site to use; things do not break for them.” (W3.org, 2014)*

Graceful degradation provides the best experience to users with latest browsers with full set of features and a gracefully degraded version of website with low-level of functionality is provided to the users with the old browser.

Users with modern browsers and devices can see a beautiful version of the website with full features. On the other hand, the users with old browsers can only see limited content with

basic functionality. The good thing is that the users with old browsers can still see the basic content which is better than nothing.



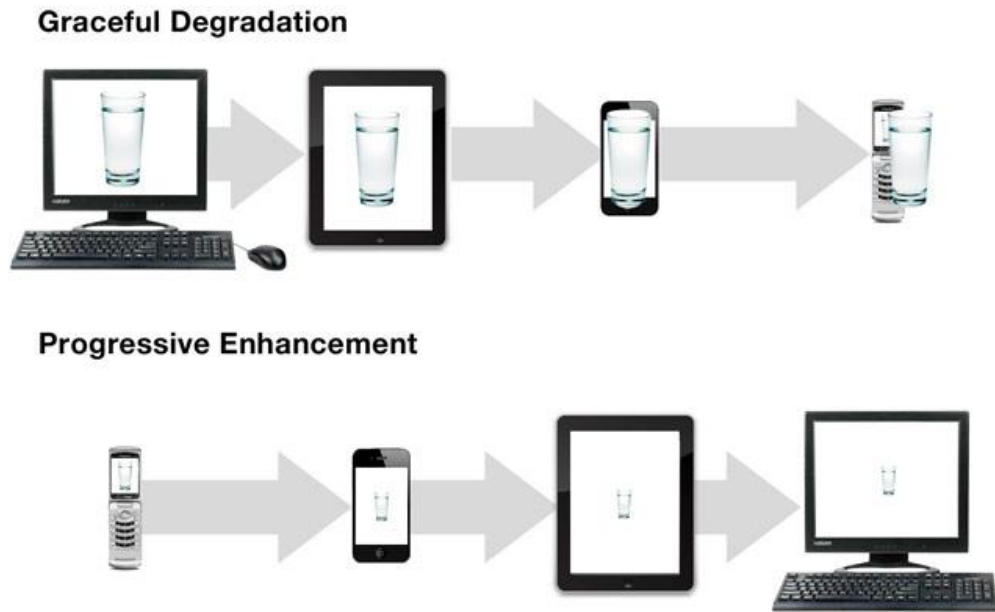
**Figure 11 – Graceful Degradation (Breezi, 2012)**

The above image shows us a perfect example of Graceful Degradation. The content of the website changes according to the browser and device. Full featured browser can see more beautiful version of the website with JavaScript effects, CSS etc. and the least featured browser can only see the content.

There are many web browsers available these days. Many one of them have less or missing features in comparison to the modern browsers. The term graceful degradation is considered a strategy which can handle web pages and designs for different browsers. Graceful degradation is basically an ability of a computer or a network which can maintain limited functionality even after a large portion of it has been destroyed or rendered inoperative. Its basic purpose is to prevent catastrophic failure since it decreases the efficiency or speed as various components fail. (Searchnetworking.techtarget.com, 2014)

### **Progressive Enhancement vs. Graceful Degradation**

*“Graceful Degradation is the technique to develop a Web site from complexity to simplicity, whereas Progressive Enhancement is just the opposite technique, which is to develop a Web site from simplicity to complexity.” (Hcltech.com, 2014)*



**Figure 12 – Graceful Degradation vs. Progressive Enhancement (Bradfrostweb.com, 2011)**

The above image shows the difference between the two techniques.

Graceful degradation technique gives the full featured content to the full featured devices or browser and it gives a low featured content to the low end devices or browsers. In the above image, we can see that the glass is of perfect size on the desktop computer and it gets over-sized when the screen resolution of the device decreases gradually. The user using the mobile will see an excessively big image.

Progressive enhancement technique enhances the content from the low featured device to the full featured device or browser. In the above image, we can see that the size of the glass remains the same irrespective of the device use.

## **2.7 Conclusion**

The conclusions derived from reviewing and analysing the different literature is documented in this section. The research is focused on Progressive enhancement technologies, HTTP adaptive streaming and user experience. Those were the main topics to research about. The

knowledge which was gained after reviewing and analysing the literature on these topics helped in the development process of the web application and what features should be included in the web application. User experience and customer experience gave an overview of how to make the web application more accessible and easy to use.

To start the review of HTTP Adaptive streaming, first HTTP was analysed to get the deep knowledge of the concept.

The four stages of the HTTP which is Connection, Request, Response and Close was discussed. Then HTTP adaptive streaming which is one of the most important concepts for this research is discussed.

Adaptive streaming can improve the user experience while watching a video over the internet. It adapts with the change in bandwidth of the user. This concept is very important for this research because this will be the base technology to develop progressive enhanced web application.

HTTP adaptive streaming setup contains three main components which are Server, Distribution and Client. Short summary of all the components is discussed in that section.

User experience is what the research is all about. So proper understanding of this concept was required. An in-depth review was done on this topic and few techniques to improve the user experience were discussed.

There are two quality attributes of user experience which is Pragmatic and Hedonic quality. Pragmatic quality refers product's ability to do goals and Hedonic quality refers to the product's ability to be support the achievement of goals.

Then some facets of user experience are discussed in detail and it gives the overview to develop the web application in a way which makes it more usable and easy to learn.

Another important topic to talk about was Progressive enhancement.

Progressive enhanced web applications are more user friendly and platform independent which is very important because many diverse ranges of devices are used like tablets, smart phones, laptops etc. Graceful degradation which is opposite of progressive enhancement is

also discussed to know how web applications were designed exclusively for the latest browsers and machines.

## **3. Technical Overview and evaluation**

### **3.1 Introduction**

This chapter provides the overview of the web application and technologies used to facilitate the purpose of this project. The web application was deployed on an EC2 instance of Amazon Web Services and it was locally made on a WAMP server. The main aim of this application is to calculate the user speed and redirect the user to the right page.

In order to get the surveys about the user experience, the web application was developed with beautiful images and nice zoom effects. The comparison is made between this web application and all the other web application in the questionnaire. The web application design was kept simple, easy to navigate and embedded with beautiful images which were downloaded from the internet. The look and feel kept beautiful so that the participants can imagine and compare it with other websites on the internet and give a valid response to the questions.

For the Group A, the web application which was developed by the researcher with the progressive enhancement technology, that contains three versions of the same website. Those three versions were divided into following categories:

- **High Bandwidth Website:** High bandwidth website was loaded when the users speed is more than 10 MBPS. This version contains very high resolution and clear images.
- **Medium Bandwidth Website:** Medium bandwidth website was loaded when the users speed lies between 5 – 9.99 MBPS. This version contains medium resolution images.



- **Low Bandwidth Website:** Low bandwidth website was loaded when the users speed is less than 4.99 MBPS. This is the default version which is loaded instantly and it contains low resolution images.

When the user opens the link of the website, the user will first see the Low bandwidth website as default. A background calculation is then made to calculate the bandwidth and the user is redirected to any of the three versions of the websites depending on the bandwidth at that time. So if the user's internet bandwidth is high i.e. more than 10 MBPS then the user will be redirected to high quality website with less load time which will improve the user experience. If the user's internet bandwidth is medium i.e. 5 - 9.99 MBPS then the user will be redirected to a medium quality website with less load time. If the user's internet bandwidth is very low then user will see low quality images but the load time will be less. In all the three cases the load time remains less which improves the user experience.

For the group B web application we will deploy the medium version of the web application and then will distribute the link. Throughout this section group A application is discussed because group B web application is the part of Group A web application.

### **3.2 Application Scope**

The application for group A was developed to merge the HTTP adaptive streaming and progressive enhancement technologies. This application can be a good solution for all the heavy size web applications like photography and astronomical web applications where load time is generally very high because of the high resolution images. The process which is used to develop the web application for the research can be used to transform any non-adaptive web application to a dynamically bandwidth adaptive web application.

### **3.3 Requirements Analysis**

This section will give an overview of functional, non-functional and technical requirements. The requirements were collected and then the development of the web application was done.

### **3.3.1 Functional Requirements**

#### **3.3.1.1 Overview**

The functional requirements for the Group A websites are defined after reviewing the literature of the user experience. Our main aim of the project is to see if the user experience can be enhanced when we use progressive enhancement technology via HTTP adaptation techniques.

#### **3.3.1.2 Redirection**

The sites main functionality is to redirect to the version which is best suitable depending on the bandwidth of the user. Those three versions were divided into following categories:

- **High Bandwidth Website:** High bandwidth website was loaded when the users speed is more than 10 MBPS. This version contains very high resolution and clear images.
- **Medium Bandwidth Website:** Medium bandwidth website was loaded when the users speed lies between 5 – 9.99 MBPS. This version contains medium resolution images.
- **Low Bandwidth Website:** Low bandwidth website was loaded when the users speed is less than 4.99 MBPS. This is the default version which is loaded instantly and it contains low resolution images.

#### **3.3.1.3 Bandwidth Calculation**

The site should run a background code to check the user's bandwidth. The result of the test is then given to the redirection code and the user is redirected to the version most appropriate to the user's speed.

### **3.3.2 Non – Functional Requirements**

- Cross Browser Site
- To be hosted on IIS 7.1

## **3.4 Technical Requirements**

The application was developed using HTML5, JavaScript, jQuery, AJAX, and CSS3. Website was deployed on a medium sized Amazon EC2 windows virtual machine. The Web Application was designed to work on, and was tested on, the following browsers:

- Google Chrome
- Safari
- Firefox
- Android Kitkat

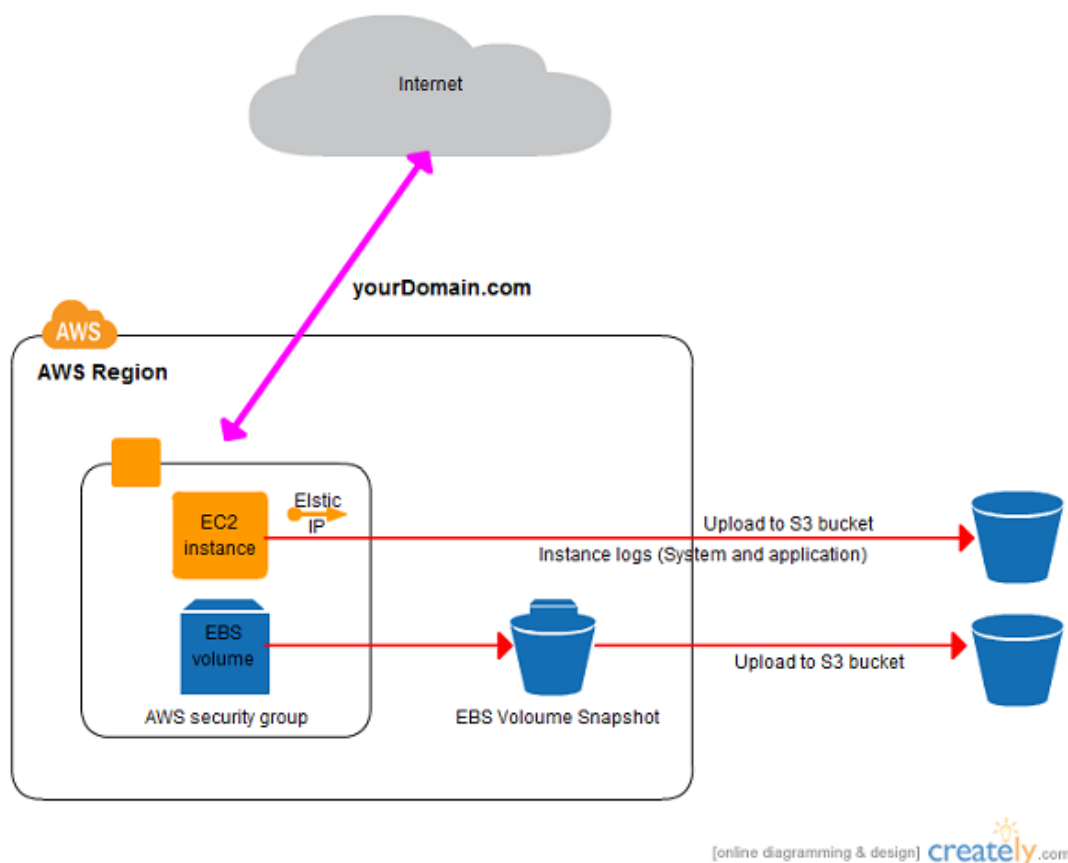
### **3.4.1 Amazon EC2**

*“Amazon Elastic Compute Cloud (Amazon EC2) is a web service that provides resizable compute capacity in the cloud. It is designed to make web-scale computing easier for developers.” (Amazon Web Services, Inc., 2014)*

Amazon Elastic compute cloud is one of the most famous and easy to use web services available in market. It provides an easy to configure web services interface which gives a

complete control on the instances deployed by the user. User can scale up and down the resources according to the needs. It's a cost effective solution for web services because the user only pays for the services they actually used. There is complete documentation and manuals to learn how to use these web services. Moreover the technical support from the Amazon web services is quick, helpful and detailed. They solve most of the problems which can occur during the deployment process or post deployment. The maintenance process is easy and reliable. Customer can easily reboot or backup the instance. They can make clones of the instances before any experimentation. It provides developers the tools to make a reliable web application and isolate themselves from common failure scenarios.

### Basic structure of a AWS EC2 instance



**Figure 13: Structure of AWS EC2 (&rarr;, 2012)**

The above image shows the basic structure of the AWS EC2 instance. It contains the following components.

- EC2 Instance: It is the actual instance which is running on the server.
- EBS Volume: *“Amazon Elastic Block Store (Amazon EBS) provides persistent block level storage volumes for use with Amazon EC2 instances in the AWS Cloud. Each Amazon EBS volume is automatically replicated within its Availability Zone to protect you from component failure, offering high availability and durability.” (Amazon Web Services, Inc., 2014)*
- Volume Snapshot: Snapshot is the copy of the EC2 instance.
- S3 Bucket: S3 is the storage bucket. It stores the files and snapshots.

## **Advantages of AWS EC2**

### **Elastic Web-Scale Computing**

*“Amazon EC2 enables you to increase or decrease capacity within minutes, not hours or days. You can commission one, hundreds or even thousands of server instances simultaneously.” (Amazon Web Services, Inc., 2014)*

Everything is controlled with web services API's and you can setup the rules which will allow your web application to scale up and down depending on its needs. (Amazon Web Services, Inc., 2014)

### **Completely Controlled**

Users have complete control over their instances. User can restart, stop, start or terminate any instance anytime. User can remotely access all the files and have root access to all the instances. User can make clones or can change the security configuration anytime from the web services APIs.

### **Flexible Cloud Hosting Services**

It is a flexible hosting service; the user can select the best suitable package depending on the needs. Users have the choice of multiple instance types, operating systems, and software packages. Moreover user can select the type of processor, memory size, and instance storage and boot partition size. User can completely assemble the instance depending on the needs.

