

Evaluation of an Integrated Paper and Digital Document Management System

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Abstract. Paper documents are still an integral component of our everyday working lives, and are likely to remain so for the foreseeable future. Fortunately, advances in electronic technology in recent years have made it possible to develop digital systems that better integrate paper and digital document management. However, as far as we are aware, none of these integrated document management systems have been evaluated to demonstrate whether the users would indeed find them valuable for managing paper documents. In this paper we present a user study of one such system, called SOPHYA, that provides a means of linking the management of real world document artefacts (e.g., folders) with their electronic counterparts, so that document management activities such as locating, retrieving, and filing documents can be better supported, especially for large collections. The study is in the form of a laboratory-based evaluation, in which participants with experience in document management used the system to perform several tasks, such as locating and retrieving folders, and provided feedback based on their own experience. The results of this study show that users are able to apply software functionality they use for storage and retrieval of electronic documents to effectively manage paper documents as well. Our study has also identified a range of other potential benefits that the users envisage for such a technology in their diverse work environments.

Keywords: Document management, paper documents, electronic documents, digital documents, tangible interfaces, evaluation.

1 Introduction

Paper documents in their various forms, whether as individual pages or as bound books, etc., are used in our work as well as ordinary daily lives. Paper as a medium of communication has a range of affordances that are not easily provided by its digital alternatives. Amongst these affordances are paper's tangibility, flexible navigation, ease of annotation, the possibility of reading and comparing multiple documents at once, and many others that have been identified by Sellen and Harper [11].

Electronic alternatives to paper documents, on the other hand, clearly have their own advantages, including their ease of storage, organisation, search and retrieval. It

is therefore not surprising that, at present, paper and electronic documents co-exist in most workplaces. As such, the need for this co-existence has been realized by many, and systems have in recent years been developed to allow some form of integration between management of paper and electronic documents.

The development of most of these demonstrative prototype systems has been made possible by the availability of trackable RFID tags, which can even be incorporated into paper itself. Examples of RFID-based document tracking systems can be found in [1, 2, 6, 8, 9].

Passive wireless technologies, such as RFID, while able to detect when a tag is in the proximity of a reader are limited in the accuracy of their location determination. Also, there are limits to the power that can be drawn by the tags, thus limiting the functionality such a system could provide. Alternative systems rely on using semi-passive or active tags that require a battery, or wired technology. An example of such a wired technology is the SOPHYA paper document management system [3, 5, 10].

Despite the development of these paper document management systems over the past decade, to the best of our knowledge, none of them has been tested by users, either in the context of a usability evaluation or in a real-world work environment. This is perhaps due to the fact that almost all of these systems are demonstrative in nature and do not provide a full range of functionality that can be tested in a realistic setting.

The overall aim of our research has been to evaluate whether an electronic paper document management system can be of potential benefit to users who deal with paper documents as part of their work, and to identify whether such users can manage to use such a system with the same level of ease with which they use digital document management systems.

We have chosen the aforementioned SOPHYA system for this evaluation because it provides for a full range of functionality in terms of paper document storage, search and retrieval, that are comparable to those provided by digital document management systems. The type of study that we have conducted is a laboratory-based evaluation, in which participants with a document management background perform tasks using SOPHYA, and provide feedback based on their experience.

In the next section we will provide a brief overview of SOPHYA, and those of its capabilities that form the basis of our user evaluation. The rest of this paper will then describe the user study we have conducted, along with its findings, and their implications for the design of other integrated paper and digital document management systems. We realise that our laboratory-based user study is not as comprehensive as a longitudinal study of the deployment of SOPHYA in a real world office environment. The aim of our study, however, was to evaluate whether users who are experienced in managing paper documents in conventional offices can easily learn to use SOPHYA to effectively perform the kind of tasks they currently perform without the support of technology. We were also interested in getting feedback from experienced office workers that would guide the future development of technology such as SOPHYA, as well as their deployment in real work settings.

2 Overview of the SOPHYA Technology

Although the architecture of SOPHYA has been designed to allow integrated management of physical and digital artefacts in general, its current prototype implementation is specific to the management of paper and digital documents. SOPHYA has a modular architecture [4] consisting of five layers, three of them (hardware, firmware and middleware) are core components of SOPHYA, while the other two (digital document management system server, and the clients) are application specific.

The hardware component of SOPHYA handles the management of individual containers, each of which can hold a collection of documents (e.g. folder, archival box, book, etc.). Containers can in turn be placed in physical storage locations (e.g. filing cabinets, shelves, in-trays, desktop, etc.). Currently there are two different, but fully integrated, implementations of the SOPHYA hardware technology. One of these implementations does not determine the order of the documents placed in physical storage location (referred to as the unordered SOPHYA [3]), while the other provides support for collections that are ordered in a particular manner in each physical storage location (referred to as the ordered SOPHYA [5]).

