Internet of Things (IoT) and Human Computer Interaction
Olja Rastic-Dulborough
School of Electronics and Computer Science
University of Southampton
Southampton, United Kingdom
ord1c08@ecs.soton.ac.uk

ABSTRACT
This paper outlines the current state of the Internet of Things from the human-computer interaction point of view.

Categories and Subject Descriptors
C.2.1 Network Architecture and Design, Network communications

General Terms
Design, Experimentation, Human Factors

Keywords
Internet of Things, Human-Computer Interaction

1. INTRODUCTION
Internet of things can be introduced as the concept where objects in our environment, through some new properties, become smart and begin autonomously communicating with each other and humans, through networks supported by interfaces. Opportunities for meaningful benefits to humans and the environment are many and varied so only a small subset of examples can be mentioned here. Specifically, the focus of this paper is to present the recent efforts and developments in the areas of interactive systems, with new affordances of the Internet of things and related technologies; emergence of and need for new and innovative ways in which human-computer interaction can support these. In section two some background is given, section three looks at different approaches researchers are taking to interaction for the internet of things. Section four reviews the research, conclusions made in section five.

2. BACKGROUND AND RELATED WORK
15 years since Internet of Things as a term was first mentioned, the field is entering a new phase of rapid expansion in all areas of business, industry, domestic and personal devices. Building on a networked device’s ability to be uniquely identifiable, which can communicate and interact with other devices, objects and humans [8]; the combination of research and development efforts both in academia and industry has opened up new avenues of exploration for how the ubiquitous connectivity can enhance our every-day lives. Because of the organic growth and development by different stakeholders, multiple standards are in existence. Although there are efforts to standardise protocols, guidelines and processes; it is recognised that doing this too early would restrict the development along many lines of investigation. Instead, it is interesting to take stock of the concerns and the state of things as Xie, Kumar, Chen at all [12] have done. Going back to the early days when ubiquitous computing was first being defined, the table in Fig 1 neatly summarises the realization of the ‘father of ubiquitous computing’ Mark Weiser about the future of computing, in the paper co-authored with Brown; “The coming age of calm technology” [11]

<table>
<thead>
<tr>
<th>The Major Trends in Computing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mainframe</td>
</tr>
<tr>
<td>Personal Computer</td>
</tr>
<tr>
<td>Internet - Widespread</td>
</tr>
<tr>
<td>Distributed Computing</td>
</tr>
<tr>
<td>Ubiquitous Computing</td>
</tr>
</tbody>
</table>

Figure 1 1996 view on trends in computing [11]

Some 20 years later, the reality is somewhat more complex, and we’re still grasping at the edges of ‘calming’ the technology that surrounds us. Looking at the prognosis for the next decade and beyond, Figure 2 illustrates that we are in the early stages of seamlessly integrating computing into our lives.

3. INTERACTION RESEARCH FOR IoT
Apart from architecture, physical device, security and protocol concerns, amongst others, there are many human-centred issues being addressed. One looks at how best to present the data collected from the real world and make it meaningful to humans. We look at several approaches to solving the interaction complexities in the Internet of Things.

3.1 Embedded interaction
Embedded interaction is a concept where ordinary objects are enhanced with input and output facilities so that they perform their original function as well as providing a way for data to be collected about the user behaviour. Combining data from several objects and interaction with them over time can result in emergent knowledge available to the user or the context aware environment to make suggestions for lifestyle improvements.

A study carried out by Kranz, Holleis and Schmidt [6] concentrated on designing prototypes for novel ways humans can use everyday objects incorporating embedded interaction and technologies which take advantage of the Internet of things affordances. They coin the term ‘netgets’ to describe objects or artefacts as specialized networked gadgets with sensors and actuators which can be embedded into anything. Netgets let users seamlessly manipulate digital information and data in the context of real world usage. Examples range from context aware kitchen utensils, interactive fabrics to using small embedded objects. Along the way, guidelines, frameworks and a toolkit are produced and recommended for future development of similar devices.
3.1.1 Smart interactive kitchen

One example from the study [6] is that of a chopping knife which has sensors not only to detect the type of food being cut but can also be used on the movement aware chopping board as a mouse / pad combination to control a computer.

There is already an implementation of a similar idea on the market – a digital fork called HapiFork[1]. It records the length of the meal,
counts fork servings per minute and intervals between fork servings. The premise is that by being aware of the speed of the meal, the user can control it, slow it down and in the process lose weight. The data from the device is uploaded to the user’s online dashboard via USB or Bluetooth and the information presented to the user is also available on the mobile devices. Meal statistics are displayed and recommendations or cautions provided based on real time data.

While both the research and the marketed product have interesting implications for the future of interaction, there is still the question of how ready the users are to engage with and invest in these products. From the viewpoint of learning about our own behaviour, it might be wise to introduce individual solutions to our home environments, one by one, as they become available, as to be exposed to the fully integrated smart home in one move might be intimidating and have the feel of the “big brother” watching.

3.1.2 Wearable touch input clothing

The same team Kranz, Holleis and Schmidt [6] created the Embedded Interaction Toolkit which enables them to quickly use and connect smart objects and has flexibility for changing the protocols for each individual type of object, as well as how the messages travel between the objects and platform. With the help of EiToolkit they were able to prototype and test touch input on clothing.

The idea of interactive clothing through sensors and displays is slowly increasing in use through the maker movement and moving into mainstream.

3.1.3 Small embedded objects

Another of the case studies conducted by Kranz, Holleis and Schmidt [6] is one using the small embedded objects in the physical world. Their prototype to establish room availability by using a small magnet placed appropriately on the board outside of the door of a room, which is detected by a hall sensor provides information about room occupancy in a very simple manner.

