Implications of Cloud Computing for People with Cognitive Disabilities

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Abstract. A public workshop was convened in the Fall of 2010 to bring together leaders from industry, education, public policy, disability advocacy, and government with a shared focus in shaping our national information and computing infrastructure to improve the lives and independence of people with disabilities, particularly those with cognitive disabilities. The workshop provided introductory presentations about the state and future of cloud computing technology, cognitive accessibility, and policy considerations, and was followed by interactive panel discussions about technical directions and opportunities; the potential benefits, opportunities, and challenges of cloud computing from the viewpoint of people with disabilities, caregivers, and advocates; and legal and regulatory barriers to accessing technology in "the cloud." This paper summarizes insights about how cloud computing could improve the lives of people with disabilities from the perspective of leading representatives from industry, academe, government, and advocacy organizations.

Keywords: cloud computing, cognitive disabilities, disability advocacy, law and public policy.

1 Introduction

On October 20, 2010 a workshop was held by the Coleman Institute for Cognitive Disabilities in partnership with the Silicon Flatirons Center for Law, Technology and Entrepreneurship, to explore how emerging developments in cloud computing could enrich and enhance the lives of people with disabilities, with a focus on people with cognitive disabilities. To this end, the workshop featured invited speakers and organized panel discussions across broad participative communities: disability experts and advocates; technical academic and business leaders; and law and public policy experts. Presentations and panel discussions were free and open to the public, presenting opportunities for interaction with the workshop participants.

This paper will present key insights from workshop discussions about how cloud computing has the potential to radically improve the lives of people with disabilities from the perspective of leading representatives from industry, academe, government, and advocacy organizations. It is important to share these perspectives so that designers and developers of future technologies have the vision to create technologies that are inclusive and accessible for all users in the near and distant future.

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2 Historical and Current Assessments about Cloud Technology, Cognitive Accessibility, and Public Policy

2.1 Historical Developments and Cloud Computing

Mr. William Coleman[1] opened the workshop by analyzing some important historical developments that frame a view of where cloud computing is today and where it is headed in the future [1]. Two key historical developments include the invention of language and the printing press. These developments were significant because they supported the widespread creation, communication, and sharing of information, and the preservation of knowledge for future generations.

The recent rise of information technology and cloud computing likewise has the potential to provide orders of magnitude improvement in knowledge creation, communication, and preservation. Information no longer resides on isolated computers where it may become inaccessible due to technical failure or obsolescence. In the cloud, knowledge is stored and preserved in a distributed network where it can be more easily searched, accessed, shared, and preserved with historically unprecedented economies of scale.

2.2 Technology Cycles and a Critical Historical Inflection Point

The current information age has been characterized by rapid cycles of innovation resulting in (1) invention, boom, and bust; (2) the build out and consolidation of information technologies and infrastructure; and (3) the commoditization of technology. Within this framework, the information age is now at *a critical inflection point* and will soon be revolutionized by the widespread commoditization of cloud technologies as a highly efficient, and low cost utility platform.

Before cloud computing can reach this level of efficiency and low cost, it is important to understand the disruptive nature of new technical innovations. In order to be disruptive, new technologies must present at least an order of magnitude better value for users. The cloud will deliver this value increase through three key services:

- Software Applications as a Service (SaaS);
- Computing Infrastructure as a Service (IaaS); and
- Platform tools as a Service (PaaS).

Cloud technologies are disruptive because they support significantly improved economic value that leverages and isolates enabling technology layers. Cloud services also provide tremendous opportunity for customization and control, and support the rapid development of new information and knowledge services.

Evolution of the cloud to a utility platform. The cloud will evolve from a collection of web-based services to a *pervasive utility platform* in three major phases:

[1] Mr. Coleman is a Silicon Valley entrepreneur and founder of technology startups including BEA Systems and Cassatt Corporation. Mr. Coleman is also founder of the Coleman Institute for Cognitive Disabilities.

- **Cloud 1.0** (timeframe 2000-2010): This stage is characterized by software, infrastructure, and/or platform, as a service. Since services are discrete, Cloud 1.0 is neither a platform nor a utility.
- **Cloud 2.0** (timeframe 2010-2020): This is the era of the Cloud as a platform, but not a utility. Cloud 2.0 is characterized by connectivity and convergence of: internal and external clouds; online and mobile worlds; and applications and data. This phase allows a Client as a Service (CaaS) model.
- **Cloud 3.0** (timeframe 2020-2030): This represents the final commoditization and consolidation of information computing technology - and emergence of cloud computing technology through "utility service providers."