These two implementations serve complementary purposes. The ordered system is better suited to long-term archival type storage, where there is a need for some natural order in storage of documents (e.g. chronological, alphabetical, etc.). Conversely, the unordered system is able to provide more functionality on the containers (e.g., user interface elements such as LEDs) and supports stacking of folders, making it more suited for everyday use, where documents are moved around and it is much more important to identify their location in temporary storage than to keep some kind of order in their placement.

The containers and physical storage locations are augmented with different electronic components, depending on the type of SOPHYA technology used (e.g. for unordered and ordered see Figure 1). In both implementations, however, each container has a unique ID, and may have optional user interface components such as LEDs. Firmware embedded in the physical storage locations is able to communicate with the containers (e.g. read their IDs and control their user interface components, etc.). This firmware also communicates with the middleware, which in turn is responsible for dealing with data coming from different physical storage locations, and sending the require information to any application specific document management system server using SOPHYA.

These three core layers of SOPHYA are separated, and abstracted away, from the application specific components that can be developed independently to utilise the SOPHYA technology (for details of how this can be done see [4]).

SOPHYA provides a two-way interaction between the physical and digital worlds. From the physical to the digital world, SOPHYA is able to communicate which collection a given document container currently resides in. Conversely, from digital to physical, SOPHYA can, for example, use LEDs on the container or storage location to give visual indication of a container's current location in the physical collections. Figure 2 depicts the levels through which communication passes, from the document management software in the digital world down to the document containers being managed in the physical world, and vice versa.

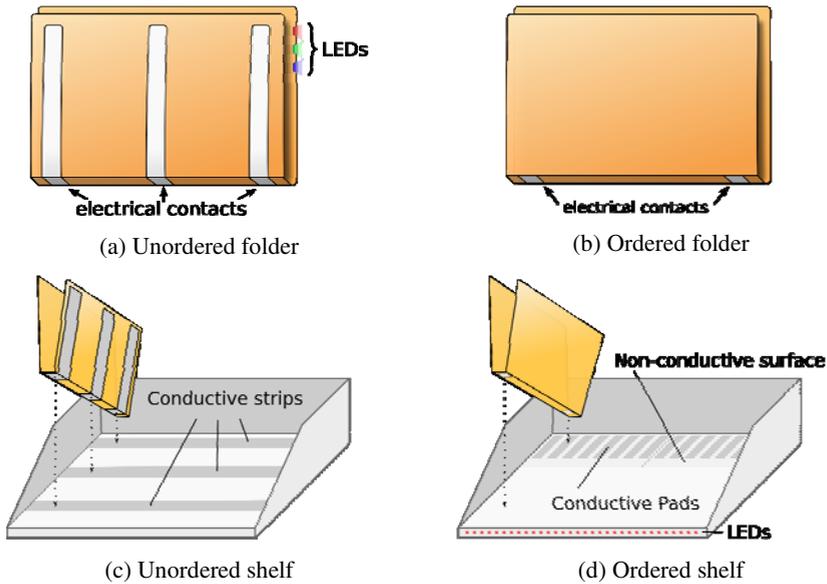


Fig. 1. Comparison of unordered and ordered variants of SOPHYA. The ordered variant is able to determine the position of folders on the shelf, whereas the unordered variant can only determine their presence.

For the purpose of the user evaluation reported in this paper, we used an integrated combination of both ordered and unordered implementations of SOPHYA. We also developed a specific client application suitable for the task scenario of our study which utilized SOPHYA. The details of our setup and client application are described more fully later in this paper.

3 User Study of SOPHYA

As mentioned earlier, a growing number of systems are being developed to manage paper documents electronically, with some of them even attempting to integrate the management of paper documents with that of digital documents. Most of these systems tend to replicate the type of functionality that computer systems have for search and retrieval of digital documents to allow similar capabilities for management of paper documents.

There are, however, no substantial user studies of these systems to provide any empirical evidence for their effectiveness in allowing users to manage the storage, search, and retrieval of paper documents using techniques adopted from systems developed for management of electronic documents.

We have therefore conducted a user evaluation of SOPHYA, which has a comprehensive set of functionality for management of paper documents, to demonstrate the effectiveness of a range of document management capabilities it provides for.

Our user study of SOPHYA was in the form of a laboratory-based evaluation. This type of study is clearly not sufficient for demonstrating whether a system such as SOPHYA will in fact be adopted in a real world environment and used long-term. However, the objective of our study was to evaluate the usability of document storage, search, and retrieval capabilities of SOPHYA, and gain feedback from experienced office workers as to whether they envisage potential benefits in adopting it as a tool in their work environment.

3.1 Methodology

Our user study consisted of three parts. It began with the participants following a tutorial in order to familiarise themselves with SOPHYA. This was followed by a set of five tasks—based on the scenario described below—that they had to complete, after each of which the participants were required to fill out a questionnaire. Finally, after the completion of the study tasks and questionnaires, we conducted a semi-structured interview with each of the participants.

