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Business Case White Paper Series

e-Accessibility in a Connected World

Global Initiative for Inclusive Information and Communication Technologies

e-Accessibility in a Connected World

A G3ict Business Case White Paper Series

Winter 2017

Acknowledgments

This G3ICT White Paper picks up and builds on the topics addressed at the 10th European e-Accessibility Forum, held on 30 May 2016 at the Cité des Sciences in Paris. Over 180 professionals, association members and scholars from around the world gathered on this occasion to discuss "e-Accessibility in a Connected World". Nine of the conference speakers and one further expert, all actively involved in e-Accessibility or the Internet of Things, have accepted the invitation to update the opinions and points-of-view expressed on this occasion in order to shape a review on this question.

BrailleNet

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G3ict wishes to express its sincere appreciation to the organizers of the European e-Accessibility Forum, Universcience and BrailleNet for making the proceedings of the European e-Accessibility Forum available for publication by G3ict and to Dominique Burger and Katie Durand for their invaluable editorial contributions in developing the concept of this white paper.

About G3ict

G3ict is an advocacy initiative launched in December 2006 by the United Nations Global Alliance for ICT and Development, in cooperation with the Secretariat for the Convention on the Rights of Persons with Disabilities at UNDESA. Its mission is to facilitate and support the implementation of the dispositions of the Convention on the Rights of Persons with Disabilities (CRPD) promoting digital accessibility and assistive technologies. Participating organizations include industry, academia, the public sector and organizations representing persons with disabilities. G3ict organizes or contributes to awareness-raising and capacity building programs for policy makers in cooperation with international organizations, such as the ITU, ILO, UNESCO, UNITAR, UNESCAP, UN Global Compact and the World Bank. It produces in cooperation with Disabled People's International the CRPD ICT Accessibility Progress Report which provides in-depth benchmarking and analysis of the degree to which countries implement digital accessibility. In 2011, G3ict launched the M-Enabling Summit Series (www.m-enabling.com) to promote accessible mobile phones and services for persons with disabilities and seniors, in cooperation with the ITU and the FCC (U.S. Federal Communications Commission). G3ict produces jointly with ITU the e-Accessibility Policy Toolkit for Persons with Disabilities (www.e-accessibilitytoolkit.org), as well as specialized reports which are widely used around the world by policy makers involved in the implementation of the CRPD. In 2016, G3ict acquired the activities of IAAP, the International Association of Accessibility Professionals which offers professional training and certification in ICT accessibility worldwide. G3ict is funded by contributions from corporations, foundations and individual members. Its programs are hosted by international organizations, governments, universities and foundations around the world.

For additional information on G3ict, visit www.g3ict.org

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Foreword

By Dominique Burger, Founder of BrailleNet and Axel Leblois, CEO of G3ICT

Each day our social and economic lives become increasingly connected as the boundaries between physical and digital spaces fall away. The scale of this expanding infrastructure, commonly known as the Internet of Things (IoT), is unprecedented and forecast to grow at an astonishing rate. Embedded in devices from streetlights to household appliances, networks of sensors will gather data which can be leveraged in real time through cloud technologies to provide specialized and contextualized services when and where they are needed. Access to an intuitive and affordable "smart" network of objects and services will reduce the need for direct human action and decision making and attempt to overcome boundaries that presently condition our interaction with the world around us. Still very much in its infancy, it is hoped that this web of intelligent and connected objects will make life a great deal easier for persons with disabilities and the elderly. Seamlessly integrated into the home, the transport network and the workplace, sensors will have the capacity to capture very specific needs and adapt services and applications accordingly. Real-life examples of the comfort and convenience offered by smart objects are emerging, and there is a great deal of research and development underway which explores and builds on the capabilities of this new technology to bridge gaps in the digital divide.

Without the necessary cooperation and control, however, the Internet of Things may in fact introduce further barriers to users with physical, sensory, or cognitive impairments. With increased connectivity comes increased complexity, and with this exposure to new threats and vulnerabilities. Standard and interoperable communication protocols that integrate accessibility alongside technology, semantics and security and privacy requirements are paramount in order to create a robust and safe ecosystem. Accessibility professionals need to work together with ICT stakeholders, device manufactures, service providers, research institutes and universities to ensure that the needs of disabled users are integrated into the incremental development of the Internet of Things.

This White Paper explores such topics as:

- The potential of the IoT to bridge the digital divide
- How dialogue can be instigated between e-Accessibility stakeholders and industry to ensure that all IoT components are born accessible
- Practical examples of how the IoT can and will improve the lives of disabled and elderly people
- How e-Accessibility stakeholders can tackle security and privacy issues and install trust among disabled and elderly users
- The need for standards to ensure that IoT solutions are accessible, robust and interoperable.

Dominique Burger
UPMC-Inserm, Chair of BrailleNet

Axel Leblois
Executive Director, G3ict

Preface

By Ségolène Neuville, French Deputy Minister for People with Disabilities

Digital technologies can contribute to greater autonomy and social inclusion for persons with disabilities. For this reason, the government has a responsibility to ensure that the digital revolution does not leave persons with disabilities behind.

The improvements to daily life and the opportunities afforded by digital technologies in many domains, such as communication, education and e-shopping, makes the push for digital inclusion a most worthwhile challenge.

For the blind and visually impaired, digital technologies provide a formidable tool to access online information independently – providing it is made accessible to assistive technologies – via a refreshable Braille display or screen reader.

For children who are only able to communicate through images, new teaching opportunities are emerging that use, for example, applications enabling users to switch between information presented as icons and audio files.

Digital solutions such as eye-tracking software allow users with severe motor impairments to navigate on the web independently by controlling the curser through eye movement.

These are just a few examples of technical innovations that have emerged from the extremely fertile and ever-evolving digital landscape.

Ensuring that people with disabilities have access to digital technology is not an extra measure but the protection of a basic right for all citizens. Furthermore, I am convinced, and there is no shortage of examples, that improving access for persons with disabilities improves overall access for all.

When the government to which I belong takes measures to enable persons with disabilities to live in the most independent way possible and to participate fully in civic life, it honors a commitment made by France in 2010 when it ratified the United Nations General Assembly Convention on the Rights of Persons with Disabilities.

Nonetheless, France is lagging behind: on this side of the Atlantic, in northern Europe for example, a number of countries have surpassed France in exploring the potential of digital technology as a vector for innovation and social inclusion.

To make up for lost time, we have opted to get the ball rolling by setting digital accessibility requirements for the public sector. It is hoped that the private sector will naturally follow suit. Our legal framework has recently been updated to ensure that all public body websites and those of affiliated organizations are accessible, in particular for blind and visually impaired people. The scope of this legislation is intentionally broad and applies to all information available in digital form, regardless of the nature of the content or the network or device used to access it.

It goes without saying that civil society, nonprofit organizations and people with disabilities themselves play a fundamental role in making our society digitally accessible, both as a force for change and a source of new ideas. This white paper “e-Accessibility in a Connected World” is the living proof of this and contributes to advancing the cause of digital accessibility for all. It is a privilege to have been invited to write the preface.

From RFID to the Internet of Things: Technologies and Challenges

These last few years have witnessed the widespread development of the Internet of Things (IoT). But what lies behind this new phenomenon? Is it simply a buzzword or a new fashion? What are the technologies behind it? What can we expect from it and, most importantly, how can it be used to give greater access to services and help the widest possible population to function in our modern world?

By Nathalie Mitton, Researcher, French Institute for Research in Computer Science and Automation (INRIA)

Nathalie Mitton graduated in engineering in 2003 and earned her doctorate at the INSA in Lyon in 2006. She was appointed a director of studies at the University of Lille 1 in 2011. She has been an INRIA researcher since 2006 and became director of the INRIA FUN research team in 2012. Her research focuses on the mechanisms of communication and self-organizing wireless technologies of the Internet of Things, in particular sensor networks, wireless robots and RFID systems. Among other things, she is responsible for implementing the Equipex FIT platform. She is active on numerous program committees and is involved in the organization of scientific events.

Introduction

There are many ways to define the Internet of Things, but in simple terms, it consists in giving life to our objects and our environment.

The first step in this process is to give a unique identifier to each connected object in the form of a passive RFID tag (see Figure 1).

Figure 1: RFID tags: HF tag (left) and UHF tag (right)

Each RFID tag is embedded with a microchip and an antenna. There is no energy source within the tag itself; an electromagnetic RFID reader is needed to interact with these tags. The reader converts the radio waves reflected back from the RFID tag into digital information that can be processed by computers. RFID tags are already widely deployed in our day to day lives and can be found, for example, in metro tickets, ski passes, and luggage tags used by airlines.

There exist different RFID frequencies:

- Low frequency (below 800MHz)
- High Frequency (13,56Hz)
- Ultra-High Frequency (900MHz)

These behave differently and vary in reach (see Figure 2).

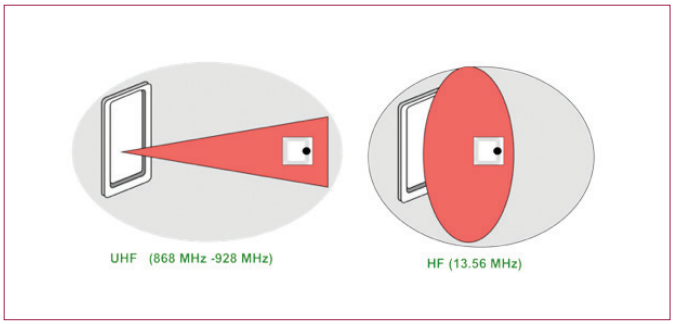

Figure 2: Variable reading areas according to radio frequency

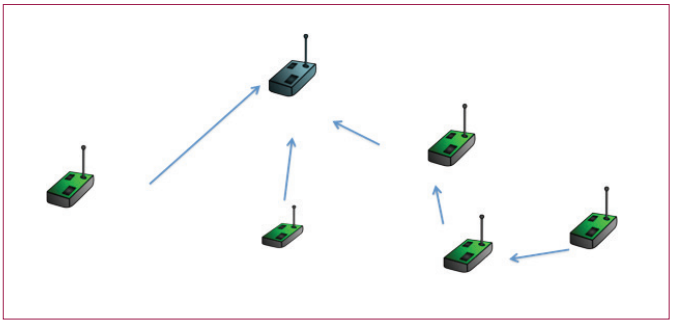

Figure 3: Example of data routing in a wireless sensor network

The choice of frequency will depend on what the tag is being used for. Low frequency technology, for instance, allows a better propagation in metallic or wet environments and is therefore widely used for tagging animals or monitoring metallic surgery instruments. High frequencies allow for short-range detection (up to 1 meter) in a spherical area and are used, for example, for controlling access to buildings or ski-lifts, or to tag library books. Finally, Ultra-high frequencies can transmit data over a long range in a specific direction and are mainly used for tracking pallets in warehouses or luggage in airports.