### **Designed for use with other Amazon Web Services**

*“Amazon EC2 works in conjunction with Amazon Simple Storage Service (Amazon S3), Amazon Relational Database Service (Amazon RDS), Amazon SimpleDB and Amazon Simple Queue Service (Amazon SQS) to provide a complete solution for computing, query processing and storage across a wide range of applications.”*

### **Reliable**

Amazon EC2 is highly reliable and the service level agreement commitment is 99.95% availability for each Amazon EC2 Region.

### **Secure**

*“Amazon EC2 works in conjunction with Amazon VPC to provide security and robust networking functionality for users compute resources.”*

- The instances of the users are stored in a Virtual Private Cloud (VPC) with an IP range which is specified by the user. User can decide which instances are exposed to the internet and which remains private.
- Security groups and access control list settings allow the user to control inbound and outbound traffic to and from the instances.
- *“You can connect your existing IT infrastructure to resources in your VPC using industry-standard encrypted IPsec VPN connections.”*

- Users can opt for dedicated instances which is an instance that runs on a dedicated hardware to a single customer for additional isolation.

### **Inexpensive**

Amazon EC2 is a very economical solution as compared to the dedicated private server. Users pay for the resources they used and they can upgrade or downgrade the resources anytime they want.

- On-Demand Instances – These instances let the user pay on an hourly basis with no long term commitments. This is a better solution than traditional private server and it frees you from the costs and complexities of planning, purchasing, and maintaining hardware.
- Reserved Instances – *“Reserved Instances give you the option to make a low, one-time payment for each instance you want to reserve and in turn receive a significant discount on the hourly charge for that instance.”*
- Spot Instances – *“Spot Instances allow customers to bid on unused Amazon EC2 capacity and run those instances for as long as their bid exceeds the current Spot Price.”*

### **Amazon EC2 Functionality (Amazon Web Services, Inc., 2014)**

Amazon EC2 provides a true virtual computing environment, allowing the user to launch instances with variety of options. The user can choose the operating system, CPU and storage. The user can change the security options and has full control over the instances.

To use Amazon EC2, user simply needs to follow these steps:

- Select an Amazon Machine Image or create one with your own applications, libraries, data and other configuration settings.

- Configure the security and network access.
- Choose the instance and then start, terminate, and monitor using the web service APIs or other management tools.
- Select the various options to run in multiple locations, utilize static IP endpoints, or attach persistent block storage to the instances.
- Pay for the resources which are actually used by the user, like instance-hours or data transfer.

### 3.4.2 IIS 7

Internet Information services (IIS) for Windows Server is the web server created by Microsoft. It is a flexible, secure and manageable Web server for hosting web applications to media streaming. (Iis.net, 2014)

*“The Web Server (IIS) role includes Internet Information Services (IIS) 7, which is a unified Web platform that integrates IIS, ASP.NET, Windows Communication Foundation, and Windows SharePoint Services. IIS 7 lets you share information with users on the Internet, an intranet, or an extranet.” (Technet.microsoft.com, 2014)*

#### Some important features of IIS7

##### 1. Increase Application density –

IIS 7.0 can increase the density of applications hosted on a single server at a time. All the applications can work at the same time via some IIS enhancements. IIS 7.0 also provides better isolation of web applications on a single server.

##### 2. Bandwidth reduction



IIS 7.0 compress the HTML text which reduces the bandwidth required by a factor of 10. Bandwidth reduction is one of the most important things which data centres required in terms of running cost. It reduces the response time and website load time decreases by factor a factor of 10.

### **3. Server extensibility**

Server is been optimised to give greater throughput and faster response. Performance is enhanced by the usage of output cache.

#### **3.4.3 HTML5**

HTML5 is a markup language which is used for structuring and presenting web pages for the World Wide Web.

*“HTML5 is the next generation of HTML, superseding HTML 4.01, XHTML 1.0, and XHTML 1.1. HTML5 provides new features that are necessary for modern web applications. It also standardizes many features of the web platform that web developers have been using for years, but that have never been vetted or documented by a standards committee.” (Pilgrim, 2010)*

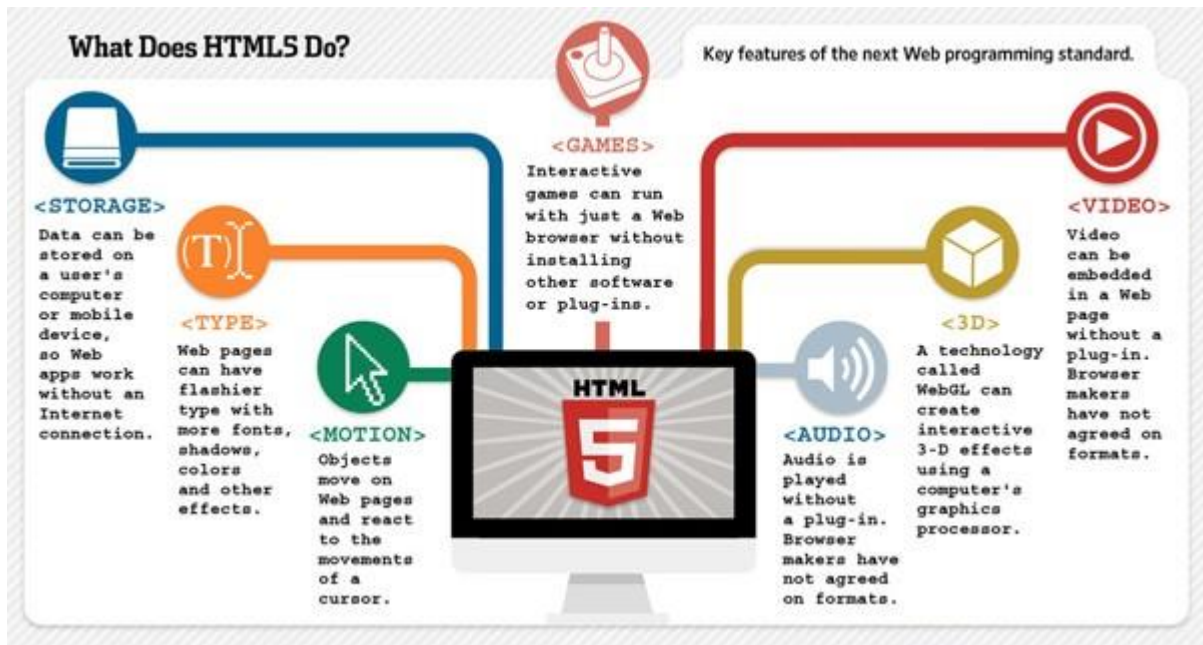


Figure 13: HTML5 Features (Flash, 2011)

The above image shows some of the key features of HTML5. (Databasepublish.com, 2014)

- Storage: Offline data can be stored on the user's computer.
- Type: More fonts, shadows, colours and other effects can be added to the webpages by declaring the Type tags.
- Motion: The webpages can react with the cursor movements.
- Games: Interactive games can be run on the web browser without installing any additional plugin or software for the game.
- Audio: Audio can be played on the web page without using any plugin. The programmer just needs to use the audio tags.
- 3D: WebGL is used to create interactive 3-D effects using a computer's graphics processor.
- Video: Video can be embedded to the webpages without the use of any additional plugin.

Html 5 has three main strengths: (Databasepublish.com, 2014)

**1. Semantic enrichment** - HTML5 introduced new tags like <header>, <footer>, <article> and <section>, pages which is a more meaningful way of organising the content. This will improve the search engine capability to index the web pages with more rich content. Search engine optimisation helps in driving more traffic to the site.

**2. Rich internet applications –**

Rich internet application is an application which can interact with the user's local system to enhance the web experience. HTML5 can store and retrieve files from the user's machine. Web applications running on the HTML5 supported web browsers can yield same results every time by accessing and manipulating files from the browser.

**3. Native support for rich media –**

HTML5 supports audio and video tags by which the developer can embed audio and video files without the need of any additional plugin.

### **3.4.3 CSS3**

*"Cascading Style Sheets(CSS) is a language designed for describing the appearance of documents written in a markup language such as HTML." (Pouncey and York, 2011)*

*"CSS3 is the latest standard for CSS. CSS3 is completely backwards-compatible with earlier versions of CSS." (W3schools.com, 2014)*

CSS3 contains modules from the old CSS specifications and in addition, new modules are added.

- Selectors
- Box Model

- Backgrounds and Borders
- Image Values and Replaced Content
- Text Effects
- 2D/3D Transformations
- Animations
- Multiple Column Layout
- User Interface

#### **Advantages of CSS3: (Mills, n.d.)**

**Font Embedding:** Developers can use custom fonts for use on websites without relying on third party replacement techniques.

**Bulletproof CSS:** Bulletproof CSS is a technique in which CSS UI like containers wouldn't break if the text was resized.

**Multiple Column Layouts:** Developers can create multiple columns like magazine layout in CSS3.

**Dynamic UIs:** CSS3 supports dynamic UIs in which the layout adapts according to the screen size. Smooth animations and transitions for user feedback is been done using JavaScript.

#### **3.4.4 JavaScript**

*“JavaScript is a powerful scripting language that can be embedded directly in HTML. It allows you to create dynamic, interactive Web-based applications that run completely within a Web browser; you don't have to do any server-side programming, like writing CGI scripts.”*  
(Flanagan, 1998)

### **Advantages of JavaScript: (Gilliam, Ting and Wyke, 1999)**

- **Platform Independence**

JavaScript's main advantage is the platform independence. Developers don't need to rewrite/recompile the code to make it work on different platforms. It's an interpreted language which means the developer just need to write the code and let the browser interpret it.

- **Client-Side and Server-Side Versatility**

JavaScript can be used to develop pages on Client and Server side. JavaScript has specific objects for the server environment which allows the developers to connect, query, and get results from a database. Server side scripting capability allows the programmer to make more dynamic pages which can perform specific tasks.

### **3.4.5 JQuery**

Jquery is a JavaScript library.

*"The jQuery library provides a general-purpose abstraction layer for common web scripting, and is, therefore, useful in almost every scripting situation." (Chaffer and Swedberg, 2013)*

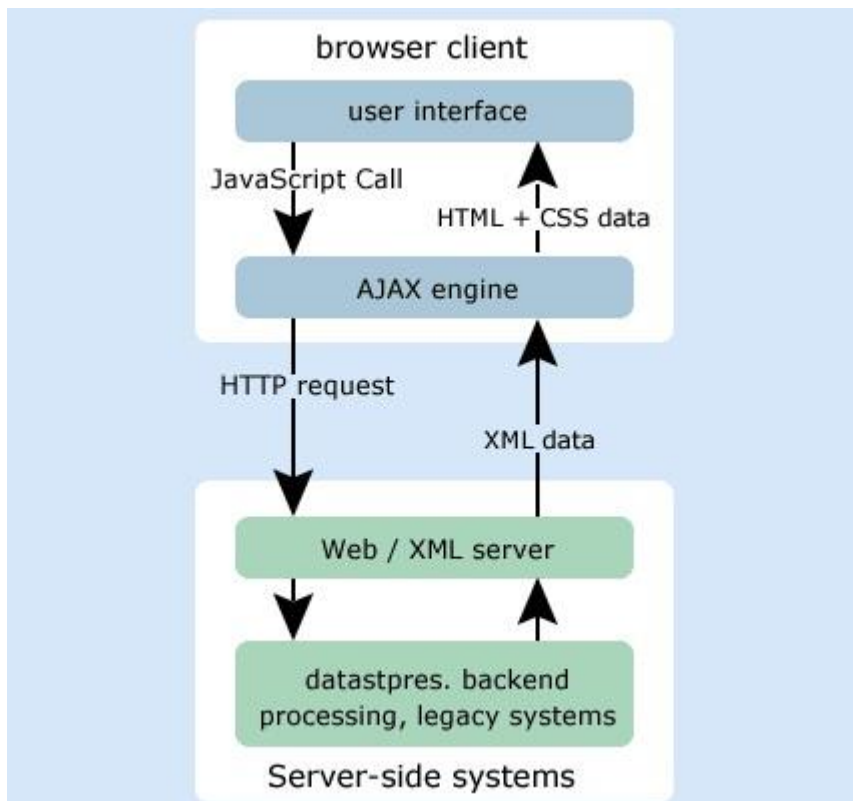
### **Advantages of JavaScript (Rutter, 2010)**

- Open Source
- Great Documentation
- Same JavaScript with less code
- Chaining
- Cross-Browser Compatibility
- CSS3-Complaint

- Graceful Degradation
- Progressive enhancement

### 3.4.6 AJAX

*“AJAX is an acronym for Asynchronous JavaScript and XML. It is the technology that enables the user to load data from the server without reloading the whole page or navigating the user to a new page.” (Holzner, 2006)*



**Figure 14: AJAX Request – Transaction**

The above image shows how AJAX requests are received and sent between the browser and the server. The AJAX engine and Web/XML server act as a mediator between the browser and the server. An HTTP request is sent to the server by the AJAX engine, and XML data is received from the Web/XML server. The AJAX engine takes the request from the browser as a

JavaScript call and gives the data as Html and CSS content. Web/XML server fetches the data from the backend system.