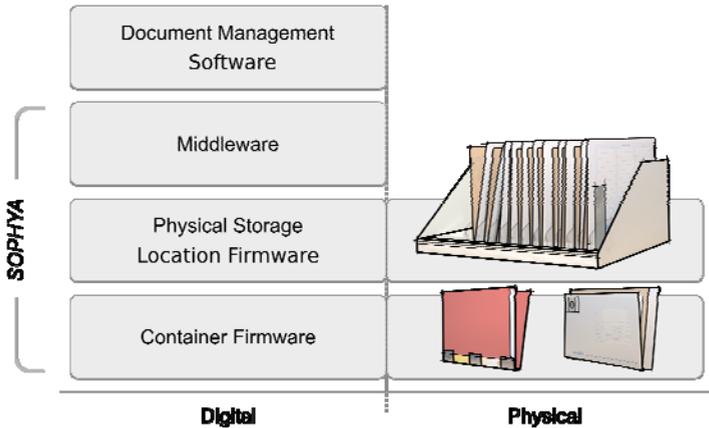


Fig. 2. Integrating the physical and digital document management systems. Physical document containers and storage locations are augmented with SOPHYA circuitry that gives them a digital element.

Task Scenario. In order to simulate a real-world office environment we developed our tutorial and study tasks based on a scenario of a business office, which we envisaged as being a potential environment for the application of the SOPHYA technology. The business office we simulated was that of a fictitious landscape design firm, in which the participants played the role of a personal assistant to the manager of the firm. Management of documents in our fictional landscape firm was job-centric. This meant that each design job was assigned a folder in the SOPHYA system, which integrated the electronically-augmented physical folder of the job with its digital representation in the document management system (see below).

Experimental Setup. We conducted the study in a usability laboratory at our university. A desk in the laboratory was set up with a laptop computer running the

SOPHYA-based client application that we developed for this study. The SOPHYA system we used consisted of two augmented shelves of folders, one unordered and one ordered, as well as an RFID tag-reader. Additionally four unaugmented conventional document trays were used for organising documents as part of the study tasks. The desk layout of our experimental setup is shown in Figure 3.

The two variants of SOPHYA (i.e. unordered and ordered) were used in this study for different purposes. Folders of the unordered type (Figure 4(a)) were used to hold documents related to the design jobs that were in-progress in the scenario, while ordered (Figure 4(b)) folders were used for the completed jobs. As mentioned earlier, we envisaged that the unordered version of SOPHYA would be more suitable for managing “piles” of folders and documents that are used regularly while they contain jobs that are in-progress, whereas the ordered version of SOPHYA would be more suitable for managing archival type folders of jobs that have been completed.



Fig. 3. The office setup for the user study



(a) Unordered folder



(b) Ordered folder



(c) Unordered shelf



(d) Ordered shelf

Fig. 4. SOPHYA folders and shelves used in the user study

Client Software. As previously stated, SOPHYA does not include an electronic document management software, because the requirements of such software would depend on the type of application environment in which it is deployed. Therefore, in order to conduct a user study of SOPHYA we had to develop a software client using the API provided by the middleware component of SOPHYA.

It should be noted that the aim of our study was to focus on the functionalities provided by SOPHYA, and not the usability of our client application. Therefore, we made the client application itself very simple in terms of its design, using it to provide the type of functionality we needed as part of our study, and tailoring it specifically to the task scenario we have described. We also used the client application to collect user study data (e.g. task completion time, etc.), as well as for presenting the task questionnaires to the participants and collecting their responses.

Perhaps the most important functionality that the client application provided was to allow the study participants to search for information about the design job folders and the documents they contained based on a number of different search criteria (e.g. keywords, dates, job types, etc.). Figure 5 shows the search screen of our client application. Once a user had completed a search activity, the client allowed the user to locate the relevant folders and documents by visually identifying them in the folder shelves (e.g. by turning their LED on to a specific colour, etc.).

