CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND

The Web is widely used in the daily life of most echelons of the society. It has transformed life as well as the computer and communication world like nothing before. The Web will continue to evolve to remain relevant to the computer industry which keeps changing rapidly. As the Web evolves to reach broad users, important issues become apparent such as accessibility. Approximately, one billion people worldwide live with disabilities (WHO, 2015). These disabilities include ambulatory, hearing, cognitive and visual impairments. As stated in the United Nations Development Program, between (76%-85%) of persons with disabilities live in developing countries (United Nations, 2012). Therefore, it is essential that the Web be accessible to everyone in order to provide equal access and equal opportunities to people with disabilities.

Web accessibility can be defined as making a website navigable and tractable by various users, especially those who have disabilities and normally face obstacles when interacting with the Web via electronic devices. Web accessibility entails overcoming most disabilities that limit Internet access. It means that people with disabilities can use, perceive, understand, navigate, and interact with the Web (Martínez et al., 2014). According to the World Wide Web Consortium (W3C (a), 2005), web accessibility enables people with disabilities (e.g. the blind and the aged) to utilize the Internet in

performing a variety of tasks such as online purchasing and browsing. As more accessible websites and software become available, people with disabilities are able to use and contribute to the Web more effectively.

In the United States, the laws and legislations for following accessibility requirements when designing websites originated from the "Americans with Disabilities Act of 1990", Section 508 (Waddell, 2006). In 1998, the Congress amended the Rehabilitation Act of 1973 to require Federal agencies to make their electronic and information technology (EIT) accessible to disabled people. Section 508 was enacted to remove barriers in information technology, open new opportunities for disabled users and boost development of technologies that will help achieve these goals (Section 508, 2015). Section 508 enforcement became effective June 25, 2001, requiring all U.S federal agencies to comply with it when they develop, maintain, purchase or use information technology so as to provide equal access inclusive of disabled people.

The World Wide Web Consortium (W3C, 2016) is an international community that aims to develop Web standards. In 1997, W3C launched the Web Accessibility Initiative (WAI) with endorsement by the White House and W3C members to increase awareness of web accessibility issues. WAI has developed a set of universal guidelines for Web development which are Web Content Accessibility Guidelines (WCAG 1.0 and WCAG 2.0). The WCAG 1.0 was published and became a W3C recommendation in 1999; it was superseded by WCAG 2.0 in 2008. The difference between WCAG 1.0 and 2.0 is the basis for determining conformance to the guidelines. While the basis for determining

conformance to WCAG 1.0 is the checkpoints, it is the success criteria (SCs) for WCAG 2.0 (for more information, refer to Appendix A).

In Malaysia, there are 445,006 people with disabilities registered with the Department of Social Welfare (UNICEF, 2013). Nevertheless, the statistics are neither complete nor accurate, since registration is voluntary and the data are not up-to-date. A number of national social welfare and social services policies protect the rights of people with special needs in Malaysia. The National Welfare Policy of 1990 aims to create a stable and secure society with equal opportunities. The National Social Policy of 2003 has been established to enhance equal rights for disabled people and ensure their full participation in Malaysian society. The objective of The National Plan of Action for Persons with Disabilities (2007-2012) is to increase awareness and create a barrier-free environment with ease of access to information, education and transportation (JKM, 2013).

The Malaysian Government has also adopted the Persons with Disabilities Act of 2008 (PWDs) to confirm that Malaysia is fully committed to enhance the welfare of its disabled people. PWDs came into force on July 7, 2008 (Rashid, 2010). This act is an inclusive document for disabled people's rights in the country. It provides social protection services and equality in areas such as public facilities, education, health services, communication and technology and access to information, guided by the National Policy for Persons with Disabilities and the National Plan of Action for Persons with Disabilities (Islam, 2015).

The Ministry of Education in Malaysia (MOE) has initiated the education Blueprint that provides a comprehensive plan for a rapid and sustainable transformation of the education system 2013-2025, in which was intended to be implemented across three waves (MOE,

2012). The plan aims to place Malaysia on the path of development by ensuring that the education system continues to progress in tandem. The Ministry has put forward policy directions for inclusive provisions in special education to ensure that students with special needs are not left behind.

The Malaysian government has made a great effort to secure equal access opportunities to disabled people by providing amenities to assist people with impaired mobility, through the provision of facilities like wheelchair ramps and elevators. Moreover, many nonprofit organizations such as the Malaysian Association for the Blind (MAB, 2016) are providing services for visually impaired people, not limited to computers, readers and Braille books.