3.2 Physical mobile interaction (PMI) and multi tag interaction MTI

Broll, Rukzio, Paolucci et al [1] collaborated on creating a system for mobile ticketing, for cinema and transportation, which users interact with on their mobile devices and smart posters (PMI) with different types of tags provided for each option and step through processes (MTI). The three types of tags used were numeric identifiers, Near Field Communication (NFC) tags and visual markers. Users get the information from the tags and use it to reach desired services. The study focused on evaluating user’s reactions and experience using the step through process of interacting with multiple tags to reach a desired goal. The main barrier to users was the non-familiarity with the system of tags and interacting with smart posters in this new way.

Most posters and leaflets these days have QR (Quick Response) codes and the action of scanning them with the appropriate application on a smartphone usually takes users to a website which they can interact with on the smartphone’s browser.

Embedding more complex interaction into posters seems unexplored and underutilised for such a cheap and widely applicable method of distribution.

An example of note in this category is the Poken idea, it started off as a USB stick with inbuilt NFC (Near Field Communication) technology on which the users’ social media accounts are stored, ready for quick exchanging with other Poken users. Through the online interface, the account could be updated and interactions with other users are tracked in a timeline. The service is now updated for mobile application use and various crowd management plans are on offer to organisers, including smart posters, Poken dongles etc.
be sent details of the app in advance and on the day, they could easily be guided through the conference proceedings, their interactions with smart posters and other attendees recorded; with analysis tools available to the organisers and contact details and presentations available to attendees, after the event.

3.3 Augmented reality approach
Gimenez and Pous [4] offer a view on issues in interaction by humans in complex smart environments, and look for most effective ways of connecting those environments and people. They put forward an argument that augmented reality offers best solutions in such cases, especially where geographically relevant information is available and can be useful to the user and conclude that the move away from Graphical User Interfaces to Tangible User Interfaces will improve Human-Computer Interaction. Augmented Reality is key in providing a technology supported layer to the existing physical environment.

Space Top [7] is an interesting example of an augmented reality device created to enable interaction with existing objects and concepts but in a new way which can easily lend itself to future use for the Internet of things projects.

![Figure 7 Space Top spatial operating environment](image)

The user is able to interact with virtual objects such as files and windows, which appear through the 3D spatial operating environment Figure 7 above.

A current offering available to smartphone users, the app Layar connects images, links and videos in the digital world to the real objects in the physical world by displaying hidden content when looked at through the screen of the mobile phone, with the help of the Layar app. Their main area of business is to develop products like AR widgets for websites or solutions for printed materials, enriching them with digital media. The app just enables consumers to access the resulting products.

This is a popular area for research with a lot of the solutions being explored to enhance what we see and know about the real world.

3.4 Virtual Reality approach
Immersing the user more into digital world, Han, Yun, Jang and Park [5] present a visually accurate 3D Virtual Reality representation of the real world space in which the real devices and the environment can be controlled remotely via a mobile application and the web. They introduce a metaverse server and client that communicate with the home server; the devices self-report their status which then updates the animation in the virtual world with which the user interacts.

This is a visualisation of the state of things in an environment and although the user can control things through an avatar moving through the virtual world, I imagine this would become tiresome after the first few times and when the novelty of having to play a game to switch the lights on or close the curtains. An option to be able to switch back to a non-gamified interface would be desirable.

A study where a similar idea of a virtual environment is used, albeit as video taken of a real environment rather than a constructed graphical representation, is the MIT Media Lab study [9] of how contextual referencing of language and speech development in relation to location and social interaction within one family was analysed through data collected over time. The concept was tested further in different environments, and extended in the TV Genome tool for use on sentiment analysis of tweets [10] with a common topic, for example, during a TV programme where spectators would share their thoughts about something a lot of other people were watching.

![Figure 8 TV Genome platform for analysing event tweets](image)

The difference here is that a new way of connecting people with things or even virtual things is emerging and creating the tools allows them to interact in a way they weren’t able to and the researchers to offer insights (or advertising) based on their analyses.

4. INTERACTION AND IoT – A REVIEW
Some of the studies and working examples presented in section three touch in specific ways on how different stakeholders in the Internet of things domain are exploring possibilities and concepts to take advantage of the new emerging affordances made possible by ubiquitous connectivity, improved processing and storage capacities as well as new display technologies, sensor device availability and decreasing hardware costs.

Primary goals include creating a link between the physical and digital worlds, embedding interaction behaviours into existing objects, providing meaning from large amounts of data gathered and eventually enabling us to learn about ourselves, others and our surroundings.

Purely from interaction design perspective, away from technical and academic research, the Internet of things is causing excitement. In their short documentary Connecting [2] the design agency Bassett & Partners showcase thoughts from the industry leaders on...
the future of Interaction Design and User Experience for the Internet of things. The affordances of the internet of things give us an opportunity to become creators instead of consumers of data and information. The by-product of intensive connectivity is a super organism where humans are not at the top of the food chain.

We can move through our physical world and see traces and footprints of our friends who walked along the same street at a different time, from the data available about the location, only the relevant information is made available to us through intelligent analysis and selective filtering.

Looking at the Hype cycle of emerging technologies – Figure 9 – we are well on the way there.

5. CONCLUSION

Internet of things is an exciting area for research, particularly when it comes to human computer interaction because the number of use cases as well as the devices and systems which the user has to interact with is constantly growing. Affordances created by the Internet of things technologies offer a glimpse into the future where the existing, familiar interactions of the past are still possible but are superseded by the smart capabilities of the same objects which have new properties and affordances. How comfortable we might be with a smart knife and a sensing chopping board remains to be seen but this might not be important. More relevant are the other findings, recommendations and discoveries made by the researchers which can then be applied in any other fields or areas, within or outside of the realm of the Internet of Things.

6. REFERENCES