RFID technology is already mature and widely deployed, yet researchers continue to explore ways to reduce the size of tags and improve detection (from both a hardware and software perspective).

Building on RFID technology to drive the Internet of Things

The next step in giving life to our objects and our environment involves capturing physical data such as the temperature or luminosity levels through wireless sensors. The distribution of such sensors in our environment and resulting data collection can be used for a great many applications, including for example the detection of forest fires or leaking pipes.

Multiple micro-sensors capable of collecting and transmitting contextual information autonomously can be deployed to create a wireless sensor network. In this way, data can be transmitted from sensor to sensor until it reaches a central station (see Figure 3).

Depending on the environment in which the sensors are deployed (indoors/outdoors, urban/rural, etc.), the nature of the information collected (mobile/static sensors, in a hostile/controlled environment, etc.), and requirements in terms of throughputs, consumption, range, etc., different wireless technologies are available, each using different frequencies and based on different communication protocols. Some of these technologies are standardized. Table 1 presents the principal technologies available. Note that the battery life varies according to energy consumption but also according to radio communications (frequency of messages, frequency of radio switch off, etc.).

	Frequency	Throughput	Range	Consumption
802.15.4	868 Mhz	20kb/s	>150m	--
802.15.4	915MHz	40kb/s	>150m	--
802.15.4 (ZigBee)	2,4GHz	250kb/s	100m	--
Wifi a	5GHz	6, 9, 12, 18, 24, 36, 48, 54 Mbit/s	100m	++
Wifi b	2,4GHz	1, 2, 5,5, 11 Mbit/s	140m	+-
Wifi g	2,4GHz	6, 9, 12, 18, 24, 36, 48, 54 Mbit/s	140m	+-
BlueTooth	2,4GHz	1Mb/s	15m	+-
UWB	3,1-10,6GHz	Up to 500Mb/s	10/15m	++
LoRA	868Mhz	100-1200b/s	Several km	--
SigFox	868MHz	100-1200b/s	Several km	--

Table 1: Different technologies used in current wireless sensor networks

All of the listed sensors are small and characterized by different hardware constraints: they are limited in memory and computing capacities, they are battery-dependent, they can only transmit information over a small distance to economize battery power and they use wireless communication links that are instable and unreliable. Further complexities arise when the sensors are mobile (such as those used in animal tracking or intruder detection) or when a single network is made up of heterogeneous sensors with variable hardware capacities using different communication technologies.

Deploying IoT technology in hostile environments

While seeking methods to optimize RFID tags, sensors and wireless networks, researchers are also looking at ways to give this IoT technology the means to move and act in the environment. It is possible to imagine situations where it may be necessary to create sensor networks both dynamically and remotely. This could be the case, for example, in a hostile environment such as a nuclear plant after an explosion. To do this, sensors could be mounted on wireless robots that can operate autonomously in areas where human access is limited. Researchers are working with manufacturers to develop algorithms that will allow robots to self-deploy and cooperate to achieve specific tasks. In addition to the research challenges listed previously, researchers need to find ways to enable robots to cooperate in a distributed way to maintain wireless connectivity and make calculated decisions despite only having access to partial and local information.

Conclusion

Combining all the discussed technologies in a single system paves the way to a large set of new and exciting applications. The Smart City, for example, promises to offer citizens increasingly sustainable and accessible services that are easier to use. New healthcare services and applications also carry great opportunity. For people with disabilities, these developments will encourage new and alternative ways to interact with the physical environment. Objects will be able to detect specific needs and react accordingly, increasing mobility within and beyond the home.

However, each new technology or interaction brings new challenges such as how these objects interact, coexist and share frequencies with each other. It is the researcher's role to find ways to overcome these challenges by finding cost-effective, energy-efficient solutions that are operational, interoperable and improve the overall quality of life for all.

Learning Points

- The Internet of Things is a novel concept that has multiple definitions. Put simply, it is a paradigm in which our objects have an identity.
- Internet of Things devices are very heterogeneous and mostly rely on wireless communications. They can be composed of RFID tags, wireless sensors, wireless robots and mobile devices.
- A large set of technologies exist, each suited to different requirements and offering different features. These technologies can cohabit.
- The Internet of Things has the potential to provide a large set of new services to assist people, to make cities smarter, to better manage natural resources, etc.
- It is the researcher's role to find ways to overcome technical and operational challenges to improve the overall performance of the Internet of Things, and in turn, the quality of life for all.

Changing the World: Strategies, Partnerships and Business Propositions for the IoT

As a membership organization centered on the needs of people with sight impairments and blindness, the RNIB has been working closely with Internet of Things stakeholders in order to set the scene for full accessibility. The accessibility sector has genuine knowledge and expertise that it can bring to industry; by developing long-term strategic alliances and business propositions that make sense from a commercial perspective, the RNIB has been instrumental in driving sustainable accessibility in this sector.

By Steve Tyler, Head of Strategy, Solutions and Planning, Royal National Institute for the Blind (RNIB), United Kingdom

Steve Tyler has worked in the sight loss sector for over twenty years commencing in the role of Transcription Manager in 1992 and progressing to his current role of Head of Solutions, Strategy and Planning. Steve has been successful in leading the strategy for new services and products for blind and partially sighted people globally. Through multi-disciplinary teams and external partners, he has been directly involved in the creation of many life changing technology-based products and is particularly motivated by leading and working with teams to achieve their goals.

Introduction

Today, the connectivity revolution is no longer confined to the domain of computer technology. Domestic appliance manufacturers are producing connected objects such as washing machines and dish washers that are controllable by apps. Accessibility is no longer limited to discussions about synthetic speech and Braille but instead, for example, how people's needs can be auto-detected using profiling systems so that the objects that populate their environment can adapt to their specific needs.

The Royal National Institute of Blind People (RNIB), based in the UK, is a membership organization centered on the needs of people with sight impairments and blindness. It provides services, products, accessible information services, is a re-publisher in alternative services, and seeks to find ways of ensuring maximum opportunity for blind and partially sighted people to live their lives as independently as they want to.

The RNIB has been working on connected objects for some time. The potential for improving the lives of disabled persons is such that it was essential to work with industry early on in order to set the scene for full accessibility. The repercussions of raising awareness and educating people that run the business side of things, and changing the way that organizations such as Microsoft, Google and Samsung think about accessibility, are enormous. By developing long-term strategic alliances and business propositions that are sustainable and that make sense from a commercial perspective, there is half a chance of ensuring sustainable accessibility.

Tools for Change

In a society where global decisions affect all of our lives, it is essential to harness our knowledge and expertise to influence standards, regulation and legal frameworks, both at home and abroad. The accessibility sector has genuine knowledge and expertise that it can bring to industry and to mainstream IoT development.

To leverage accessible commercial solutions, the RNIB utilizes:

- European technical standards;
- Campaigns for legal or regulatory change both Europe and UK wide;
- Research that informs the world on the state of play where accessibility is concerned;
- User experience data gathered through ergonomic and observational evaluations conducted directly with consumers.

The RNIB has found, however, that working directly with the blue-chip organizations in business not only achieves enormous step changes in real world accessibility, but informs internal decision making inside the corporate world.

How Do We Do It?

The RNIB has worked with such companies as Amazon, Energy UK, Google and Samsung to ensure their IoT solutions are accessible out of the box. Each partnership requires a different strategy for ensuring the sustainable take up of accessibility. But ultimately, working with us saves these companies money as accessible products appeal to a larger clientele as they serve all ranges and types of user needs.

Perhaps the easiest way of describing our activity is to use a couple of real cases.

Case 1: TV Access

Our agenda was simple. As a result of the digitization of TV platforms across the world, and the vast amounts of viewing choice this would bring both in real time and online, we sought to change the face of the user interactions consumers could expect.

Our strategy – to fully engage with the industry; to understand where the decisions were taken, who owned the standards, how manufacturing actually took place and in which ways major manufacturers developed and delivered product.

We had already tried influencing UK Government and had attempted to change expectations within the regulatory frameworks, but to no avail; and yet our market research clearly showed that, like everyone else, blind and partially sighted people rely on TV as the key means of getting information, entertainment, and access to culture.

Resistance in the industry was enormous to our proposition that full access meant, for example, synthetic speech on TV platforms enabling fullest access to menus, settings, and most important, electronic program guide access and recordings, background and foreground color contrast and font control, re-definition of user experience with regard to the flow of information to and by the user, and of course audio description service access.

We played the role of a commissioner of product and engaged with the middleware manufacturers (the holders of the software found in many TV and set top box products), and the chipset manufacturers.

We developed a proof of concept clearly demonstrating what an accessible product looked and felt like whilst maintaining mainstream branding and delivery systems.

We proved that technically this could be done, and delivered a proposition under a mainstream brand to the UK market.

We made the tools available to the industry, delivered technical white papers designed to influence the more innovatively driven parts of the sector, and presented at key industry conferences and events.

We learnt about relationships within the industry and behaviors by key players there, along with political alliances and knowledge holders used by the industry and influenced them.

Today, as a direct result of our activity:

- Two TV manufacturers deliver a range of accessible TV sets to the market across the world;
- We influenced the development of US-based TV delivery mechanisms;
- We created in partnership accessible apps (another means of driving set top boxes and TV sets);
- We pushed for online service accessibility.

As a result, we have built up a consultancy in this area and now sell that consultancy to industry, along with a reward process that notes achievement in the area.

Case 2 – Mobile Access

Through our on-going monitoring of technical development, we saw the importance of the mobile arena as far back as 1998. We could envision not only the development of devices that would facilitate information delivery between people (messaging, web access, and much more), but also the potential for the device in your pocket to be the controller of the environment, products and services around you.

Through brokering a deal with a mobile company in the UK, giving us finances to support intervention in this space, we sought to find engineers that could influence the Symbian platform (and Nokia) – at that time a very closed environment.

