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Using the Technology Enhanced Interaction Framework for Interaction Scenarios involving Disabled People

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***Abstract*—This paper focuses on the development of a general interaction framework to help design technology to support communication between people and improve interactions between people, technology and objects, particularly in complex situations when disabled people are involved. The main and sub-components of the framework are described. A tool was developed to provide advice on design and development factors for technological support. Work is now in progress to validate the framework and the tool with expert designers and accessibility experts before evaluating it with technology designers.**

***Index Terms*—Mobile Web, Interaction Framework, Disability, Design**

I. Introduction

As information and communication technology has become more important in society, many researchers have been concerned with how to use technology to support communication between people and improve interactions between people, technology and objects [1, 2, 3, 4, 5, 6, 7]. There has, however, been no framework that has helped technology designers and developers to consider all of the possible interactions that occur at the same time and in the same place although there have been projects concerned with how to use technology to support some of these interactions. For example, artefact-mediated-communication has been used to support cooperative work [8, 2, 3, 7], a mobile digital guidebook has been used to enhance visitors' interaction with physical objects in museums [9, 6] and mobile devices have been used as mediators for the interaction with a physical object using QR codes, RFID tags and NFC tags [10, 5]. Many publications and projects in human computer interaction (HCI) focus on using technologies as a tool to enhance experiences: in the same place but at a different time (e.g. using systems for supporting group learning such as notice boards, questions and answers, electronic debates and collaborative learning [11]); in a different place but at the same time (e.g. using a Synchronous Communication Tool such as video conferencing, instant messaging and online chats to interact with learners to improve their communication with the instructor [12]); and in a different place at a different time (e.g. using blended learning, students can access e-learning in order to learn in a different place at a different time [13]). This paper focuses on the development of a general interaction framework adapted from and extending the work of Dix [14] and Gaines [15] to help design technology to support communication between people and improve interactions between people, technology and objects, particularly in complex situations involving disabled people. The paper is structured as follows: Section II reviews Interaction Frameworks, Section III explains the Technology Enhanced Interaction Framework and Section IV describes a tool to help design technologies in complex situations, particularly, face to face when disabled people are involved.

II. Review of Interaction Frameworks

A review of interaction frameworks showed that many frameworks focus on people to people communication in the same time and at the same place but not using technology to enhance communication. Some frameworks address many interactions between humans and computers [3, 6]. Dix's framework for Computer Supported Cooperative Work [14] seems to address some of the possible interactions but it misses out some important interactions in the same time and at the same place situations such as people using technology to interact with real objects. In Dix's framework, the participants communicate with other participants in what is called 'direct communication'. Furthermore, the participants also interact with artefacts (man-made technology tools) by "controlling" or "acting". Sometimes an artefact is shared between the participants; in this case, the artefact is not only the subject of communication but can become a medium of communication, called 'feedthrough'. In communication about work and the artefacts of work, various means are used to refer to particular artefacts, and Dix terms this 'deixis', as shown in Fig 1. However, no current framework addresses all of the interactions covered by the Technology Enhanced Interaction Framework explained in the next section.

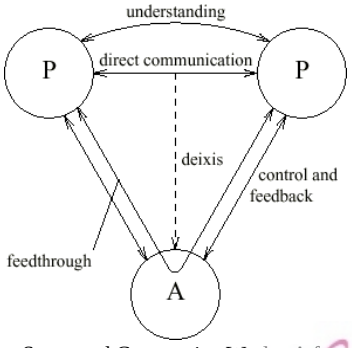

Fig. 1 Computer Supported Cooperative Work - A framework [14]

III. THE TECHNOLOGY ENHANCED INTERACTION FRAMEWORK

The Technology Enhanced Interaction Framework supports the design of technology enhanced interactions by developers and designers.

A. *Terminology*

1) Communication is the process of passing information from one person to another [16].
2) Technology is a tool that helps people achieve their purpose.
3) 'People' means anyone involved in direct communication or interaction with an object, technology, or other people.
4) 'Object' is anything that is not a technology or a person involved in communication or interaction.
5) Interactions can be between people and objects (P-O) or people and technology (P-T). People can also use technology to mediate interaction with people (P-T-P) or objects (P-T-O).