#### **Advantages (Jscripters.com, 2014)**

- **Better** **interactivity**  
Interaction between the user and the website is improved by the use of AJAX calls. The user doesn't need to navigate from one page to another and the load time is improved as the whole page is not reloaded.
- **Easier navigation**  
AJAX based web applications are easier to navigate in comparison to traditional back and forward button on a browser.
- **Compact**  
*"With AJAX, several multipurpose applications and features can be handled using a single web page, avoiding the need for clutter with several web pages."*  
(Jscripters.com, 2014)

#### **3.4.7 Monochromed: A responsive HTML5 website Template**

Monochromed is a free HTML5/CSS3 based web template which was used to develop the web application. (Free-css.com, 2014)

### **3.4.8 ElevateZoom – Zoom effect on the images**

Elevate Zoom is a JQuery image zoom plugin which zooms on the image when hovered by the mouse cursor. This plugin uses jQuery libraries to zoom over the images. Lens zoom was used to zoom over the images in the web application. (Elevateweb.co.uk, 2014)

### **3.4.9 Jsbandwidth - JavaScript Bandwidth Tester**

JSBandwidth is a plugin to run browser-based bandwidth tests quickly and easily within a LAN / WAN. It calculates the bandwidth of the user by downloading a small file from the server, the time difference is measured, and then the speed is calculated. (Code.google.com, 2014)

### **3.4.10 WAMP**

*“Wamp Server is a Windows web development environment. It allows you to create web applications with Apache2, PHP and a MySQL database. Alongside, PhpMyAdmin allows you to manage easily your databases.” (WampServer, 2014)*

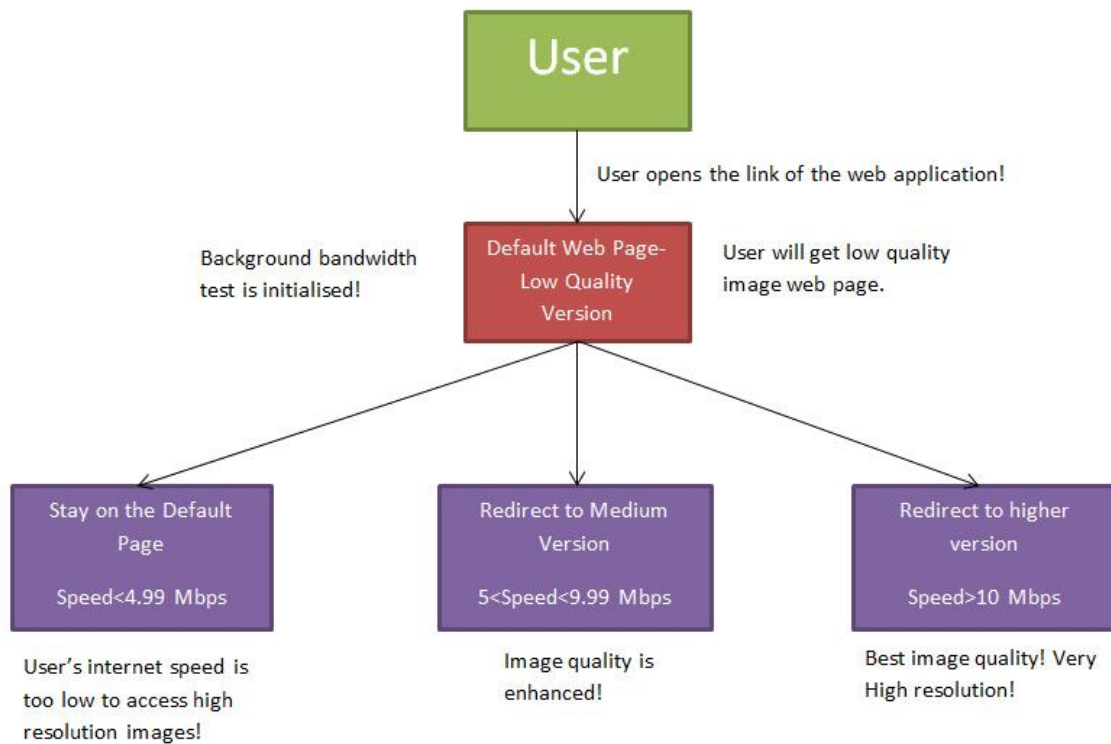
## **3.5 Implementation**

This section describes the challenges and how I timely completed my web application. The HTML5 with java script on a WAMP server was ideal as it enabled RAD (Rapid Application Development) using an Agile and iterative development methodology.

All the previous development experience on Amazon cloud during the course helped a lot to complete the project. Medium size EC2 instance on an Amazon cloud was used to deploy the web application.



## Logic flow of the application



**Figure 15: Flow chart of the application**

The above explains the working of the web application. When the user opens the link of the web application, user can see the default web page. The default web page is a low quality web page (i.e.) the image resolution is not very high. The bandwidth speed test will then check the speed of the internet in the background and the redirection code will take the value of the speed after the completion of the test.

## The Redirection Code Logic

```
1      breakme: if (speed < 5.00)
2      {
3      break breakme;
4      }else if(speed < 10.00)    {
5          var url = "/medium";
6
7      }else
8      {
9          var url = "/high";
10     }
```

**Figure 16: Redirection Code**

The Speed test gives us the value of speed variable in the code.

The “if else” loop was used to redirect the user to the web page depending on the speed. If the speed is less than 5 Mbps (Mega Bits per Second) then break the loop which means the user will stay on the same page. If the speed is less than 10 Mbps then the user will be redirected to the URL “/medium” which is the medium quality images version of the webpage. Finally if the speed is above 10 Mbps then the user will be redirected to the URL “/high” which is the high version of the web application and it contains the best quality images. So the user will get to see the webpage depending on the bandwidth of the internet. It makes the load time fast and enhances the user experience.

## Bandwidth Test

Bandwidth test calculated the user bandwidth. It calculates the bandwidth of the user by downloading a small file from the server, the time difference is measured, and then the speed is calculated.

```

1  var start = 0;
2      var end = 0;
3      var binfile = '';
4      var binfileSize = 256000;
5      function TestDownload() {
6          start = new Date().getTime();
7
8          $.ajax({
9              type: "GET",
10             cache: false,
11             url: "randomfile.txt",
12             dataType: "text",
13
14             success: function(msg) {
15                 binfile = msg;
16                 end = new Date().getTime();
17                 diff = (end - start) / 1000;
18                 bytes = msg.length;
19                 speed = (bytes / diff) / 1024 / 1024 * 8;
20                 speed = Math.round(speed*100)/100;

```

**Figure 17: Bandwidth Test - Code**

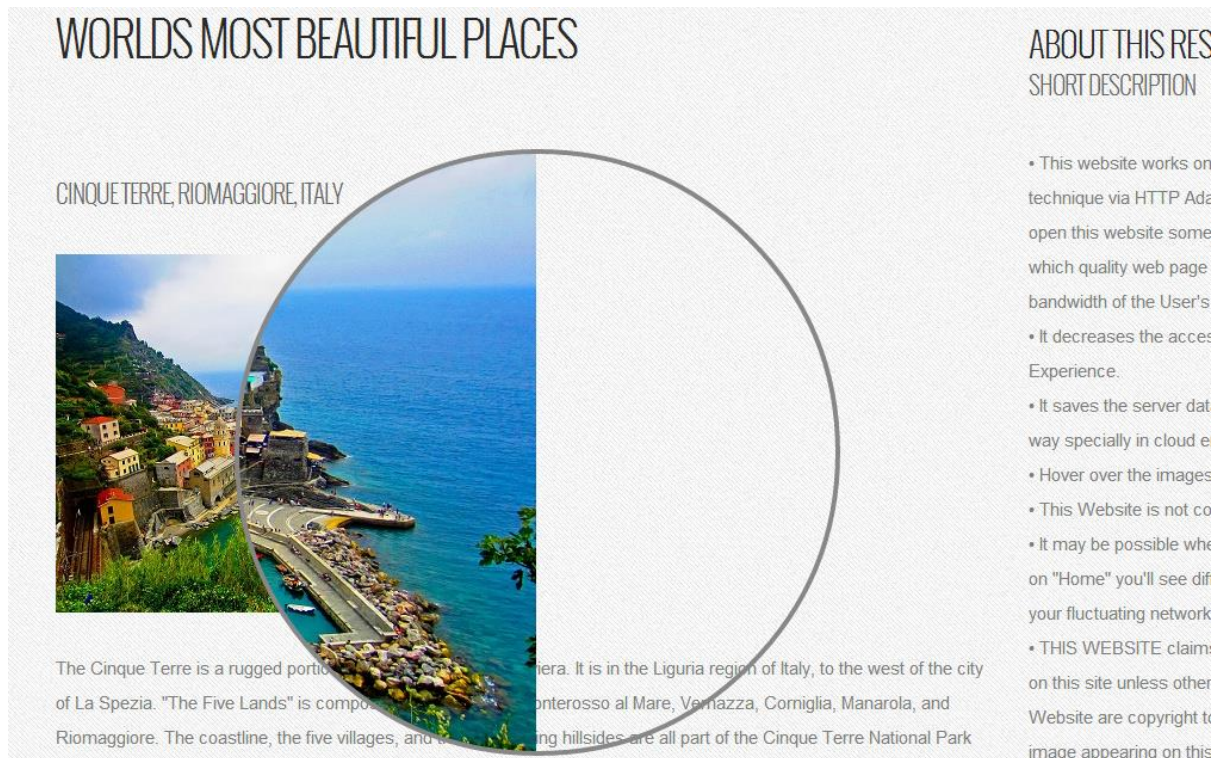
The above image shows the code of the bandwidth tester plugin. This test basically stores the time before the test is initialised in a variable named as start and then it starts downloading a file from the server by making an AJAX request. Once the download is complete it checks the time again and stores it in the variable named as end. Then the time difference is calculated to know how many seconds it took to download the file. The size of the file is divided by the time taken to download that file and then we get the final result of the calculation, the speed of the broadband in Megabits per second (Mbps).

### **Comparison of different versions of the web application**

The website is divided in three different versions for group A. In this section we will see the difference in quality of the images in different versions of the web applications. The user experience is better when they see high quality images. But if the load time is high the user experience gets worse.

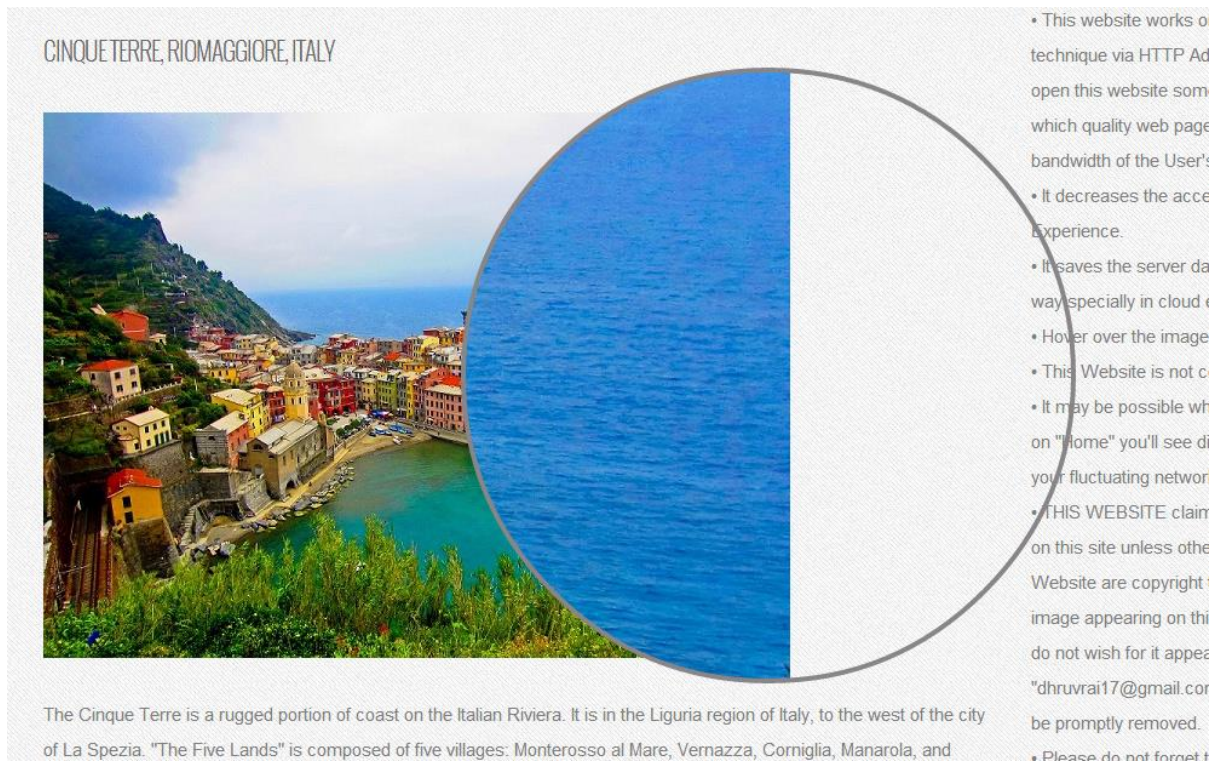
For group B, we used only the medium version of the group A web application.

The images below are cropped at the same resolution and quality of the image is better in bigger images. Even the zoom looks better, the resolution is higher.



**Figure 18: Default Version – Lowest Quality/Resolution**





**Figure 19: Medium Quality – Bigger images than the lower quality version**



**Figure 20: Highest Quality – Bigger and clearer images**

### **3.6 Conclusion**

This section showed us how the web application was setup, its working and the different versions of the application. To facilitate the creation of web application, requirement analysis was used to gather all the relevant information to develop the application. Tests were done to check if it calculates the speed correctly or not as well as to check the code if it redirects the user to the right page after calculating the speed. In the next chapter the findings from the questionnaires are discussed and conclusion is made.

## **4. Analysis and findings**

### **4.1 Introduction**

The fourth chapter of the study presents data collected during the research using the quantitative research method. The survey questionnaire was conducted for this project to derive reliable and most appropriate results; two survey questionnaires were prepared and distributed them into two groups. Two web applications were made; first web application was made with the HTTP adaptive technology and second without it.

A survey link was sent to random population with a link to the web application.

Group A got the link of the web application with the HTTP adaptive technology and group B without technology.

Questionnaire was distributed amongst 107 regular internet users. The email link was randomly sent to the population and a total of 107 internet users filled the questionnaire, which included 75 users for Group A and 32 for Group B respectively.

All the participants participated on their own will and no participant was forced for any sort of contribution. This chapter of the study, at first, presents the data that has been collected from the participants and later it will be thoroughly analysed by the researcher using the right data analysis technique.

For Group A, the web application developed by the researcher with the progressive enhancement technology contained three versions of the same website. Those three versions were divided into following categories:

- **High Bandwidth Website:** High bandwidth website was loaded when the users' speed is more than 10 MBPS. This version contains very high resolution and clear images.
- **Medium Bandwidth Website:** Medium bandwidth website was loaded when the users' speed lies between 5 – 9.99 MBPS. This version contains medium resolution images.
- **Low Bandwidth Website:** Low bandwidth website was loaded when the users' speed is less than 4.99 MBPS. This is the default version which is loaded instantly and it contains low resolution images.

When the user opens the link of the website, he/she first sees the Low bandwidth website as default. A background calculation is then made to calculate the bandwidth and the user is redirected to any of the three versions of the website depending on the bandwidth at that time. So if the user's internet bandwidth is high( i.e.) more than 10 MBPS, then the user will be redirected to high quality website with less load time which will improve the user experience. If the user's internet bandwidth is medium (i.e.) 5 - 9.99 MBPS then the user will be redirected to a medium quality website with less load time. If the user's internet bandwidth is very low then the user will see low quality images but the load time will be less. In all the three cases, the load time remains less which improves the user experience.

