# Inter-Personal Browsing: Supporting cooperative web searching by face-to-face sharing of browser pages

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**Abstract:** We are studying a framework that facilitates the gathering and sharing of information in group work situations where several people are working on multifaceted problem-solving or emergent tasks by cooperating and sharing the workload. In particular, we are developing a framework for the smooth sharing of public information to stimulate debate while maintaining the focus of the group's web searching activities and confining private information on the PC screens of individual users. In this paper, we report on the implementation of Inter-Personal Browsing - a framework where each user has a small shared display in addition to the PC display, and can use this to share web browser screens with other users. Having introduced this system into a mechanism for practical learning of group work methodology, we introduce the results of studying its effectiveness from the viewpoint of information sharing and communication.

(a) A user's iPad automatically displays the window of the web browser running on the user's own PC.


(b) A user can receive pages by touching other's iPad.

Figure 1 Concept of Inter-Personal Browsing

## Introduction

In the fields of education and business, there has been renewed recognition of the importance of group work, where several people work on multifaceted problem-solving or emergent tasks by cooperating and sharing the workload. Recently, there have also been greater opportunities for people to bring laptops or PCs into group work situations, but in this case the attention of users is drawn towards their individual computer screens, thus depriving them of the communication opportunities that group work is supposed to provide. One possible reason for this is that the screens of other people's laptops and PCs are highly likely to show private information, which can make people feel apprehensive about perusing someone else's screen. However, having people direct their attention entirely toward their own computer screens is undesirable with regard to facilitating the exchange of information in group work situations. We have therefore been looking into ways of addressing this situation by using such means as projector displays to produce large-screen public displays that are shared by all the members of a group, or by using terminal displays whose orientation can be changed, such as iPads. However, this sort of approach can lead to problems such as private information being displayed on a large screen, or information only being publicized to a subset of the group members, or to users having to go to the trouble of changing the orientation of their terminal screens.

Against this background, we considered that a new framework is needed to facilitate the sharing of public information that can stimulate debate in group work situations while keeping private information confined to the computer screens of individual users, without the need for intentional operations to be performed by the users. In particular, we focused on web browser windows as a source of information to be made public in group work performed using PCs. Recently, web searches have been often used in group work on PCs, especially at the investigatory stages. According to Morris (2008), 97.1% of people have taken part in joint web searches, but over 80% of them used inefficient methods for sharing their search results, such as looking at the screen over the other person's shoulder, sending search results by email, or sharing the screen display by turning it towards the other person. We therefore used iPads and browser extensions to implement a mechanism that satisfies three conditions: (i) only the browser window is made public as shown in Figure 1(a), (ii) it is easy for users to access the search results of other users in their own PC as shown in Figure 1(b), and (iii) this framework can be set up instantly without having to introduce any special equipment. Since this framework supports website browsing between multiple individuals, we called the proposed system Inter-Personal Browsing.

In this paper, we first present a detailed introduction to the Inter-Personal Browsing system that we implemented from this viewpoint. Then, by using this system in a group work situation, we compare its performance with group work performed using existing information sharing tools such as notes written on paper and Google Documents shared via PCs, and we study how this system changes the nature of the group work, such as the ease with which information can be shared, and the degree to which it stimulates communication. We conducted verification trials to test these effects in a practical work group lecture.

## Related Works

Systems that support joint web searching have mainly used either a shared display such as a computer screen, or a tabletop device.

Systems implemented using a shared display include SearchTogether (Morris & Horvitz, 2007) and CoSearch (Amershi & Morris, 2008). SearchTogether is software that allows multiple users in remote locations to use a single shared display to perform searches, and includes features such as a text chat function, individual user search history displays, and a search results display window. CoSearch is an enhanced version of SearchTogether, but unlike SearchTogether it assumes that the users are all situated around a single computer. Although shared display systems make it easy to share information and provide information with better clarity, they have drawbacks such as being unable to secure adequate workspace for each user, resulting in poorer individual work efficiency.

Tabletop systems include WeSearch (Morris et al., 2010) and WebSurface (Tuddenham et al., 2009). These systems exploit the space and interactivity offered by a tabletop workspace. An experimental study comparing the execution of collaborative tasks on personal devices and on a tabletop device (Heilig et al., 2011) has also confirmed that people are more likely to interrupt and engage in the actions of other users' actions when using a tabletop device. Tabletop systems eliminate the drawbacks of shared displays, but their high cost and lack of portability have impeded the introduction of these systems.