Life on the web in 2040. Assuming the future trend of "the cloud as a utility platform," Mr. Coleman foresaw a future that allows individuals to customize and leverage vast expanses of the technology infrastructure at very low cost. Individuals will create a web presence with virtual capabilities that augment their native abilities, and transcend personal disabilities. This future vision includes a "self-aware proxy for life" with customizable "dashboard" controls, and identity technologies that ensure secure privacy and civil liberties. This vision also includes a dramatically improved productivity that enables most of the world to advance into a "middle class" society.

If this vision is to be realized, several near-term issues must be addressed:

- the development of new business models that support the creation of enabling technologies supporting Cloud 3.0;
- the need for common standards that reward creativity while enabling interoperability; and
- identification of legal, privacy, and security requirements necessary for widespread acceptance, adoption, and use.

2.3 Cognitive Disabilities and Technology Accessibility

Dr. Michael Wehmeyer[2] presented historical and modern contexts for understanding disabilities. Historically, a disability was viewed as a personal characteristic or problem within an individual's internal health state. In 1980, this view began to shift toward understanding disability in the context of a person-environment fit or interaction model. In 2001, the World Health Organization introduced an International Classification of Functioning, Disability and Health (ICF) schema that reflects impairments, disabilities and handicaps in terms of the impact that the disability has on a person's external functions, activities and social contexts. Within this modern framework, a disability serves as an all-inclusive term for describing limitations or restrictions on participation in daily activities and social environments [2].

Diagnostic methods for cognitive disability have likewise shifted from historical frameworks that considered internal measures of intelligence (intelligence quotients and mental age estimates) to modern methods that evaluate a person's functional impairments and the restrictions which those impairments have on daily activities and

[2] Dr. Michael Wehmeyer is President of the American Association on Intellectual and Developmental Disabilities, a Professor of Special Education, and Director of the Kansas University Center on Developmental Disabilities.

social participation. This approach represents a shift from "fixing the person" to understanding and addressing the gap(s) that may exist between a person's capabilities and the demands of their environment. This approach is "strengths based" and outcomes oriented.

Since abilities often coexist with disabilities, it is important to identify long-term personalized supports that empower and leverage a person's strengths, while addressing disabilities in manner that is appropriate and acceptable to the person and his or her social context. Technology represents an important tool that can be applied to narrow the gap between one's capabilities and the environment.

To design a technology that is *cognitively accessible*, a design should also incorporate features that accommodate people who may have problems with:

- visual perception;
- auditory reception;
- language ability;
- reasoning and idea production;
- memory and learning; and
- cognitive speed.

Strategies for designing cognitively accessible software interfaces include, but are not limited to:

- *Providing approaches that minimize errors*: remove unnecessary controls and buttons, rather than graying them out.
- *Designing for flexibility and simplicity*: reduce display clutter; provide only needed functionality; consistently place familiar buttons in the same place; minimize cryptic metaphors and images – images of paperclips and floppy disk icons may convey little meaning to a person with a cognitive disability.
- *Minimizing physically challenging controls*: operations that require double clicking or dragging objects and manipulating scroll bars may present accessibility barriers.
- *Providing multi-modal presentation and translational options*: some examples include text captioning, text to speech, TTY, and hearing aid support.

Creating accessible interfaces and websites is only part of the solution – barriers in hardware design and resident software (operating systems and portal applications) must likewise be addressed to design an accessible system.

2.4 Legal, Regulatory, and Public Policy Concerns for Technology Accessibility

Dr. Peter Blanck[3] presented an overview of recent legal and regulatory policies that impact the lives of people with disabilities. Technology accessibility represents the next major barrier in a struggle that people with disabilities have historically faced to gain access to public buildings and services, education, and employment. Because of challenges in obtaining suitable accommodations in the workforce, people with disabilities suffer significant underemployment and a lower standard of living [3].

[3] Peter Blanck, Ph.D., J.D. is a University Professor and Chairman of the Burton Blatt Institute at Syracuse University.

Recent legislative reforms include:

- the 2008 American with Disabilities Amendments Act which provides broad rights to anyone with a disability, without regard to the severity of their disability, and
- the Twenty-First Century Communications and Video Accessibility Act of 2010 which states: "a manufacturer of equipment used for advanced communications services, including end user equipment, network equipment, and software, shall ensure that the equipment and software that such manufacturer offers for sale or otherwise distributes in interstate commerce shall be accessible to and usable by individuals with disabilities" [4].

