

File Sharing and Group Information Management

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ABSTRACT

Groups that interact digitally often communicate and collaborate through shared files. Managing access to these shared files can be complex: one needs to provide sufficient access to allow collaboration, but not so much that sensitive files are inadvertently exposed. Preliminary evidence suggests that file sharing problems decrease security and interfere with collaboration. We collected data in order to develop a comprehensive picture of how users carry out file sharing, and the problems they encounter. We present our results, and describe the implications for group information management. We also describe some design ideas, and discuss how these can be adapted for file management in the “disappearing desktop” context.

Author Keywords

File sharing, group information management, collaboration, security, information presentation

ACM Classification Keywords

H5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

INTRODUCTION

File sharing is a common task within organizations, and is an important way for groups to circulate information. However, managing shared files can be a complex and error-prone procedure. There have been many incidents in which people have unwittingly revealed private data, or have neglected to share key files in collaborative activities or teamwork. For example, one study of a peer-to-peer sharing system showed that some people had inadvertently shared the contents of their entire hard drives, when they intended only to share their music files [4]. This study included a cursory search of the Kazaa peer-to-peer filesharing network, which discovered a number of files

that users likely did not intend to share, such as email files. These cases illustrate that users are often unaware of the degree to which they are sharing.

On the other hand, when working collaboratively, people need access to the objects and resources that are required to complete their joint tasks. If a shared file is made inaccessible to a colleague, this becomes an obstacle to effective teamwork. There is evidence that people forget which items they have shared, and with whom, which interferes with effective collaboration [10] and becomes an enterprise inefficiency. Bellotti theorized that collaboration necessitates control over access to shareable data, and that when users engage in file sharing, they often forget what their settings are and unwittingly make items too public or too private [2].

In this paper we describe our research on file sharing, which investigates the fundamental issues regarding how files are shared and the difficulties encountered when managing files in collaborative environments. To explore this problem we surveyed a group of people regarding the extent of their file sharing, their use of different sharing methods, and the problems they have encountered with file sharing in their personal and professional lives. We present our findings and discuss the implications for group information management (GIM). We also discuss our design ideas, with a short discussion on how these can be adapted for the “disappearing desktop” environment.

WHAT IS FILE SHARING?

We define file sharing as the activity of making specified file(s) available to an individual or group, with the option of granting specific rights (e.g., ability to view, edit, delete) over those files. This task requires some interaction with a set of files, or the file system. Examples of file sharing include sending email attachments, or uploading a file to a shared folder and giving specific users the right to read and edit that file. This definition excludes such actions as simply telling someone where to find a file, without placing the file there oneself; for example, emailing someone the URL for a public file on the Web. There are key items in this definition: the parties who are sharing files (individuals and groups); the files themselves; the means of making the files available; and rights over those files. To take a sender-

centric perspective (for the sake of simplicity), these items can be re-framed as

- the sender
- the recipient(s)
- the file(s)
- the sharing mechanism
- the action(s) that can be taken on the file(s)

In addition, in order for the sender to properly manage file sharing, then there must be sufficient information to determine whether sharing has been successful; this is a requirement for detecting and correcting errors. This information might include file permissions in a shared folder, or a set of recipients of an email message. These items are represented graphically in Figure 1.

Note that there is a distinction between two types of mechanisms: those in which the sender transmits the file directly to the recipient (e.g., email attachment), and those in which the sender places the file in a location that the recipient can access later (e.g., shared folder). Volda et al. describe this as “push-oriented” vs. “pull-oriented” sharing [3]. Note also that the desired set of recipients and rights, and the actual set, may differ: if these are in conflict, there is a fundamental breakdown in sharing. In other words, the sender wants to ensure that the right people have access, and that they can perform the right actions. Configuration errors can create conflict between the sender’s intentions and the actual system settings. Similarly, updates in the environment, such as a change of team members or the addition of new files, can also create conflict, such that settings must be adjusted to take into account this new situation. Thus, having information about a dynamic

environment becomes of central importance.

