Paper-based Interface for Interpersonal Communication on the WWW

Olivier Liechti and Kenji Mase
ATR Media Integration and Communication Research Labs
Seika-cho, Soraku-gun, Kyoto 619-0288 Japan
{olivier,mase}@mic.atr.co.jp

Abstract

This paper describes the *Gribouilli Messaging System*, developed to support lightweight interpersonal communication. Focusing on domestic settings, the system aims to increase mutual awareness within "intimate" social networks. One system component, the *Gribouilli Pad*, allows its users to initiate communication by quickly scribbling notes (gribouillis) on real paper. It thus enables an immediate, flexible and very natural interaction. The notes captured by the *Gribouilli Pad* can be shared asynchronously with relatives and friends, via either email messages (push) or personal Web sites (pull). Additionally, the system is interfaced with mobile phone systems – it is therefore very easy to access and takes advantage of users *idle time*. A simple scenario first gives an overview of the *Gribouilli Messaging System*. Its hardware and software components are then described in more details.

WWWを使った個人的なコミュニケーションのための紙ベースインタフェースの提案

オリビエ・リヒティ　間瀬 健二
ATR知能映像通信研究所

インターネットの家庭内での利用を促進して親密な関係をもったユーザ間での相互のアウェアネスを高めることを目的とした，手軽な個人間コミュニケーションを支援する，Gribouilliメッセージシステムを提案する．送り手は，Gribouilliパッドと呼ぶ装置を使って，紙の上にはしり書き(フランス語でgribouilli) をすることで，メモを家族や友人に手軽に送ることができる．また，受け取った側は，電子メール(push型)や個人WWWサイト(pull型)を使って，メッセージを非同期に読める．さらに，携帯電話インタフェースを提供することで，いつでもどこでもメッセージを受け取ることが可能である．本稿では，利用シナリオとシステム構成について詳細に報告する．

1. INTRODUCTION

Most of the established Computer Mediated Communication (CMC) technologies were initially developed to support work-related activities. Some of them were later transferred into domestic environments. This is true for electronic mail, newsgroups and the WWW. However, there are also a few examples of applications developed specially to target home users. One example is the PostPet™ email client, where the main aspect is entertainment. Another example is the concept of "virtual postcard", which is now a service offered on many Web sites. Some of these sites have quickly become very popular and drive an enormous traffic.

In a previous article [10], we have discussed related issues in more details. Looking at the outcome of several ethnographic studies [7, 8, 15], we have drawn a number of guidelines for the design of domestic CMC technologies. These guidelines were applied in the *KAN-G* framework, which aimed to increase mutual affective awareness among relatives and friends. For that purpose, the system fostered the exchange and annotation of digital photographs, using an integrated collection of hardware and software components. The *Gribouilli Messaging System*, described in this paper, shares common goals with the *KAN-G* framework. However, it uses a different expression medium and integrates other kinds of devices.

Essentially, our main motivation is to make *interpersonal communication less constraining, more impulsive, and as result more frequent.* This motivation has emerged from our own experience with CMC applications. Of course, electronic mail and personal Web sites are already very useful in the home. They offer quick and cheap ways for relatives and friends to keep in touch, removing geographical and temporal barriers. But at the same time, they require substantial effort from their users, who often perceive their use as a burden. Writing emails or updating one's home page are time-consuming tasks.

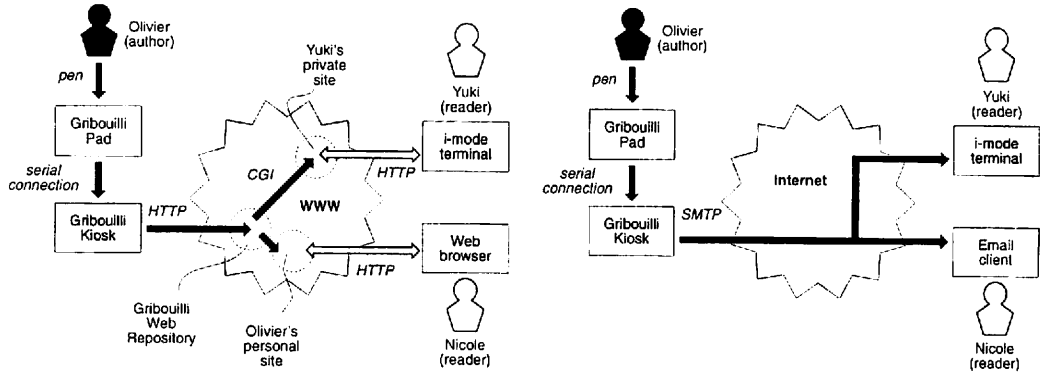

Figure 1. Overview of the *Gribouilli Messaging System* (push and pull)

As a result, people quickly stop using these tools, or at least do not use them as often as they *wish* they would. The ubiquitous communication infrastructure that virtually connects everyone to everyone, at any time and in any place, seems therefore not to be exploited very efficiently.