B. *Main Components*

There are seven main components in the Technology Enhanced Interaction Framework. People can have roles, abilities, and disabilities. The components 'Object' and 'Technology' are used in order to extend Dix's framework to show any type of interaction. Objects are defined as having three sub-components: dimensions, properties, and content. Technology has a cost and can be electronic or non-electronic, online or off-line, and mobile or non-mobile. Furthermore, it may or may not have stored content and may additionally have an interface and be an application or provide a service. Interactions and communication are classified into three groups:

1) Direct Communication:
   a) People to People (P-P) - People in one way or two way communication with other people.
2) Direct Interaction:
   a) People to Technology (P-T) – People can control technology and may also be able to use it to store or retrieve information.
   b) People to Objects (P-O) - People can control objects and retrieve information from objects.
3) Technology Mediated Interaction:
   a) People to Technology to People (P-T-P) - Technology can mediate communication between people.
   b) People to Technology to Objects (P-T-O) - People can control objects with Technology and may also be enabled to use objects to store and retrieve information.

Time and Place can be divided into four categories [17]: same time and same place, different time but same place, same time but different place, and different place and different time.

Context can include factors and constraints such as location, signal quality, background noise, and weather conditions.

Interactions and communication may be classified into six interaction layers, adapted from Gaines [15] as follows:

1) Cultural layer includes countries, tradition, language, and gesture.
2) Intentionality layer involves understanding, purpose and benefit.
3) Knowledge layer involves facts, concepts, and principles [18].
4) Action layer involves actions and procedures [18].
5) Expression layer describes how actions are carried out (e.g. correctly or with errors).
6) Physical layer is the lowest layer at which people interact with the physical world.

For example, pressing of the letter 'h' on the keyboard when typing 'hello' as a greeting when sending a text message can be thought of as:

1) Cultural layer: 'hello' is a normal greeting used in the culture.
2) Intentionality layer; the intent is a greeting.
3) Knowledge layer; how to spell the word "hello".
4) Action layer; pressing key 'h'.
5) Expression layer; pressing the correct key and not hitting neighbouring keys.
6) Physical layer; the button is depressed and so sends the electronic code for the letter to the application.

C. *Architecture of the Technology Enhanced Interaction*

The overall architecture of the Technology Enhanced Interaction Framework involves people, technology and objects (Fig. 2). The general framework covers the use of any technology, which may or may not be electronic; the main difference is that electronic technology can store information. The Technology Enhanced Interaction Framework extends Dix's framework [14] for computer supported cooperative work to include interaction with objects.

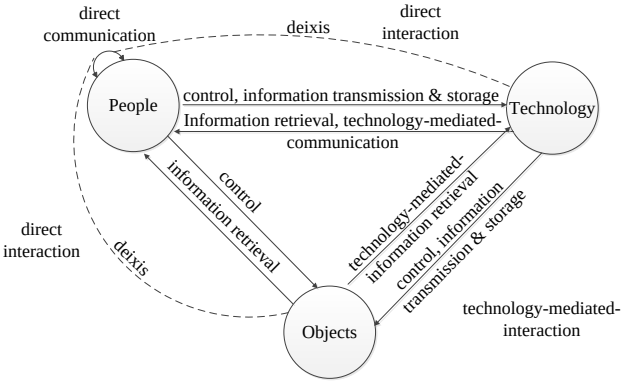

Fig. 2 Technology Enhanced Interaction Framework extended from Dix [14]

IV. SCENARIO, QUESTIONS AND ANSWERS

In order to explain how the framework is instantiated in a tool, the following example scenario is provided which shows problems faced by the visitors, the museum's owner and suggests requirements for a technology solution.

A. *Scenario*

Suchat Trapsin allocated some parts of his house to become the Museum of Folk Art and Shadow Puppets, in

Thailand. There are exhibits of shadow puppets inside the museum, but there is no information provided in text format. This is because Suchat normally explains the history and tradition in Thai by talking to visitors. He presents the same information in the same order every time.

On Friday afternoon, Chuty (who has been hearing impaired since birth) and her parents (who have some hearing loss due to their age), who are local people, visit the museum. Suchat starts the talk by explaining about the exhibits. During the talk, Chuty and her parents find that it is very difficult to hear Suchat clearly. Chuty asks Suchat some questions about the exhibits. Suchat answers the questions, but Chuty misses some of the words. While Chuty and her parents are watching the shadow puppet show, they also cannot hear the conversation clearly because of the background music which is part of the show. It is also fairly dark which makes lip-reading very difficult for them. Suchat would like to have a technology solution that makes it easier for Chuty and her parents to understand him. There is good Wi-Fi at the museum so he would like to use Chuty's and her parents' smartphones to keep his costs low.