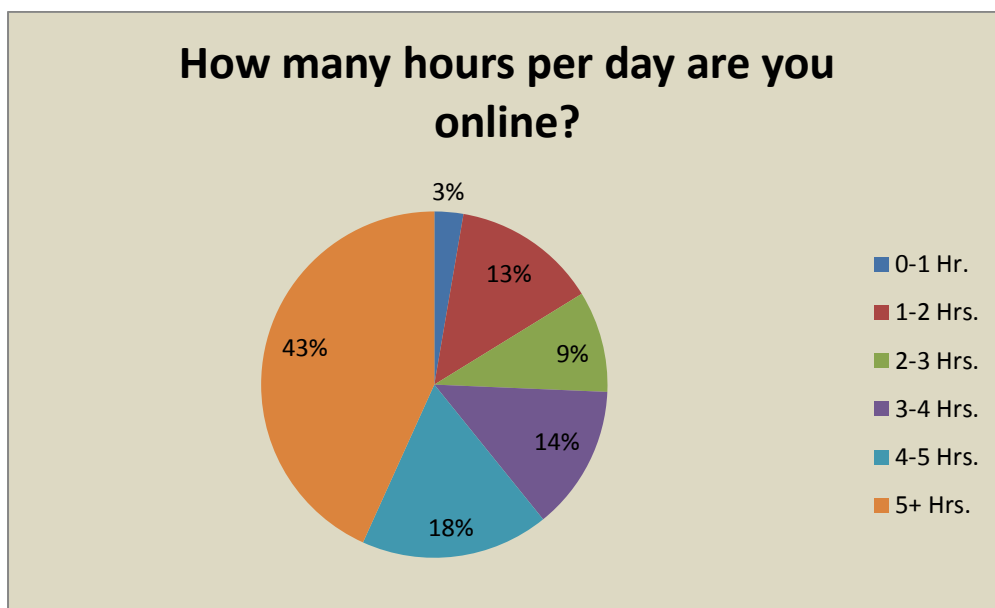
For the Group B, the medium version of the website was used without any redirection code. So the user will see medium quality images and the load time will vary according to the internet bandwidth. If the user has a high speed internet, the load time will be very less and on a slow speed internet; the load time will be more which may lead to poor user experience.



## 4.2 Measurement of Group A

In this section, we will discuss the findings of the Group A survey results. 75 people filled the survey in Group A. This group got the link for the web application which was created using HTTP adaptive technology and comparison was made with all the other websites.

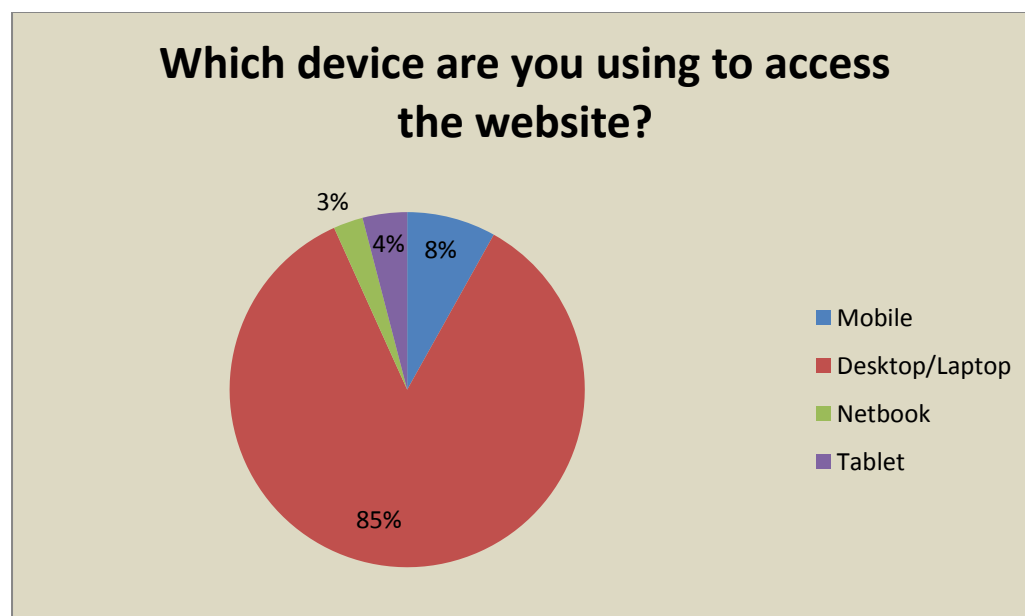
The very first question concerned the number of hours spent online. This question was asked to ascertain if the user knew how to use the internet to access the web application from the survey link and fill the questionnaire. The findings show that most of the users spend more than 4-5 hours on the internet, so it can be concluded that the users can easily access our web application and can complete the survey.



The above chart was created from the results derived from the surveys. 43% of users are online for more than 5 hours whereas only 3% of users are online for less than 1 hour. However, 13% of users are online either for 1-2 hours or for 3-4 hours. 9% of users are online for 2-3 hours and 18% for 4-5 hours.

The study clearly indicates that most of the users are online for more than 5 hours which surely corresponds to current trends.

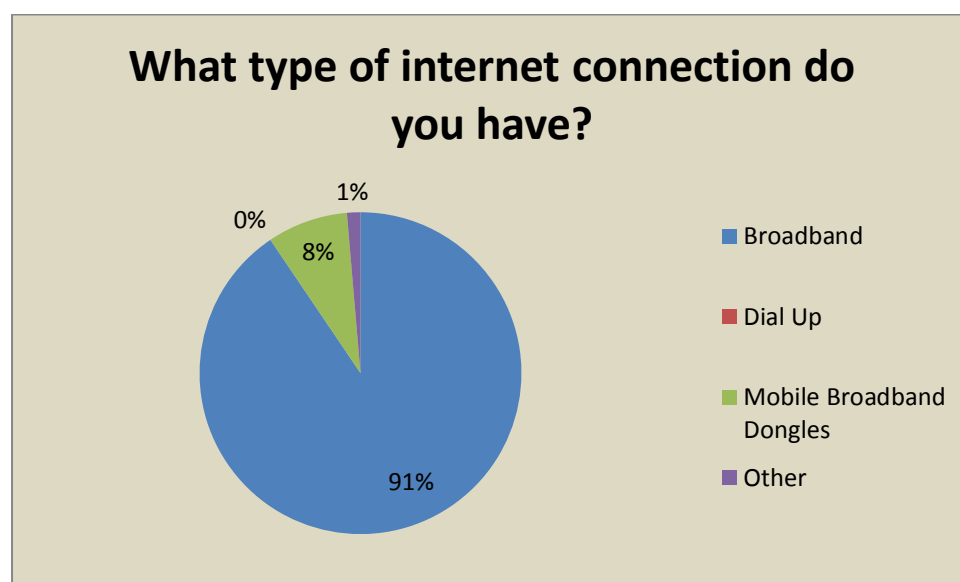
Our next question was one of the most important questions in our questionnaire. It was very important to know which device they were using to access our web application. Our web application used various technologies and scripts which may not perform well on smartphones and tablets. The load time on smartphones and tablets is not that fast as compared to Desktops/Laptops. Our findings show that most of the users were using Desktop/Laptop computers while accessing our web application which makes our research more appropriate.



The participants of the study were also asked about which device they were using to access our web application. While 85% of the users were using desktop or laptop as their medium, only 3% were using net book. Results indicate that 8% are online via mobile and 4% accessed the web application via tablet. This evidently states that the popularity of laptops

or desktops clearly outweighs any other device and we can conclude that our web application must be responsive and fast for most of the users.

The next question related to the internet connection in use. The user experience is most affected by the broadband speed because slow speed internet means high page load time and poor user experience.

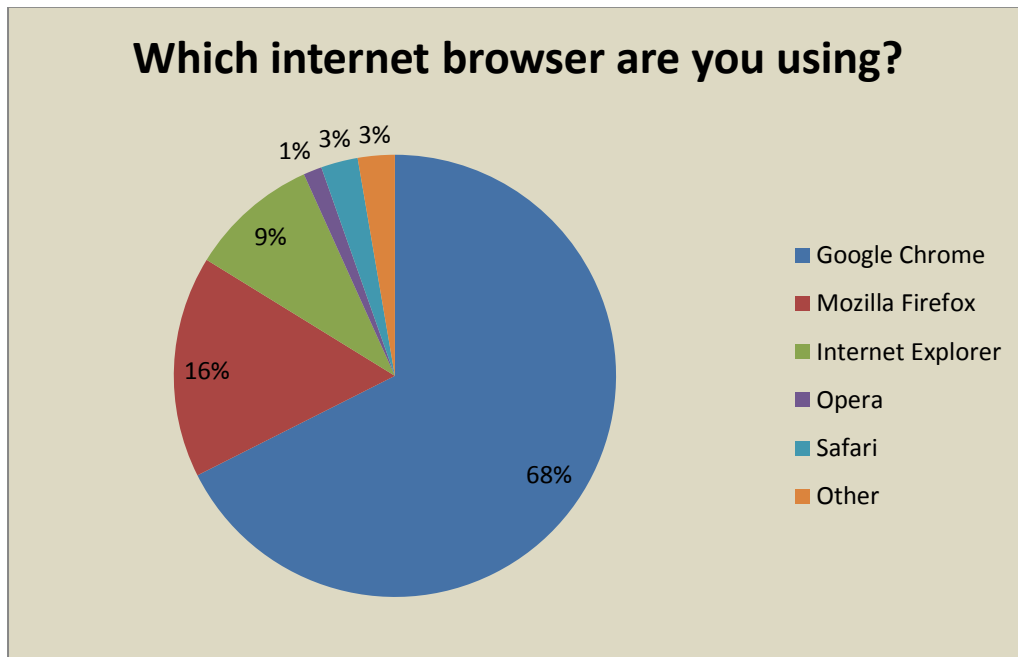


According to the survey, none of the users are currently using dial-up connection whereas 91% of users are presently using broadband connection. However 8% of users are using mobile broadband dongles whereas 1% of users are right now availing some other services.

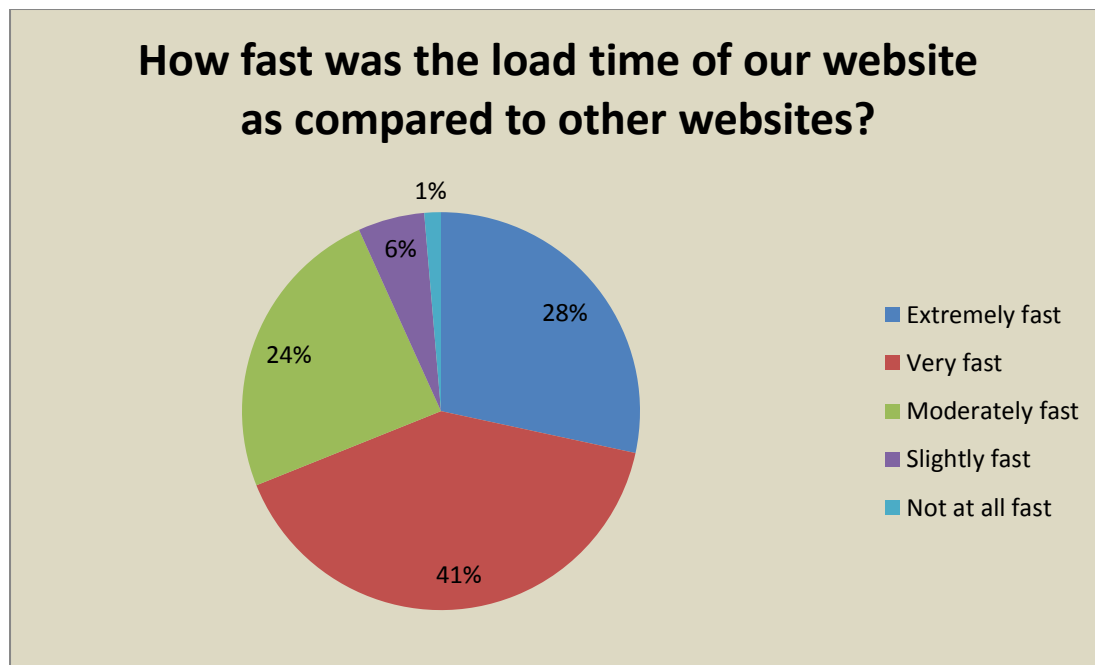
The above study throws light on the fact that dial up connections are no longer in use whereas broadband services are used by majority of the users.

Next question is about the web browser they are using to access our web application. Web application performance depends on the performance of the web browser as well. Different

web browsers use different algorithms to render pages and run scripts. Better browser performance means low page load time and better user experience.



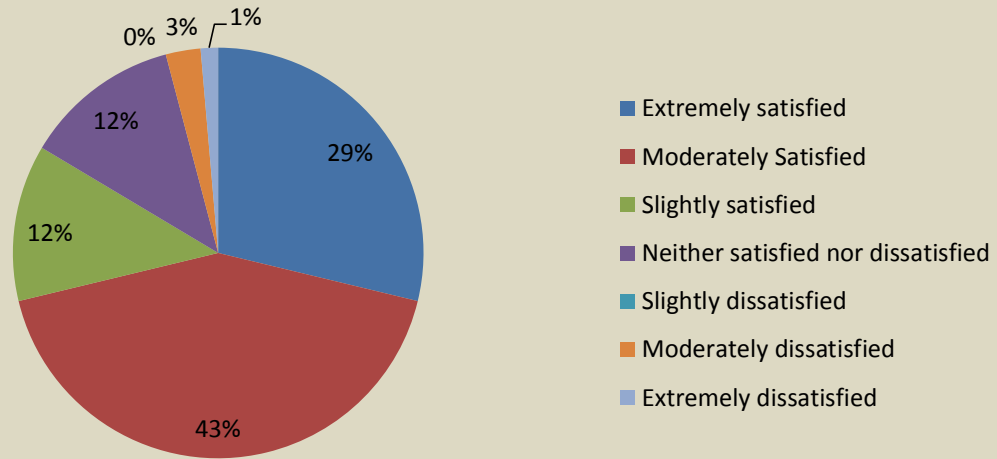
Our findings from this question are as follows: Google Chrome is the most used web browser with 68% users using it whereas only 16% of users are online via Mozilla Firefox. 9% of the participants use Internet Explorer and 1% of them use Opera. However 3% of the user uses Safari and any other browser for internet access. Google Chrome is one of the fastest web browsers in the market right now, so that means most users will not experience degraded performance because of the browser they are using. (Mashable, 2008)



Next we asked the users about the load time of the website. Was it fast to load than the other websites? For 41% of the users, it was very fast whereas for 28% it was extremely fast. According to 24% of the users it was moderately fast and for 6% it was slightly fast. For 1% of the users, the website was not at all fast to load. Overall, the load time for the website was very fast as compared to others.

This question answers our research that the users think that the website is faster in terms of load time as compared to others. This means that the Progressive enhancement technology actually improves the load time and affects the overall user experience.

**Overall, are you satisfied with our website,  
neither satisfied nor dissatisfied with it, or  
dissatisfied with it?**



Next question interrogates the user about their level of satisfaction from the website. For 43% it was a moderately satisfying experience whereas 29% of the users were extremely satisfied. 12% of the users were neither nor dissatisfied and 12% were slightly satisfied. 3% of the users were moderately dissatisfied and 1% of users were extremely dissatisfied. Overall, it was quite a satisfying experience for them.