CHARACTERIZING FILE SHARING

The majority of existing file sharing research has taken place within the context of specialized domains and applications. For example, there have been studies on web-based collaborative systems that include document sharing [1], and on ad hoc collaboration tools [8]. However, these studies are restricted in scope: little research has been conducted that characterizes the individual level of file sharing. There have been two preliminary user studies about file sharing practices that describe dominant behaviors and concerns; one is by Volda et al. [10] and the other is our exploratory work on this topic [11]. We will not detail these study results here, but note that while these two studies provided preliminary data on file sharing, there remained a number of unanswered questions about the fundamentals of file sharing. These questions needed to be answered in order to design appropriate technological solutions. We will focus our discussion here on those questions most relevant to personal and information management; due to the nature of file sharing, many of these involved security and confidentiality issues. The questions can be grouped into the following categories:

Characterizing the file sharing task: frequency, recipients, and methods

- How often are people sharing files? (Is sharing a frequent task?)
- How many different groups do people share with?
- What are the advantages and disadvantages of different sharing methods? (What factors influence people’s choice of a sharing mechanism in a given situation?)

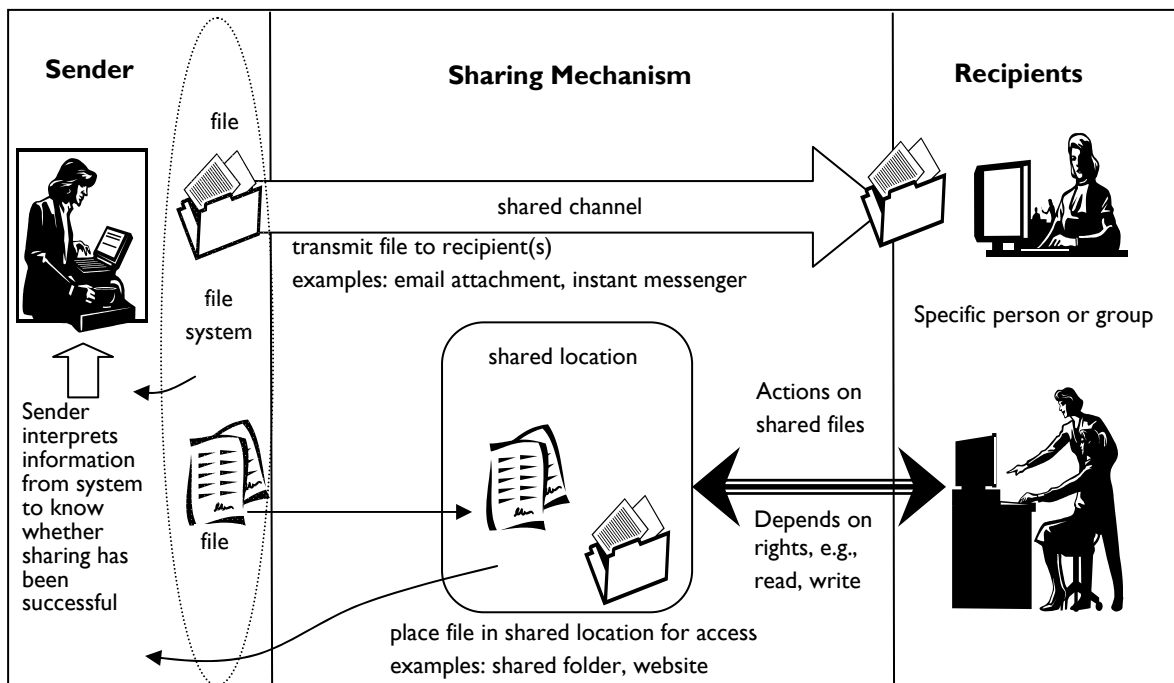


Figure 1: fundamental dimensions of file sharing

Managing limits around file sharing: security, file permissions, and errors

- Are security and privacy a concern when sharing files?
- How often do people need to manage file permissions?
- What file permission errors do people encounter? How long does it take to detect these errors?
- Do people put limits on individual shared items, or on folders?

In addition, we replicated and expanded some of the core questions from our earlier study [11], as well as from Volda et al.[10], to validate and extend these preliminary findings:

Characterizing the file sharing task: recipients and methods

- How many different methods of file sharing (e.g., email attachments, shared folders) are people using? Which methods are most commonly used?

Managing limits on sharing: security and sensitivity

- Do people need to manage limits around their shared files and computers? If so, what kinds of limits (access control) do they set?
- What percentage of people have sensitive items on their computers? What are these items (e.g., email) and do they share these items?