However, despite the monumental endeavor that has been made by the Malaysian government, there is no enforcement of web accessibility legislation. Thus, Web developers do not follow web accessibility guidelines to make the Web a more accessible environment for people with disabilities especially for people with visual impairments. As a result, many Malaysian websites suffer from lack of accessibility.

In spite of the importance of making websites accessible to users with special needs, the majority of websites being developed are still not fully accessible (Hashemian, 2011; Nahon et al., 2012). Most websites suffer from accessibility barriers that make it hard for disabled people to use them. A barrier can be defined as any condition caused by the website that hinders user's progress towards accessing a website, resulting in a failure mode. Since this work focuses on WCAG 2.0, failing to meet a success criterion within these guidelines would result in a barrier. For the sake of clarity, the terms barrier, error,

defect, bug, and violation will be used interchangeably in this thesis. Web accessibility is about eliminating those barriers so that disabled users can use the Web effectively.

Indeed, there are many challenges that contribute to making a Web inaccessible; these challenges lead to barriers which are often difficult for Web developers to consider and correct accordingly. One possible solution to increase the level of web accessibility for disabled people is through determining severe barriers that limit the web accessibility and fixing them accordingly instead of wasting time in correcting less severe barriers (Hudson, 2010). Once the severe barriers are determined Web developers can fix them by applying web accessibility guidelines in their coding practices. The present work aims to define the most common web accessibility barriers types that make the use of the Web difficult for many disabled people. For this purpose, an innovative quantitative metric has been developed to measure the severity of accessibility barriers in order to rank them based on their influence and impact on the accessibility level. The websites sample has been chosen from Malaysia in order to identify the most severe barriers then see the difference that fixing them can make to the websites accessibility level.

1.2 PROBLEM STATEMENT

Web inaccessibility equates to barring disabled users from accessing and navigating the internet. For example, users suffering from visual impairments may not be able to access most websites even with the use of screen readers. The problem stems from Web developers' noncompliant ways of coding which not adhere to accessibility guidelines. Web developers face many challenges that lead them to improper coding, such as: challenges related to accessibility standards and guidelines, challenges arising during website's design and development, and challenges faced during testing and evaluation. Unfortunately, these challenges which lead to incorrect ways of coding produce inequities and barriers for assistive technologies. Thus, assistive technologies such as screen readers would not be able to interpret the presented contents on the monitor which will contribute to making websites inaccessible to disabled users.

Although the WAI of the W3C have published online guidelines such as WCAG 1.0 and WCAG 2.0, many IT professionals are unaware of them (Brown & Scott, 2015). Even if they heard about the guidelines many are not motivated to follow them (Villena et al., 2014). According to Shin et al. (2013), only few web designers follow accessibility guidelines. Long and detailed WAI documents, such as WCAG 2.0, tend to be time consuming. All the documents related to WCAG 2.0 exceed 450 pages with few hundred navigation links on each single page. Within these guidelines, there are many success criteria (SCs) to follow and accessibility barriers to avoid. This would take extensive hours to navigate and understand and require a certain level of technical knowledge of accessibility. Therefore, when developers or designers are required to implement

accessibility, they do not always understand how to achieve the desired requirements unless they undertake a sufficient training (Alonso et al., 2010). Moreover, WCAG 2.0 tends to create supporting documents that can be updated more regularly than the standard itself, which can be a burden to web developers since exploring these updates necessitates time and effort.

As a result, real-world developers do not follow WCAG 2.0 and the accessibility level remains low. Thus, a new way to simplify following guidelines is needed to increase the accessibility. This work took a step forward in order to simplify adherence to guidelines for Web developers by proposing a metric that reveals the most prevalent and severe web accessibility barriers that affect websites in a certain sample, and then rank them based on their severities. Web developers and designers can increase the accessibility level of their websites if they focus on checking against a concise list of SCs that are related to the most severe barriers which occur frequently and repairing them accordingly, instead of wasting time and effort in studying large set of barriers that may rarely occur (Hudson, 2010).

This research was inspired by web accessibility challenges mentioned by other scholars (Baowaly & Bhuiyan, 2012; Lujan-Mora et al., 2014; Sloan & Horton, 2014). These challenges are covered in Chapter 2. Research questions, objectives and activities are summarized in Table 1.1.