We sent messages directly and via the media encouraging innovators to make contact, finally coming across an accessibility specialist, Torsten Brandt, and an engineer; thus, the beginning of Talks for the Nokia platform. We continued our behavior of maintaining pressure, creating partnerships, influencing software through recommendations and standards. It is notable that today, the IOS system from Apple, Android, and increasingly Windows mobile platforms are accessible all without product accessibility regulation to support this.

Today's Challenge for Tomorrow

We are now in a place where our expertise and knowledge are recognized enough by the industry that it pays for that knowledge. Through incremental changes, we have brought about tighter legislation – but the real win has been the ability to offer genuine support and understanding of the business challenges that the owners of large operating platforms and IoT solutions face.

By creating real innovation, new customers, and genuine partnership with the likes of Google, Microsoft, Samsung and Apple, and through collaborating to embed accessibility into these systems, the new order of app driven controls, and the emergence of what used to be specialist accessibility (synthetic speech delivered information) becoming mainstream through such platforms as Amazon, Google and Apple, we are seeing the next challenge as being the plethora of services impacting our lives and the connectivity of these services through intelligent agents and things.

Our influence today through using these strategies, improved and learnt as we move forward, see us delivering many more successes, now extending into the consumer electronics market. Because in the end, if we can create sustainable propositions that are attractive from a market reach perspective and gaining new customers, whilst benefiting the wider population, industry will buy the argument; after all, the argument means genuine translation into new customers previously deemed too difficult to reach or too complex to service.

Learning Points

- Accessibility is no longer limited to discussions about synthetic speech and Braille but instead, for example, how people's needs can be auto-detected using profiling systems so that the objects that populate their environment can adapt to their specific needs.
- The RNIB takes a partnership-based approach to furthering its objectives in the field of accessible technology; the repercussions of working directly with people who run the business side of things and changing the way they think about accessibility are enormous.
- It is important to harness and value the knowledge of accessibility organizations through consultancy offerings and proofs of concepts that are sustainable and make sense from a commercial perspective.
- Incremental changes have resulted in tighter legislation – but the real win has been the ability to offer genuine support and understanding of the business challenges that the owners of large operating platforms and IoT solutions face. Out of the box accessible solutions enable businesses to increase their reach and gain new customers previously deemed too difficult to reach or too complex to service.

My Internet of Things: Considering the needs and uses of disabled users

The Internet of things (IoT) undoubtedly heralds great new opportunities for persons with disabilities. Users are fully aware of the inclusive potential of this new technology and the leverage for empowerment that personalized services offer, many already adopting some type of IoT device in their daily lives. However, users are already facing a number of hurdles as ill-designed, non-inclusive devices and systems hit the market. In this panel discussion, three users discuss their own experiences of IoT technologies and highlight key areas that must be considered in order to build a fully inclusive connected world.

By Stéphanie Lucien-Brun, Conseil Français des Personnes Handicapées pour les Questions Européennes (French Disability Forum)

Stéphanie Lucien-Brun has been committed to developing an inclusive approach to Information and communications technology (ICT) since 2001. From 2001 to 2009, she developed an ICT and disability resource center for Handicap International, focusing on experimental projects and the training of professionals. During this period, she became involved with the French Disability Forum (Conseil Français des Personnes Handicapées pour les Questions Européennes) and began coordinating the work of the Digital Accessibility working group. She is a member of the European Disability Forum's ICT experts group.

Introduction

Internet of Things advocates and enthusiasts argue that IoT technology represents a ground-breaking revolution. But will this revolution open up new perspectives for persons with disabilities or instead introduce new barriers? What safeguards must be put in place to ensure that the IoTs potential to empower all users is fully exploited? What issues must be kept in mind when building a truly inclusive connected world?

Stéphanie Lucien-Brun put a series of short questions to a panel of three users with physical, visual and hearing impairments who bear witness to the uniqueness of individual user perspectives.

Expert Panel

The user panel included three people with disabilities who are involved in online and offline digital activities on a day-to-day basis:

Sophie Drouvroy offers a unique take on day-to-day life as an active deaf woman in her blog "Vis ma vie de sourd" (Living my life as a deaf person). Through the Medias-soustitres website, Sophie promotes the importance of accessible media, particularly subtitling for deaf and hard of hearing people. A qualified Web integrator with a wider perspective on digital accessibility, she is committed to raising awareness around the barriers that face disabled people. Sophie can be reached on Twitter @ cyberbaloo and on her personal web site sophie-drouvroy.com

Vincent Aniort is chief digital accessibility officer at the French Association for the Paralysed (Association des Paralysés de France). He is actively involved in the Digital Accessibility Working Group of the French Disability Forum and an active member of the French digital accessibility community. Vincent is a qualified AccessiWeb Expert (2006), a member of the AccessiWeb Working Group (GTA) and was one of the translators of the international web accessibility standard WCAG 2.0. He is committed to a number of OpenSource projects, including AcceDePDF and AcceDeWeb. His interest in IoT lies in his belief that it brings strong opportunities for people with disabilities.

Antoine Brouchet works in the field of ICT and is specialized in adaptive technologies and new usages. He is currently working on the improvement of vocal functionalities of mobile devices for Orange's Research & Development lab.

Discussion

What role do IoT technologies play in users' lives today?

According to **Antoine Brouchet**, connected interfaces are already a staple feature in many disabled people's lives, most significantly through mobile services provided through smartphones. As a user of such devices, he believes two key hurdles must be overcome to ensure the effective take-up of IoT technologies. Firstly, control interfaces must be fully interoperable. Secondly, service providers must guarantee continuity of service from one device to another to ensure that changes in hardware and operating systems over time do not jeopardize the availability and effectiveness of IoT services.
Vincent Aniort is both a user of IoT technologies and a close observer of usage by fellow people with disabilities. He believes that the Internet of Things is not a passing fad, but rather a long-term technological evolution with far-reaching implications. As such, it is paramount that the needs of all users be considered from the outset and reflected in all stages of development. He illustrates his own use of IoT technologies by two practical examples. To ensure his body temperature remains stable, he needs to adjust the temperature of his home on a regular basis. To do this, he has installed connected appliances such as shutters and a heating system that can be controlled by a central device. On a more anecdotal note, as someone who works from home several days a week, he has installed a system to detect and alert him when his office plants need watering so that he can call upon the services of his colleagues. This system helps keep both his plants and his relationship with his colleagues alive remotely!
In the near future, Vincent Aniort hopes to experience greater independence and mobility through developments in IoT technology. Increasingly effective geolocation technology will allow him to have improved access to safety features and assistance services while driving his car. He also believes direct access to important travel information will be greatly improved, with, for example, automatic updates on arrival times for buses in the vicinity, or alerts when lifts are out of access in metro stations on a given route appearing on his connected device.

For **Antoine Brouchet**, in its role as the gateway into an increasingly connected world, it is essential to ensure that smartphone devices are fully accessible, both in terms of their operating systems and the applications that they run. He outlines the importance of a secure and reliable transfer of information from connected devices to smartphones, or the IoT "chain of use", something he fears in not yet fully accessible.

Sophie Drouvroy has noted that the smartphone is no longer used primarily for its integrated functionalities and applications (text messaging, video chat apps, geolocation, etc.) but rather as a means to connect to services, devices and objects. As a person with a hearing impairment, Sophie has already come to rely on IoT technologies in her day-to-day life: she uses an activity tracker to access her messages as soon as she wakes up in the morning and a connected doorbell and camera system to indicate movement in and outside the house via a flashing light and alerts sent to a connected watch.

What risks do users associate with IoTs technologies?

Antoine Brouchet identifies the marked need for accompaniment to ensure that users with disabilities are sufficiently equipped to make full use of IoT technologies. This includes the need for clear and reliable troubleshooting when a device or service does not function as it should. In order for IoT technologies to become useful, or even essential tools in the day-to-day lives of people with disabilities, IoT stakeholders will need to build confidence and understanding among users and take the whole chain of use into consideration.

For **Vincent Aniort,** four key risks have to be addressed to avoid exclusion:

- Affordability
  While the cost of some digital devices has dropped significantly (it is now possible to buy a low-cost computer for as little as €40), the prices of connected devices remain high, especially considering the budget that most people with disabilities dispose of.

- Design
  Design and development should always focus on producing inclusive solutions, and be led by working processes that include people with disabilities to ensure that their specific needs and requirements are taken into account from the outset.

- Data quality
  This is particularly important for connected e-health devices; guarantees must be put in place to safeguard the quality of data collected to avoid potentially fatal errors.

- Data security
  IoT devices and systems collect specific personal information on what people do and how they live. It is crucial that this data is safely stored and handled and does not become a tool for discrimination.

Sophie Drouvroy identifies three areas of risk:

- Accessibility
  While the increase in vocal features improves accessibility for some, such solutions can introduce further barriers to users with hearing and speech impairments.

- Security
  On the one hand, taking increased control of one's environment through IoT technologies procures a feeling of security. On the other hand, unreliable security features can prove harmful and lead to unwanted intrusion and a subsequent loss of control by users.

- Design
  The same device might be used at different times by multiple users with very different needs. To avoid the exclusion of certain users, it is essential to adopt an inclusive design approach that will guarantee universal access to all.

What considerations should IoTs stakeholders be taking into account as the IoT ecosystem evolves?

Antoine Brouchet believes that, as with the Web, common standards and protocols must be drawn up to ensure the interoperability of the IoT. He feels that the limited or insufficient take-up of IoT solutions at present can be put down to the inaccessibility of existing applications and a fear that services will not be maintained over time. If a service is changed, it is essential that an alternative be provided to ensure that the functionality remains accessible over time. That implies a fight against planned obsolescence in favor of long-term longevity.

Vincent Aniort calls for a pragmatic approach to the IoT based on Universal Design principles.

Sophie Drouvroy, like her fellow panelists, believes that the IoT brings unprecedented opportunity for persons with disabilities and is insistent that the varied needs and requirements of different user groups must be taken into consideration in the design process to ensure that all users benefit from this increasingly connected world.

Learning Points

- The IoT is already being used to leverage inclusion for persons with disabilities and undoubtedly has the potential to bring further opportunities.
- Like all ground-breaking technological revolutions, such as the Internet and the advent of mobile phones before it, the Internet of Things carries a certain number of risks which must be addressed from the outset to ensure that persons with disabilities can reap the benefits without the risk of further exclusion.
- Universal Design and its principles must be fully embedded in the IoT development process.
- Data protection represents a significant challenge which must be addressed to ensure personalized services do not lead to further discrimination.
- Standardization, interoperability and continuity of service must be considered as a matter of urgency to ensure that all users' needs are factored into IoT solutions from the outset.