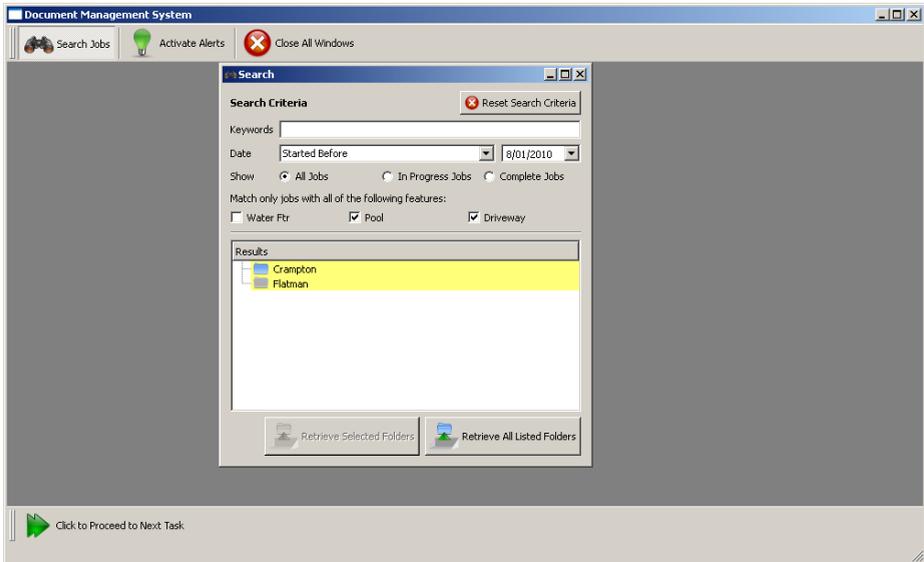


Fig. 5. The client application developed for the user study, showing the search dialog

Tutorial. The study participants completed a short, simple tutorial before starting on the main study tasks. The tutorial described the fictitious design firm, identified different components of the experimental setup, and showed the basic functionality of the client application, which included searching for folders, locating and retrieving folders, and returning folders to one of the two shelves depending on whether they

were jobs in-progress or completed. The tutorial on average took around 11 minutes to complete.

3.2 Tasks

The participants were asked to perform five tasks, each consisting of several steps. The aims of these tasks were to get the users to utilise SOPHYA to perform a range of *filing* activities which are normally carried out in a typical office environment. These tasks are described below.

Retrieving Specific Folders. The first two tasks aimed to demonstrate the link between electronic search and physical retrieval. For each of these tasks, the participants were required to retrieve folders matching a given date criteria. The first task was to retrieve folders of two jobs in-progress (from the unordered shelf), while the second task was to retrieve the folders of two completed jobs (from the ordered shelf).

Collating Specific Documents from Different Folders. The third task required the participants to retrieve several completed job folders based on various criteria and find a specific document in each of them. The participants then needed to place these documents into a new folder, and return the original folders back to their shelf. Although the task sheet provided clear steps to achieve this task, the task required some cognitive effort on the part of the participants as they had to retrieve the folders in multiple steps.

Returning the folders to the shelf required using SOPHYA to guide the placement of folders on the shelf. The folders used in this task were for completed jobs (from the ordered shelf), and also had RFID tags attached to them. Placing these folders over the RFID tag reader instructed SOPHYA to turn on LEDs in the position where the folders belonged on the shelf.

Combining Paper and Digital Documents. The aim of the fourth task was to demonstrate how SOPHYA could be used to integrate the management and use of both digital and paper documents. This task required the participants to browse the electronic contents of a given folder to find a specific digital text document. They then had to retrieve certain paper documents from their physical folder, and compare these paper documents against a list of changes in the digital text document.

Generating Alerts. The final task aimed to demonstrate how the folder LEDs could be used to provide visual alerts when certain conditions were met. Two types of alerts were demonstrated, a time-triggered alert, and an action-triggered alert. As this task was intended as a demonstration of the alert feature it did not require the participant to actually setup alerts, but rather asked them to make use of alerts that had been previously setup.

The time-triggered alert caused the LEDs of all the in-progress job folders that had not been accessed in the past seven days to be turned on. The event-triggered alert, on the other hand, turned on the LED of a completed job folder when a document that had to be returned to its folder was placed on the RFID tag-reader on the desktop.

3.3 Questionnaires

After the completion of each task the participants were automatically presented with a questionnaire in the client application, which they had to fill out before being allowed to proceed to the next task.

The questionnaire consisted of five questions, which were repeated for each of the five tasks the participants performed. Each question had to be answered in two parts: a rating part on a scale 1–7 (1 being very difficult and 7 being very easy) and a why part, asking for the reason for the rating. The five questions of the questionnaire are shown in Table 1.

Table 1. Tasks questionnaire

No.	Question
Q1.	How easy was it to understand the task you have just performed?
Q2.	How easy was it to perform the task using SOPHYA?
Q3.	How easy would it be to perform this task again using SOPHYA?
Q4.	How helpful was SOPHYA in assisting you to perform this task?
Q5.	How easy would it be to perform this task manually (without SOPHYA)?

3.4 Participants

Selection of the participants for this study was carried out very carefully to make sure that the chosen participants had sufficient real office experience of dealing with paper documents and were familiar with the process of filing, search, and retrieval of folders and documents. The main reason for these selection criteria was to have study participants who could provide us with some level of comparison between paper document management tasks performed in our study using SOPHYA and their real-life experience of doing such tasks in their normal work environments.

In total 16 participants were selected for this study, of whom 10 were female and 6 male. The participants were mostly from various units across our university. Thirteen of the participants worked in offices where they dealt with paper documents and files on a daily basis, one participant had previously worked as a librarian, one was a researcher in the field of knowledge management, and one worked solely with digital documents.