Information about file sharing

- Are people aware of their shared files and sharing activities?
- What types of file sharing activity might people want to know about?

To answer these questions, we conducted a web-based survey at a medium-sized university. While other methods could have been used (e.g., interviews), we adopted the survey method in order to gather data from as many people as possible; this approach allowed us to broadly characterize a range of diverse practices and concerns.

Next, we will present the data we collected in this survey, which may be useful to researchers who include aspects of file sharing within their information management work. These results will be followed by a discussion that puts the data in the broader context of GIM and design.

RESULTS

Seventy-nine respondents (25 female, 54 male) completed the survey. Sixty-two percent of respondents had over 10 years of computer experience, and 34% of them had between five and ten years' experience. Because some respondents did not answer all questions, the number of responses for each question varied from 22 to 79.

File Sharing Fundamentals

Respondents provided details on their file sharing activities: how often they shared; the file sharing methods they used; the types of files they shared; and the people with whom they shared files. File sharing was a frequent professional

activity for most; 49% shared files daily, and 25% shared files weekly. (Only one respondent never shared files professionally.) Personal file sharing was also frequent, with 30% of people sharing daily and 47% sharing weekly.

There were a number of file sharing methods used: respondents were provided with a list of methods, choosing all that they had used, and could list additional methods. Table 1 shows the most widespread sharing methods (n=69). On average, each person used approximately six sharing methods. No one used fewer than three methods, and the greatest number reported was 10 different methods. Respondents also identified their most commonly-used sharing method (n=68). Email attachments were by far the most popular (43%), followed by network file share (15%). These results are shown in Table 2.

Sharing method	% of people that used this method
email attachments	99%
physical devices (e.g., USB token, CD)	97%
network file share	81%
instant messenger (e.g., MSN, Yahoo)	77%
Web server (e.g., webpage, wiki)	71%
peer-to-peer (P2P) (e.g., KaZaa)	70%
file copy protocol (e.g., scp, ftp)	67%
iTunes (17%); proprietary systems, e.g., Lotus Notes (12%); other (e.g., cables, CVS)—15 varied responses (~1% each)	17% or less

Table 1: most widespread sharing methods

Most commonly-used sharing method	
Email attachments	42.7%
Network file share	14.7%
Peer-to-peer program	10.3%
File copy protocol	10.3%
Instant messenger	8.8%
Web server	5.9%
Physical devices (e.g., USB token)	5.9%
iTunes music sharing	1.5%

Table 2: most commonly-used file sharing methods

Respondents also described the positive and negative properties of the sharing method that they used most often, using free-form responses. These responses were coded, and a summary of the most frequently-mentioned features is presented in Table 3. Note that the number of responses varied: some people listed a method but provided no details, and a few more people replied to the question on positive features than negative (n=64 and n=60, respectively). The positive and negative features listed below are not specific to any one method, but are grouped to show recurring issues across all sharing methods.

positive features (advantages)
convenience/ease of use widespread availability of method (can reach all recipients) provides access control or security features understandable (by both sender and receiver) ensure item is received by intended recipient(s) well-suited to task (e.g., collaborative writing) well-suited to organizational structure and needs fast
negative features (drawbacks)
limits on file size or file space lack of access control or security features inconvenient for multiple files can't reach all recipients (e.g., across organizational boundaries) need specialized application (e.g., file copy software) poorly suited to collaboration slow

Table 3: advantages and drawbacks of file sharing methods

Sharing Groups

Respondents indicated how many distinct groups that they shared with, such as friends and colleagues (n=65). Over 69% of respondents shared with two to four groups, and another 25% shared with five to 20. (Three people shared with over 20 distinct groups.) Respondents optionally listed these groups: common examples included family and friends; colleagues; research groups; general public; professional associations; and classmates.

People also indicated how often they shared a file with multiple groups (n=56); they chose from a five-point scale ranging from “never” to “very frequently.” Seventy-one percent shared items with multiple groups “sometimes”, “often”, or “very frequently”.

Detailed Example of Sharing

Respondents detailed their most recent instance of file sharing: the type of material, the method they used, and who the recipients were (n=59). Responses were coded and categorized. The three most common types of materials shared were text documents, programming code or software, and images. The three most common recipients were coworkers or teammates, friends, and supervisors. (In three instances, people sent the same material to two distinct groups, such as a boss and a family member.) Finally, the three most common sharing methods were email, shared folders, and instant messenger (IM). In two cases, people used multiple methods to share the same material with different recipients.