Building accessible cities using smart technologies

While working on parallel projects to improve navigation for people with disabilities in built and digital environments, Ross Atkin noted that design approaches in the two spheres varied considerably. While "one size fits all" solutions tend to be favored in the physical environment, digital designers are increasingly moving towards responsive solutions that adapt to the very specific needs of individual users. Through his 'Intelligent Street Furniture' line, developed in collaboration with UK Manufacturers Marshalls, Ross made use of IoT technology to enable the built environment to automatically adjust to user-specified requirements.

By Ross Atkin, Ross Atkin Associates

Ross Atkin holds Masters Degrees in Industrial Design and Mechanical Engineering from the Royal College of Art and the University of Nottingham respectively. He has worked on technological development in industry at major UK manufacturers like Dyson and on academic research at the Royal College of Art. He maintains a design and development practice concentrating on the interfaces between disability, technology and the city. Ross has been working with pervasive computing since 2007 and actively developing Internet of Things products since 2011. His Responsive Street Furniture project was nominated for the Design Museum's Designs of the Year award 2015.

Background

As part of a succession of research projects commissioned by public bodies such as UK municipalities, the central government's advisor on architecture, and major vision impairment charities like Guide Dogs and the RLSB, several groups of disabled people were shadowed as they navigated streets and other public spaces. Accompanied by a designer and a researcher on a journey in their local area, the participants were encouraged to describe how they navigated, what they felt, and which factors hindered or facilitated their journey. The entire experience was filmed.

The first such project was called Sight Line and focused on producing a document for street designers that helped explain the needs of street users with vision impairments[1]. As part of the Sight Line project, a design opportunity to make on-street construction sites and other temporary streetscape changes less disruptive for people with sight loss was identified. This resulted in a set of design improvements to the signs and barriers used at on-street construction sites and the provision of additional information in high-contrast visual, tactile and digitally accessible forms. The physical elements of the system were tested in controlled conditions by 13 people with sight loss. 11 of the participants preferred the improved signage over the conventional set up, with the remaining two registering no preference[2]. The London Municipal Transit Authority is currently funding a three month trial on a real street construction site in North London.

A second shadowing project was undertaken in 2012 as part of a participatory access audit for the City of York. 15 people with a selection of cognitive, sensory and mobility impairments were shadowed on the streets of York City Centre[3]. In the process of recommending accessibility improvements to the City, it became apparent that many design decisions were a trade-off between the needs of different disabled people. For example, while people with walking difficulties would benefit from increased seating along walking routes, this would constrain footway width and subsequently present a barrier to wheelchair and scooter users.

1. 'Sight Line, Designing Better Streets for people with Low Vision', CABE, 2010 http://webarchive.nationalarchives.gov.uk/20110118095356/http:/www.cabe.org.uk/publications/sight-line
2. 'Street works and vision impairment: improving signing and guarding', Municipal Engineer, 2015 http://www.icevirtuallibrary.com/doi/abs/10.1680/muen.14.00015
3. 'York City Centre Access and Mobility Audit Summary Report', CAE 2012 (PDF) https://www.york.gov.uk/download/downloads/id/3340/access_and_mobility_audit_reportpdf.pdf.

In parallel, Ross Atkins Associates were commissioned by the UK disability charity Scope to undertake a digital accessibility research project. This research revealed the value of adaptability when seeking to meet the needs of all users[4].

A stark contrast between the way accessibility was managed in the built environment and the digital sphere became apparent. A "one-size-fits-all" approach dominated street design, with the final configuration being an awkward compromise between different people's needs. Conversely, digital devices, applications and websites were designed to adapt to the needs of different users, giving each user an experience tailored to his or her specific needs.

Applying responsive design to the built environment

It became apparent that the principle of adaptability and responsiveness that characterizes Internet of Things technology could be applied to the built environment. Bluetooth technology could be used to identify the needs of individuals and enable a connected infrastructure to respond accordingly, providing tailored assistance[5]. The concept was pitched to Marshalls, a leading UK manufacturer of street furniture and paving, and a collaboration ensued. Marshalls' line of 'Intelligent Street Furniture' is the result of that collaboration[6].

Marshalls' Intelligent Street Furniture

The system is currently triggered by Bluetooth key fobs[7] but smartphone support is being developed. Users are required to register on a web app to input the address of their key fob and specify the services they require. From then on, whenever they approach a responsive item, it will adapt to their specified needs. Street lighting, for example, may adjust to take into account a visual impairment, or a certain type of audio information may be given in a specified language. The system can support as many different kinds of assistance as its installers wish to provide.

At present, connected street furniture items available include a bollard, a map totem and street lighting (Figure 1). Work continues on deeper integration of the system with other pieces of infrastructure including road crossing points and bus shelters. It is hoped that users of the system will eventually be able to obtain seamless assistance wherever they go.

Smart cities and building confidence in disabled users

Over the past five years, as these two projects have taken shape, a discourse criticizing the 'Smart City' has taken shape in both academic institutions like the London School of Economics[8] and in wider society[9]. The term has become associated with global technology companies who are attempting to impose large integrated solutions on city governments and undermining local democracy and data protection in the process.

Figure 1: A bollard providing audio information, a map totem detailing extra places to sit and responsive street lighting

Public discomfort with the idea of the smart city presents a challenge to the deployment of Internet of Things technology to improve accessibility and solve other problems for citizens. After a discussion on these issues at South By Southwest Interactive[10] in 2015, a manifesto was drawn up to describe how technology could solve problems for citizens in opposition to the 'Smart City' vision of the large technology providers.

The 'Manifesto for the Clever City' presents an alternative bottom-up view of the smart city and describes five actionable principles for how technology can be built to meet citizens' needs while protecting their privacy and increasing transparency[11]. It suggests that Clever City services:

1. Use digital technology to solve problems experienced by citizens.
2. Are built around the needs of the people whose problems they are trying to solve.
3. Are as simple as they can be and easy to explain.
4. Only collect and store data that is necessary to satisfy the needs of citizens.
5. Are not all or nothing platforms but bottom-up solutions that make a real difference to people's lives right now.

The manifesto has provoked some interesting discussions around the world and it is hoped it will continue to do so.

4. 'Enabling Technology', Helen Hamlyn Centre for Design 2013 (PDF) http://www.rca.ac.uk/documents/278/EnablingTechnology_SCREEN_1.pdf
5. 'Responsive Street Furniture', Ross Atkin Associates, http://www.rossatkin.com/wp/?portfolio=responsive-street-furniture
6. 'Intelligent Street Furniture'. Marshalls, http://www.marshalls.co.uk/commercial/street-furniture/intelligent-street-furniture
7. A form of remote control
8. 'Against the smart city (The city is here for you to use Book 1)', Adam Greenfield 2013.
9. 'The truth about smart cities: 'In the end, they will destroy democracy', The Guardian 2014 http://www.theguardian.com/cities/2014/dec/17/truth-smart-city-destroy-democracy-urban-thinkers-buzzphrase
10. South by Southwest Interactive is a festival and conference focused on emerging technology that takes place each year in Austin (Texas).
11. 'Manifesto for the Clever City', 2015, http://thecleverecity.net/

Learning Points

- With the advent of IoT technology, it is no longer necessary to design “one size fits all” solutions for the built environment; instead designers should be seeking ways to enable the city to adapt to the very specific needs of individual citizens.
- IoT solutions that improve the lives of disabled users are of interest to industrial partners as inclusive products appeal to a large clientele.
- Detractors of Smart City solutions fear that large corporations are using IoT technology in the built environment to collect data on citizens that can undermine their privacy and freedom of movement. However, these fears must be addressed and overcome promptly so that IoT technology can be used to leverage accessibility and make a real difference to people’s lives.
- Pervasive computing and connectivity present huge opportunities to solve very real problems for citizens; a manifesto describing how a “Clever City” might operate has been drafted to mitigate fears associated with IoT.

Emerging Privacy Challenges with Radio-Communicating Objects

People are carrying an increasing number of smart objects with embedded radio communicating capabilities around on their person. By sending and receiving frequent radio messages, these objects leave virtual trails that expose their owners to tracking. To what extent is this tracking already happening, and what can be done to prevent it?

By Mathieu Cunche, Associate Professor, Institut national des sciences appliquées, Lyon

Mathieu Cunche is an Associate Professor for undergraduate programs at INSA-Lyon. He is a member of the CITI laboratory and the INRIA Privatics project team. He holds a PhD in Computer Science from the University of Grenoble and an engineering degree from ENSIMAG. His research focuses on issues around privacy protection and security related to new information and communication technology. He is particularly interested in the implications of the use of radio technologies in mobile devices on privacy. Anonymous communication systems and issues around Internet censorship are also central interests.

Introduction

Whether they be smartphones, tablets, smartwatches, smart cars, or wearable devices for fitness and healthcare, an increasing number of smart devices accompany us in our daily lives. To reach their full potential, these devices must exchange data either locally or over the Internet. As radio-communication technologies are the most convenient way to do this, our smart devices are equipped with one or more of these technologies, the most popular being Wi-Fi and Bluetooth.

For all the benefits that smart devices provide, the threat of tracking is inherent. Indeed, radio signals transmitted from communicating objects always include a unique identifier that can be attributed to their wearers. While people are generally aware that they can be tracked online, they are rarely conscious that the same thing can, and is already happening in the physical world. Industry is scrambling to provide efficient countermeasures while data protection authorities investigate potential privacy violations.

Portable radio beacons

Smart devices generally embed at least one radio interface which allows the transmission and reception of a radio signal carrying radio messages. To enable efficient communication, these radio messages indicate the source and the destination of the message via unique identifiers. In Wi-Fi, this identifier is called the MAC address and is attributed to each device by the manufacturer.

Given the open nature of radio communications, it is easy to monitor exchanges and to intercept messages and their content. The content of these messages can sometimes be protected by encryption, but the identifiers of the source and destination are generally visible to all. Using freely available tools, it is possible to passively collect all the identifiers of radio communicating devices within a given range[12].

It is important to note that a device reveals its identifier not only when it is connected to a network or to another device, but whenever its radio capabilities are activated. This, for instance, is the case for Wi-Fi-enabled devices, which send out messages several times per minute in order to identify nearby Wi-Fi access points. A Wi-Fi-enabled device, such as a smartphone, therefore acts as a personal radio beacon, broadcasting a unique identifier that can be received at a distance of up to several tens of meters[13].