We believe that part of the solution to that problem is to offer complementary communication tools to home users. Instead of supporting *explicit* communication (i.e. conversations), these tools should rather focus on *tacit interaction*. That is, they should offer lightweight means for people to engage in shared experiences, or merely to exchange impressions and emotions. This approach has roots in the Computer Supported Cooperative Work (CSCW) literature, where the notion of *awareness* has been studied for a long time. Several systems have shown that even apparently insignificant information, when shared by a group, could increase the cohesion of this group and foster interaction among its members [2, 3, 9, 13, 14, 16].

The *Gribouilli Messaging System* takes his name from the French word "gribouilli". A gribouilli refers to a particular kind of drawing or handwriting. It is generally rather *small* and is drawn very *quickly*. It captures *one idea*, or a small number of related ideas. Gribouillis are often drawn almost *unconsciously*, as a peripheral activity. Think for example of a student attending a lecture and scribbling drawings without really paying attention to them. An example of gribouilli is what people write on Post-It™ sticky notes. Another example is what people draw in the margins of their books or notepads. Most people produce a *substantial quantity* of gribouillis in their daily life, *naturally* and *without any perceived effort*. Moreover, a gribouilli often reflects the *current state of mind* of its author.

The *Gribouilli Messaging System* was designed to exploit these interesting properties. It supports interpersonal communication by enabling the distribution of gribouillis created by individual users. One component in the system is a hybrid notepad, which digitizes pen strokes made on real paper. Electronic gribouillis can then be exchanged over digital communication networks. The system supports both *push* and *pull* mechanisms, via respectively emails and Web sites. The system is also interfaced with mobile phone systems, making it easily accessible for browsing – especially at times when users have nothing much to do, such as in public transportation or standing in a queue.

The remaining sections of this article are organized as follows. The second section gives a general overview of the *Gribouilli Messaging System*. With a simple scenario, it shows how users interact with various hardware and software components to exchange messages. The third section examines the system in more details. Its hardware and software components are presented individually. The fourth section mentions some of the related work. Finally, the conclusion summarizes the benefits and current limitations of the system. Future development steps are also mentioned.

2. THE GRIBOUILLI MESSAGING SYSTEM

In Section 3, we will describe the architecture of the *Gribouilli Messaging System* in details. In preamble, this section considers a simple usage scenario. The goal is to give a general overview of the system and to describe its functionality by identifying the different tasks performed by its users.

The architecture of the whole system is shown in Figure 1. Users fit into two categories: *authors* and *readers*. *Authors* create notes with a special device, the *Gribouilli Pad*. Through a user interface embedded in real paper, they specify how these

notes, or gribouillis, should be shared with the *readers*. The system supports two distribution modes, initiated when the *Gribouilli Pad* is connected to a *Gribouilli Kiosk*. Firstly, the author can publish the notes on the WWW, which then requires readers to *pull* information from the system. Secondly, the author can directly *push* the notes towards readers, via email. The choice for one of these two distribution modes depends on the application and on the user situation. It should also be pointed out that readers can access the system with *fixed* appliances, but also with *mobile* appliances (Web-enabled phones).

2.1. Usage Scenario

The following scenario is largely inspired from the first author's personal situation. His intimate social network is scattered across three continents, and he has been in a good position to appreciate the benefits – but also the limitations – of current CMC technologies for keeping in touch with his relatives and friends.

The first user, *Olivier*, is a Gribouilli *author* who lives in Japan. He owns a *Gribouilli Pad*, which allows him to take quick notes on real paper. These notes are automatically digitized and can thus be first transferred to a personal computer, and then shared over the Internet. *Olivier* also maintains a *personal Web site*, which contains both work-related and personal information. One problem with this site has always been the effort needed to update the information – and thus to keep it interesting for regular visitors. The *Gribouilli Messaging System* is addressing this particular problem. Indeed, gribouillis can be automatically published on his Web site, making its content very dynamic, with little effort.