Sensitive Materials

Respondents described their handling of sensitive materials; firstly, whether they had any sensitive material that they wished to keep private (n=60). Eighty percent did have some sensitive material. A list of possible sensitive materials was presented; respondents selected all applicable items, and indicated whether they shared these types of material with others.

All respondents with sensitive data provided details. Results are in Table 4. In the first column, percentages reflect the proportion of respondents who reported having such material. In the second column, percentages reflect the proportion of people with that material who share it (e.g., of the 85% who have personal items, 27% share them). Respondents then described what steps they took to limit access to these sensitive files (n=22). People described their approaches in a free-form response and could list multiple methods. Their responses are categorized in Table 5.

Type of sensitive material	I have this material	I share this material
personal items that you wish to keep private (e.g., email)	85%	27%
personal financial or medical information	79%	11%
professional data or documents sensitive to your work organization	75%	44%
professional data or documents governed by law/regulation	52%	28%

Table 4: sharing of sensitive material

Method of protection	% of people using this method
Passwords	19%
Obscure filenames and/or location	14%
Limit physical access to computer	14%
Access control lists/file permissions	14%
Firewall	11%
other (e.g., file encryption; securing operating system; private user account)	6% or less

Table 5: methods for protecting sensitive files.

Respondents indicated whether they had accounts on shared computers (i.e., with other user accounts), and whether they had private items on this computer (n=58). Eighty-three percent used a shared machine; of these, 54% had private items and 44% did not. (One person did not know.)

Respondents indicated how often security and privacy were a concern when sharing files, using a five-point scale ranging from “very frequently” to “never”. Sixty-four percent stated that this was a concern at least “sometimes.” (Twenty-two percent were concerned “very frequently.”)

Managing Limits on Shared Files

Another set of questions dealt with managing boundaries around shared files, such as file permissions. Eighty percent of respondents had configured file permissions (n=60); 63% configure permissions at least once per month, and 42% do so every week (n=57).

Respondents also described their reasons for reconfiguring permission settings; they were given a list of reasons and chose as many as were applicable (n=42). The most common reasons are listed in Table 6.

Reason for change	% who encountered this situation
needed to restrict access after temporarily sharing file	64%
file that was not being shared needed to be shared	60%
file that was being shared shouldn't be shared anymore	52%
an error had to be corrected	52%
needed to relax limits after temporarily restricting access to file	36%
set of people to share file with changed	31%

Table 5: reasons for resetting permissions

Respondents next selected the type of sharing error—too restricted or too open—that they most recently corrected (n=46). Sixty-three percent had permissions set too tightly, while 35% had permissions that were too open. They were next asked how long the delay was in discovering and fixing the most recently-encountered error; they selected from a list of times, ranging from “immediately” to “years”, as well as “unknown.” Twenty-three percent said that they did not know when the error was made, and a further 30% reported delays of at least hours.

Respondents also described how they managed limits (if applicable): whether they mainly placed limits around individual files, or around groups of files (e.g., put files in a controlled folder), or used both approaches equally (n=48). The majority—54%—placed limits around groups of files, with 17% placing limits around individual files and 29% using both approaches equally often.

Information about Sharing

Respondents were next asked about the types of sharing information they might wish to know about, and how confident they were that they knew what files were being shared. These questions were derived from those of Volda et al.[10], and consisted of five-point Likert scales, where “strongly agree” corresponded to a score of five and “strongly disagree” to a score of one. The questions, with the mean for each, are in Table 7 (n=79).

Knowledge about sharing & shared files	mean
I am generally aware of all of the files that I am sharing and with whom I am sharing them.	4.0
When I share my files, it is important to me to know exactly who has access to the files.	3.8
When I share my files, it is important to me to know when others are using the shared files.	3.0
I would like to be able to know who was using each file.	3.3

Table 6: knowledge about shared file settings and activities

Summary

Not unexpectedly, we confirmed that file sharing is a common activity, with over 70% of respondents sharing work and personal files at least once per week. Many types of sharing tools were used: on average, about six types. The most popular of these was email, with networked folders a distant second; this corresponds with the findings of Volda et al. [10] and our previous study [11].