12. A. B. M. Musa and Jakob Eriksson. 2012. 'Tracking unmodified smartphones using Wi-Fi monitors' in Proceedings of the 10th ACM Conference on Embedded Network Sensor Systems (SenSys '12). ACM, New York, NY, USA, 281-294
13. 'Smartphone, Wi-Fi et vie privée : comment votre smartphone peut se révéler être votre pire ennemi', Mathieu Cunche, MISC HS no 008, octobre 2013, http://connect.ed-diamond.com/MISC/MISCHS-008/Smartphone-Wi-Fi-et-vie-privee-comment-votre-smartphone-peut-se-reveler-etre-votre-pire-ennemi

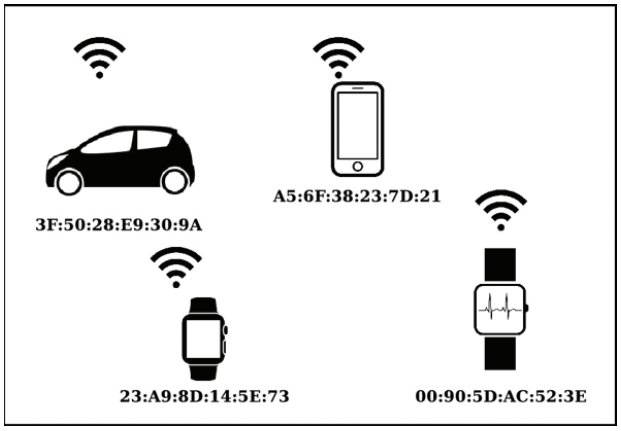

Figure1: Radio-enabled devices broadcast their unique identifiers on the air.

Figure2: Radio-tracking allows third parties to track the position of an individual and thus to monitor his or her itinerary, in this case in a shopping center.

Radio-tracking & Privacy

Capturing this readily available unique identifier is the first step towards tracking an individual's activity in the physical world. Several parties have seized the opportunity and started to collect radio identifiers for various uses.

The first is known as "physical analytics" and involves measuring human activity in a specific location. Physical analytics systems provide aggregated information on visitors to a given location, such as how many visitors were present per day, peak times, the frequency and duration of visits or the most popular routes in a shop.

A second use of this data is to build profiles on consumer interests and habits in order to deliver targeted advertising. For instance, if data reveals that a person visits a particular shop several times, an interest in a given brand of clothing can be extrapolated. When this person walks by a digital advertising board, it will detect his or her unique identifier and associated profile and serve a targeted advert for the said brand.

Finally, radio tracking can be used for surveillance and stalking. The military, surveillance organizations and the police already have tools to track individuals based on the radio signal emitted by their portable devices. It goes without saying that the fact that people can be tracked in the physical world represents a serious threat for privacy. Data on the whereabouts of individuals can reveal a lot of personal, even sensitive information on a given individual. For instance, frequent visits to medical facilities could tell third parties something about a given person's health conditions. The magnitude of this threat is reinforced by the fact that tracking is passive and that the majority of the population is unaware that it is happening.

Towards technical countermeasures

The privacy issues associated with the use of radio-communicating devices have quickly been identified by the research community and telecommunications industry. Some mobile phone companies have reacted by deploying quick fixes aimed at mitigating the impact on privacy, for instance by replacing the unique and stable Wi-Fi identifier by a random identifier[14] when the device is in the discovery phase.

These modifications only go some way towards fixing the issue; a deep-rooted overhaul of existing systems is needed in order to stop the seamless tracking of radio-communicating devices. Standardization bodies in charge of these radio technologies have initiated works to ensure that the next generation of radio technologies will not allow tracking[15]. Results of these standardization efforts can already be seen with the version 4.0 of Bluetooth technology, which does not include a unique identifier in its messages[16].

14. http://arstechnica.com/apple/2014/06/ios8-to-stymie-trackers-and-marketers-with-mac-address-randomization/
15. https://standards.ieee.org/develop/project/802E.html
16. http://blog.bluetooth.com/bluetooth-technology-protecting-your-privacy/

The role of data protection authorities

The practice of radio-tracking has not gone unnoticed by Data Protection Authorities (DPA). Indeed, private information collected by radio-tracking companies (including the unique identifier and device location) is protected by laws; data is generally collected without the explicit consent of the person. As a result, the DPAs are keeping a close watch on tracking practices and have taken action against some cases of abuse. For instance, the US Federal Trade Commission has settled deception charges against a radio-tracking company that did not provide an opt-out mechanism[17] and the French Commission nationale de l'informatique et des libertés (CNIL) has rejected a project on the basis that the collected data was not correctly anonymized[18].

Learning Points

- Radio communicating devices such as smartphones transmit their unique identifiers to anyone who has the technical capacity to capture them.
- Third parties are already tracking smartphones to measure human activity or to profile people.
- This tracking, already happening in the real world, represents a privacy threat to the users of radio-communicating objects.
- Aided by the research community, the telecommunications industry is developing technical solutions to reduce the threat of tracking.
- Potential trackers are under the close watch of Data Protection Authorities, such as the CNIL in France and the Federal Trade Commission in the USA.

17. https://www.ftc.gov/news-events/press-releases/2015/04/retail-tracking-firm-settles-ftc-charges-it-misled-consumers
18. http://www.numerama.com/magazine/34310-la-cnil-s-oppose-au-tracage-des-pietons-par-wi-fi-a-la-defense.html

How the Internet of Things is changing healthcare

Today, the value proposition of smart devices is centered on individual prevention, but still falls short of transforming medical practices. There is a gap between the rapid adoption of smart health-tracking devices by end consumers and the seemingly slow transformation of healthcare into something where one day, we will be alerted to perform check-ups before we are sick. Can existing healthcare systems really adopt efficient prevention mechanisms based on existing wearable technologies?

By Alexis Normand, Director of Research & Development in Healthcare, Withings

Alexis Normand is Director of Research & Development in Healthcare at Withings, leader of IoT Healthcare. A graduate of HEC Business School and the Paris Institute of Political Studies (Sciences-Po), he has a background in industry and strategy consultancy, notably assisting public healthcare policy reform for government agencies in the Gulf. He also serves on a French Think Tank.

Introduction

Withings is a French company that was set up in 2008 to develop devices and apps for self-monitoring and self-sensing, also known as "the quantified self". In 2009 Withings introduced the first Wi-Fi scales on the market so that users could monitor and log changes in body weight. Following on from the successful take up of this device, a blood pressure monitor, a high-definition wireless security camera, a smart sleep system, and a line of automatic activity-tracking Bluetooth watches were developed.

The Internet of Things as an agent for change

As highlighted by BJ Fogg, Professor of behavioral science at Stanford, changing to healthier habits (i.e. becoming more active, quitting smoking, eating better food, etc.) is one of the most difficult things to achieve; most people, in their willingness to become perfect, set unrealistic goals that end up proving counter-productive. This leads to both disappointment and failure. If people are suffering from physical disabilities, staying healthy may prove even more difficult. But there is hope! Fogg's behavioral model lists three key success factors: motivation, ability, and trigger. Smart devices are aimed at getting all these elements right. To put it simply, data generated by a smart watch or connected scales creates awareness and motivation by allowing people to set simple objectives. Most importantly, small achievable efforts repeated day after day generate virtual rewards through data. This can help to transform efforts into habits that end up being effortless. From Withings' perspective, this is not simply an assumption. Data from trackers helps prove actual impact, as highlighted by a growing number of academic publications[19].

The impact of smart technologies in the workplace

How does the consumerization of healthcare affect existing organizations today? Impact has been felt both in the workplace and in medical institutions. Amazingly, eHealth has taken root in corporations, not in hospitals. Acting as insurers in the US, big corporations have a strong incentive to roll-out prevention programs. The prevalence of obesity and hypertension have risen to epidemic levels in the US. Nearly $153 billion are lost each year due to a lack of productivity caused by chronic health conditions. Similarly, stress is believed to account for half of the 550 million sick days taken by American workers every year, according to the American Institute of Stress. The Withings Health Institute estimates that these sick days represent a deficit of nearly $80 billion.

19. JMIR 2016 Jan; 18(1): e17. Who Self-Weighs and What Do They Gain From It? A Retrospective Comparison Between Smart Scale Users and the General Population in England

Companies have thus begun to incorporate trackers in their wellness programs to fuel engagement with technology. While existing corporate risk assessments may be successful in raising awareness about certain health topics, they lack the interactivity and playfulness of device-based programs. Smart devices now provide real time feedback to users about their activity levels helping to set and achieve health goals. Connected devices and associated apps allow for effortless health assessment, early detection of risk, and more efficient management systems. Wearables are not just disrupting workplace wellness; they are leading employers to engage in activities previously left to healthcare professionals.

Medical institutions and patient generate health data

What about healthcare organizations? In only a few years, the concept of the quantified self, whereby individuals track everything they can about themselves, has been replaced by that of "patient generated health data" (PGHD). This comes as a testimony of the growing legitimacy of smart devices and their growing integration in healthcare. Apple has understood this consumerization of healthcare better than most health IT companies, leading the charge with its Healthkit app. Apple has convinced major Electronic Health Record (EHR) providers to offer patient apps that connect to the Apple's Healthkit, allowing patient generated data to flow from devices such as those produced by Withings to doctors' files through a smartphone. This is a major leap forward. As a result, more and more hospitals are following patients with chronic illnesses at a much lower cost. Soon, instead of eHealth, we may be simply talking about health, because connectivity will have become fully integrated.

Healthcare players are realizing that end consumers are now empowered with remote monitoring tools that used to be only accessible to healthcare professionals. Costs have shrunk dramatically for the same services (i.e., following one's blood pressure). Now that you can track the evolution of your weight or blood pressure seamlessly and send the information easily with your smartphone to a doctor, it has become difficult for many patients to understand why they should not benefit from added-value prevention services. Beyond prevention for the healthy, chronically ill patients who use smart devices begin to take ownership of their health data in a whole new way. This is truly a paradigm change because health is no longer something you begin to think about the day you are sick when talking to your doctor. Now, the patient is at the center of the information and wants to play an active role before it is too late. Patient-centric medicine means more prevention, prediction, personalization and patient participation.