1.3 RESEARCH QUESTIONS

1) How can we formulate a mathematical metric that gives measurable weight to each barrier in order to rank them based on their influence and contribution to accessibility problems (inaccessibility)?
2) Does the metric meet the requirements of a valid and reliable metric?
3) To what extent does fixing highly ranked severe barriers (detected by the proposed metric) would increase the accessibility level for a set of websites?

1.4 RESEARCH OBJECTIVES

This work tries to fulfill the following objectives:

1) To propose a quantitative metric that ranks accessibility barriers based on their severities.
2) To evaluate the metric reliability and validity through empirical studies.
3) To measure the degree of accessibility level improvement for a set of websites after fixing the top severe barriers detected by the metric.

TABLE 1.1: Research Objectives, Questions, and Activities

Research Questions	Research Objectives	Research Activities
How can we formulate a mathematical metric that gives measurable weight to each barrier in order to rank them based on their influence and contribution to accessibility problems?	To propose a quantitative metric that ranks accessibility barriers based on their severities.	Design a quantitative metric that meets the requirements as a measurement for scientific research. The metric formulation is inspired by previous work as well as information retrieval approaches. (Chapter 4)
Does the metric meet the requirements of a valid and reliable metric?	To evaluate the metric reliability and validity through empirical studies.	Conduct four empirical studies to apply the metric in different contexts to check its validity and reliability. (Chapter 5)
To what extent does fixing severe barriers detected by the proposed metric would increase the accessibility level for a set of websites?	To measure the degree of accessibility level improvement for a set of websites after fixing the top severe barriers detected by the metric.	Measure the improvement of accessibility level after fixing or removing the top severe barriers weighted by the metric. (Chapter 5)

1.5 SIGNIFICANCE OF THE RESEARCH

This research represents a modest contribution to the web accessibility field. Although several studies have proposed metrics to measure the degree of WCAG 1.0 conformance (Zeng, 2004; Arrue et al., 2005; Vellemian et al., 2006), little attention has been paid to study the effect of barriers on accessibility level. To put it another way, most proposed metrics were more concerned about measuring the accessibility level of websites. Moreover, different approaches were suggested to determine severe barriers (Erickson et al., 2007; Socitm, 2008; Hudson, 2010). However, these approaches lack of a clear mathematical model to identify and rank barriers based on their severities, since these approaches are either based on evaluator experience in determining severe barriers or on surveys sent to Web developers to indicate the most common barriers they face when evaluating websites (Web accessibility metrics as well as the different approaches to

determine severe barriers are discussed in details in Chapter 2). Thus, the present work proposed a quantitative metric that assign numerical weight to each identified accessibility barrier based on its severity and impact on accessibility level. Following, the barriers can be ranked based on their weights. Thus, novice Web developers can concentrate on fixing limited set of highly ranked barriers (most severe) instead of wasting their time in correcting less important types of barriers that score low weights (least severe).

The metric aims to help web accessibility evaluators in determining the severity of barriers when evaluating a large dataset of websites. Most evaluators do not limit themselves to diagnosing a small number of websites since this would not help their statistical analysis. Now, by applying the metric to their findings, they can determine the severity of barriers which will aid them in deciding the root cause of accessibility problems of their evaluation set. Hence, they can suggest solutions and recommendations to the intended Web development team. Evaluators' reports about the common types of barriers to a specific set of websites should increase the awareness of the intended Web team and motivate them to correct the coding errors as well as avoid them in the future (Hudson, 2010).

In order to determine the severity of each barrier, the proposed metric took into account three measurements: (1) The importance of the barrier to the other barriers that violate the same priority level; (2) The importance of the barrier to the webpage; and (3) The importance of the barrier to all other barriers in the whole dataset.

1.6 ASSUMPTIONS

The leading assumptions of this work are that the metric will be suitable to use with any evaluation technique that can reveal the type and the frequency of barriers for each website such as: automated tools, expert reviews and lab studies. However, automated tools were chosen to show the mechanism of the metric because of their ability to reduce the evaluation time and support large scale evaluation studies. It is also assumed that A-Checker and TAW tools would provide valid, reliable, and practical results - although some literature, e.g. (Lazar et al., 2013; Martínez et al., 2014; Gordón & Moreno, 2014) highlighted the drawbacks of automated tools.

1.7 RESEARCH SCOPES AND DELIMITATIONS

The Web Accessibility Barrier Severity (WABS) metric developed in this research is intended for measuring the barriers weight based on their impact on websites accessibility. This metric is not appropriate for the purpose of accessibility checking. Automated tools do not check all the SCs violations, since some of the SCs need human intervention. Thus, when exclusively utilizing automated tools results, the metric will only serve as a proximate measure of barriers weight, not a real measure, which requires using the results of manual checking and human judgment.

