Service History: The Challenge of the 'Back button' in Mobile Context-aware Systems

Annika Hinze[1] **Knut Müller**[1,2] **George Buchanan**[3]

[1] University of Waikato, Hamilton, New Zealand
Email: hinze@cs.waikato.ac.nz

[2] Humboldt University Berlin, Germany
Email: knut.mueller@informatik.hu-berlin.de

[3] City University London, United Kingdom
Email: george.buchanan1@city.co.uk

Introduction This paper discusses the challenge of providing effective interaction for navigating a user's browsing history in context-aware mobile services. Mobile systems are often composed of a number of services, and navigation must be understood both in terms of a single service and of movement between different services over time. The semantics of simple navigational steps such as "back" and "forward" becomes much more complex than on traditional interfaces, and there is also a need to understand the difference between navigation based on the user's actual physical context (i.e. their real location) and exploratory navigation at a different virtual site. The challenges of composition and geography both need to be effectively addressed to build a complete and usable history of a user's interaction with the system.

Interaction between collaborative services There are two established methods for keeping track of a user's activity history. (1) For most desktop software, the history is understood to be the sequence of system states that occurred in their interaction. (2) Web browsers include tabs and other props, but keep to the tradition of each document view (tab, or window) maintaining an independent history. We found that familiar expectations may be misleading when mobile systems use collaborative context-aware services.(Hinze et al. 2011) We have shown that the tab-based solution of independent histories, commonly found on web browsers, is inadequate in a service context. This is because changes between services are ignored and no overall history would exist. The history solution (undo/redo) of a stand-alone, discrete software is also not sufficient as the existence of different services is ignored and one single history does not allow distinction between services and user context. Similar to the motivation for the iPod wheel access, we believe that no history entry should ever be deleted: users need to feel certain that they can bring up a previously seen page.

We aim to design a history and back-button behaviour that allows access to all previously seen pages. We need to distinguish how a user accessed the page (e.g., direct physical visit to a sight vs. only browsing to it). User context, such as movements in the real world and their location need to be considered.

Contextual Histories Histories depending on a given context have been previously suggested (e.g., in an electronic whiteboard(Igarashi et al. 2000), Greenberg's browser history(Kaasten & Greenberg 2001) and the history tree plug-in). The electronic whiteboard is the only system that records all user interaction. However, it does not need explicit interactions to change context/focus as all information is available at one glance. Browser-based approaches have to deal with overlap in tabs and windows – explicit change of focus is necessary but not recorded in any of the histories. The back/undo buttons refer to the current context of the tab or whiteboard section. The whiteboard also supports an overall undo/redo. The history tree works within traditional Firefox – back/forward buttons refer to the current tab. The tree refers to each window. The whiteboard is the only solution with a tree that covers all sections. Distinction between location change and browsing does not exist in any of the systems. Context has only two dimensions: time (order) and location (tab/windows or section). Services may be seen as tabs, windows or sections. Additional contexts such as physical location as well as interactions for changing focus (e.g., switching tabs) have to be included.

We require a history that keeps all information (such as the history tree within each window) but gives layered access such as for the whiteboard. The limited size of a mobile screen reduces the useability of navigating large history trees. Strictly separate histories for each service (as in Greenberg's approach) are not sufficient. Information about physical location adds yet another dimension to the overall history.

History design We now identify implications of modes and contexts on the history and navigation elements (back/forward). We propose to keep one history for all interactions of the user and to define **context-based views** onto this history. The concept of views onto complex data is borrowed from data warehouses, whereas principles of drilling down into certain aspects of data (context) are taken from data warehouses. This implies that no elements should be deleted from the history but only rendered invisible for a certain view. Each view may contain one or several contexts for selecting and sorting of the history. We first identify the contexts for user interaction and display and the challenges these create (see Fig. 1). Some information can serve as either items in the history or as context, i.e., view dimension onto the history. The order of page opening is typically used for histories in web browsers. We also want to allow the order of page views to be available. Identity of pages

Data	Type	Detail
Time of access	Item/Context	time or order of page openings/page views
Page identity	Item/Context	IS pages are easily identifiable. RD pages can be identifed by the POI they relate to or by the items on the list. Identity of maps with location markup are more complex.
User model	Context	physical, virtual and interacting user.
Display mode	Context	virtual mode and actual mode.
Physical location	Item/Context	coordinates of the user location, identity of place, coordinates of POI
Virtual location	Item/Context	coordinates of POI visited in hyperspace, identity of place
Service	Item/Context	identity of collaborating services
Additional	Context	user-defined contexts such as business/private travel or time of the day.