Transforming medical practices

Making the case for the integration of patient-generated health data in healthcare is not enough to bring about a change. There needs to be strong economic incentives for doctors and hospitals to follow patients remotely. This is beginning to take shape. In the USA for instance, Obamacare was trying to organize healthcare along the principle of "fee for outcome" instead of "fee per doctor visit". Beyond the economic incentive, we must still work on providing evidence that patient engagement leads to better health outcomes. Last but not least, technologies that improve chronic illness management can potentially lead to a growing digital divide as they are adopted by people, organizations and countries at different paces. Prevention typically benefits the richer and more health-conscious people. To allow technology to benefit those that need it most, strong public support is all the more necessary.

Learning Points

- Individuals, employers and healthcare providers all have a vested interest in maintaining a healthy lifestyle.
- For aging populations or people suffering from physical disabilities, staying healthy may prove even more difficult.
- Motivation, ability, and reward are three behavioral factors that encourage people to adopt healthier lifestyles. Data generated by devices such as smart watches or connected scales can help people to set achievable objectives that can transform efforts into habits that end up being effortless.
- It is believed that the remote monitoring of patients through IoT devices can significantly reduce healthcare costs and allow patients to take ownership of their health, encouraging more prevention, prediction, personalization and patient participation.
- IoT take up in healthcare is slow; to ensure that the health benefits are not experienced only by a privileged few, evidence that patient engagement leads to better health outcomes must be reinforced and presented to public bodies.

IoT Applications in the Health Sector

There is no doubt that the IoT holds great promise when it comes to empowering and increasing autonomy for people with disabilities. With few accessibility applications on the market, looking to the use of IoT in the health sector can provide a useful insight into the issues surrounding the successful deployment and take up of IoT devices and solutions. This article looks at connected devices that have been designed both to help individuals and their carers to manage health on a day-to-day basis, and to gain a better understanding of the specific characteristics and needs of particular user groups in order to improve overall quality of life.

By Marie-Christine Jaulent, Director of Research, INSERM (French Institute of Health and Medical Research)

Marie-Christine Jaulent studied computer engineering and completed a doctorate in Artificial Intelligence in 1986. She directs the LIMICS research laboratory (UMRS 1142, Inserm, UPMC, UP13) which specializes in Medical Informatics and Knowledge Engineering for e-Health. In April 2016 the LIMICS organized an international conference in Paris called STC 2016: "Transforming Healthcare with the Internet of Things". Marie-Christine Jaulent has written over 100 articles in scientific journals and has been involved in international standardization work (IHTSDO). In 2012 she was appointed co-editor of the International Medical Informatics Association's Yearbook.

Introduction

A plethora of connected devices and smartphone applications are making their way onto the mainstream market. These vary from new services and facilities designed to support all users in their daily lives to more specific services adapted to the needs of particular user groups. In a 2013 study, the global investment bank Morgan Stanley estimated that by 2020 there will be around 75 billion connected objects[20].

A growing number of these connected objects are designed to support good health by monitoring and encouraging improved fitness, wellbeing, aging, and health protection. With a growth in chronic disease and poly pathological illnesses, teamed with an increasingly aging population, these objects hold great promise. There is no doubt that the Internet of Things has an important role to play in helping health professionals to diagnose and provide appropriate care, medical researchers to gather and explore increasingly detailed data, and patients to improve their health and maintain a certain level of autonomy.

Practical applications to support healthcare and medical research

There are numerous examples of connected objects that have been designed to help improve health on a daily basis. One such object is the connected spoon designed specifically for patients suffering from Parkinson's disease[21]. Not only does the spoon self-stabilize to help to minimize the effects of tremors during meal times, it allows health professionals to monitor and improve their diagnosis by using the device to measure the frequency, duration and scale of tremors. Such objects are also invaluable to researchers who can conduct clinical trials on a targeted population and gather detailed data to evaluate the effectiveness of a given treatment in reducing the adverse symptoms of a disease or condition.

20. http://www.businessinsider.com/75-billion-devices-will-be-connected-to-the-internet-by-2020-2013-10?IR=T
21. https://www.liftware.com

At present, however, despite the growing number of such IoT devices, their use in the health sector is limited. As with prescription drugs, it is necessary to run extensive clinical trials to prove effectiveness and be granted CE standard classification for use in healthcare and medical research.

Recognizing connected objects as medical devices

While there is little doubt that connected objects will give health practitioners more precise and even new data relating to the health of their patients, there is some concern about how doctors go about evaluating the overall performance of these devices and how they can be monitored before, during and after their arrival on the market.

To be used in a clinical environment, an object must be recognized as a medical device and this depends largely on the purpose for which the object has been designed.

For example, there are a number of IoT solutions on the market that help users to keep tabs on their sleeping patterns, allowing them to collect data on periods of light or deep sleep and overall sleep quality. While this information is informative for users, it is of little scientific value to health professionals as the reliability of the data collected and the positive impact on patients suffering from sleep disorders has not yet been proven. On the other hand, there are devices such as connected glucometers used to measure blood sugar levels and calculate insulin dosage that have been evaluated in clinical trials and are now used widely by doctors to monitor and treat diabetes.

Successfully getting connected objects recognized as medical devices also depends on the determination of the product manufacturers. A connected heart rate monitor, for example, could be used by sportsmen to monitor personal performance, but also by doctors to monitor cardiovascular disease. Marketing the product as a recreational device requires no costly clinical testing and CE certification applications, so many manufacturers opt to focus on IoT solutions for "wellbeing" rather than clinical devices for use within the medical profession.

The shift in the doctor-patient relationship through connected devices

Whether they be used as recreational or medical devices, connected objects can have a significant effect on the classic doctor-patient relationship and have the potential to bring about real changes in the way medicine is practiced today as the patient takes an increasingly active role in his or her healthcare. By using connected devices, the patient necessarily has a better understanding of his or her health, how this can be improved, and the tangible consequences of medical intervention. In addition to reducing medical costs and reducing hospital admissions through remote monitoring, a more assiduous approach to administering medication is a necessary benefit of giving patients increased control over their health through connected devices. As a result of these significant preventative benefits, health professionals are increasingly "recommending" connected devices to patients alongside overall lifestyle changes.

Concerns over the use of IoT healthcare solutions

According to several studies and surveys in France[22], many people still have reservations about the use of connected devices in healthcare. Concerns around such issues as data protection and confidentiality, and the close monitoring of our personal lives need to be addressed and resolved before IoT solutions are fully embraced by both doctors and their patients and the resulting data fully exploited.

Making sense of IoT data

Data collection is an inherent part of the Internet of Things. Large volumes of data are collected and can be consulted in real time, yet this data is increasingly specialised and specific to the device being used which can pose a real challenge for interoperability and overall usability.

There is a belief that the data collected by IoT devices can be used as soon as it is collected, but in reality, with no agreed standard in place, this data is usually device-specific, cannot be shared and risks losing all coherence when analysed out of context. While many manufacturers are taking steps to ensure their data can be exported in standardized formats, there remains some way to go. To overcome these data interoperability and usability issues, information management researchers are experimenting with repositories capable of storing and processing data from different sources and adding a layer of semantic mark-up, annotation and metadata that will help give this data meaning so that it can be used for a multitude of purposes beyond those that it was originally collected for.

22. http://www.atelier.net/en/trends/articles/french-people-want-healthcare-professionals-adopt-connected-objects_434513

Learning Points

- While IoT devices in the accessibility sector are only just emerging, the use of this technology in the health sector can provide an interesting insight into both the challenges and the benefits for individuals, their carers and researchers seeking ways to gain a better understanding of the needs of specific user groups.
- The introduction of IoT devices has a significant impact on the doctor-patient relationship as patients gain greater control and understanding of their health, and become less dependent on professionals and medical facilities.
- Despite the growing number of IoT devices that monitor health and wellbeing, their use in the health sector is limited as manufacturers do not always have the resources, nor the desire, to run extensive clinical trials to prove effectiveness and be granted CE standard classification.
- At present, much of the data collected cannot be used to its full potential as issues around data protection and interoperability persist. Researchers and manufacturers need to work to overcome these challenges before a wide scale take-up is possible.

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Internet of Things Research Challenges

The Internet of Things marks an important turning point in the evolution of our society. It represents a major step change capable of revolutionizing the way existing services are designed, built and used. However, in order to realize its full potential and in particular to better meet the specific needs of people with disabilities, researchers need to address a number of technological, conceptual and practical challenges.

By Dr. Mehdi Ammi, Associate Professor, LIMSI, Department of Computer Science, University of Paris-Sud

Mehdi Ammi gained an MS degree in Computer Science at the University of Evry Val d'Essonne in 2002. He completed a PhD in Robotics at the University of Orléans in 2005. In 2006 he was appointed Associate Professor at the University of Paris-Sud and LIMSI. His research focuses on Human Machine Interfaces and the Internet of Things. He leads the HAPCO team at LIMSI-CNRS. He was co-president of EuroVR Haptic-SIG and he is currently co-chair for the IEEE TCH publication. He is an associate editor of the ISTE Internet of Things journal, and in 2016 he organized the national conference on the Internet of Things.

The Internet of Things as a personalized services ecosystem

The Internet of Things promises an almost unlimited number of customizable services which will better meet the needs of users, particularly the elderly and those with disabilities. With a rising and aging population, increasingly sedentary lifestyles, poor diet, a decline in access to medical care for some populations and tightening medical budgets for others, our society is confronted with increasing public health challenges.

In most parts of the world, the coming decades will also see real demographic upheaval as the elderly population increases. According to forecasts by the INSEE[23], by 2050, nearly one in three people will be over 60 years old (compared to one in five in 2005). Our societies must therefore make provision for this massive influx of dependent people and the growing imbalance between active and non-active populations. Aging populations will need help and support to complete basic day-to-day activities such as eating, washing, walking, etc.

Because of its proximity to users, the Internet of Things will play a key role in the healthcare and home support system of tomorrow by offering a services ecosystem that will be efficient and articulated with existing infrastructures and professionals.

A number of connected products capable of measuring and monitoring our physical and biophysical activity are already on the market. These will soon be used to establish diagnoses, to make contact with professionals, or even to offer advice on how to improve one's lifestyle in order to avoid certain pathologies.

With their ability to capture and respond to specific needs, connected objects will also enable us to put in place effective solutions to facilitate life at home. Artificial intelligence will help automate this support environment and reduce the workload of able-bodied people.

