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# PaperChain: A Collaborative Healthcare System Grounded in Field Study Work

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**Abstract**

In this extended abstract we summarise our recent experiences of designing and deploying PaperChain, a system to support real-time information sharing in healthcare work. A guiding principle has been the development of a deep understanding of the work as the foundation for effective system design. We summarise the field work that motivated the development of PaperChain, some of the key findings and the resulting system. We briefly reflect on the benefits gained from undertaking substantial HCI work in the design of a healthcare system.

**Keywords**

Collaborative work, healthcare systems, digital pen

**ACM Classification Keywords**

H.5.3. [Information interfaces and presentation (e.g. HCI)]: Group and Organization Interfaces – *computer-supported cooperative work*.

**Introduction**

In a world where healthcare work is increasingly complex and collaborative, and where healthcare systems and organizations face significant challenges in managing huge volumes of information, there are interesting opportunities for new technologies to

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facilitate and enhance the effectiveness and safety of the work. Yet in spite of this, studies of healthcare work reveal a continuing reliance on artefacts such as informal paper notes, forms and status boards and there have been several notable failures of Information and Communication Technologies (ICTs) introduced in clinical settings. One reason for this has been a failure to take adequate account of the situated clinical work. In response, there is now a greater appreciation of the important contribution that many disciplines, including human-computer interaction, can make to the design of healthcare ICT systems. This view has underpinned recent work that we have undertaken in the development of PaperChain, a novel system to support one specific form of collaborative healthcare work known as clinical handover. The design of PaperChain was user-centered and participatory; it was motivated and inspired by workplace studies of handover. In this paper, we briefly summarise our studies and the resulting PaperChain system. Our aim is to exemplify the rich insights we gained from a strong focus on the work and the benefit this brought to the design.

## **Background**

Clinical handover is the process by which responsibility for patient care is transferred from one healthcare practitioner or group of practitioners to another and in which relevant information may be shared between the two parties [3]. We have been investigating clinical handover for a number of years and one of our interests has been the potential role of information technology in supporting effective handover.

To understand this role, where technology may be useful and where it may be less so (e.g. see [2]), we have undertaken substantial field studies of handover.

These studies were located within a variety of hospital settings [3] and focused primarily on nursing shift handovers, medical shift handovers, temporary delegations of responsibility and transfers between settings (e.g. from an Accident and Emergency department to an admitting ward). The studies took the form of non-participant observations recorded as field notes, audio recording of verbal communications and informal interviews with staff. We have spent over 700 hours in the field undertaking these studies and have acquired a rich set of data.

Handover has tended to be regarded as a baton-passing activity, in which there is a single point of transfer of responsibility and information. Based on our field studies, we have suggested that it may instead be fruitful to view handover as a process and the attendant information sharing as on-going activity (rather than a single transition) that promotes good clinical situation awareness [3]. This reframing of handover motivated and has grounded the development of PaperChain, a system designed to support the real-time sharing of clinical information for one of our field study sites, a paediatric ambulance transport service in London, UK.

## **Workplace Studies**

The ambulance service transports critically ill children from regional hospitals that do not have intensive care facilities to the paediatric intensive care units (PICUs) of major London hospitals. It also provides advice on the treatment of children either prior to transporting them or instead of doing so, in situations where transport is deemed inappropriate. The service is staffed by doctors and nurses, and the transport or

“retrieval” of each child is a collaborative activity involving multiple healthcare professionals.

We spent 111 hours at the ambulance service as part of our initial field studies (and many more hours since then). We observed the work at the base office, travelled on retrievals, and conducted informal interviews with the staff. The retrieval of a child starts when a regional hospital phones the office of the transport service. At the time of the field studies, details of the case were then recorded on a multi-page paper form by an administrator and a trainee doctor known as a “fellow”. If the decision was made to retrieve the child, a team consisting of the fellow, a nurse and an ambulance driver would be mobilized and would travel to the regional hospital taking the paper form with them to record further clinical details. Senior physicians, who generally remained at the base office, did not have access to the information on the form and had to rely on a telephone handover from the fellow prior to authorizing transport of the child.