Figure 1: History Elements and Contexts

need to be analysed carefully in its meaning for different services. One may also design means to collapse sequences of similar pages (e.g., referring to the same place). Different user models (virtual, physical and interacting) as introduced in (Hinze et al. 2006)) may allow for a more structured history. Modes in the history could distinguish between places that have been visited physically and virtually. The user history may offer a view according to the users physical or virtual location. The history should allow a service-based view (similar to the layered history in the whiteboard).

Ideally, the complexity of the navigation we present here should be dramatically reduced for the user, and also the complete history of their interaction should be recoverable. At its simplest, a linear access should enable retrieval of information the order the user experienced before. Linear structures are insufficient for internal storage of the history; a complex history tree needs to be kept. However, given the screen size, a context-driven linear view (selecting only items pertinent to a given context) may provide a sufficient alternative. Collapsing and expanding information based on context could provide richness without overburdening the user.

History variations can be distinguished based on context dimensions. A *simple temporal history* of page visits does not include duplicate visits. *Page identity* may made explicit (repeated visits to the same page) or treated as separate visits. Different services may be distinguished: one can easily see how local histories for each service may be offered. A distinction by time and physical user location means that all interactions at the same location are aggregated. This mapping needs either a distance threshold or semantic information about POIs. Partial time per location then allows for ordering of page views in each location.

We propose to see the history as a *multi-dimensional hyper-space cube of access data* that can be accessed using aggregation methods known from data warehouses (drill-down and roll-up) and views from databases. Drill-down opens new dimensions, roll-up collapses dimensions. Slice and dice are the equivalent operations to dynamically change the combinations of dimensions that are being viewed. The dimensions and views are determined by the context.

Prototypes We implemented two functional prototype to evaluate our interface and user interaction design for the tourist information system TIP. In the first one, we used a history with temporal order where the services are indicated by the symbols used (two context dimensions), details can be found in (Thunack 2008). A second prototype explored the aggregation of history items (e.g., by location) Other options are aggregations along the context dimensions as discussed before, for example, aggregation of history items in a temporal grouping or by service. We evaluated the ability of users to retrace their trip us-

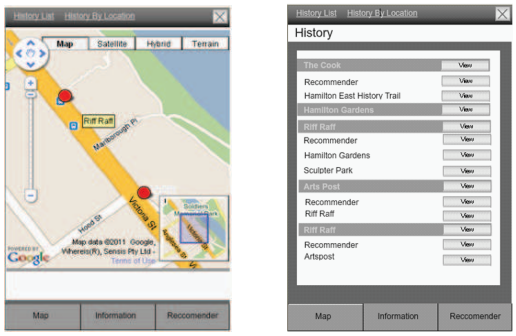

Figure 2: Aggregation on Map (l) and on history (r)

ing the different history designs. Participants were asked to find the point of interest they visited after visiting another point of interest. The overwhelming majority of the participants found it easier to retrace their steps using the new history system. This was because they only needed to follow the heading links to see the locations that were actually visited. In the history list the participants were forced to look through the interactions and remember which ones constituted an actual visit to the point of interest, as opposed to simply viewing information about the place via a recommendation. Detailed information is available in (Campbell 2010).

Conclusion This paper extends the existing research on the navigation of a user's history of interaction in hypertext. We are concerned with software that is built on heterogeneous service collaboration (as opposed to, e.g. the homogenous operation of a web browser), and includes mobility, location-dependency and the use of small screens, in addition to hypertext links. We wish to capture a full history of a user's interactions with the system, so that previously seen information can be recalled in the order encountered by the user. We seek a design that provides a single universal history giving the user different views of (projections onto) the data, with minimal effort. We propose to use techniques known from databases and data warehouses to provide context-aware access to complex history data.Further research is needed on how best to present the history information on a small screen.

References

Campbell, W. (2010), There and back again: Navigating location-sensitive interaction history, Honours thesis, University of Waikato, New Zealand.

Hinze, A., Malik, P. & Malik, R. (2006), Interaction design for a mobile context-aware system using discrete event modelling, *in* 'Australasian Computer Science Conference (ACSC 2006)', Hobart, Australia, pp. 257–266.

Hinze, A., Mueller, K. & Buchanan, G. (2011), Service history in mobile context-aware systems, Working paper, Waikato University.

Igarashi, T., Edwards, W. K. & LaMarca, A. (2000), An architecture for pen-based interaction on electronic whiteboards, *in* 'In Proceedings of the Working Conference on Advanced Visual Interfaces', ACM, pp. 68–75.

Kaasten, S. & Greenberg, S. (2001), Integrating back, history and bookmarks in web browsers, *in* 'CHI '01 Human factors in computing systems', pp. 379–380.

Thunack, C. (2008), Konzeption einer benutzerschnittstelle fuer ein kontextsensitives informationssystem, Master's thesis, FHTW Berlin, Germany.