New trends have also emerged recently. These include frameworks that facilitate the integrated use of heterogeneous devices, and PCs equipped with double-sided displays. The former approach makes it easier for individuals to obtain the information they need in a system where it is possible to use tabletop displays and mobile displays in combination with each other (Doring et al., 2010; Seifert et al., 2012). However, it fails to address issues such as the drawbacks and high cost of tabletop displays. On the other hand, the Asus Taichi (a laptop PC that went on sale recently) is equipped with a double-sided full HD IPS display. This offers an inexpensive way of displaying information on the front (facing the user) and back surfaces of a display, but does not allow the user to select specific information on the screen and have just this information displayed on the back surface. This makes it difficult to share information safely.

The Inter-Personal Browsing system proposed in this paper tackles these issues from a different viewpoint by employing a simple configuration whereby users install a browser extension on the PCs they use every day, and they each have their own iPad for use as a public display.

## Inter-Personal Browsing

This paper summarizes the Inter-Personal Browsing framework, where private information is kept on the user's individual PC, while public information that can stimulate discussions in the group work is displayed on a separate web browser screen. First, after describing the concept of an individualized public display, we present a detailed discussion of Inter-Personal Browsing.

### Individualized public display

When a projector or the like is connected to a PC's external display terminals, it is generally operated either in a "mirror" mode where the PC's screen (main display) and the shared screen (external sub display) display the same content, of an "extension" mode where they each provide separate displays. For example, if private information is shown in a mail application and public information is shown in a browser application, then the content of the mail application would be displayed to others on the shared screen in the mirror mode. Also, in the extension mode, when a browser is displayed on the shared screen, the user is forced to constantly work while looking at the shared screen. Instead, this paper proposes a method where the mail and browser applications continue to be displayed on the PC screen in the normal way, while a mirror of just the browser window is displayed on the shared screen. These relationships are summarized in Table 1.

Table 1 Information presentation concepts in the proposed method

| | PC screen (Main display) | Shared screen (External sub Display) |
|---|---|---|
| Mirror | Mail, Browser | Mail, Browser |
| Extension | Mail | Browser |
| Proposed method | Mail, Browser | Browser |

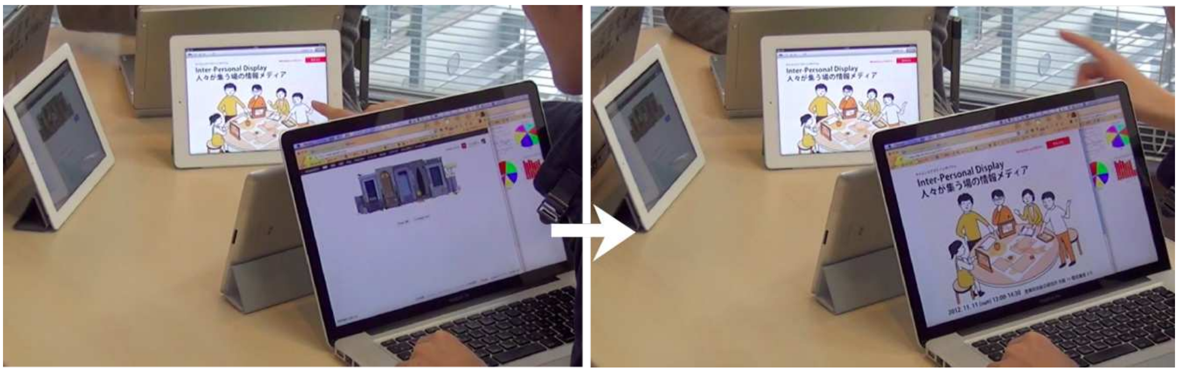
In this paper, a shared screen is owned by each individual user. This is called an individualized public display. By using the individualized public display to show only a mirror of the browser window, users can check each others work status without having to exercise restraint, resulting in group work with smoother communication.

## System overview

In this paper, we used iPads to implement the individualized public displays discussed above. Figure 2 shows the configuration of the Inter-Personal Browsing system.