23. French Institute for Statistics and Economic Studies

Connected objects will be capable of providing rehabilitation platforms integrated into the user's everyday environment. Once deployed, these platforms will solicit the user at certain times of the day to carry out tasks previously identified by the carer (e.g. preparing tea or preparing something to eat). The sequence of events will be analyzed in real time to ensure that all runs smoothly. If the user confuses actions or completes these out of sequence, they will be alerted so that they can be remedied. The connected SyMPATHy glass, for example, allows the medical follow-up of people who have suffered a first stroke and also offers fun and interactive exercises for patients [Bobin, 2016].

Better yet, connected objects and mobile applications will help create and improve the social bond and benefit from neighboring services in an eco-responsible approach. Beyond services, connected objects will provide social behavior monitoring and social coaching functions to avoid social isolation.

However, in order for these solutions to be deployed effectively, a number of technological, conceptual and practical hurdles must be overcome.

The challenges of capturing, collecting and analyzing data

The development of the Internet of Things relies on data relating to the user and his or her environment. The entire process of capturing, collecting, processing, analyzing and modelling personal data to provide personalized services, in particular for people with disabilities, represents new challenges that need to be addressed.

Sensors must be as user-friendly as possible (discreet, flexible, etc.), sensitive to variable environmental conditions (rain, sweat, high temperatures, etc.), energy efficient, and affordable. The latest advances in nanoscience, materials and electronics will be needed to develop and design new sensors that can be integrated into textiles, portable objects (bracelets, glasses, shoes, etc.), robots (hands, bodies, etc.), or even the environment (building materials, carpets, wallpapers, etc.). For example, the use of functional polymers (e.g. piezoelectric[24]) will offer new perspectives for the design of a wide variety of powerful, transparent, energy-independent sensors (force, acoustics, thermal, etc.) that can be easily integrated to objects, and especially with very low manufacturing and integration costs [Yoon, 2013]. The optimization of certain processes, such as capacitive processes, will make it possible to propose new sensors that will not require physical contact with the user (presence, movement, geolocation, etc.). It will also be necessary to develop more flexible calibration procedures to correct sensor responses in situ. For example, with auto calibration approaches taking into consideration the environmental conditions and past responses of the sensors.
Integrating Internet of Things solutions into everyday life poses a series of challenges that must be considered when studying and developing tools to process and analyze data.

First of all, it is necessary to develop efficient data management and computing architectures by adapting both to technological constraints (embedded architecture, sampling frequency, cloud technologies, network speed, etc.), application constraints (response time, accuracy requirements, etc.), but also ethical constraints (data sharing or protection, system security, etc.). Indeed, data storage and algorithms can either be embedded in an internet box, distributed between several connected objects, made simply in the cloud, or generated using hybrid solutions. The main challenges of this aspect of Internet of Things technology will be identifying sufficiently high-performance hardware and software solutions and developing optimized algorithms (parallelization[25], GPU[26], etc.) to efficiently carry out data processing while reconciling user needs and privacy requirements.

In terms of data processing, attention will have to be paid to the different methods used to merge data from diverse sources in order to make the most of dense sensor networks in these new environments (robots with cameras, connected watches, etc.). Data learning and the generation of computer models based on physiological processes (cognitive, motor, social, etc.) will also play a key role in this domain.

The challenges of meeting user needs

The successful deployment of the Internet of Things will depend on how services perform, but also on the user experience provided. Internet of Things technologies will open the door to a multitude of new uses. In order to design and develop services that are efficient and user friendly for multiple audiences, these new uses must be identified and studied.
A successful user experience relies on a user-friendly Human Machine Interface (HMI). Interactions may result from a direct and conscious action from the user, or be automated via a non-conscious action.

In recent years, the HMI landscape has been shaken by the appearance of mobile devices, portable devices, physiological capture techniques, and new non-intrusive stimulation and rendering techniques [Sodhi, 2013]. It will be increasingly possible to capture and respond to information collected directly from the user's body. Robots, which have the ability to evaluate and recognize certain situations, will also play a key role in the process of immersing and supporting the user in this new environment.
It is necessary to take all of these evolutions into account when designing and studying future HMIs in order to propose efficient, accessible and usable solutions for different users.

24. Material which is electrically polarized by mechanical stress (eg pressure)
25. Simultaneous processing of data corpuses
26. Calculation on graphics processors

Learning Points

- Because of its proximity to users, the Internet of Things will play a key role in the healthcare and support systems of tomorrow by offering a services ecosystem that will be efficient and articulated with existing infrastructures and professionals.
- Sensors used to capture, collect, process and analyze personal data must be increasingly discreet, energy-efficient and affordable, without compromising privacy, in order to provide highly personalized services.
- It will be increasingly possible to capture and respond to information collected directly from the user's body.
- The successful deployment of the Internet of Things will depend on optimal performance and user experience.

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Accessible Open Web Platform: A universal interface to the Internet of Things

At present, the Internet of Things suffers from a lack of interoperability between different ecosystems and platforms. A comprehensive framework of technologies and protocols with rich functionality, known as the Open Web Platform, has been developed by the W3C to provide a solid framework on which dynamic and interoperable applications can be built to function across systems and devices. The Web Accessibility Initiative (WAI) addresses the accessibility of the standardized protocols and formats that make up the Open Web Platform to ensure that people with disabilities benefit fully from the new products and services that the IoT can provide.

By Shadi Abou-Zahra, Activity Lead of International Programme Office, W3C Web Accessibility Initiative (WAI)

Shadi Abou-Zahra coordinates WAI outreach in Europe, accessibility evaluation techniques, and international standards promotion and harmonization activities. As Activity Lead, he is responsible for education and outreach, coordination with research, general discussion on web accessibility, coordination with the WAI Technical Activity, and WAI liaisons with other organizations including standards organizations and disability groups. He is the scientific coordinator of the WAI-DEV Project (IST 611612), and is an editor and staff contact for the Education and Outreach Working Group (EOWG).

Background

The Internet of Things promises revolutionary changes and benefits to all aspects of our modern world. This includes smart buildings and cities, transportation and mobility, medicine and health, industrial development and productions, and much more. This is all enabled by a new generation of telecommunications and information technology (IT) that is ubiquitous in all aspects of our daily lives. Every day the IoT-enabled infrastructure is expanded through the deployment of more connected devices with sensors and actuators. That is, every day we come a little closer to this vision of a truly connected world.

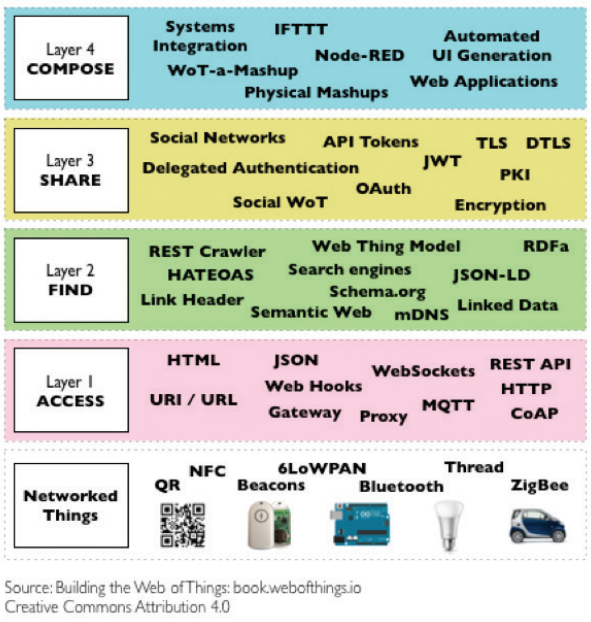
However, it is not sufficient to have internet-enabled devices. Connectivity is the base but devices must be actually able to talk to each other in standardized protocols and formats. Currently IoT suffers from a lack of interoperability between the different ecosystems and platforms that exist. It is not plug-and-play. In fact, there are significant data silos among and within the different data sources. There are varying IT architectures and application programming interfaces (APIs), which lead to high costs for development, and often to a limited market potential. It is similar to the competing and non-interoperable networking technologies and solutions that existed before the (traditional) internet emerged.

The World Wide Web provides a compelling approach to regain the interoperability and universality that is desperately needed. Over the years the Web has expanded to become the predominant user interface for the traditional internet. It has diversified into all domains and onto many different devices. It has also moved from a more static and document-oriented set of specifications to a comprehensive framework of technologies and protocols with rich functionality: the Open Web Platform. Today the Web enables applications that are dynamic and interoperable across devices. Thus the Web of Things (WoT) is the natural evolution, to provide a universal interface to the Internet of Things.

Web of Things (WoT)

Many technologies to build the Web of Things already exist, in particular on the level of base application programming interfaces (APIs) and the semantic web for open data exchange[27]. In the book *Building the Web of Things*[28], Dominique D Guinard and Vlad M Trifa describe a possible model. It includes the following layers:

- **Networked Things:** infrastructure of connected sensors, actuators, and devices
- **Access:** provides access to connected things, including HTTP, WebSockets, etc.
- **Find:** enables the findability of connected things, also through the semantic web
- **Share:** supports sharing, authentication, and access control of connected things
- **Compose:** supports the compositions, to create the actual products and services



Source: Building the Web of Things: book.webofthings.io
Creative Commons Attribution 4.0

Figure 1: Illustration of the previously described layers of WoT (details available at: http://webofthings.org/book/)

Accessibility

In particular, people with disabilities could immensely benefit from the new products and services that WoT can provide. For example, independent adapted living that was once a specialty domain is becoming, thanks to smart home solutions, increasingly mainstream and increasingly affordable. Also smart and self-driving cars provide accessibility for many persons with disabilities. In fact, many specialized solutions, such as text-to-speech and optical character recognition (OCR) are now widely spread and available in nearly every modern mobile phone, tablet computer, and other mainstream device. However, these products and services only serve people with disabilities if we can ensure that they are in themselves accessible. Otherwise they may be more excluding than inclusive.

The Web Accessibility Initiative of the World Wide Web Consortium addresses the accessibility of the Web, including the Web of Things, through several mechanisms. These include the following types of activities:

- Cross-review of W3C specifications and technologies for accessibility support
- Development of the internationally recognized standard for web accessibility:
  - **Web Content Accessibility Guidelines (WCAG)** – defines accessibility of web content, including text, image, multimedia, scripting, and more
  - **Authoring Tool Accessibility Guidelines (ATAG)** – defines criteria for accessible tools for the production of accessible web content (e.g. CMS)
  - **User Agent Accessibility Guidelines (UAAG)** – defines criteria for the accessibility of web browsers, media players, and assistive technology
- Development of specific web accessibility specifications, such as WAI-ARIA
- Carrying out education and outreach to promote awareness and build capacities
- Coordinating standards development internationally, to support harmonization

Much progress has been made on these aspects over the past years, including addressing trends and developments such as the increased dynamic nature of the Web and the rapid emergence of mobile technology. However, one of the next big challenges is the current rapid evolution of the Web of Things, and the accessibility of it.