Results show that there are a number of factors influencing the choice of sharing method used. Major factors are convenience and ease of use, which were cited across several different types of sharing mechanisms. People also needed to be able to reach recipients (sometimes across organizational boundaries), so they needed a method that was available to all parties. Another important factor was the suitability of the method to the organization or task at hand. There were also a number of drawbacks identified, such as limits on file space, lack of security features, and the inability to reach all recipients.

Our respondents shared with multiple groups: the vast majority reported sharing with between two and four groups. In addition, most respondents needed to share the same item with multiple groups: 71% of them reported doing this at least “sometimes.”

Sensitive materials were commonly used by our respondents, with 80% having such files on their computers. These materials were also shared, to some degree: 44% of respondents with professional files shared them with others, although only 11% of people shared their financial or medical information. People used a variety of methods to control access to these files; some are technical (passwords and permissions), but others are socially-controlled, such as hiding files.

In accord with our previous findings [11], file permission management was a task that most respondents engaged in. Eighty percent had experience with setting permissions with the majority (63%) performing this task at least once per month. Permission settings were also dynamic; the most common reason for resetting permissions was because of a temporary sharing situation, after which sharing was restricted.

People took different approaches in terms of placing boundaries on objects: some clustered files together, some managed limits around individual files, and some did both. This indicates that shared files might not always be grouped together in the file system; for many users, they are likely to be scattered in various directories. (This is especially true for files that are sent as email attachments; it is unlikely that all attachments originated from the same directory.)

Our respondents reported encountering errors with permission settings; approximately half of our respondents needed to correct such an error. Permission errors were also not always quickly detected: 23% of respondents who corrected an error stated that they did not know when the

error was made, and a further 30% reported a delay of at least hours.

We also saw evidence that users wanted to know about shared file activity (such as who was using a file), and to be sure that they knew who had access to files. As in Volda et al. [10], although our respondents self-reported a high degree of awareness of what was shared, and with whom, this may not be an accurate result. For example, many respondents discovered errors in their settings after some delay, which suggests that awareness was lacking. In addition, respondents described the dynamic nature of file sharing, with changes in groups and materials requiring settings to be updated (e.g., to accommodate a new group member).

DISCUSSION: GROUP INFORMATION MANAGEMENT AND FILE SHARING

The goal of this study was to characterize file sharing, particularly in terms of task frequency, methods used, and recipients. Our results are relevant to designing for group information management, as they reveal some of the practices that have been adopted as standard practice and some of the major issues with managing shared files.

Our survey identified several key attributes of file sharing. Email attachments are the most widespread, and the most common, method for sharing files. It has a number of advantages, chief amongst which are convenience and availability, but also the ability to add context regarding the file in the form of the email message content. It provides a flexible means for accessing diverse groups of people, both within and outside an organization, and is well-suited for short term collaboration (e.g., one-time file transfers). These strengths indicate that email is likely to remain a dominant sharing tool for some time, and necessitates the invention of a technical solution to manage this process.

Although email is the dominant sharing method, people use multiple methods to carry out sharing and sometimes use different methods even when sharing the same file. Users choose the method(s) most suited to their task, and there are a variety of factors that influence their choice. It is very difficult (if not impossible) to support various sharing requirements using a single mechanism. First, it is harder to keep track of sharing activity, since it is carried out in multiple applications. Second, users need to correlate activities between different applications, since they all contribute to the overall sharing task. A user may, for example, need to know that one file was sent through email and another through an instant messenger program, but that they went to the same person (under different identities/ usernames).

We also wished to discover how people managed limits around file sharing, focusing on security concerns and the difficulties that users encountered. Security was a central concern for many users who share files (and like the examples discussed the introduction highlight a significant

concern for systems managers). Many users possessed and shared sensitive files, and stored confidential files on machines shared with others. Both of these situations require the management of boundaries around access, to ensure the maintenance of confidentiality. We also saw that errors were made in configuring these boundaries, which indicates a need for more usable access control.

The dynamic nature of file sharing means that limits change over the life of a file; our respondents indicated that they often shared temporarily, or had to reset permissions due to changes in team membership or shared materials. This dynamic environment required users to keep tabs on access to shared files. For example, it is difficult to remember when a reset is required, which could be rectified by event-based notification to serve as a reminder. A user may need to open a directory temporarily to allow a person to download a file; it would be helpful to provide notification when that action occurred, so that the permissions could then be immediately reset, or automatically reset once the action takes place.