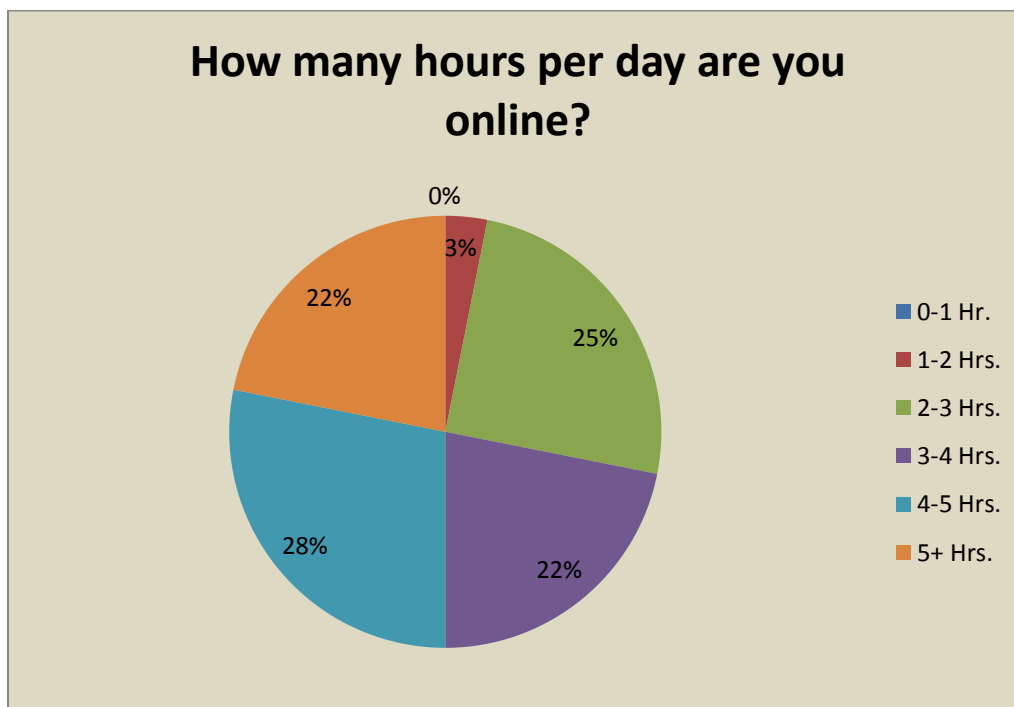
We are making a comparison with all the other websites which want to give a certain level of quality to make the comparison more appropriate.

### **4.3 Measurement of Group B**

In this section, we will discuss the findings of the Group B survey results. 32 people filled the survey in Group B. This group got the link for the web application which was not created using HTTP adaptive technology.

The very first question concerned the number of hours spent online. Our findings show the similar result as group A, (i.e.) most of the users spend more than 4-5 hours over the

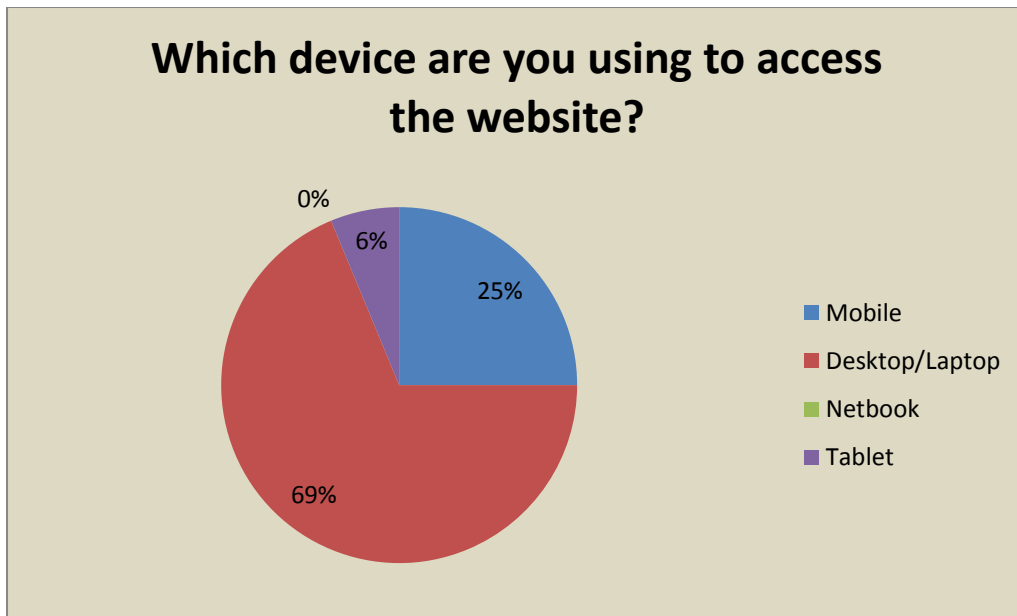
internet, so we can conclude that the users can easily access our web application and complete the survey.



22% of users are online for more than 5 hours whereas 0% of users are online for less than 1 hour. However, 3% of users are online either for 1-2 hours and 22% of users are online for 3-4 hours. 25% of users are online for 2-3 hours and 28% for 4-5 hours.

The study clearly indicates that most of the users are online between 4-5 hours which surely corresponds to the current trends.

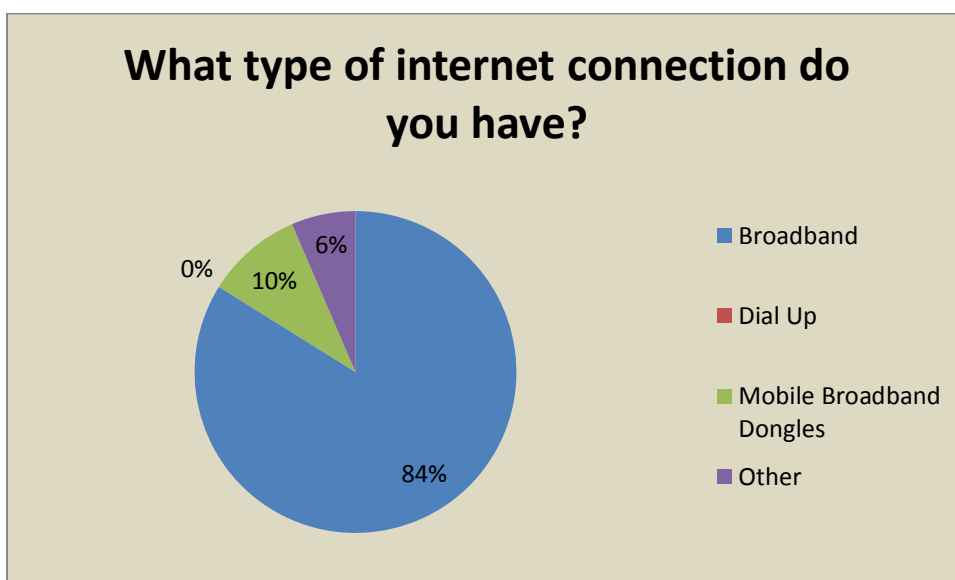
Our next question related to the use of device for accessing our web application? Our web application used various technologies and scripts which may not perform well on smartphones and tablets. The load time on smartphones and tablets is not that fast as compared to Desktops/Laptops. Our findings shows that most of the users where using Desktop/Laptop computers while accessing our web application.



The participants of the study were asked about the device being used to access our web application. 69% of the users were using desktop or laptop as their medium and nobody was using the net book. Results indicate that 25% are online via mobile and 6% accessed the web application via tablet.

Our website was optimised to work better on the Desktop/Laptop computer, and hence the above results make our research more appropriate.

The next question is concerned with the internet connection that the user possesses.

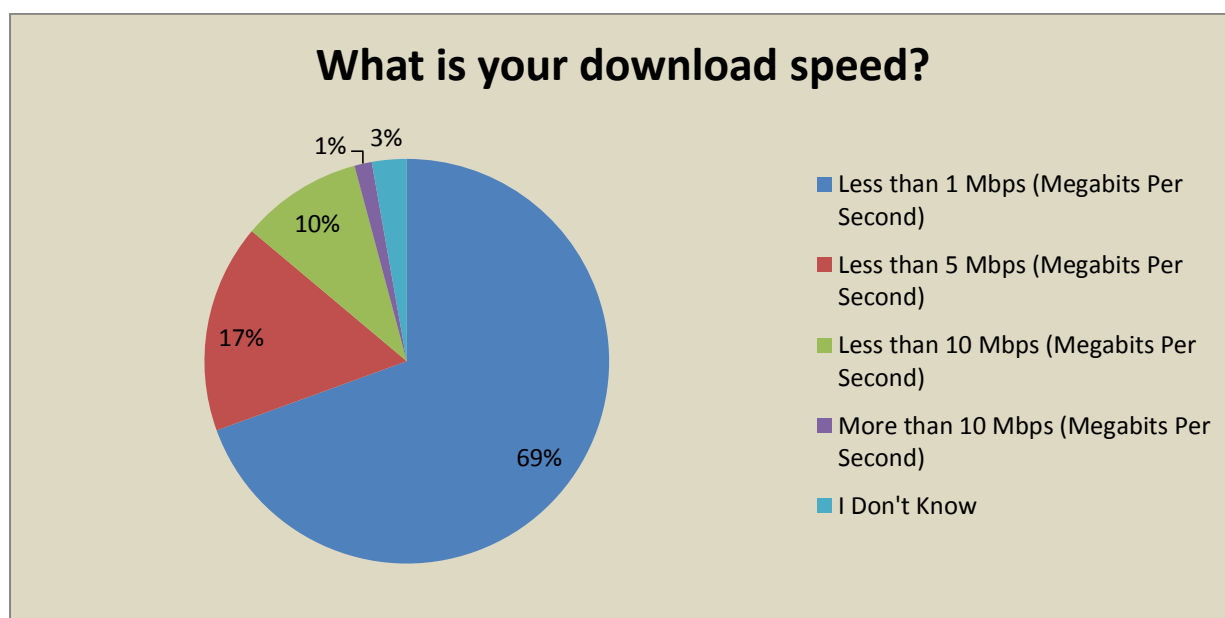




According to the survey, no user is currently using dial-up connection whereas 84% of users are presently using broadband connection. However 10% of users are using mobile broadband dongles whereas 6% of users are right now availing some other services.

The above study shows that broadband services are used by majority of the users.

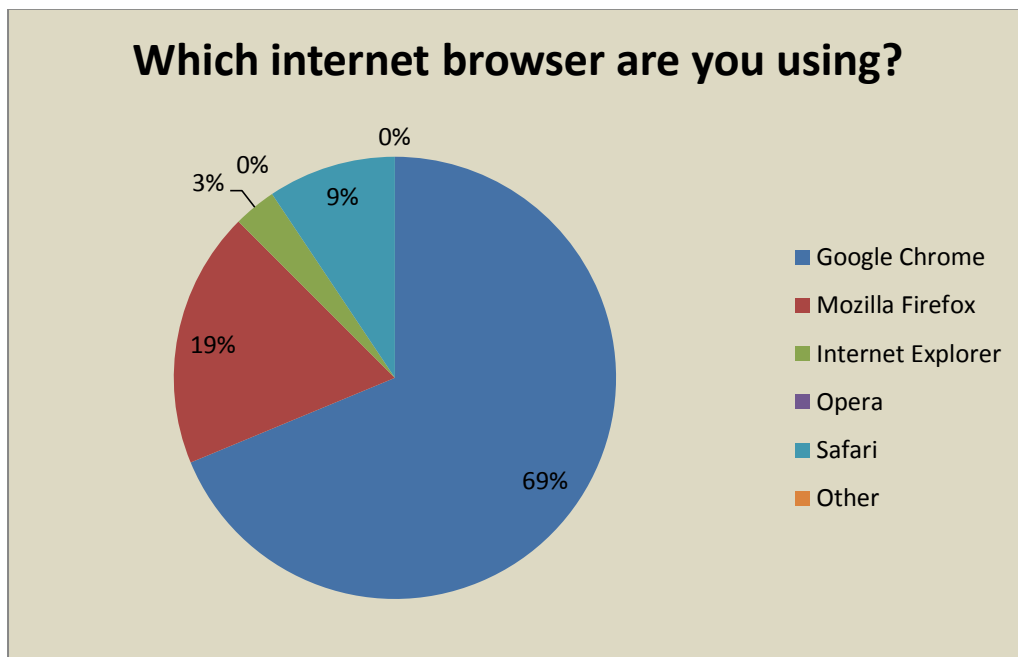
Our next question was to ascertain the download speed of the internet from their ISP. If the user has a high speed package then the load time will be very less.



Our result shows that 69% of users are getting less than 1 Mbps package and 1% of users have package more than 10 Mbps. 17% of users have less than 5 Mbps, 10% have less than 10 Mbps and 3% people have no knowledge about their download package.

The above shows that most of the users are not getting a high speed broadband which means when they access our website or any website of same size, then the load time will be high. The user experience will be poor for most of the users and progressive enhancement technology may help in this case.

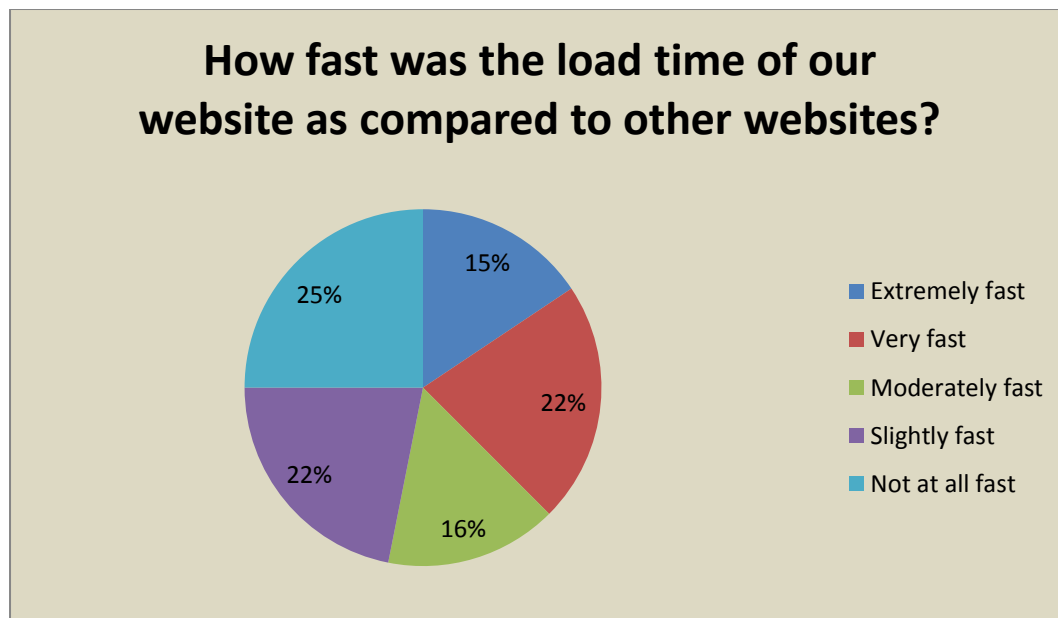
Next question is about the web browser they are using to access our web application. Better browser performance means low page load time and better user experience.



The results of the survey show that Google Chrome is the most used web browser with 69% users using it whereas 19% of users are online via Mozilla Firefox. 3% of the participants use Internet Explorer and none of them were using Opera. However 9% of the user uses Safari.

Google Chrome is the most widely used browser. Our web application was working fine on Google Chrome which makes our research more appropriate.

Our final question was the most important question, how fast was the load time of the website as compared to other websites?