27. Web of Things development at W3C: https://www.w3.org/WoT/
28. Guinard, D and Trifa V 2015, Building the Web of Things, Manning, ISBN 9781617292682

Challenge

The challenge for the entire accessibility community is to provide input into the current development of the Web of Things, to ensure its use for people with disabilities. This is a timely opportunity to provide input ahead of and during development, rather than after full deployment and needing to retro-actively address accessibility. Specifically, some of the input that is currently needed includes:

- **Use cases on a protocol level** – that is, not user interface aspects but lower-level aspects to ensure accessibility of the user interface. For example:

  "A home heating system can be controlled remotely. The thermostat needs to provide the current temperature in text format (as opposed to an image only), so that it can be transformed into other formats, such as to voice. Access to this text format needs to be available for assistive technologies through open and standardized APIs and data formats."
- **User needs for technologies and specifications** – accessibility needs of users with disabilities for the WoT technologies and specifications. For example:

  "Data protocols and formats need to support provision of text alternatives for non-text content that is being exchanged between sources"
- Research in applicability of solutions in practice – that is, how are solutions actually used in practice and how well do they work? For example:

  "Sensor for detecting people in a room does not detect wheelchair users"

Further background can be found in some of the position papers submitted to the WoT Workshop held on 25-26 June 2014 in Berlin, Germany[29]. Further research in these areas is critical to inform the development of accessible WoT specifications and technologies.

Invitation

The W3C Web Accessibility Initiative (WAI) invites you to participate and contribute to this development and to web accessibility more broadly. Opportunities to participate and contribute to the development of WoT and WoT accessibility include the following:

- **WAI Accessible Platform Architectures (APA) Working Group** – responsible for cross-checking W3C specifications and technologies, to ensure accessibility: https://www.w3.org/WAI/APA/
- **W3C Web of Things (WoT) Interest Group** – pre-standardization group with the task of defining the W3C specifications and technologies needed for WoT: https://www.w3.org/WoT/IG/

Also share your research findings and exchange knowledge with accessibility specialists and practitioners through the WAI Interest Group (IG): https://www.w3.org/WAI/IG/
More information about getting involved with WAI can be found at: https://www.w3.org/WAI/about-links.html

Learning Points

- Connectivity is the base of the IoT, but the large-scale take up of these technologies will only happen when devices are able to talk to each other in standardized protocols and formats.
- The W3C has built a comprehensive framework of technologies and protocols with rich functionality, known as the Open Web Platform, that can provide the interoperability and universality that is desperately needed.
- The WAI is responsible for ensuring that Open Web Platform specifications and technologies support accessibility. In order to do this effectively, further research into user needs, use cases and current shortfallings is needed.
- The WAI calls upon the accessibility community to participate and contribute to working groups overseeing the accessibility of IoT specifications and technologies and to share their research and experience in this field via the WAI Interest Group.

29. Workshop submissions available at https://www.w3.org/2014/02/wot/submissions.html; More specifically https://www.w3.org/2014/02/wot/papers/sajka.pdf and https://www.w3.org/2014/02/wot/papers/velasco.pdf

EU-funded research and innovation of ICT for persons with disabilities: ongoing actions and future opportunities

The risk of marginalization is highly related to the ability to connect digitally. The European Commission strives to ensure that all EU citizens can contribute and benefit from the digital economy and society. The Learning, Multilingualism and Accessibility Unit of the European Commission provides financial support to projects that develop advanced digital solutions to address the needs of people with disabilities.

Marco MARSELLA, European Commission, Directorate General for Communications Networks, Content & Technology (DG CONNECT)

Marco Marsella is Head of the Learning, Multilingualism and Accessibility Unit (G3) at CONNECT Directorate-General. The Unit contributes to policy development, innovation and research implementation in the areas of Digital Inclusion, Digital Learning, Multilingualism and Better Internet for Kids. Previously, Marco worked on the Unit's Safer Internet and eContent projects. He has also served as project and policy officer in the Cultural Heritage & Technology Enhanced Learning Unit.

Introduction

The DG CONNECT Unit "Learning, Multilingualism and Accessibility" is based in Luxemburg and works in four important areas:

Education and Learning

The Unit promotes inclusive 24/7 digital learning for all. It enables Europe's youth, workers and citizens with relevant knowledge and skills to work and live in the 21st century. This includes looking at approaches and digital tools to improve learning and modernize education. Moreover, the Learning, Multilingualism and Accessibility Unit promotes cutting edge research on tools for adults and children with disabilities.

Better Internet for Kids

The Unit supports efforts to empower children through technology and ensure they have access to positive experiences and content online, in a trusted and secure environment. The Unit also strives to better understand the risks involved. Avoiding exposure to harmful online content and behavior is central to this and the Unit supports Safer Internet Centers across the European member states.

Accessibility

The Unit drives efforts to provide all citizens, particularly those with disabilities or at risk of exclusion, with the digital skills and tools needed to access the internet as part of their daily lives. The Unit is responsible for following up the implementation of the Web Accessibility Directive.

Multilingualism

The Unit supports research and innovation actions in language technologies - as well as deployment actions under the Connecting Europe Facility program - to overcome language barriers in the online market, contributing to the emergence of the multilingual and inclusive Digital Single Market, enabling every European to access quality information anywhere in Europe regardless of their mother tongue.

The Web Accessibility Directive and Research and innovation technologies for people with disabilities

The Unit uses two major instruments to carry out its missions on Inclusion:

- A policy legislation initiative;
- Financial support for research and innovation projects to improve social inclusion. These projects cover four main areas: Accessible Web, Social Inclusion, Assistive Technology and Skills.

Accessible Web

The European Web Accessibility Directive provides the first EU-wide rules for making public sector websites and mobile apps more accessible. The Directive was adopted by both the Council and the European Parliament and was published by the end of 2016.

The Directive - based on the accessibility standards established in the European Standard EN 301549 - requires Member States to implement the provisions for making public sector websites and mobile apps accessible, and to monitor and report on their accessibility on a regular basis. By harmonizing the accessibility requirements for public sector bodies' websites and mobile apps in Member States, the Directive aims to eliminate barriers hampering competition in the web accessibility market.

Assistive Technologies

The Unit supports leading edge research on effective solutions designed to improve the quality of life for people with disabilities. Recent projects include:

- The TOBI project developing brain-computer interaction (BCI) technology for people with motor impairments[30].
- The Able-to-Include project looking at ways to improve the integration of people with intellectual disabilities[31].
- The Back Home project developing new brain-neural computer interfaces (BNCI) for independent home use by people with motor impairments[32].
- The Cloud4All project developing a new paradigm in accessibility, which replaces specific, adapted solutions with the automatic personalization of mainstream products or services through cloud technologies[33].
- The Blindpad project developing a personal assistive device for blind and visually impaired people[34].
- The COCOHA (Cognitive Control of a Hearing device) project using brain signals (EEG) to help steer acoustic scene analysis hardware for deaf people[35].

Stakeholders

The Unit works with different stakeholders, from research groups to disability groups, from carers to developers and industry players.

Next call for projects

As part of H2020 ICT-23-2017 Interfaces for accessibility, the Commission opened a new call for projects in December 2016[36]. The Commission is looking for projects that propose intelligent, affordable and personalized interfaces for people with cognitive disabilities.

There is a budget of 10 M€ for Research & Innovation projects to develop and test:

- Intelligent, affordable and personalized interfaces for people with cognitive disabilities that will be able to detect users' behaviors and recognize patterns, emotions and intentions in real life environments;
- Solutions, models and algorithms to improve (and act upon) information extraction from brain and neural signals, including through advances on state of the art electrodes and implantable devices.

The expected results of next funded projects should contribute to:

- Provide more effective solutions, designed with people with disabilities and their carers, to mediate communication experiences or for more natural interactions with their environment;
- Enhance cognitive accessibility;
- Improve the capacity to decode and use brain signals in order to help to accelerate the development of solutions for people with communication disorders.

In addition, to support the Web Accessibility Directive, the Unit will be looking for support tools to help public sector bodies to assess compliance to Web accessibility standards and guidelines. An additional budget of 2M€ will be allocated to funding such Innovation Actions to develop and demonstrate decision support tools.

The European Parliament also approved a 600 K€ budget for a Pilot Project aiming to have settings incorporated in authoring tools or platforms that meet the accessibility requirements of European Standard EN 301549.

30. http://www.tobi-project.org
31. http://able-to-include.com
32. http://www.backhome-fp7.eu
33. http://gpii.net/cloud4all
34. https://www.blindpad.eu
35. https://cocoha.org
36. 36 http://ec.europa.eu/research/participants/portal/desktop/en/opportunities/h2020/topics/ict-23-2017.html

Learning Points

- The Unit provides financial support for digital projects that use technology, including IoT technologies, to improve the lives of persons with disabilities.
- Many of the projects funded by the Unit contribute not only to improving the lives of EU citizens, but to the development of a global public inclusion infrastructure.
- The Unit was active in pushing through the Web Accessibility Directive which came into effect at the end of 2016.
- Regular calls for projects are made to identify innovative yet affordable inclusive solutions that are eligible for EU funding.

Conclusion

Each successive expansion of connectivity brings new opportunities and challenges that must be addressed by the e-Accessibility community. As this white paper demonstrates, the IoT has the potential to bring with it new services that adapt and respond to users' specific needs. Out of the box accessible IoT solutions are already being used to leverage inclusion for persons with disabilities and the elderly and are enabling businesses to gain new customers previously deemed too difficult to reach or too complex to service.

This global connected infrastructure is poised for massive growth in the next decade and IoT technologies are evolving at a tremendous speed. While it is still very much in its infancy, the IoT is rapidly taking root across industry and the public services sector.

To seize the benefits and ensure that personalized services do not lead to further discrimination for persons with disabilities, it is essential to address the challenges raised in this white paper as a matter of urgency. E-Accessibility stakeholders need to work together with industry and standardization bodies to build on their shared experience shaping an accessible connected world.

But expertise and resources must be pooled to ensure that concerns around data protection, interoperability and user experience are resolved swiftly and that the Internet of Things becomes an acceptable vehicle for both connectivity and inclusion.

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