Another survey goal was to determine what types of information about file sharing, and file sharing settings, would be helpful to present to users. Our results suggest that there is insufficient information about file sharing being provided to the user. Our respondents indicated a desire to know about activity on shared files; particularly, to know who used them. In addition, people wanted to be sure that they knew who could access their files. People also interacted with different groups; this suggests that it could be helpful to support viewing sets of files associated with different groups, in such a way that it was made clear which files each group had access to.

FUNDAMENTAL DIMENSIONS OF FILE SHARING

These survey results characterize many aspects of file sharing, such as the “who, what, when, and how” elements that define this task. These results presents a snapshot of current practice, revealing a number of elements that had not been previously explored or verified. These results can also be plotted against the dimensions of file sharing identified in Figure 1. We explored in detail how people used sharing mechanisms (e.g., frequency of use), including both shared channels (email) and shared locations (folders). The survey also described relationships between senders and receivers (e.g., attributes of sharing groups), as well as the management of access rights on files (e.g., file permissions). Our results highlighted the need to support the sender in interpreting information from the system, so that sharing could be carried out correctly and effectively.

Clearly, people used both shared channels and shared locations, depending on their needs; the same file was shared using different methods. This complexity makes it difficult to keep track of shared files, since the user needs to go back to each application (and possibly to different folders) to identify which files have been shared and with whom. In addition, users must have knowledge of the

actions that have occurred on shared files so that they can identify whether the settings are correct; for instance, if an unknown user reads a file, this may indicate that the file has not been properly protected. The survey showed that people encountered errors in file permissions (sometimes after a long delay), and they were not cognizant of the actions that had been taken on shared files.

Maintaining a history of sharing an object has benefits both for security and for collaboration. For example, if an error is made, and a file is made too public, it would be helpful to know whether anyone had accessed that file while it was exposed; the degree of “damage control” depends on the degree of exposure. In collaboration, it can be useful to see what sorts of group sharing took place over time: if a new member joins a group, it may be necessary to determine which files were shared over the last year, to ensure that the newcomer is given access to all the relevant documents. (This set of documents might include, for example, some files sent over email, as well as files in shared folders.)

Other information that could be useful is notification, to allow users to keep track of changes in the system. For example, we observed that people needed to allow temporary sharing. In these cases, it might be beneficial to send an alert after a certain action was detected (such as a file being downloaded from a shared directory); the user could then have a reminder about a necessary reset. A person might also want to monitor specific sensitive files, so that they could be aware of unexpected activity. Another useful notification would be when access was denied: this could be due to a mistake, or to an intrusion.

Presenting sharing information in a clear fashion is also important. There may also be many different items shared, in multiple contexts; it would be helpful to allow a user to create a customized view that shows only the most relevant information: for example, “all files shared with Bob”, or “all accesses on report.doc in the past 2 months.”

We explored these ideas of information presentation in follow-up work. We adapted research from the domain of computer-supported cooperative work, particularly in workspace awareness (e.g., [6, 7, 9]), to determine what types of information to present, and how to assist users in becoming aware of this sharing information. We will not detail this theoretical work here, but will outline some of the elements that we determined were key for supporting user awareness for shared file management.

DESIGNING FOR SHARED FILE MANAGEMENT

Our goal is to allow users to perceive and comprehend information about shared files. Of greatest relevance in this context are presenting data from the environment (e.g., “who can access this file?”); of providing extensive history information (such as event and artifact history); of supporting event notification; and of supporting individualized views (e.g., “show all files available to, or sent to, Alice and Bob”). Note that file sharing events and settings can be incorporated into file metadata. In this way, a file accretes information about its “sharing” aspects, which can be used for queries and for archiving an extensive history of interaction and transmission.