This work focuses on visual and auditory disabilities without making a distinction between people with disabilities (blind and deaf people) and the elderly. As our vision and hearing prowess generally diminishes with age, the difference between people with

and without disabilities is a matter of degree, rather than a clear distinction (Bradbard & Peters, 2010).

A previous study conducted by the researcher (Abuaddous et al., 2013) aimed to diagnose the accessibility status of the Public Higher Educational Institutions websites in Malaysia. Two experiments were conducted in 2012 and 2013 to see if there are any significant changes in accessibility condition. Homepages of twenty universities have been evaluated automatically. Unfortunately, none of the websites was fully accessible. The results revealed some significant issues, and no big improvements were made to the websites from 2012 to 2013. In this regard, enhancing the accessibility of websites is considered as a prerequisite to qualify Malaysia to be a developed nation by 2020. Thus, the researcher was motivated to focus on Malaysian websites to test the metric quality as well as measure the degree of improvement in the Malaysian websites accessibility level after fixing the most severe barriers. Therefore, three experiments were conducted using a sample collected from Malaysian websites and the results of the first experiment were further explored to check the degree of accessibility level improvement after fixing the most severe barriers, whereas the fourth experiment was conducted using a sample collected from global websites to check whether the barriers weight significantly change when data are collected from different sample other than Malaysian websites. Analyzing the effect of page sampling can help in testing the metric's reliability as well as show whether Malaysian developers and designers follow different programming practices when it comes to accessibility (the full list of Malaysian websites and global websites can be found in Appendix B).

The following delimitations are presented in this work:

1) This work is delimited to Taw and A-Checker automated tools.
2) The metric is formulated on the basis of WCAG 2.0's SC.
3) This work focuses on the SCs violations that can be checked automatically; warnings and generic problems which need human intervention will be ignored.
4) The metric quality is verified in terms of validity, reliability and sensitivity. Other quality measurements such as complexity and adequacy are not considered.
5) The sample set for each experiment does not exceed 500 websites.

1.8 ORGANIZATION OF THE RESEARCH

This research work consists of six chapters: Chapter 1 is an Introduction; Chapter 2 presents literature review, theoretical and conceptual framework; Chapter 3 describes the methodology; Chapter 4 exposes the Web accessibility quantitative metric (WABS); Chapter 5 presents the results, analysis and discussion of the findings; and Chapter 6 concludes the work, suggests some recommendations and provides suggestions for future work. Description of each chapter is provided in Table 1.2.

TABLE 1.2: Research Work Outline

Chapter	Description
Chapter One: Introduction	Discusses the research background, the problem statement, research questions, research objectives, significance of the research, assumptions, scopes and delimitations, and study organization.
Chapter Two: Literature Review	Discusses the disability types and reviews the impact of web accessibility challenges and the primary problems associated with each challenge. Moreover, metrics proposed by other scholars to measure the accessibility level are highlighted. Furthermore, approaches to increase web accessibility level are explained. The chapter shows the intersection of these topics which form the theoretical framework of this research. Finally, the conceptual of framework shows how the suggested metric will be validated and how it will increase the accessibility level.
Chapter Three: Research Methodology	This chapter discusses the process of validating the metric's quality and covers the hypotheses development to test the quality. The methodology to validate these hypotheses is explained as well. Furthermore, The process of measuring the degree of accessibility level improvement obtained by the metric is discussed. This chapter also explains the procedure of data collection as well as selecting the right automated tools.
Chapter Four: Web Accessibility Quantitative Metric	Covers the requirements and assumptions to build a good metric. Metric formulation steps are explained followed by an example to demonstrate metric calculations in details.
Chapter Five: Results, Analysis and Discussion	Presents the analysis and actual results for the research experiments to test research hypotheses. Descriptive and inferential statistics are adopted to analyze experiments results. The quality of the metric is checked in terms of validity, sensitivity and reliability based on experiments findings. Following, the results of the first experiment are further explored to measure the degree of accessibility level improvement when highly ranked barriers suggested by the metric are removed.
Chapter Six: Conclusions and Future Work	Summarizes the entire work and addresses the contributions of this work. It provides practical recommendations to overcome accessibility challenges. Finally, the chapter presents implications for future research.