Floodwatch: building a web application for flood detection and prediction
(Technical project)

Exploring frameworks for building equitable and effective web accessibility standards
(STS project)

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On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

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Introduction

As the internet becomes increasingly embedded in day-to-day culture, the browser has become a commonplace and invaluable tool. For many, the experience of interacting with a browser is fairly simple: navigate to a page through keyboard input, interact with the page using a mouse and parse information from audio/visual content. However, consumers of the web can drift from this simplified user experience flow due to factors such as device limitations, environment and technical expertise. In particular, users with disabilities can have drastically different experiences and may rely on specialized browser features to aid with interaction: for example, a screen reader to assist users with visual impairments or keyboard-only navigation for those who cannot operate a mouse (Zahra & Brewer, 2022).

Modern browsers are implemented independently, usually by large entities; for example, Apple building Safari and Google building Chrome. While specific features of browsers can vary, core functionality of rendering and interacting with pages is defined by formal specifications which all browsers aim to adhere to (Grosskurth & Godfrey, 2007, p. 5). These specifications are largely defined by entities such as the World Wide Web Consortium (W3C), an international group which manages the development of web standards. By adhering to these, developers can write universal web applications supported on a variety of browsers; likewise, users can receive a consistent experience regardless of their browser choice (Wood, 1999, p. 49).

Within the context of accessibility, this means that the end-user experience for an individual with a disability may vary drastically depending on their browser of choice. The W3C manages the User Agent Accessibility Guidelines (UAAG) which aims to define a baseline set of accessibility standards for browsers to incorporate (Allan et al., 2015). However, individual

browser vendors still need to ultimately decide the scope and prioritization of particular features to implement while also evaluating suggestions from alternate standards.

In contrast, my technical topic is focused on increasing flood prevalence in Vietnam. As sea levels continue to rise at alarming rates worldwide, coastal flooding has become a significant concern in many regions. In particular, Ho Chi Minh City is at severe risk, ranking among the top ten cities likely to be affected by climate change (*Ho Chi Minh City Adaptation to Climate Change*, 2010, p. 4). While there are ongoing efforts to address flooding, these are often costly, difficult to scale, and fail to address the immediate concerns of citizens (Lempert et al., 2013, p. 4). My topic discusses my work on a UVA research team developing Floodwatch, a web-based flood detection platform. Using this, we aim to enable citizens in Vietnam to make informed decisions about their safety and collaboratively assist others through a real-time reporting platform.

My STS topic aims to explore the development and iteration of web accessibility standards, both from large entities such as the W3C as well as smaller organizations, as a means of determining equitable frameworks for future standards development. My technical topic describes my work developing Floodwatch as a platform for data distribution and proactive flood protection. Through both of these, I aim to analyze the design and implementation of technological infrastructure as a means of effectively serving users in a given problem space.

Technical Topic

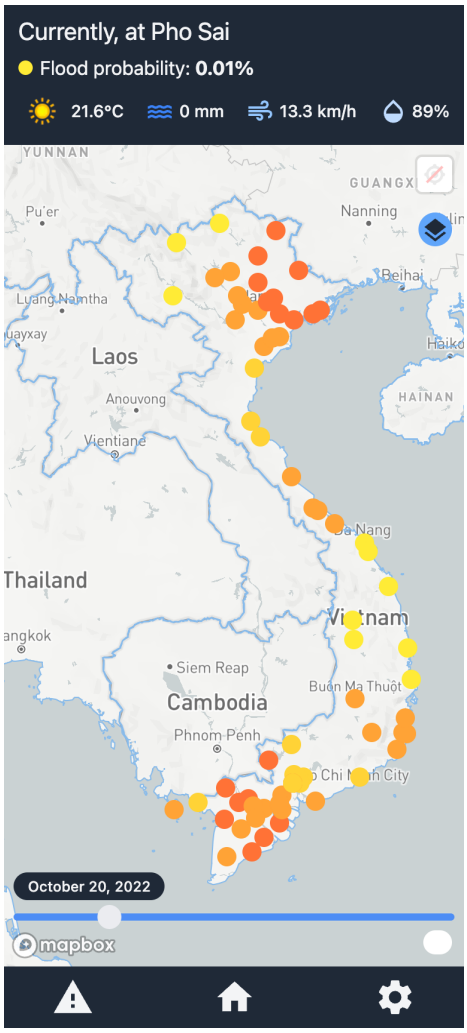
Recent models of global tide, storm surge and wave trends have suggested that 52% of the global population will be at risk of flooding by the year 2100 (Kirezci et al., 2020). While this is becoming an increasingly relevant topic in regions worldwide, areas such as Ho Chi Minh