While such laws provide broader accessibility rights for people with disabilities, there are also public policy considerations:

- Could national accessibility laws and regulations create a competitive disadvantage for businesses and entities competing in international markets?
- How will conflicts between international and national laws be resolved?
- Must foreign-hosted services comply with national laws and regulations?
- In the U.S., public places must be accessible – is the internet also a "place" for the purposes of the Americans with Disabilities Act, or is it something else?
- Is privacy an evolving concept, or will it be a static property that can be regulated?
- Should copyright laws evolve to permit synthesis of existing protected materials to create new intellectual property?
- Could legislation, regulation, and public policy provide standardized access to technology at the expense of future creativity and innovation?
- How can laws, regulations, and public policy keep up with the evolution and innovation of new technologies?

3 Multidisciplinary Perspectives about Potential Opportunities and Challenges of Cloud Computing for People with Disabilities

The preceding presentations were followed by multidisciplinary panel discussions. Panels were comprised of mainstream and assistive technology experts; disability advocates; and government, legal, and public policy experts. Panelists were invited to make short presentations or statements within their areas of expertise, followed by interactive public discussions. Panel discussions were organized into three major areas: technical opportunities and commercial infrastructure; potential benefits, opportunities, and challenges of cloud computing for people with cognitive disabilities; and legal and regulatory barriers to accessibility "in the cloud." Findings from each of these panels will now be summarized.

3.1 Technical Opportunities and Commercial Infrastructure

A panel of industry, academic, government, and assistive technology experts made short presentations about the opportunities and challenges of building a technical

infrastructure that is accessible and usable by people with cognitive and physical and disabilities. The panel offered the following insights.

Disabilities, technology, and accessibility. Disabilities are often viewed as a special interest problem that affects only a small portion of society. With improvements in health care and longevity, a growing number of mainstream users will require some form of assistive technologies and services in the near future. As discussed in Dr. Wehmeyer's overview, disabilities should not be viewed as a personal trait but rather a relative condition where there is a mismatch between a person's abilities and his or her environment. To design for accessibility, it is helpful to focus on approaches that support a range of functional preferences and needs. This design approach has been described as "what I need" vs. "what I am." Within this framework, accessibility is viewed as the ability to customize a particular technology to fit the needs and preferences of a user.

When designing technology to serve people with disabilities, no single technical solution will satisfy all users. Instead, accessible design requires a common language for specifying and managing personal needs, preferences, and service delivery frameworks.

Technical landscape, opportunities, and issues. Industry experts project that infrastructure speed, bandwidth, and quality of service currently available on desktop platforms will soon be pervasively available on wireless mobile devices and handsets. Most assistive technology applications are custom tailored for a delivery platform (desktop, laptops, handsets, personal digital assistants, etc.) and are purchased as an "add on" at a significant cost to the consumer. In the future, assistive technologies will be universally available through cloud applications and services, regardless of what device is used by the consumer.

As assistive services are more available on the cloud, there is a question of how accessibility innovation will evolve on mainstream hardware interfaces. Will manufacturers continue to invest in built-in assistive technologies (text to speech, screen readers, etc.) if there is a widespread perception that assistive technology is readily available through cloud services? There is also a question of how cloud technology developers can understand the needs of users with disabilities who remotely access their services. Will concerns about online privacy and security create barriers to participation and acceptance by caregivers and families who share a concern about potential vulnerability and welfare of their clients?

Technical initiatives and research opportunities. The Global Public Inclusive Infrastructure (GPII) initiative [5] is exploring how National Public Inclusive Infrastructures (NPIIs) can be built in various countries to work collaboratively and enhance broadband infrastructure. One aspect of the GPII initiative is to explore how user profiles can be defined and used to create inclusive technologies appropriate to a user's capabilities and preferences. For example, if a person has a visual deficit, text to speech and descriptive voice captioning of visual objects and animations may be appropriate to access a presentation with complex animations. User profiles would support the creation of secure and persistent accommodations so if a user changes or upgrades a device, the accessibility profile would still be available to automatically adjust the new device and serve the user's information in an appropriate modality.

In a world of multimedia presentations, portals, and animated widgets, user attention is a scarce resource and design simplicity is a virtue. More research is needed to understand the cognitive and physical barriers created by user interface complexity, and what strategies and services might be useful to reduce or eliminate these loads.