B. Framework Tool Questions, Answers, and Explanations

The Framework tool asks 22 multiple choice questions to aid elicitation of requirements and seven examples of the questions, answers and explanations are provided in this section. (☐ means more than one answer can be chosen and ○means only one answer can be chosen)

1. What role do people have in the scenario?
   - ☐ a. presenter - audience (the presenter gives information to the 'audience' which could be only one person or many people and so controls the interaction. The audience can ask the presenter questions)
   - ☐ b. peer - peer (any person can give information or ask questions to any other person and therefore no one person controls interaction)
   - ☐ c.no communication between people only interaction with technology or objects

   The answer is a. presenter - audience

   Explanation: the 'presenter' (Suchat) talks to the 'audience' (Chuty and her parents) and the audience ask the presenter questions.

1. Where and when does the scenario take place?
   - ○ a. same time / same place
   - ○ b. same time / different place
   - ○ c. different time / same place
   - ○ d. different time / different place

   The answer is a. same time / same place

   Explanation: Suchat, Chuty, and her parents are in the same place (The Museum of Folk Art and Shadow Puppets, Thailand) and at the same time (Friday afternoon).

2. What interaction types occur in the scenario?
   - ☐ a. people to people
   - ☐ b. people to objects
   - ☐ c. people to technology
   - ☐ d. people to technology to people
   - ☐ e. people to technology to objects

   The answers are a. people - people and b. people – objects.

   Explanation: Suchat communicates with Chuty and her parents (people - people), and Chuty and her parents watch the shadow puppet show (people - objects).

3. Does the audience have a disability?
   - ○ a. Yes
   - ○ b. No

   The answer is a. Yes

   Explanation: Chuty and her parents have hearing impairments.

4. What kind of disability does the audience have?
   - ☐ a. hearing impaired
   - ☐ b. visually impaired
   - ☐ c. physically impaired

   The answer is a. hearing impaired

   Explanation: Chuty has had hearing impairment at birth and her parents have hearing loss due to their age.

5. What level of hearing loss does the audience have?
   - ○ a. mild or moderate hearing loss
   - ○ b. severe or profound hearing loss
   - ○ c. I don't know

   The answer is c. I don't know

   Explanation: There is no detailed information about the level of hearing loss of audience member in the scenario.

6. What type of technology would be appropriate for the solution to the scenario?
   - ○ a. online technology
   - ○ b. off-line technology
   - ○ c. I don't know

   The answer is a. online

   Explanation: there is good Wi-Fi at the museum and Suchat would like to use Chuty's and her parents' smartphones.

7. Where does the situation take place?
   - ○ a. indoors
   - ○ b. outdoors
   - ○ c. I don't know

   The answer is a. indoors

   Explanation: the situation takes place inside the museum (the Museum of Folk Art and Shadow Puppets).

8. Does the customer have a limitation of cost in designing technology?
   - ○ a. yes
   - ○ b. no

   The answer is a. Yes

   Explanation: Suchat would like to use Chuty's and her parents' smartphones to keep his costs low.

V. TECHNOLOGY SUGGESTIONS AND SOLUTION

Technology suggestions and explanations are provided by the tool and 4 of these suggestions, with indications of how they meet the requirements, are shown in Table I. The numbers and letters identify the appropriate tool questions and answers for the example scenario and the ticks indicate

which requirements are met by the technology suggestion and the total score is the number of ticked requirements. Based on all the suggestions provided by the tool, a solution to the scenario is shown in figures 3 and 4. The Mobile Web Interactions (Fig. 3) shows the interactions which happened between people (Suchat, Chuty and her parents), technologies (mobile phones, the mobile web, and a server) and objects (a poster and exhibits). The interaction diagram assists developers to understand the interactions which are involved in the scenario. The Use Case Diagram (Fig.4) is designed to help the developers understand the applying of the technology suggestions (TABLE I) to develop technology solutions.

For the scenario, the technology solution can be explained as follows:

Suchat has a role in the communication which is important because he can control technology to send an instant message to Chuty and her parents' phones to make them vibrate to let Chuty and her parents know when the conversation starts. The technology solution selected to enable this is instant messaging which was chosen over SMS. Instant messaging is suggested because it is free of cost using wireless and smartphones [19][20][21]. Moreover, it can also vibrate Chuty's and her parents' smartphones which is better than turning lights in the room on and off to notify them as this may not be noticeable in sunlight.