For 22% of the users, it was very fast whereas for 15% it was extremely fast. According to 16% of the users it was moderately fast and for 22% it was slightly fast. For 25% of the users, the website was not at all fast to load.

Overall, the load time for the website was not fast as compared to others.

#### **4.4 Conclusion**

To summarise the chapter, it is evident from the survey that the web application with progressive enhancement technology performed better and faster. The load time was less and user experience was better. From the findings, we can see that the users were using different types of browsers and devices but still the page load time was less as compared to other websites on the web for Group A.

There were many common findings as well derived from both groups. Most of the users were online for 4-5 hours per day. Most widely used device is Desktop and laptop computers. Most of the users have Broadband connection at home and nobody uses dial-up connection anymore. Google Chrome is the most used web browser.

For Group B, when we asked about the download speed package, we came to know that most of the users have slow speed broadband and thus it was expected that their user experience of accessing the website will not be that great. The results showed the same thing.

## 5. Conclusions

This chapter provides an overall perspective of the research conducted in this project and summarises its main contributions.

### 5.1 Overview

One of the most important aspects of development is to develop user friendly and high performance websites. User's experience should be fine to the utmost level. If the user is not satisfied he/she will not visit the website again. Majority of the users are not getting a good speed broadband in their premises which make it very difficult to access web pages of a good quality without waiting for long. User experience is strongly affected by the high load time. Users get frustrated when the page doesn't open and often closes it before the loading is even complete. The increasing number of internet users and types of devices being used by them gives a new challenge to the web developers. Web developers now have to consider all the facts about the user and the device. Developers need to meet the requirements of the customer from the web application as well as they need to give the best user experience possible. The user experience can be great while browsing the website if it loads fast; it is platform/ device independent and has good quality content.

This research was done to develop a solution for the majority of internet users. Majority of internet users do not have broadband which is capable enough to load high quality images or watch HD videos. This research proposed a solution for slow speed broadband users by merging two technologies i.e. HTTP adaptive streaming and Progressive enhancement.

The research question for the dissertation was

"Can progressive enhanced website via Http adaptive technology improve the user experience?"

The fundamental aim of this research is to merge two technologies by which the user experience can be enhanced on the web. In order to fulfil this aim further sub-objectives are developed. These objectives are as follows:

1. To explore that how progressive enhancement via HTTP adaptive streaming affects the user experience.
2. To explore that how a normal website with high load time affects the user experience
3. To survey people on the web and see which is more effective.

## **5.2 Contribution to the body of knowledge**

This projects primary aim was to reduce the load time for heavy websites so that the users with slow internet connection can also browse those websites without waiting for too long. If this research proves that the Progressive enhanced web application via HTTP adaptive streaming improves the user experience then it can provide a solution for majority of slow speed internet users over the internet?

The first contribution to this knowledge area was detailed steps for the creation of a web application which can incorporate these two technologies and reduce the load time. This will be the first time that these two technologies are used in the same web application to serve the purpose. The steps involved are comprehensive and should serve as a solid guide for any future developments.

The second contribution from this research is that it will show that if the load time is high the user experience will not be good. The web developers can keep it as a note before they start developing the new web applications as the load time is one of the most important aspects to be considered while developing a web application.

The main contribution from this research is to prove if this approach of web development can enhance the user experience by decreasing the load time. This approach can be used as a solution for heavy websites to improve the user experience. In future web developers can use it and deploy heavy websites without worrying about the load time.

## **5.3 Future Work**

Throughout the process of this research a number of additional research areas were identified. The following sections will explain the concepts of the new research areas and an overview of how this might be approached from a research perspective.

### **5.3.1 Cost Saving in Cloud**

This technology can be used to save the cost of data transmission over the cloud. The users with low bandwidth will not get high quality images and the overhead to send heavy data will be saved. The server load will decrease and the cost of transmission will be reduced. There can be a future research on how much cost can be saved if this technology is used in future in a cloud environment. The strategy to deploy web applications with this approach can really help in saving the cost of the cloud for enterprise.

### **5.3.2 Dynamic Content Updating - Remove Page Reload.**

The web application which was developed to serve the purpose of this research contains the redirection code. When the web application is accessed by the user it reloads the page to a higher quality depending on the bandwidth of the user.

The web application can be recoded to update the content using AJAX calls. AJAX calls will not refresh the page but it will upgrade the images. There can be many other possibilities to develop a website with the same functionalities but different languages and plugins.

### **5.3.3 More Browsers Support**

The web application which was developed doesn't work on Internet Explorer. The redirection code and the bandwidth calculator can be recoded to make it compatible with the internet explorer.

### **5.3.4 Device Independence**

The bandwidth calculator doesn't work on the non-smart phone web browsers. Non-smart phone browsers do not have big local storage to download the file and run the redirect scripts. The majority of people use smart phones these days but still the code can be redesigned to make it compatible for non-smart phones as well.

## **5.4 Conclusion**

The main objective of this research is to prove if this approach of web development can enhance the user experience by decreasing the load time. This approach can be used as a solution for heavy websites to improve the user experience. In future web developers can use it and deploy heavy websites without worrying about the load time.

Questionnaire was distributed amongst 107 regular internet users. The email link was randomly sent to the population and a total of 107 internet users filled the questionnaire, which included 75 users for Group A and 32 for Group B respectively.

All the participants participated on their own will and no participant was forced for any sort of contribution. This chapter of the study, at first, presents the data that has been collected from the participants and later it will be thoroughly analysed by the researcher using the right data analysis technique.

For Group A, the web application developed by the researcher with the progressive enhancement technology contained three versions of the same website. Those three versions were divided into following categories:

- **High Bandwidth Website:** High bandwidth website was loaded when the users' speed is more than 10 MBPS. This version contains very high resolution and clear images.
- **Medium Bandwidth Website:** Medium bandwidth website was loaded when the users' speed lies between 5 – 9.99 MBPS. This version contains medium resolution images.



- Low Bandwidth Website: Low bandwidth website was loaded when the users' speed is less than 4.99 MBPS. This is the default version which is loaded instantly and it contains low resolution images.

When the user opens the link of the website, he/she first sees the Low bandwidth website as default. A background calculation is then made to calculate the bandwidth and the user is redirected to any of the three versions of the website depending on the bandwidth at that time. So if the user's internet bandwidth is high( i.e.) more than 10 MBPS, then the user will be redirected to high quality website with less load time which will improve the user experience. If the user's internet bandwidth is medium (i.e.) 5 - 9.99 MBPS then the user will be redirected to a medium quality website with less load time. If the user's internet bandwidth is very low then the user will see low quality images but the load time will be less. In all the three cases, the load time remains less which improves the user experience.

To summarise the chapter, it is evident from the survey that the web application with progressive enhancement technology performed better and faster. The load time was less and user experience was better. From the findings, we can see that the users were using different types of browsers and devices but still the page load time was less as compared to other websites on the web for Group A.

For Group B, when we asked about the download speed package, we came to know that most of the users have slow speed broadband and thus it was expected that their user experience of accessing the website will not be that great. The results showed the same thing.

There are many common findings derived from both groups. Most of the users were online for 4-5 hours per day. Most widely used device is Desktop and laptop computers. Most of the users have Broadband connection at home and nobody uses dial-up connection anymore. Google Chrome is the most used web browser.

So we can say that Progressive enhanced web application via HTTP adaptive streaming improves the user experience. Moreover, websites with high load time makes the user experience poor.

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## Appendix A

### Group A

**\*1. How many hours per day are you online?**

- ☐ 0-1
- ☐ 1-2
- ☐ 2-3
- ☐ 3-4
- ☐ 4-5
- ☐ More than 5

**\*2. Which device are you using to access the website?**

- ☐ Mobile
- ☐ Desktop/Laptop Computer
- ☒ Netbook Computer
- ☐ Tablet

Other (please specify)

**3. What type of internet connection do you have?**

- ☐ Broadband
- ☐ Dial Up
- ☐ Mobile Broadband Dongles
- ☐ Other (please specify)



#### 4. Which internet browser are you using?

- ☐ Google Chrome
- ☐ Mozilla Firefox
- ☐ Internet Explorer
- ☐ Opera
- ☐ Safari
- ☐ Other (please specify)

#### 5. How fast was the load time of our website as compared to other websites?

- ☐ Extremely fast
- ☐ Very fast
- ☐ Moderately fast
- ☐ Slightly fast
- ☐ Not at all fast

#### 6. Overall, are you satisfied with our website, neither satisfied nor dissatisfied with it, or dissatisfied with it?

- ☐ Extremely satisfied
- ☐ Moderately satisfied
- ☐ Slightly satisfied
- ☐ Neither satisfied nor dissatisfied
- ☐ Slightly dissatisfied
- ☐ Moderately dissatisfied
- ☐ Extremely dissatisfied

7. Please provide your Email address. (We would like to assure you that the information you provide will be treated with the strictest confidence and will only be used for research purposes)

[Prev](#) [Done](#)

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## Group B

**\*1. How many hours per day are you online?**

- ☐ 0-1
- ☐ 1-2
- ☐ 2-3
- ☐ 3-4
- ☐ 4-5
- ☒ More than 5

**\*2. Which device are you using to access the website?**

- ☐ Mobile
- ☐ Desktop/Laptop Computer
- ☐ Netbook Computer
- ☐ Tablet

Other (please specify)

**3. What type of internet connection do you have?**

- ☐ Broadband
- ☐ Dial Up
- ☐ Mobile Broadband Dongles
- ☐ Other (please specify)

**\*4. What is your download speed?**

- ☐ Less than 1 Mbps (Megabits Per Second)
- ☐ Less than 5 Mbps (Megabits Per Second)
- ☐ Less than 10 Mbps (Megabits Per Second)
- ☐ More than 10 Mbps (Megabits Per Second)
- ☐ I Don't Know

**5. Which internet browser are you using?**

- ☐ Google Chrome
- ☐ Mozilla Firefox
- ☐ Internet Explorer
- ☐ Opera
- ☐ Safari
- ☐ Other (please specify)

**6. How fast was the load time of our website as compared to other websites?**

- ☐ Extremely fast
- ☐ Very fast
- ☐ Moderately fast
- ☐ Slightly fast
- ☐ Not at all fast

**\*7. Please provide your Email address. (We would like to assure you that the information you provide will be treated with the strictest confidence and will only be used for research purposes)**

Prev

Done

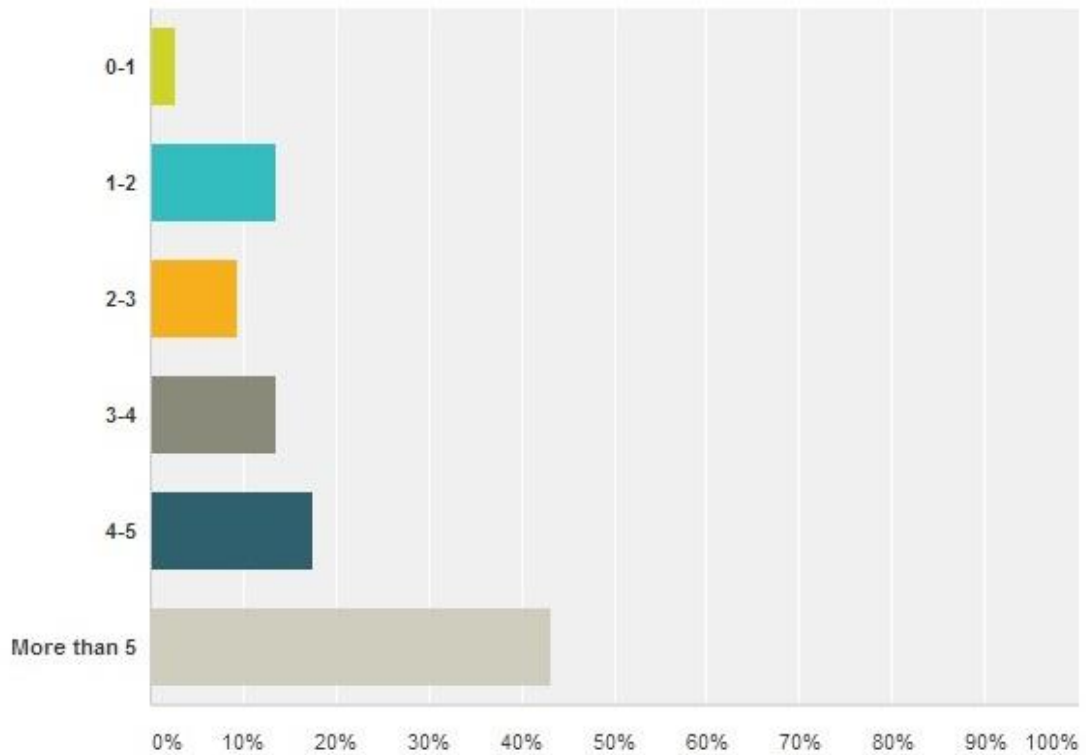
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## Appendix B

### Group A

#### Q1. How many hours per day are you online?

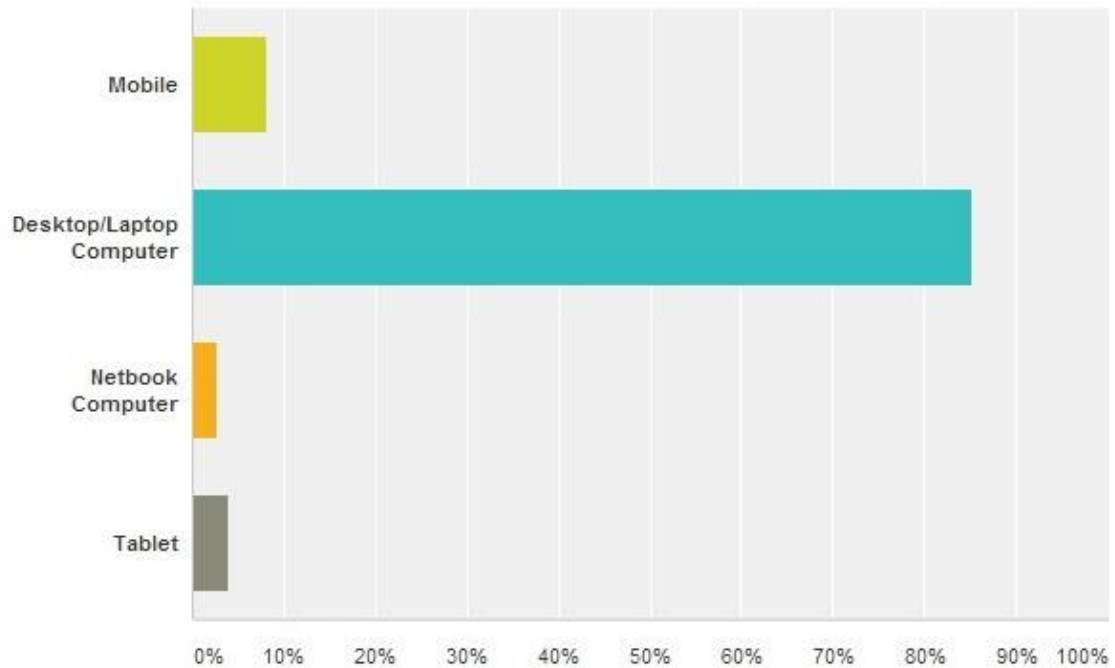
Answered: 74 Skipped: 1



Answer Choices	Responses
0-1	2.70% 2
1-2	13.51% 10
2-3	9.46% 7
3-4	13.51% 10
4-5	17.57% 13
More than 5	43.24% 32
Total	74