City are already greatly susceptible to coastal flooding with the issue worsening due to factors such as growing urban expansion (Duy et al., 2017, p. 197). A 2010 report from the Asian Development Bank details a broad range of sectors impacted, ranging from transport to energy infrastructure (*Ho Chi Minh City Adaptation to Climate Change*, 2010). As a result, there have been ongoing efforts to mitigate flood risk, both to ensure safety of those affected and minimize associated damages. While these sorts of endeavors may be promising long-term, they aren't without their own challenges; efforts such as a $2.6 billion USD ring dike have unclear timelines and may ultimately displace citizens living in construction zones (Yarina, 2018). Furthermore, newly emerging and rapidly changing data can conflict with original projections, resulting in inadequate short-term solutions (Lempert et al., 2013).

Floodwatch aims to address these limitations by delivering current, historic and projected flood information to users in Vietnam through a mobile web application. The app provides weather data in various flood-prone cities, labeling each through simple color-coded markers to indicate risk severity. Additionally, users can report and view real-time flood events through a crowdsourced submission tool. Through these mechanisms, we aim to enable citizens to make informed choices about their personal safety.

Given inevitable constraints of developing physical flood mitigation strategies (be it cost, time or even political decision making), Floodwatch presents a practical and accessible data distribution platform for citizens. The notion of real-time, crowdsourced flood reports also presents a new perspective when considering the idea of "technological citizenship"; rather than individuals needing to rely solely on relatively opaque government entities, they can instead empower and benefit from other citizens through a new form of civic involvement (Andrews, 2006, p. 5).

The app is implemented as a mobile-friendly web application, allowing anyone to easily access the platform. Performance has been a key consideration throughout many architectural design decisions so as to reduce any potential barriers when loading in poor network conditions or on low-end hardware; this is achieved through choices such as an auto-scaling serverless backend and optimized client-side JavaScript bundles. Beyond its current functionality, Floodwatch aims to support long-term democratized distribution of critical flood data; by archiving relevant weather data and user-submitted reports, we can enable increasingly robust and accurate predictive models to better serve users in moments of flood crisis. Additionally, we plan on widening the range of data sources utilized in modeling; though the platform currently relies primarily on third-party weather APIs, we have ongoing efforts in creating custom hardware modules to perform data capture ourselves in flood-prone locations throughout Vietnam.



Note. Floodwatch map displaying flood risk level in various Vietnam cities. From "Floodwatch [Unpublished engineering capstone project]", by Nguyen et al., 2022, University of Virginia

STS Topic

Given the internet's (and thus the browser's) widespread prevalence, the efficacy of accessibility techniques on modern websites is an ever-present sociotechnical problem in ensuring equitable access to digital resources. Susan Leigh Star's "The Ethnography of Infrastructure" provides a framework for viewing these web-based platforms as infrastructure, highlighting a range of properties common to all forms of infrastructure. For example, Star explores the concept of "[artifacts becoming] visible upon breakdown", describing the invisible

nature of infrastructure in everyday practice until its eventual collapse (Star, 1999, p. 381). When considering browsing behavior through the lens of accessibility, this notion becomes all the more evident; as users with disabilities encounter lapses in content accessibility, their ability to rely on digital platforms as infrastructure diminishes.

Beyond web-based platforms, the underlying standards guiding their development can also be considered through Star's framework of infrastructure. While inheriting all of the same properties, web standards in particular highlight the framework's notion of infrastructure "[wrestling] with the inertia of the installed base" (Star, 1999, p. 381). A unique aspect of the web is its inherent backwards-compatibility with legacy content; though beneficial, it can arguably hinder the scope of possible accessibility patterns. For example, the W3C's ubiquitous set of WAI-ARIA standards are solely based on HTML element attributes, resulting in a relatively limited range of options for supporting accessibility-oriented user workflows.