3.5 Results

Table 2 shows the results of task accuracy and average completion time for each of the five study tasks. Considering the fact that the participants were not familiar with the organisation of the documents and folder, and had to rely totally on SOPHYA to perform the tasks, the average times taken to do the tasks were between 2 to 6 minutes.

The accuracy of tasks completions were high for most tasks, except for Task 2. In fact most of the errors in completing the tasks were caused by what could be considered “clerical” errors rather than being caused by SOPHYA.

Table 2. Percentage of participants who completed each task accurately (e.g. retrieved the correct folders) and average time taken to complete each task

Task	Accuracy (%)	Time (mm:ss)	
		Avg.	Std. dev
T1.	94	02:35	01:38
T2.	50	02:55	00:27
T3.	81	05:46	01:18
T4.	94	04:23	01:15
T5.	100	03:04	01:41

For instance in the case of Task 2, the task asked the participants to retrieve folders for jobs completed before a given date in 2009. However, 10 of the 16 participants missed this detail given in the task specification and entered criteria for the correct day and month, but in 2010. Thus, rather than the search resulting in two folders, 12 folders were returned. Upon seeing such an unexpectedly large number of results, 3 of the participants re-read the instructions and re-entered the criteria, while seven proceeded to retrieve all 12 folders.

For Task 3, the encountered difficulties were mainly due to the participants either not realising that two separate searches were required to retrieve the required folders, or not clearing the criteria in the search form between searches.

Table 3 shows the average ratings for each of the questions of the questionnaire for each of the five study tasks. The participants rated SOPHYA very highly in relation to ease-of-use, re-use, and the assistance it provided (Questions 1-4). They also felt that based on their experience performing the study tasks would be reasonably difficult to do without SOPHYA (Question 5). The main reasons that participants gave for their ratings to Question 5 were:

- SOPHYA saves time over manually looking through all the files;
- SOPHYA provides the ability to search the database for folders matching given criteria; and
- it is easier to find folders with SOPHYA when unfamiliar with the filing system.

Table 3. Median (left column) and inter-quartile range (right column) of ratings given for the questions of each task questionnaire

	Questionnaire Ratings									
	Q1.		Q2.		Q3.		Q4.		Q5.	
T1.	6.0	0.640	7.0	0.063	6.5	2.000	6.0	1.300	7.0	1.000
T2.	6.0	1.300	7.0	0.047	7.0	1.000	7.0	1.300	7.0	1.000
T3.	7.0	1.000	7.0	0.000	7.0	0.480	7.0	1.000	7.0	0.000
T4.	6.0	2.300	7.0	0.480	7.0	1.000	7.0	1.000	6.5	1.000
T5.	4.0	2.300	3.5	3.000	3.5	2.000	4.0	2.000	4.0	2.000

3.6 User Interviews

Although the results of the task completion time and accuracy, as well as the ratings of the participants were very positive, perhaps the most important findings of our

study came from the interviews conducted with the participants after the study tasks were completed.

The interviews we conducted with our study participants were semi-structured. To guide our interviews we used a set of open-ended questions that we followed broadly. These questions (see Table 4) can be divided into three groups: those relating to the background of the participants and their previous office experience, those relating to the usefulness of SOPHYA, and those relating to its adoption in real world.

Table 4. Interview questions

Question
Background
Do/have you worked with paper documents in your work?
How did/do you manage them?
How large was the collection of documents?
Would others use the documents/files as well?
How would you collaborate/share the documents/files?
Did you deal with sensitive files?
How was security implemented? How did you control access to files?
Usefulness of SOPHYA
Based on your experience, do you think a system such as SOPHYA would be useful in the offices you have worked in?
Why/why not?
Can you see any other situations where it might be useful?
Barriers to adoption of SOPHYA
Can you see any barriers to using such a system?

In the following sections we have grouped the feedback we got from the participants into a number of categories.

Ease of Use. Most of the comments we got from the participants supported their positive ratings of SOPHYA's ease of use. The participants commented on how easy or intuitive it was to use SOPHYA. While, the simplicity of the tasks and the design of the client application specifically for this evaluation (as opposed to general purpose document management software) may have had some bearing on the perceived ease of use, it is likely that many of the features of SOPHYA would remain easy to use even in a more complex setting. Some of the feedback related to ease of use included:

- *“With that [SOPHYA] you just find where everything is and where it should go.”*
- *“Because the light was flashing it completely removed any kind of thinking process and seemed to speed up the file retrieval process hugely.”*
- *“It seems to me very simple, find it, there goes a light, swipe it, put it back; it's pretty intuitive in that regard.”*
- *“It's very easy to use once you've got the hang of it. And the more you used it the easier it is.”*

Usefulness of SOPHYA in Offices. Six of the 13 participants who work in an office with paper documents on a daily basis, said that SOPHYA would be useful in their

current or previous office. The seven other participants that did not think SOPHYA would be useful in their office provided a range of reasons for this. They generally felt that their office was not suited to using SOPHYA or that their current system was serving them well enough. For instance they said that their office was too small to need such a system, or that they already knew their current system well enough that there would be no gain to using SOPHYA in their office. However, one participant who said that he knew his own system well enough also stated that SOPHYA would be useful when retrieving documents from his co-workers if they used SOPHYA.