## Q2.Which device are you using to access the website?

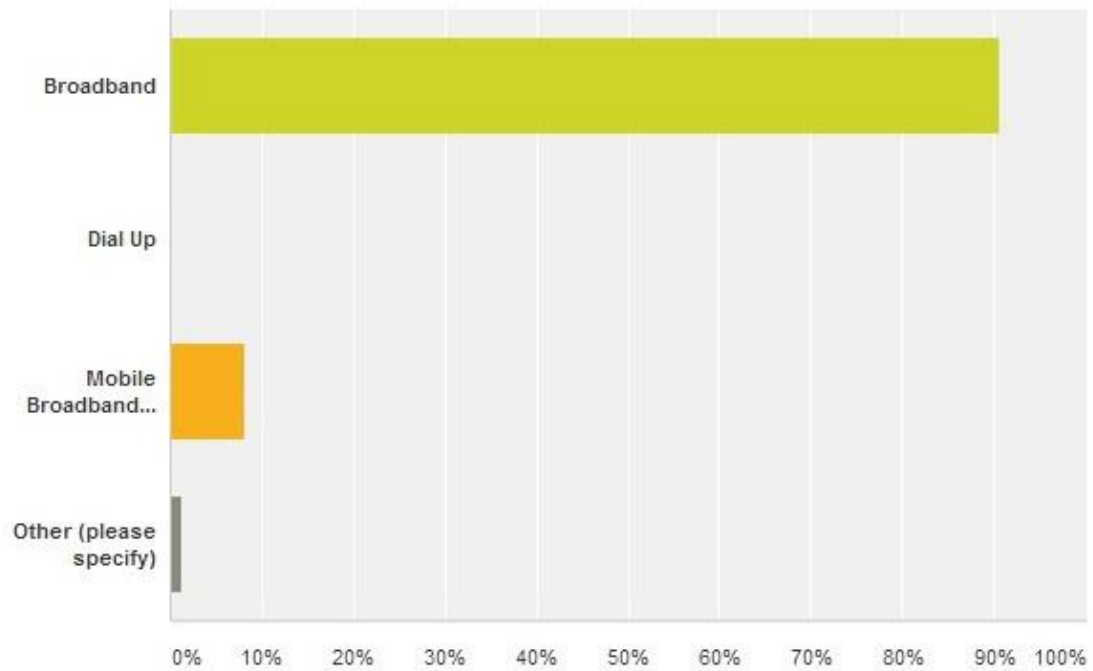
Answered: 74 Skipped: 1



Answer Choices	Responses
Mobile	8.11% 6
Desktop/Laptop Computer	85.14% 63
Netbook Computer	2.70% 2
Tablet	4.05% 3
Total	74
Comments (3)	

### Q3. What type of internet connection do you have?

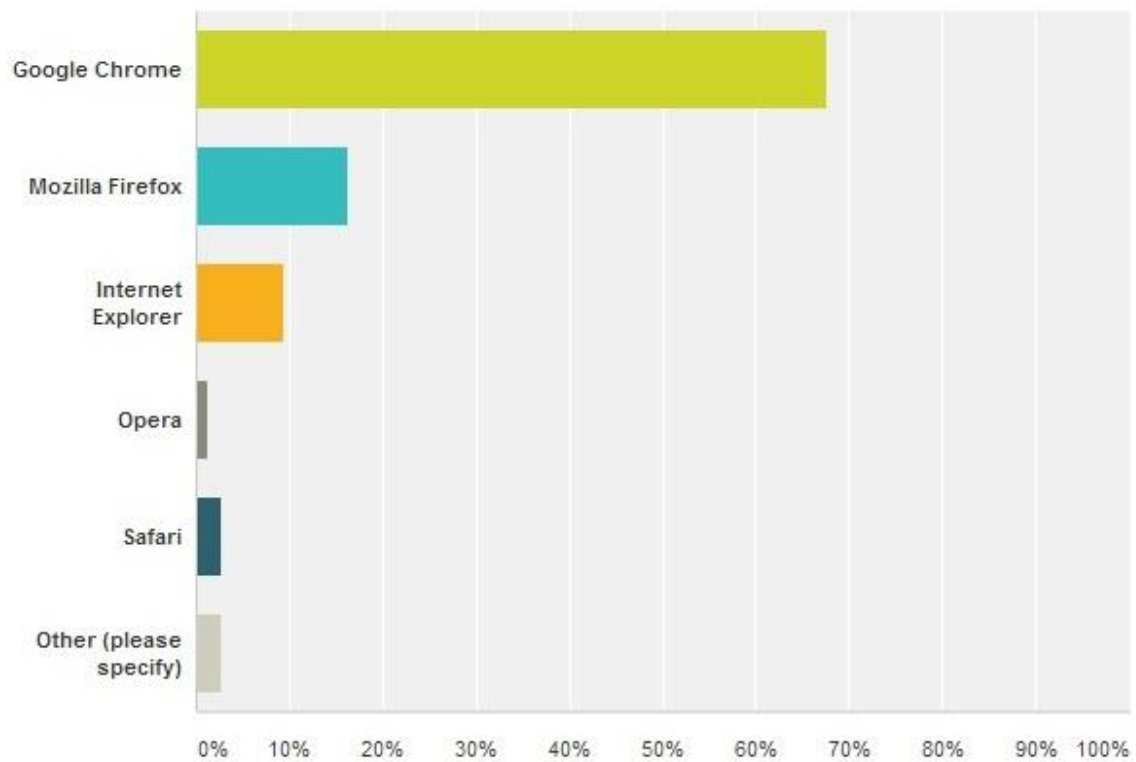
Answered: 74 Skipped: 1



Answer Choices	Responses	
Broadband	90.54%	67
Dial Up	0.00%	0
Mobile Broadband Dongles	8.11%	6
Other (please specify)	1.35%	1
Total		
		74

## Q4. Which internet browser are you using?

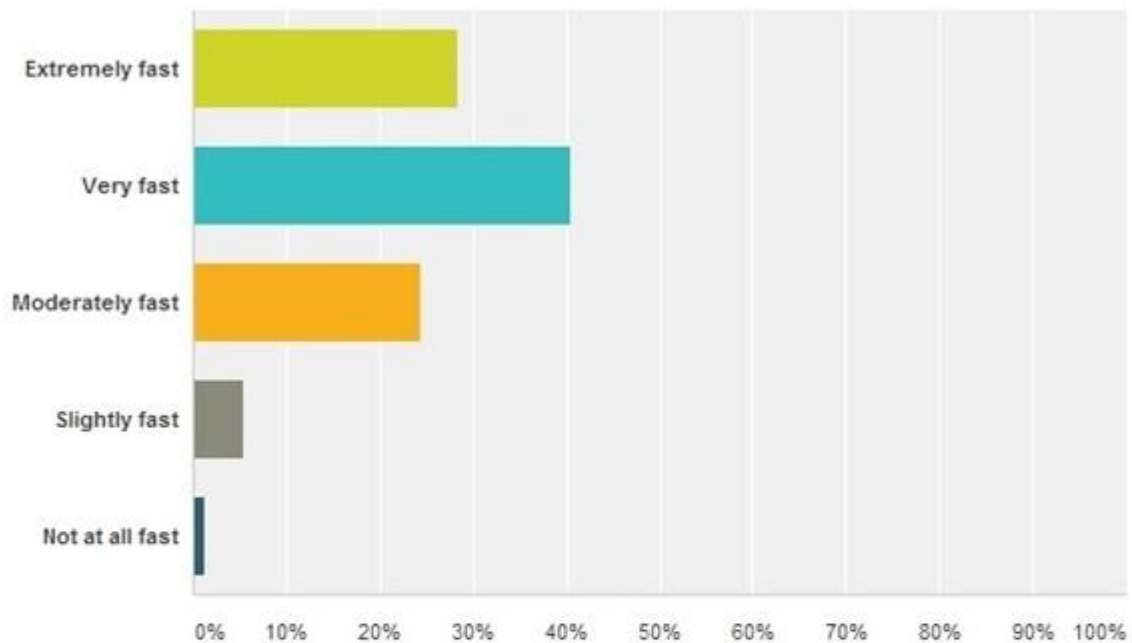
Answered: 74 Skipped: 1



Answer Choices	Responses
Google Chrome	67.57% 50
Mozilla Firefox	16.22% 12
Internet Explorer	9.46% 7
Opera	1.35% 1
Safari	2.70% 2
Other (please specify)	2.70% 2
Total	74

## Q5.How fast was the load time of our website as compared to other websites?

Answered: 74 Skipped: 1

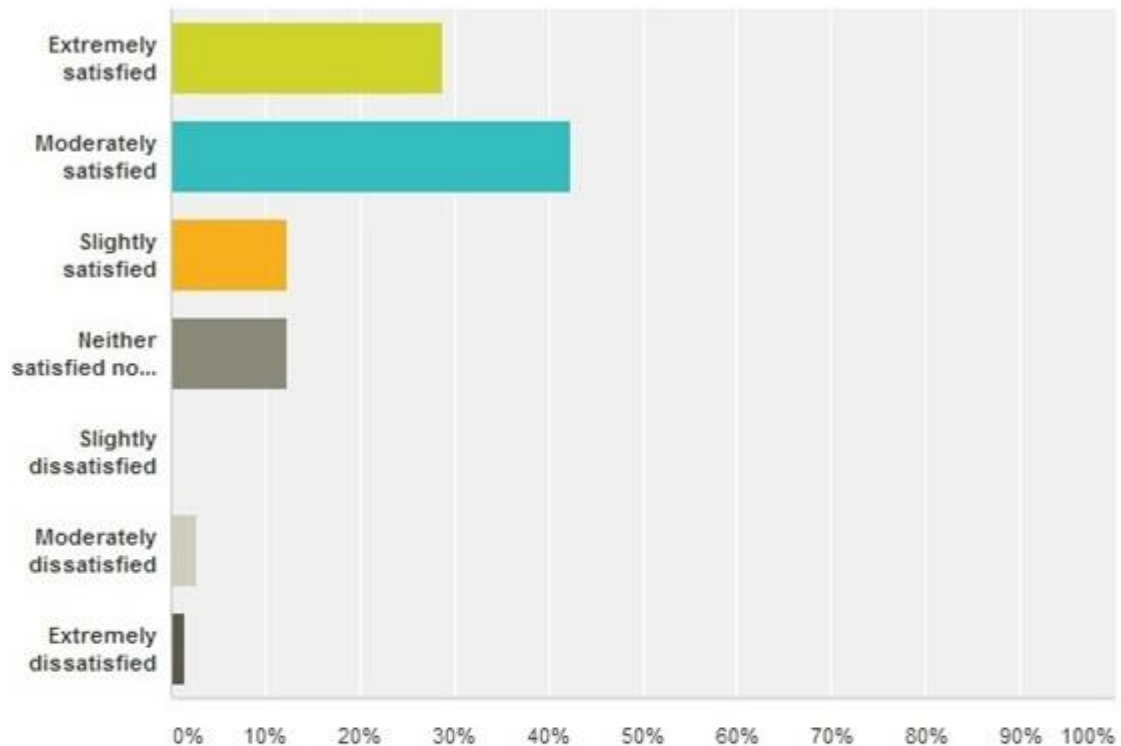


Answer Choices	Responses
Extremely fast	28.38% 21
Very fast	40.54% 30
Moderately fast	24.32% 18
Slightly fast	5.41% 4
Not at all fast	1.35% 1
Total	74



**Q6.Overall, are you satisfied with our website,  
neither satisfied nor dissatisfied with it, or  
dissatisfied with it?**

Answered: 73 Skipped: 2



Answer Choices	Responses	
Extremely satisfied	28.77%	21
Moderately satisfied	42.47%	31
Slightly satisfied	12.33%	9
Neither satisfied nor dissatisfied	12.33%	9
Slightly dissatisfied	0.00%	0
Moderately dissatisfied	2.74%	2
Extremely dissatisfied	1.37%	1
Total	73	

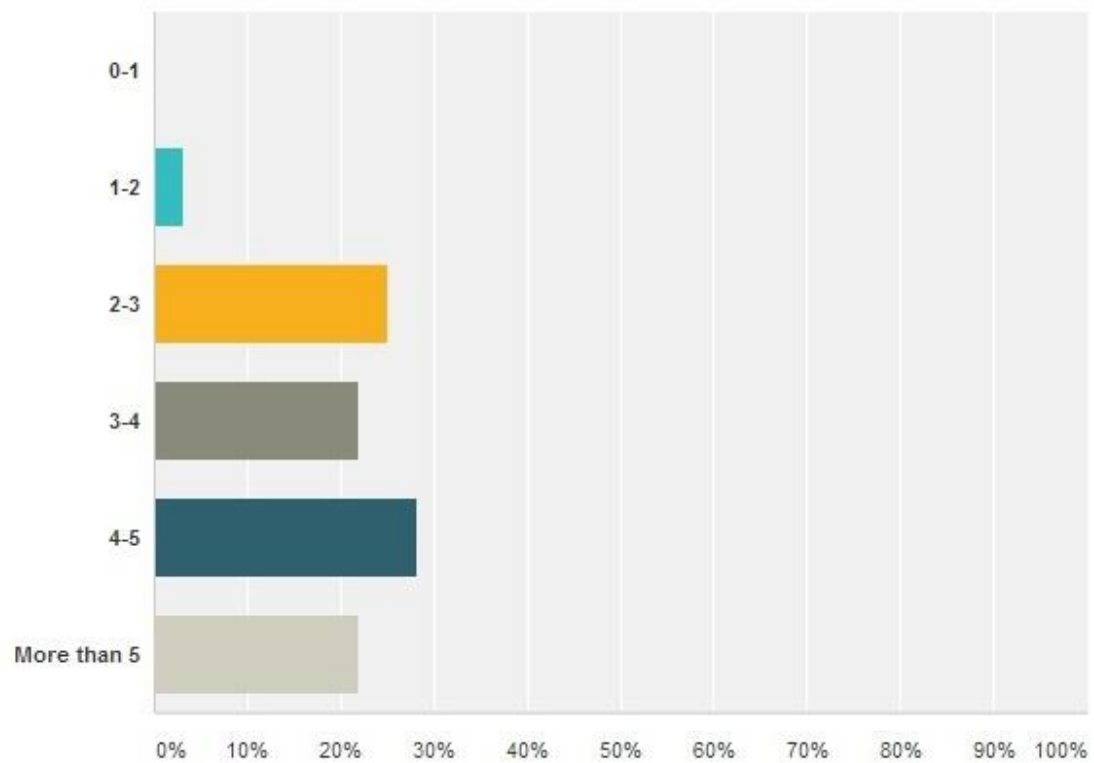
**Q7. Please provide your Email address. (We would like to assure you that the information you provide will be treated with the strictest confidence and will only be used for research purposes)**