Captions can be of value to everybody, especially people with no useful hearing, and were selected as the solution of choice [22][23][24][25]. Thai speech recognition is not very accurate for spontaneous speech [26] and therefore as Suchat already knows what he plans to say the best solution is pre-prepared summary captions.

As he presents his talk Suchat controls the changing pre-prepared captions on the mobile website using his smartphone. He has an application on his phone that can send a message to the webserver to display the next caption on the webpage that Chuty and her parents are looking at. This solution was chosen over using a pre-prepared captioned video as that would not have supported live face to face communication and interaction between Suchat and his visitors.

Chuty and her parents ask spontaneous questions about some of the exhibits in the museum. Suchat will not have been able to pre-prepare the order of the captions. In this case, Suchat can introduce machine readable QR codes. QR codes were selected rather than other possible approaches (e.g. barcodes, RFID tags, image recognition, typing a code number) because they are simple, cheap, quick and work with smartphones using free software to provide a link to information on a mobile website [27].

TABLE I Examples of Technology Suggestions

Technology suggestions	**Explanation**	**Which requirements the technology meets**																		
		1a.improve communication	2a.same time/ same place	3a.presenter-audience	4b. 1presenter-many	8b. presenter speaks Thai	10a. hearing impaired	12b. Audience speak Thai	13a. people – people	13b. people - objects	14a.Online technology	15a.Mobile devices	16a.Pre-prepared speech	17c. no audio or video	18a. indoor	20a. noise	20e.inadequate lighting	21a. low cost technology	22a. work with smart	Total score
Mobile web site	A Mobile Web refers to access to the world wide web, i.e. the use of browser-based Internet services, from a handheld mobile device, such as a smartphone, a feature phone or a tablet computer, connected to a mobile network or other wireless network. For more information about basic guidelines of mobile web practice see: http://www.w3.org/TR/mobile-bp/	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	18
Pre-prepared caption/ subtitle	Captions are text versions of the spoken word. Captions allow the content of web audio and video to be accessible to those who do not have access to audio. Though captioning is primarily intended for those who cannot hear the audio, it has also been found to help those that can hear audio content and those who may not be fluent in the language in which the audio is presented. More information about captions see: http://webaim.org/techniques/captions/	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓		✓	✓	16
Instant messaging	This is a simple, easy and convenient way of connecting through your pc or wireless device by sending text messages. For more information about IM see: http://en.wikipedia.org/wiki/Instant_messaging	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓		✓	✓	16
Quick Response Code (QR-code)	QR codes are commonly used to identify objects or link data to the website. There is no requirement for a special scanner to scan QR-Codes; instead users can use smart phones to access information by installing appropriates software on their mobile phone. User's can access a website by using the URL represented by the QR codes and can save their information to the library easily. QR-codes are able to encode large amounts of information. For more information about QR codes see: http://www.whatisaqrcode.co.uk/	✓	✓	✓	✓		✓			✓		✓	✓	✓	✓	✓		✓	✓	13