The study participants were also asked if there were any other types of offices in which they thought SOPHYA technology would be useful. The most common suggestion was that it would be useful for large paper-based offices, such as legal offices and accounting firms. There are also other situations where there are large, unwieldy documents such as diagrams or maps, which are not suitable to have in digital format. Additionally, it was suggested that SOPHYA would be useful in offices where there are many casual or temporary staff, as SOPHYA does not require familiarity with the filing system in order to use it.

One of the participants had experience as a librarian and pointed out that SOPHYA would be very useful in a library. She mentioned that *“once [a book] is misfiled it’s useless, so if this can take out misfiling things it is very appealing”*. This confirms the research findings of others [7] who have noted that library patrons often have difficulty locating books. A system such as SOPHYA, designed to integrate management of physical and electronic artefacts, would be useful in a library. Its use would also simplify the process of shelving, reducing the training required, and allowing skilled librarians to concentrate on other tasks.

Another suggestion, though not specifically related to an office environment, was that a system such as SOPHYA would be valuable in the aviation industry. The participant described a system used for storing spare parts, where the parts are allocated randomly to bins (rather than in sections, e.g. screws, bolts, etc.) in order to reduce the chance of the wrong part being retrieved, as there are many similar parts. He stated that SOPHYA would be perfect in this scenario, as it would allow a search for the part to be performed electronically, and then a light could indicate the appropriate bin where the part could be retrieved from. We have already stated that SOPHYA has in fact been designed for management of physical artefacts in general, and therefore this type of application would be suitable for it.

Potential Benefits of SOPHYA. One of the major benefits mentioned by the participants was that SOPHYA would save time when retrieving or returning documents. For some it was an alternative to *“fumbling through”* their folders in order to find the one they needed. Having the LED to display the folders to be retrieved, especially if it could be coupled with tagging of documents, would save time.

The integration of searching with display of the search results on the folder LEDs was also mentioned by participants as a benefit. Several participants pointed out, simply looking up the position of a single folder may not be of great benefit, but integrating it with search makes it a useful tool. As one participant said: *“If it was just ‘oh where should I put this file’ then it’s probably not really going to be that successful, people are going to say ‘it’s just as quick to find it alphabetically,’ but when it’s connected to searching for certain things it is really good.”*

Another potential benefit mentioned is ensuring that folders are returned to the correct place once people have finished using them. This is especially pertinent in a larger office where multiple people share files and the filing schemes may be complex. Two of the participants described cases in which the people in their office had returned folders to the wrong place. *“Often with that amount of files, go to look for a file and someone has used it and has put it just a little bit out of place; because either they’ve transposed the numbers in their mind as they’ve put it back or put it according to the numbers, but then we have special files that are not filed by that numerical number, they have their own separate shelf as well because they are special projects.”* With traditional systems once the folder is misfiled someone has to manually scan through the folders in order to find it rather than just relying on, for instance, the numerical or alphabetical ordering. Similarly, some of the participants considered SOPHYA as technology to prevent document loss. It was also suggested by one participant that by making the task of filing easier it would change people’s filing behaviour so that they would be more organised.

Another participants talked about wanting to keep her documents in order, so as to feel in control of them; *“however, with so many people having access to them that it was not possible to control them. But having a system like SOPHYA would remove the need to keep them in order as the LEDs could show their position.”*

The ability to locate a file that has been removed from the collection (e.g. filing cabinet) was seen as another benefit of SOPHYA. *“There’s always emails going around ‘has anyone seen the file for such-and-such’.”* *“With the files I deal with sometimes I’ll have to, say for example, get sign off from another manager. So I will give the files to them. In my tracking spreadsheet I will put down—so I know where it is—‘have put on bla-bla-bla’s desk’.”* One participant suggested that requiring the user to swipe their ID card when retrieving a folder from SOPHYA would mean that the system could keep track of who has taken which file.