Answered: 74   Skipped: 1

## Group B

### Q1.How many hours per day are you online?

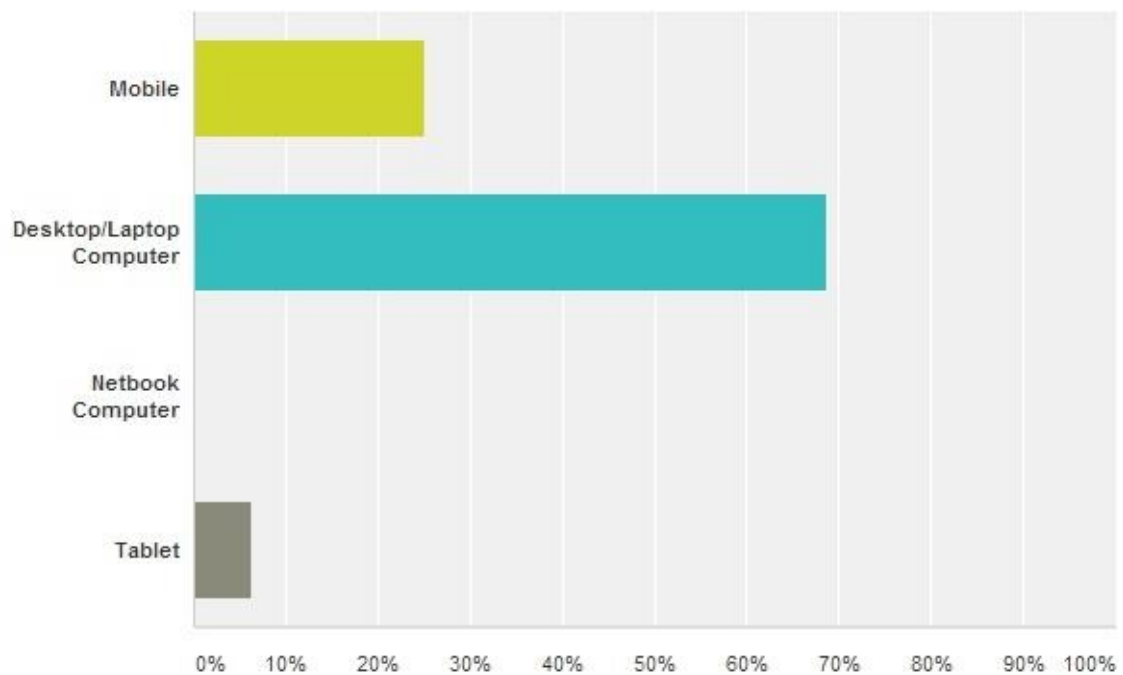
Answered: 32 Skipped: 0



Answer Choices	Responses
0-1	0.00% 0
1-2	3.13% 1
2-3	25.00% 8
3-4	21.88% 7
4-5	28.13% 9
More than 5	21.88% 7
Total	32

## Q2. Which device are you using to access the website?

Answered: 32 Skipped: 0

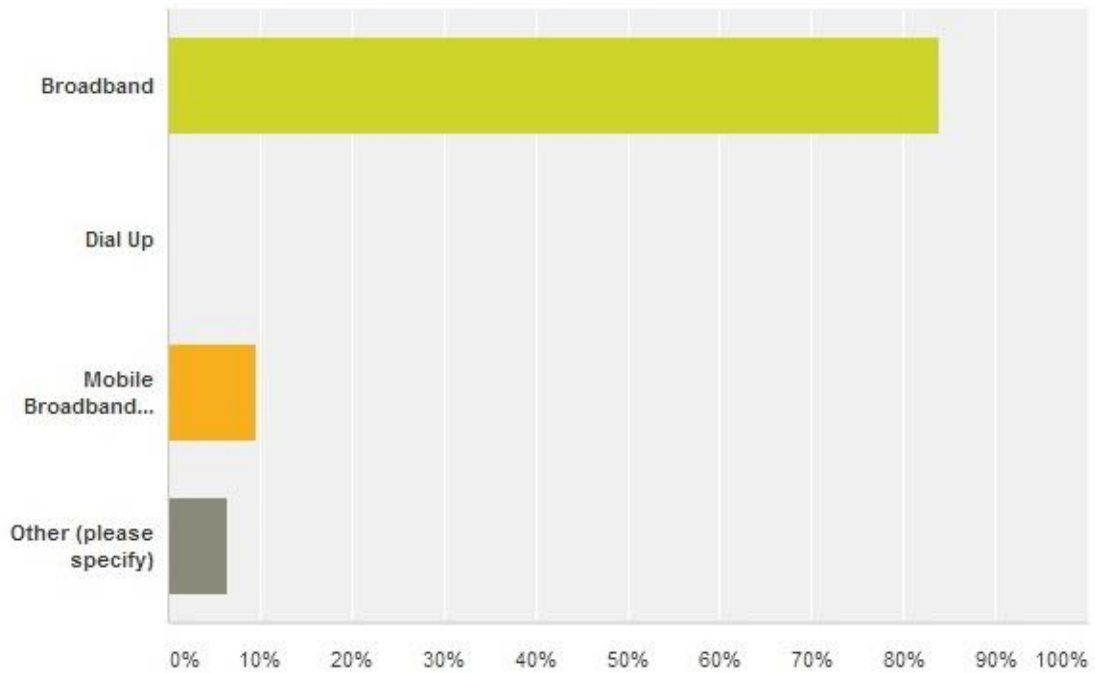


Answer Choices	Responses	
Mobile	25.00%	8
Desktop/Laptop Computer	68.75%	22
Netbook Computer	0.00%	0
Tablet	6.25%	2
Total	32	

[Comments \(1\)](#)

### Q3. What type of internet connection do you have?

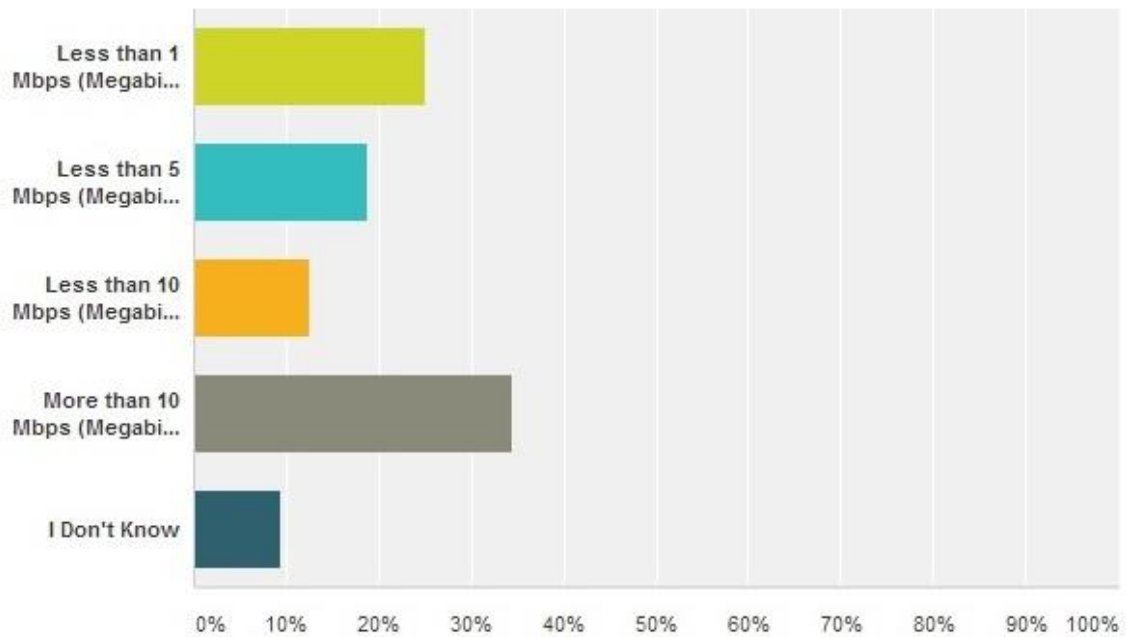
Answered: 31 Skipped: 1



Answer Choices	Responses
▼ Broadband	83.87% 26
▼ Dial Up	0.00% 0
▼ Mobile Broadband Dongles	9.68% 3
▼ Other (please specify)	Responses 6.45% 2
Total	31

#### Q4.What is your download package?

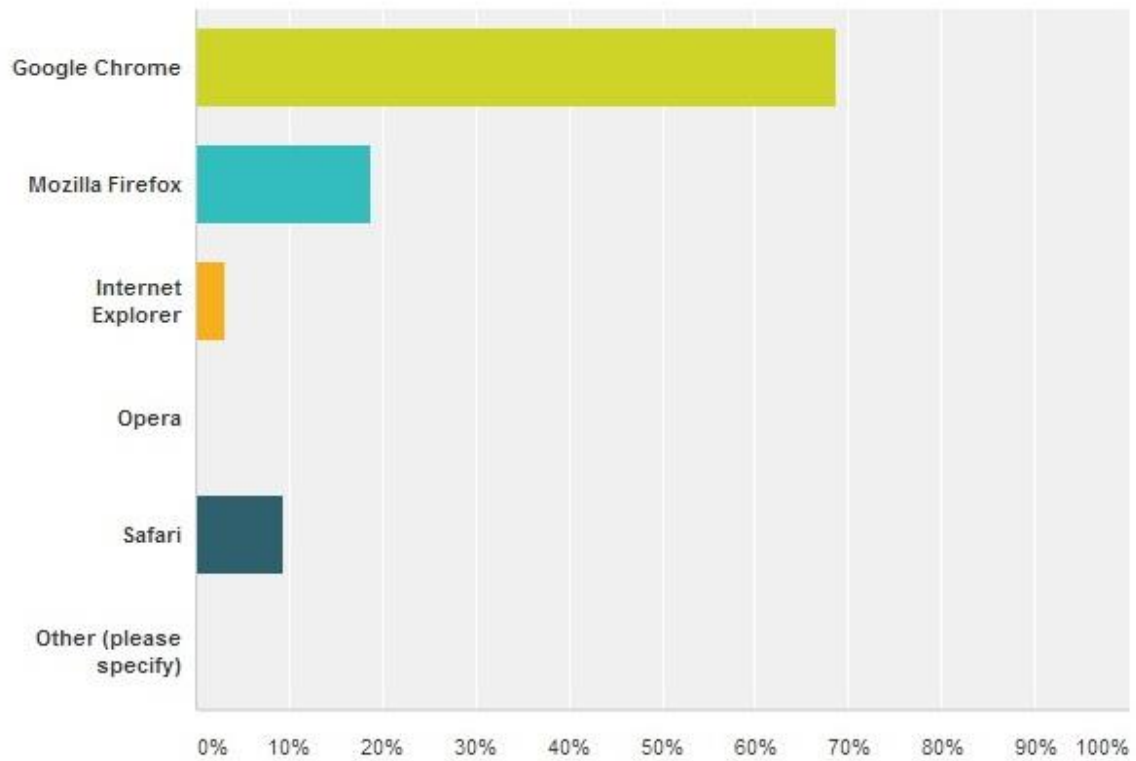
Answered: 32 Skipped: 0



Answer Choices	Responses	
Less than 1 Mbps (Megabits Per Second)	25.00%	8
Less than 5 Mbps (Megabits Per Second)	18.75%	6
Less than 10 Mbps (Megabits Per Second)	12.50%	4
More than 10 Mbps (Megabits Per Second)	34.38%	11
I Don't Know	9.38%	3
Total	32	

## Q5. Which internet browser are you using?

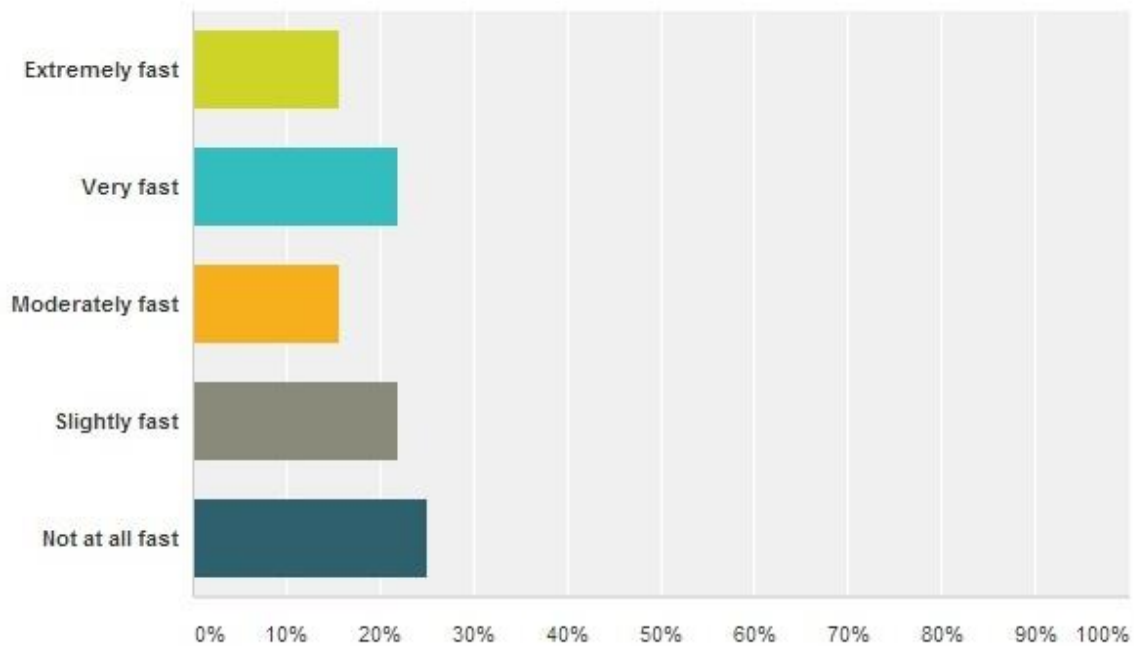
Answered: 32 Skipped: 0



Answer Choices	Responses
Google Chrome	68.75% 22
Mozilla Firefox	18.75% 6
Internet Explorer	3.13% 1
Opera	0.00% 0
Safari	9.38% 3
Other (please specify)	0.00% 0
Total	32

### Q6.How fast was the load time of our website as compared to other websites?

Answered: 32 Skipped: 0



Answer Choices	Responses
Extremely fast	15.63% 5
Very fast	21.88% 7
Moderately fast	15.63% 5
Slightly fast	21.88% 7
Not at all fast	25.00% 8
Total	32

### Q7.Please provide your Email address. (We would like to assure you that the information you provide will be treated with the strictest confidence and will only be used for research purposes)

Answered: 32 Skipped: 0