Though web accessibility has become a fairly universal term in the space, some introduce the notion of “web adaptability”. A paper from the University of Bath explores this concept: by viewing web application features as opportunities for customization beyond aiding disabilities rather than checklist items in an accessibility audit, users can have greater control over their own experiences while allowing developers to more effectively support a wider range of user contexts. This concept of adaptability contrasts with many popular accessibility standards which instead lean into a single, all-encompassing set of guidelines. As the paper argues, “adaptability shifts the emphasis and calls for greater freedom for the users to facilitate individual accessibility in the open Web environment” (Kelly et al., 2009, p. 2). However, others dispute that this widened scope can distract from the original goal of supporting users with disabilities. Henry et al. advocate for this form of accessibility-first design in contrast to adaptability (or as they

describe, “universal design”); as mentioned in their article, “although there is significant overlap between designing for accessibility and designing for situational limitations, addressing one set of needs does not necessarily provide sufficient solutions for other needs” (Henry et al., 2014). This balance of user design is evident in Steve Woolgar’s sociotechnical notion of “configuring the user”; as web standards are developed, they must explicitly decide how much focus should be given to an explicitly accessibility-first design (and thus, prescribe a particular accessibility-friendly interface) as opposed to a broader, highly-flexible set of options (Woolgar, 1991).

Aside from content, analyzing methodologies for development of standards themselves is crucial to ensuring that relevant stakeholders (that is, actual users with disabilities) are involved in discourses of standards development. Adam & Kreps argue that existing efforts, specifically the W3C’s web content accessibility guidelines working group (WCAG WG), have failed to meet that threshold; as they describe, “the WCAG WG is not inclusive in its representation and does not engage in dialogue on corporate social responsibility and public accountability” (Adam & Kreps, 2009, p. 1055). The notion of developmental context informing standards infrastructure itself aligns with Langdon Winner’s “Do Artifacts Have Politics?”; though all accessibility work is well-intentioned, the stakeholders involved can drastically alter the scope and effectiveness of generated standards (Winner, 1980).

Research Question and Methods

Given the wide range in scope and design of existing web standards, my research question asks: how can previous efforts in web accessibility standards development inform frameworks for developing future standards in an equitable manner for users with disabilities?

Though the importance of web accessibility is fairly universal, I argue that analyzing the iteration and surrounding discourse of standards development is essential to ensuring this infrastructure achieves its overarching goal of enabling all forms of users.

I plan on exploring this topic primarily through the lens of policy analysis. As mentioned in previous sections, the W3C is a dominant entity in the web standards space with documents such as WCAG being recognized even as legal requirements in certain jurisdictions (Spina, 2019). As a result, analyzing the content and historic context behind standards such as UAAG (oriented towards browser vendors), WCAG and WAI-ARIA (oriented towards application developers) will provide a holistic overview of prevalent documents in the web accessibility space (Diggs et al., 2017). However, I'm also interested in exploring lesser-known, highly-specialized standards; for example, the AASPIRE guidelines were developed primarily with autistic users in mind, specifically citing shortcomings in WAI's methodologies as inspiration (Raymaker et al., 2019).

Similarly, I'm interested in utilizing literature review to examine critiques of current accessibility standards; "Affordable Web Accessibility: A Case for Cheaper ARIA" is an example of this, arguing that WAI-ARIA's impractical guidelines ultimately limit progress towards a more accessible internet (Puzis et al., 2015). I plan on explicitly exploring literature from individuals with disabilities to holistically evaluate the evolution and current effectiveness of accessibility standards.

Conclusion

Using knowledge gained through my STS research topic, I plan on synthesizing possible strategies for standards and application developers alike to consider when evaluating how to best

serve their full range of users. Though there cannot (and should not) be a single recommendation, I hope to assess the effectiveness of historical approaches in order to promote future equitable frameworks. The importance and scope of this accessibility-oriented work is immense in today's digital climate and will only increase over time.

Through my research on the Floodwatch platform, we aim to deliver a functional and practical flood mitigation strategy for citizens in Vietnam. Though the majority of the app's core functionality is complete, we plan on further exploring alternate methods of data aggregation, visualization and reporting to best serve real-world users. In doing so, we hope to enable citizens to make informed decisions about their own safety using historic, current and predicted data.

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