To operationalize these ideas, we developed a prototype file manager (illustrated in Figure 2) that displays additional

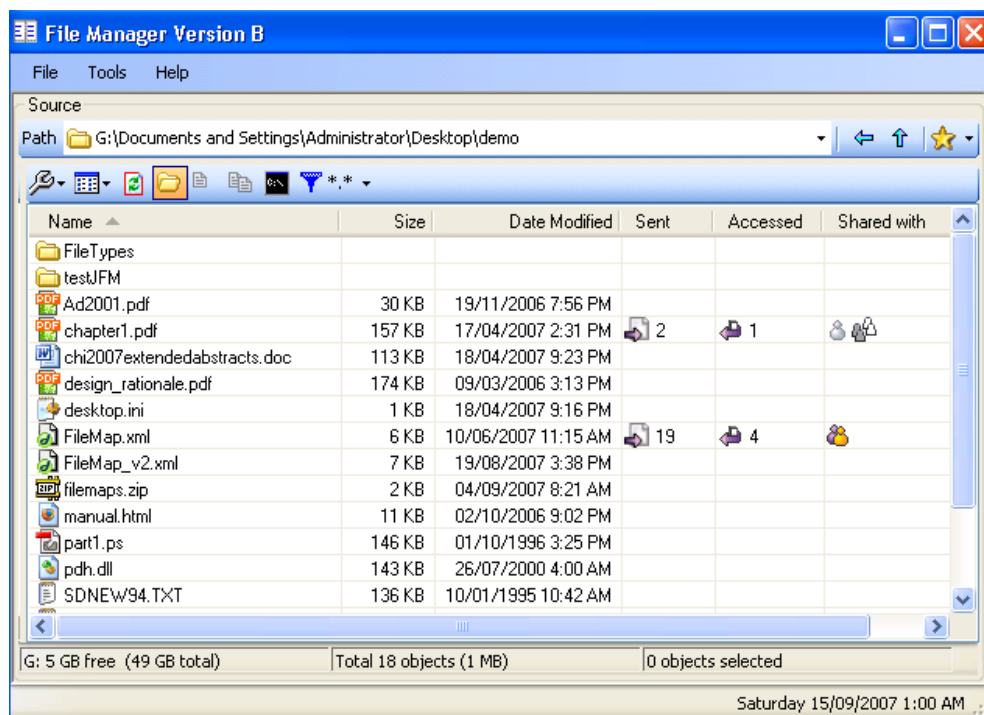


Figure 2: prototype file manager, with additional information on file sharing

information relevant to sharing, and includes a console for gathering additional details as required. The file manager shows how many times a certain file has been sent (e.g., over email or IM), as well as accessed (e.g., in a folder), and shows file permissions. A small amount of additional detail is available in mouse-over pop-ups (infotips), such as details of the last “send” event (e.g., to whom, method, subject line). This file manager allows a person to have background awareness of sharing-relevant information, which they can view while they complete other tasks.

If a person needs more detail, however, they can call up a console which gives the complete sharing history on a file, and lets them craft a query for listing files matching certain criteria (e.g., “all files emailed to bob@company.com”). This is similar to the folderless desktop searches supported by Google Desktop Search [5] or Microsoft Research’s PHLAT tool [3], but incorporates file sharing metadata as additional information. The console also allows a user to set alerts for events relevant to file sharing, such as being notified when a certain user accesses a file. Our designs have been refined through a user-centered design process, and we are about to commence formal lab evaluations.

THE DISAPPEARING DESKTOP AND SHARED FILE MANAGEMENT

Although our design efforts have focused on desktop-based solutions for presenting information, the basic approach of collecting and displaying metadata about shared files is very relevant for the “disappearing desktop” environment that many users encounter. For example, returning to the basic model in Figure 1, we have shown one person sending to others; in fact, sometimes the “other” is oneself in another context or environment. Take, for example, the case in which files are copied to a USB drive or web location so they can be accessed for work from home. This can be considered as a type of file sharing, in which the user needs to make files accessible, possibly needing to circumvent technical limits to do so.

If metadata on file transfers and copies was collected, this could help a person to keep track of where a file is (and has been) located; trying to remember such information, particularly in multiple contexts, is quite difficult. This situation makes it harder for a user to recall, for example, whether a file was copied to a shared drive or whether only a personal copy was made. It is also helpful to have a complete history in the event of an information leak; knowing whether a file had been copied to a lost USB keychain could help determine whether sensitive files had been exposed.

In summary, there are many benefits to be gained by collecting and displaying extensive file sharing information, including current settings and detailed histories. In addition to facilitating secure information exchange, it can assist in

navigating the complexities of group information management, across multiple environments.

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