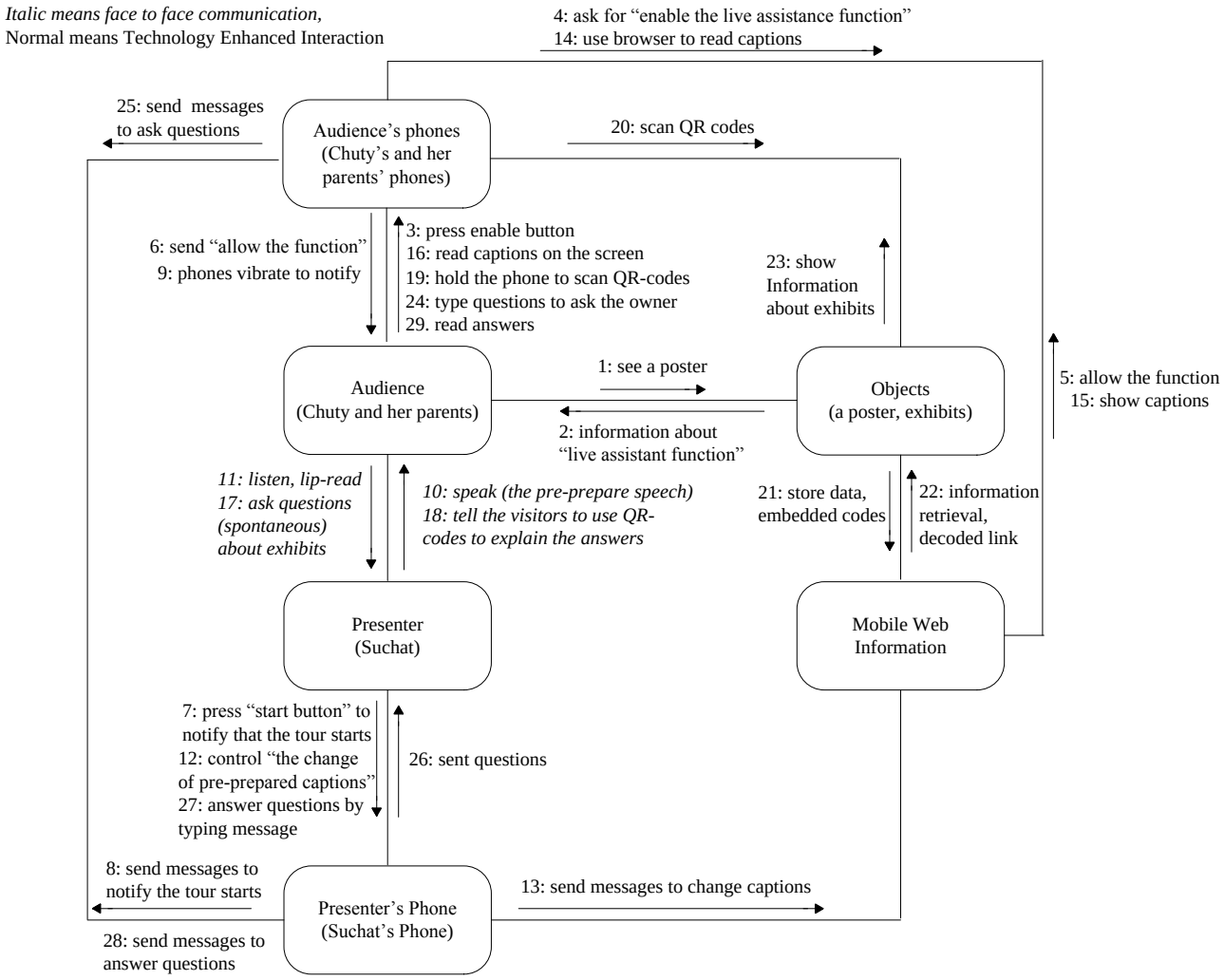

Fig. 3 Mobile Web Interactions Diagram

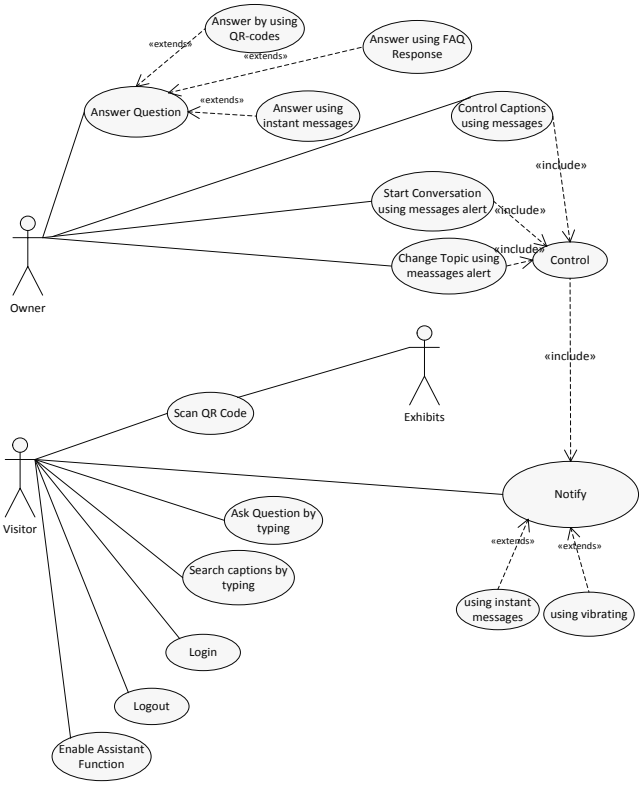

Fig. 4 Use Case Diagram

I. Conclusion

The scenario and technology solution described in this paper demonstrates how the Technology Enhanced Interaction Framework and its associated tool addresses the issue that, until now, there has been no framework to support technology designers and developers in considering all of the interactions that might occur in complex communication and interaction problems and situations. Work is now in progress to validate the tool that helps apply the framework to create technology solutions for situations occurring at the same time and in the same place involving disabled people.

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