Making it easier for people to use a filing system when they were unfamiliar with it was another benefit mentioned for SOPHYA. The fact that people become very familiar with the files they work with everyday is well known. This is something that is demonstrated when people try to use a filing system they are unfamiliar with: *“You really notice how complicated your filing system is or isn’t when you have new staff. They just have no idea, can’t find anything.”*

The alert feature of SOPHYA was also considered valuable by a number of participants. One participant described the alert system in use in their office, effectively an electronic listing of things to do during the week. However, while this lists what needs to be done in the coming week, if they are busy they may not get to them. The participant mentioned that she would be more inclined to pay attention to flashing lights on the folders than electronic reminders: *“if there were flashing lights on my rotascan I would so deal to those quickly before anyone else saw them. You’re sitting there and your boss comes in and sees lots of flashing lights on these files, they’re gonna know you’ve been slack.”*

SOPHYA alerts are in fact more peripheral than electronic alerts on computers. Alerts on the computer are considered more *“in-your-face”* and could be easily closed; whereas, it was suggested that if one was required to walk over to the folders in order to acknowledge the alert, then *“I might as well pull the file out now that I have to go all the way over and touch it.”*

The ability to identify folders that have not been used in a certain period of time was also seen as being useful. For example: *“sometimes you’re so busy with other students, ones that are knocking on the door all the time, you forget about the ones that don’t even bother to turn up to anything. Having some kind of system like that so you can keep on top of everything would be awesome.”*

It was also pointed out that SOPHYA could reduce duplication, because if it was easier to find documents that are already in a shared archive then people may no longer feel the need to keep their own personal copies. *“It was so much of a pain to find the contracts I ended up printing them myself. Every year it must have been over a 1000 pages of contracts and other stuff that was all in the files but it was just such a performance to find it some of the times that it was just easier to print it out.”*

Barriers to Adoption of SOPHYA. In order to get some idea of the kind of problems that may be encountered when attempting to deploy a system such as SOPHYA, participants were asked what barriers to implementation they could foresee. The participants provided us with a range of responses that are summarised below.

Possibly the biggest barrier described by the participants was the cost. The cost/benefit ratio would have to make it worthwhile to deploy such a system, balancing the setup and maintenance costs with the savings in time. As one participant noted: *“being inefficient might prove to be cheaper, even though it might be more frustrating and annoying.”* For instance, if a large number of documents have to be tagged with RFID tags for use with SOPHYA, then this could incur a large overhead. *“You’d have to see if doing it this way uses less energy overall compared to your traditional style of office maintenance which is put it in a pile somewhere then physically search through it later.”*

It was also pointed out, that if the organisation in which SOPHYA is deployed is not itself organised then just adding new technology is not necessarily going to solve the deeper problem. *“But that’s like any technology. If you’re not good at running meetings then doing teleconferences isn’t going to help you. Your technology emphasises what you’re good or bad at rather than fixing something necessarily. But for those ones that do have systems and do have policies around that sort of stuff I’d imagine they could almost use it straight away.”*

Another potential problem that was mentioned is that this type of automated system is only as good as its data entry. If information about documents is entered incorrectly into the system then it would make it more difficult to find documents.

Additionally, the staff who have to use the system may resist it if it threatens them: *“with something new, depending on how it was introduced to the staff that had to run it [may be a barrier].”* It was suggested that if the staff do not like technical advancements, or do not want change they may become a barrier to its adoption. Similarly, training is another overhead that would be required. Although this study has shown that learning to use SOPHYA is not likely to be very difficult or time consuming.

The risk of the system breaking would be yet another barrier. The system would need to be reliable, especially if using such a system resulted in staff with less filing training using it: *“then if something went wrong they may not notice a problem or not be able to deal with it.”*

Finally, personalisation was also seen as a potential pitfall: *“Everyone might have a different way of dealing with their files. That could be a barrier in terms of trying to find a way to personalise it to every person.”*

4 Discussion

Our study has provided us with many valuable insights into the effectiveness of SOPHYA as an integrated paper and digital document management system. The study has indicated that a system such as SOPHYA would be beneficial if deployed in real offices. In particular, the offices that would benefit most from SOPHYA would be larger offices, with more complex filing and document management requirements. Examples of such offices include those with a large number of paper documents, or a large number of staff who share access to the paper document management system. Systems such as SOPHYA would also benefit offices with a lot of staff turnover, inexperienced or temporary staff who would need to access documents without having to get considerable amount of training on the organisation of the manual document management system. However, in such cases where people accessing the system are less experienced they are likely to be much more dependant on the system, and thus would require very high levels of reliability from the system to be able to perform their document management activities.

Beyond the obvious benefit of providing for faster and easier search and retrieval of documents and folders, the potential benefits of systems such as SOPHYA for large and complex offices include the possibility of integration with organisational database systems, providing linkage between online and offline documents, assisting with maintaining consistency and accuracy of document archives (e.g. by helping the users to put folders in the right place, or finding out when they are not in the right place), providing alert mechanisms which could be used to maintain the security of paper documents, as well as allowing users to manage the usage and tracking of documents across the organisation, and so on.