A user's iPad automatically displays the window of the web browser running on the user's own PC, and is automatically made available for sharing at the location of the group work. However, as shown in Figure 2(a), this is not implemented as a simple screen copy, but by running a separate browser in the iPad to show the content of the same URL. Next, as shown in Figure 2(b), an iPad is placed beside each user in addition to the user's own individual PC so that it can be seen by other users. After making it possible for users to keep track of each other in this way, the next important requirement is to make it possible for users to interact with the system in order to transfer information from another user's public display to their own PCs. To allow group work to proceed smoothly while sharing information, it is important to make it easy for users to transfer pages to their own PCs where they can view them in more detail without interrupting the work of other users. For this purpose, we implemented a mechanism whereby a user can use the iPad's touch input functions to receive pages without anyone else's involvement. Specifically, as shown in Figure 2(c), this is done by touching the other user's public screen (iPad) while holding down a control key. To implement this function, we require a framework for specifying the PC of a specific user out of multiple other users. It is also essential that it is implemented in a way that does not require users to use a specific platform or operating system.


(a) Sharing a URL on an individualized public display (b) System arrangement



(c)Turning pages by touch input

Figure 2 System Configuration of Inter-Personal Browsing

### System implementation

In this system, mirror displays on iPads and the transfer of information to other users is achieved by transmitting URLs between the iPads and web browsers. We used browser extensions to allow the system to be used in a wide range of PCs and operating systems, and we also implemented an iPad application to work with these extensions. We set up a server to centrally manage the flow of information between PCs and iPads to facilitate many-to-many communication, and the communication was all routed via this server. The display of web pages on the iPads was implemented by transmitting a URL to the iPad every time the browser loads a new page. With a browser extension API, we capture an event whenever a new page is loaded in the browser, whereupon the URL of the new page is transferred to the iPad. Communication is implemented by HTTP between the browser and server, and by socket communication (TCP) between the server and iPad. The procedure is as follows.

(1) Fetch the URL of the web page displayed by the browser.
(2) This URL is sent to the server, and is transferred from the server to the iPad.
(3) The same page is then displayed on the iPad.

The web page transfer function is implemented so that when the receiving user touches the iPad, the URL displayed by the iPad is transferred to the user's PC. For this to happen, it is necessary to identify which user touched the iPad. In this paper, as an interaction method for implementing this, we provided a framework whereby the user holds down the Ctrl key while touching the iPad in order to designate himself or herself as the receiving party. In this way, it is possible for multiple users to receive information simultaneously with a single touch operation. The processing procedure is as follows.

(1) The browser extension is used to report to the server when a Ctrl key is pressed.
(2) When an iPad is touched, its URL is transmitted to the server.
(3) The server identifies the users that are pressing their Ctrl keys.
(4) The URL information is sent from the server to the browsers running on the individual PCs of these users.
(5) On receiving this URL information, the browsers open the URL in a new tab.

The browser keypress events are implemented using the browser extension API, and the iPad touch events are implemented using the iOS API. For the communication of URLs, it is necessary for them to be transmitted from the server to the clients. In the communication systems currently available in web browsers, support for server-to-client communication is provided by Comet and WebSocket web technologies. Comet uses HTTP communication to achieve artificial bidirectional communication. Although WebSocket is faster and generates lower server loads, it is still relatively new and its specifications are not yet fixed. We therefore decided to use Comet in this system.

## Verification of concept

To examine how the quality of group work is changed by using Inter-Personal Browsing proposed and implemented in the above way, we performed group work tests using Inter-Personal Browsing in a lecture course that we are currently teaching. This lecture course is called "Groupwork of the future - future classroom technology", and is being taught as part of the 2012–3 masters course at Tokyo University. Its aim is to provide practical education in the use of digital tools and group work methodologies, and it comprises 13 lessons targeting 9 undergraduate students.

The specific aim of practical research through this course is to use Inter-Personal Browsing in a comparative study to see if it changes the quality of group work with regard to communication and the sharing of information. For comparison, we also provided group work based on notes written on paper (paper-based group work) and group work using existing digital information-sharing tools like Google Documents (https://www.google.com/intl/en/drive/start/index.html) and Dropbox (https://www.dropbox.com/home) running on PCs (PC-based group work). The PC-based group work differed from paper-based group work in that it was able to handle larger quantities of information and made it easier to share resources such as the results of the group work. However, it also resulted in less communication because the users' attention was directed toward their computer screens, and it was difficult for them to share work processes. Our study focused mainly on the issue of whether the introduction of Inter-Personal Browsing, where information can be shared easily with the browser window, causes any changes in communication or information sharing (especially during the investigation process). The details of these discussions and our findings are summarized below.