Based on the field studies, we set out with the goal of developing a system to support better real-time information sharing between the clinical staff, thereby taking the pressure off “baton-passing” handovers. Specifically, the aim was to improve information sharing between the team who travelled to the regional hospital to stabilise and transfer the child, the senior physicians and others at the base office and the PICU staff. The field studies yielded valuable information about handovers, how they happened, what information was communicated etc, and this informed the design of PaperChain. However, some of the most valuable insights were not about the functionality of the

system but about the nature of the work and the circumstances in which it was conducted. For example:

#### *The fiction of a normal course of events*

Healthcare work is well-known for its contingent and responsive nature. When we spoke to the staff about their work they gave us a high-level, process-oriented description of how the service operated and what happened on a retrieval. This was very valuable but with the field studies it rapidly became apparent that retrievals rarely (or never) conformed to this idealized description. Instead, they varied in myriad ways that we could not have anticipated and which the staff would not have been able to articulate easily. It became clear that our system should not be constrained by a strong, process-oriented view of the work but instead should acknowledge the non-normal courses of events, allowing staff to flexibly capture and view relevant clinical information irrespective of what happened in practice.

#### *Benefit without pain*

The priority for the doctors and nurses on a retrieval is looking after the patient. They are working in high-pressure, sometimes life-critical circumstances. When dealing with a critically ill patient they have no capacity or motivation to use a system that adds to their work or removes their attention from the patient unless there is some immediate benefit to be gained. For us, this was an imperative for truly lightweight data capture and an argument against the perhaps obvious solutions of a PDA or tablet PC-based system. Similarly, staff at the base office are busy and perhaps unlikely to access a display that requires effort on their part. We needed a display paradigm where information was “pushed” not “pulled”.

## PaperChain

PaperChain uses a novel combination of digital pens/paper and shared displays to provide light-weight capture and sharing of information in (almost) real-time. Digital pen and paper is a relatively new technology. Anything written on digital paper with a digital pen is captured electronically and can be immediately transferred to a central server via the mobile phone network.

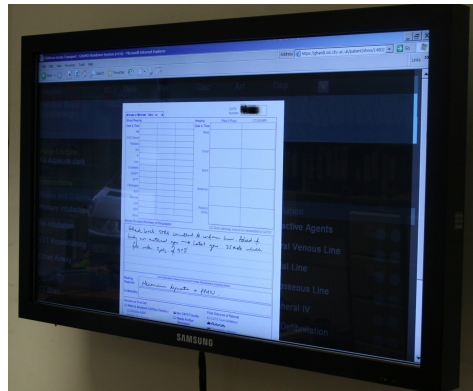


Figure 1: Shared display with one page of the clinical form overlaid on summary information

We replaced the existing paper forms used by the ambulance service with digital pens and paper so that all written information about a retrieval is now automatically captured in electronic form. Hence, with minimal change to the work of the ambulance team, we are able to capture information about a retrieval while it is in progress. This information is then transmitted to base office and the PICU where shared displays make it readily available. A large shared touchscreen display in the base office acts as an “awareness display” [1], providing a continuously updated view of current cases and giving staff access to the digital form (Figure 1).

## Status and Brief Reflection

PaperChain is a robust research prototype. It has now been deployed for several months and is in routine everyday use. We are currently evaluating its impact through post-deployment field studies using multiple evaluation methods. While there have inevitably been some practical problems, our experiences thus far, and the enthusiasm with which the clinical staff have embraced PaperChain, suggest that this combination of technologies has much promise. The strong focus on the work provided by the detailed workplace studies was invaluable and demonstrates (yet again) the benefit of multidisciplinary approaches in healthcare ICT design. The value of the studies was not just what they revealed about the tasks and the information flow, but what they told us about the many ways in which work routinely varied from the norm and which had to be accommodated in a flexible design.

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