There are also several potential barriers to adoption of paper document management systems such as SOPHYA. Those identified by our study include concerns for the cost of such system, staff resistance to its introduction, the need for personalisation of filing systems, the risk of user dependency and lack of effective access to documents in cases of system break down, and the heavy reliance of such systems on good organisational disciplines for maintaining accurate information about documents in the system. It should, however, be noted that most of these concerns and potential barriers are often expressed before the introduction of any computerised system into organisations that deal with manual or paper-based systems. Clearly unless a system such as SOPHYA is introduced into an organisation and used over a considerable period of time it would be impossible to find out to what extent these kinds of barriers and concerns are serious and cannot be improved upon over time.

One limiting factor to the use of SOPHYA which needs to be addressed is that SOPHYA deals with the management and tracking of folders. Although this level of granularity might be enough for some offices it would not be sufficient for others. Some offices may require document tracking as well as folder tracking, for instance by using RFID-tagged documents in combination with SOPHYA. In such cases,

however, in order to keep the cost of tagging down, document tracking may only need to be applied to important or sensitive documents.

There are already several document level tracking systems proposed by others, and referred to earlier in this paper. We envisage that any comprehensive paper document management system would be a combination of wired (e.g. SOPHYA) and RFID-based systems. The main advantage of SOPHYA over purely RFID-based systems is in its ability to provide for a two way interaction—whereas document tracking with RFID is limited to one-way tracking of the location of documents, with SOPHYA there is also the possibility of two-way communication with the folders and storage locations.

5 Conclusions

In this paper we have presented a user evaluation of SOPHYA, which is an integrated paper and digital document management system. Although the study was based on using SOPHYA, many of its findings are equally relevant to other physical document management systems.

We would, however, like to point out that the real success of paper document management systems would be dependant on the range of applications that seamlessly integrate the digital and paper document collections and information systems. At present, due to the lack of reliable underlying technology, such as SOPHYA, the range of client level applications is limited or they are completely lacking. Further research is needed to guide the development of such interactive applications and information visualisation techniques to fully utilise systems like SOPHYA.

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References

1. AbuSafiya, M., Mazumdar, S.: Accommodating paper in document databases. In: DocEng 2004: Proceedings of the 2004 ACM Symposium on Document Engineering, pp. 155–162. ACM, New York (2004), <http://portal.acm.org/citation.cfm?id=1030428>
2. Arregui, D., Fernstrom, C., Pacull, F., Rondeau, G., Willamowski, J., Crochon, E., Favre-Reguillon, F.: Paper-based communicating objects in the future office. In: SOC 2003 Smart Object Conference (2003), <http://citeseerx.ist.psu.edu/viewdoc/download?doi:10.1.1.2.2.920&rep=rep1&type=pdf>
3. Jervis, M., Masoodian, M.: Digital management and retrieval of physical documents. In: TEI 2009: Proceedings of the 3rd International Conference on Tangible and Embedded Interaction, pp. 47–54. ACM, New York (2009), <http://portal.acm.org/citation.cfm?doid=1517664.1517682>
4. Jervis, M.G., Masoodian, M.: Design of a modular architecture for integrating paper and digital document management systems. In: PaperComp 2010: Proceedings of the 1st International Workshop on Paper Computing, Part of the 12th ACM International Conference on Ubiquitous Computing, pp. 44–47. ACM, New York (2010)

5. Jervis, M., Masoodian, M.: SOPHYA: a system for digital management of ordered physical document collections. In: TEI 2010: Proceedings of the Fourth International Conference on Tangible, Embedded, and Embodied Interaction, pp. 33–40 (2010), <http://portal.acm.org/citation.cfm?id=1709894>
6. Kojima, H., Iwata, K., Nishimura, N.: Document management and information organizing method using RFID tags. In: Jacko, J.A. (ed.) HCI 2007. LNCS, vol. 4553, pp. 601–610. Springer, Heidelberg (2007), <http://portal.acm.org/citation.cfm?id=1769451.1769523>
7. McKay, D., Conyers, B.: Where the streets have no name: how library users get lost in the stacks. In: CHINZ 2010: Proceedings of the 11th International Conference of the NZ Chapter of the ACM Special Interest Group on Human-Computer Interaction, Auckland, New Zealand, pp. 77–80 (2010)
8. O’Neill, J., Grasso, A., Willamowski, J.: RFID: enhancing paper documents with electronic properties. In: CSCW, Computer Supported Cooperative Work, Workshop Collaborating Over Paper and Digital Documents (2006)
9. Raskar, R., Beardsley, P., Dietz, P., van Baar, J.: Photosensing wireless tags for geometric procedures. *Commun. ACM* 48(9), 46–51 (2005)
10. Seifried, T., Jervis, M., Haller, M., Masoodian, M., Villar, N.: Integration of virtual and real document organization. In: Proceedings of the 2nd International Conference on Tangible and Embedded Interaction, pp. 81–88. ACM, New York (2008), <http://portal.acm.org/citation.cfm?id=1347410>
11. Sellen, A.J., Harper, R.H.R.: *The Myth of the Paperless Office*. MIT Press, Cambridge (2003)