### Overview of the proof-of-concept experiment

In this experiment, group work was performed using three different tools, and a combination of behavioral observation and questionnaires was used to clarify the level of communication activity and the ease with which information could be shared during the examination phase of the group work. Since this experiment was performed in tandem with lectures, it was difficult to maintain absolute control over the tasks, and the tasks performed using each tool were also different. This approach was adopted because our purpose here is to clarify the general feasibility of Inter-Personal Browsing (IPB) through practical experience. The first tool was paper, and users were given the task of creating a billboard for the Nikkei newspaper. In this task, the users had to decide which articles were worthy of inclusion, summarize these articles, and create the final layout. This is called method 1. The second tool was a combination of paper and PCs, and users were given the task of creating a time-line of a celebrity's career. In this task, it was necessary to determine which aspects of the celebrity's career should be included in the time-line (e.g., awards won by the celebrity), gather data on the celebrity's name and active time period, and then assemble this information in a time-line where it can be easily understood. Here, the PCs were used to access Google Documents as an online document creation tool and Dropbox as an online storage tool. This is called method 2. The third tool was a combination of paper, PCs and IPB, and users were given the task of designing the interior of a shared house for female college students. In this task, the users had to clarify their target residents (which area they live in, what their interests are, etc.), put forward concepts that these residents might like, create a collection of interior furnishings needed to realize these concepts, and produce summaries of these concepts together with costs and images. This is called method 3. In each system, the group work was performed over three sessions of approximately 90 minutes, including time for practice, presentation, review and so on. The nine students were split into two groups, and the members of these groups were replaced for each method.

To perform a comparative study of the quality of group work in each of these methods, we first observed the state of communication in each group by having on average about two observers constantly watching each group. The observers concentrated on group characteristics such as the amount of conversation, lines of sight and seating arrangements (the students were instructed to arrange the desks and chairs and move around as much as they wanted in order to facilitate communication). The last ten minutes of the lecture was designated as a review period in which the students were asked to complete questionnaires. As shown in Table 2, the questionnaire included two questions where students were asked to reflect on the level of activity in the discussions. Next, in methods 2 and 3, we used the separate questionnaire shown in Table 3 to compare the ease of sharing information during the examination phase with and without Inter-Personal Browsing.

## Results and discussion

### Communication

To examine the effectiveness of communication in the group work, the students in methods 1, 2 and 3 were asked to complete the two questions shown in Table 2.

First, with regard to the all questionnaire of Table 2, in methods 1 and 3 the students responded that they had all actively participated in the group work and that the group itself facilitated active discussions, suggesting that active communication had taken place. On the other hand, in method 2 where group work was performed using PCs, some students responded that they had been unable to participate actively in the group work or play an active role in discussions (38% answered "No" to Q1-1 "Did you actively participate in the group work?" and 63% answered "No" to Q1-2 "Were there active discussions in your group?"). There were students who gave this response in each group.

From photographs of the discussions, we can see that in method 1 (Figure 3(a)), the students took steps such as moving the desks around so they could speak more easily with the other students, and in method 3:IPB (Figure 3(c)) they were also seen to lean across the desk while in conversation. The amount of conversation itself was found to be large. However, in method 2 (Figure 3(b)), the students continued to direct their gaze at their computer screens even when carrying out the actual work itself, and there was less conversation than in methods 1 and 3.

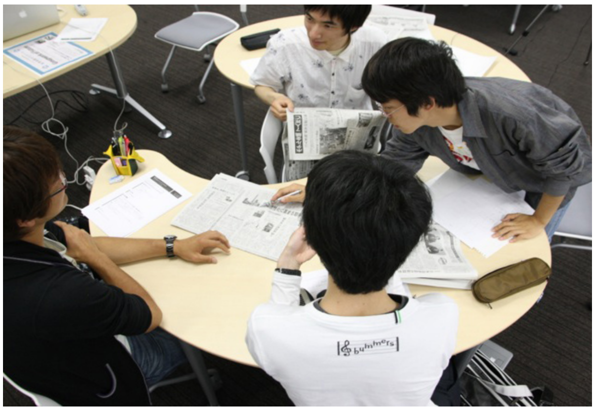
These findings suggest that the use of Inter-Personal Browsing allows for more communication than existing PC-based group work, and a high level of activity close to that of traditional paper-based group work.