3.2 Potential Benefits, Opportunities, and Challenges from the Viewpoint of People with Disabilities, Families, Caregivers and Advocates

A panel of advocacy and public policy experts explored how cloud technology could potentially benefit people with cognitive disabilities and their caregivers. The panel indicated that the current economic climate has further eroded support for federal and state funding that assists people with disabilities. Many states maintain waiting lists for people with cognitive disabilities who seek community-centered living services. As they wait for openings after completion of secondary schooling, families often provide daily care, guidance, and explore opportunities for independent living and employment.

It is a widely held misconception that people with cognitive disability are unable to effectively use consumer technology. Since a majority of people with cognitive disabilities are classified as having moderate to mild impairments, most are able to learn to use a computer with proper coaching. Many people with cognitive disabilities who have access to a computer can learn to communicate on email, browse web sites, and play games.

Cloud technology has the potential to foster new opportunities for people with disabilities through social networking, vocational training, and electronic health care records. Social networking sites can facilitate meeting others in the local community with common interests, and offer support through informal groups for caregivers. Vocational training and tutorials may also be offered on the cloud, enabling a person with a disability to prepare for a new position and obtain job coaching outside of the home if necessary.

Cloud services that store electronic health records could also play a major role in improving quality of life and providing continuity in health care over the lifespan for patients who have memory or communication issues. This is especially important when experiencing major life transitions, such as a move to or within a community centered service provider, or when a mentor or knowledgeable caregiver is no longer available to communicate the health history of a patient.

Disability advocates feel that access to the internet and cloud computing services fosters a strong sense of independence, self-determination, and empowerment for people with cognitive disabilities. Designing content with appropriate vocabulary and navigational controls is critical to making cloud services accessible. Elimination of distractions, such as pop-up ads, may also be very helpful for many people with attention problems. Using appropriate language and eliminating the need to scroll for “hidden information” is also a useful strategy for designing accessible sites.

3.3 Legal and Regulatory Barriers to Accessibility “In the Cloud”

Details about where information is hosted, where it is requested, and how it is served can present legal and public policy challenges due to copyright, privacy, and digital

rights management regulations and laws. For example, if text-based web content is requested by a user with visual disabilities through a cloud-based screen reader service, content is "transcoded" into a different modality and then served to the user. While this type of service allows cloud content to be accessed by a broader audience, it can also present legal challenges for the service provider if the accessed materials are protected by copyright or digital rights management laws.

Services that access content hosted in foreign countries may also present problems if that country has restrictive national, regional, or local laws. Customs and practices also shape the future technology landscape, and concepts such as personal privacy, copyright and digital rights management may not be mutually respected or strictly enforced across international borders.

In the U.S., a National Broadband Plan [6] was initiated to make high-speed internet services accessible so all Americans have the same opportunities for education, civic engagement, and participation in the global information economy. While many details are being defined and debated, this initiative represents a major national effort to create comprehensive plan that addresses the need for an accessible national public information infrastructure supporting broad societal participation.

4 Implications for Creating Accessible Cloud Technologies

Designing technologies and services that support the needs of people with disabilities has shifted from an "after market" activity (a feature or service added to a system after it is designed, built, and purchased) to a first class design imperative. While it is easy to view this shift as a positive development for people with disabilities, it also has the potential to benefit *all users* because of:

- shifting market demographics, with a growing global population of elderly users who may have decreased physical and/or cognitive function;
- the demand for cloud services by distracted users who are multitasking while using mobile devices with small displays in noisy real world environments;
- economic pressures seeking lower cost delivery platforms for formal education, training, media, entertainment, and personal communications; and
- legal and regulatory changes that are shifting toward a view of information access as a fundamental human right in an information society and economy.

The central issue is no longer about *why* information services should be accessible, but *how* accessibility standards can be created to make information systems and services usable by the broadest user audience. Basic research is needed to support the creation of effective standards that support accessibility for people with disabilities who need cloud computing services. This research should include longitudinal participative design with disability experts and advocates who face broad and diverse physical and cognitive challenges and consider how people actually use technology in activities for daily living, as well as their social and environmental contexts.

Accessibility standards must ubiquitously support privacy, security, customization, and personal preferences. Standards will allow accessible design to move from proprietary "one-off" technical demonstrations and support industry design methodologies that build upon technical substrates with embedded accessibility standards.

The challenge is how to create effective accessibility standards that are open and flexible, while simultaneously supporting innovation, creativity, and unforeseen technical opportunities.

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