### Sharing of information

For a more detailed consideration of the sharing of information in the examination phase of the group work, the students in methods 2 and 3 were asked to complete the three questions shown in Table 3.

First, in method 2, most of the students were concerned about what the other students were examining during the task (88% answered "yes" to Q2-1 "Were you concerned about what the other students were examining?"). On the other hand, in the question relating to how students ascertained what the other students were doing (Q2-2), we received a number of similar responses such as "I just looked at the comments on shared sheets in Google Document". Moreover, in the question about issues experienced when sharing what the students had examined (Q2-3), we received responses such as: "It was difficult to find out what the other members were studying, or how much, so I didn't know how far I should go with my own study", "We were all working at the same time, and ended up studying the same things", "It took longer than I expected to share things, and it was hard to ascertain straight away what the others were doing". That is, in group work conducted as in method 2 where information is shared via services such as Google Documents and Dropbox, it is difficult for people to share what they are studying in real time, so people do not know how much progress the others are making, it is difficult to split tasks up because people are unaware of how much progress the others are making, and a number of the students felt that the task took longer than it should have. A possible explanation of how this situation arose is that when people used Google Documents, they were focused on the screen so much that they did not notice what the others were doing. This would have made it harder to know who had provided each bit of information, thereby depriving the users of opportunities to talk to each other.

In method 3, as in method 2, most of the students were concerned about what was being studied by the other students during the task (88% answered "yes" to Q2-1"Were you concerned about what the other students were examining?"). In the question relating to how students ascertained what the other students were doing (Q2-2), we received a number of similar responses, including "When someone found an interesting site, they said so, and the other members used their iPads to display and assess this site on their own computer screens". Moreover, in the question about issues experienced when sharing what the students had examined (Q2-3), we received many responses such as "No, nothing in particular", but there was also a response that pointed out a problem with the system: "The page sharing sometimes didn't work properly". Consequently, in group work using Inter-Personal Browsing as in method 3, users can share information indirectly with one another, and can communicate verbally if there is something they want to convey to the others or something important they need to know. It is thus inferred that the students themselves were able to figure out a way of actively participating in the group work while switching between different channels of communication.



(a) Method 1: paper

(b) Method 2: paper & pc

(c) Method 3: IPB

Figure 3 The appearance of group work in each method

Table 2 Results from questionnaire 1 (average ratio of participating students who answered affirmatively)

| | Method 1 | Method 2 | Method 3 |
|---|---|---|---|
| Q1-1 Did you actively participate in the group work? | 100% | 63% | 100% |
| Q1-2 Were there active discussions in your group? | 100% | 44% | 100% |

Table 3 Results from questionnaire 2

| | Method 1 | Method 2 | Method 3 |
|---|---|---|---|
| Q2-1 Were you concerned about what the other students were examining? | – | 88% answered “yes”. | 88% answered “yes”. |
| Q2-2 How did you ascertain what the other students were examining? | – | 75% just looked at the comments on shared sheets in Google Documents | 88% used Inter-Personal Browsing and taught each other orally. |
| Q2-3 Did you have any difficulty sharing what you had examined? | – | 50% had difficulty finding out what the other members were studying. | 63% did not have no difficulty in particular. |

## Conclusion

We have proposed a framework called Inter-Personal Browsing that facilitates the sharing of information by displaying a web browser window on an individualized public display, and we have performed a proof-of-concept test as part of a practical lecture course in group work, in which we performed a comparative study of group work using this framework and other tools. Our results suggest that the proposed Inter-Personal Browsing facilitates more active communication than group work using ordinary PCs alone, and allows task processes to be mutually shared more smoothly. However, the proposed Inter-Personal Browsing still has several issues. For example, its framework currently only allows web pages to be shown to other users. On the other hand, when diverse tasks are performed by a group, there may be many other different combinations of applications that users want to keep private and applications that users would want to show to other people. In the future, we intend to provide greater freedom in the choice of applications and introduce a framework where users can take part in group work while diversely switching between information they want to show (public information) and information they want to keep to themselves (private information).

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