The second user, *Nicole*, is *Olivier's* mother. She lives in Switzerland and owns a personal computer, with Internet access. She is not computer literate, but manages to perform simple tasks. For the last few years, *Olivier* and *Nicole* have exchanged almost daily *email messages*. This has helped them to maintain a "continuous" mutual awareness and has been a good complement to less frequent telephone conversations (which are more affective). However, the redaction of daily email messages has raised several issues. Firstly, even if it only takes a couple of minutes, this task is often perceived as a burden or a distraction. Secondly, the use of a personal computer severely restricts *when* and *where* the messages can be composed. The third problem relates to creativity and inspiration: *Olivier* and *Nicole* often have problems to come up with good content for their messages, which tend to be repetitive and unsubstantial. *Nicole* should benefit from the system, because *Olivier* is likely to compose more messages. Moreover, the specific nature of gribouillis, likely to be more spontaneous and affective, should be an interesting complement to email discussions. Also, *Nicole* will be able to receive messages from *Olivier's* son, *Sacha*. Because he is only one year old, *Sacha* is not able to write email messages. But he will certainly soon be able to scribble gribouillis with a pen.

Finally the third user, *Yuki*, is a friend of *Olivier*. She also lives in Japan and owns an *i-mode* Web phone – a mobile terminal interfaced with the *Gribouilli Messaging System*. As it was the case before, *Olivier* and *Yuki* try to keep in touch mostly by email. Yet, the situation is quite different than with *Nicole*, since there are fewer commitments between *Olivier* and *Yuki*. As a result, the negative factors previously mentioned have a more drastic impact on the volume of messages. Indeed, while they *could* exchange messages with *apparently* little effort, and so on a very regular basis, they do not. This is a problem experienced by many people, which highlights a paradox of digital communication technologies. The fundamental problem is that although the *actual* effort needed to communicate is quite small, the *perceived* effort is too high. As mentioned before, addressing this issue has been a foremost motivation for the design of the *Gribouilli Messaging System*.

2.2. Tasks

Task 1: Lightweight capture of notes

The *Gribouilli Pad* is a special device used to compose gribouillis. It looks like a regular paper notepad, with an apparently normal ink pen. This paper interface enables a very natural, flexible and spontaneous interaction. It is an example of what Weiser and Brown have called "calm technology" [16], one that "disappears". It makes the creation of gribouillis a very intuitive process, one that is also often impulsive and semi-attentive. When the user scribbles a note, he also has to specify how it should be distributed (i.e. to which Web sites and email recipients it should be sent). This is done by making marks in particular locations on the notepad (we will later describe these locations as Paper User Interface widgets).

The *Gribouilli Pad* is a mobile device, thus used in different places and situations. For example, *Olivier* can take it when he attends talks and meetings, when he commutes by bus, or when he watches television. These three situations have in common the fact that *Olivier* is relatively idle. While a certain level of his attention is required, he has enough spare *cognitive* and *physical* resources to compose brief messages as a peripheral activity. In other words, the system exploits the fact that interpersonal communication can sometimes be performed synchronously with other activities. The same property would be much more difficult to achieve with tools like email.

Task 2: Interactive validation and distribution

From time to time, maybe once a day, *Olivier* connects his *Gribouilli Pad* to his personal computer and presses his pen on the "Upload" button on the device. All his notes are then quickly transferred to the computer, and the *Gribouilli Kiosk Application* is automatically launched. This application displays the gribouillis, proposes an action for each of them (send or delete) and asks for the confirmation of the user. The interface is designed to make this process as fast as possible.

Of course, the gribouillis could be automatically processed and distributed, without any further interaction. When gribouillis are drawn on paper, the user specifies where and how they should be sent. But obviously, since no interactive feedback is given at composition time, this approach would not be very appropriate. The main issue is that users need a way to control what is published, *before* it is published. They need a way to verify that the system has correctly interpreted their input, and to *confirm* or *cancel* the actions proposed by the system. Without such a mechanism, many people would be reluctant to use the system, fearing that inappropriate material could be accidentally sent to third parties.

Task 3: Access via fixed appliances

Once a day, *Nicole* switches her computer on, establishes a network connection and launches a Web browser. Soon, she will not have to go through this lengthy process. Instead, she will use one of the Web-enabled devices embedded in her home, whether it is the fridge, the television or the phone. Anyway, once she has opened the browser, she can go to *Olivier's* personal Web site. On the *home page*, she can already see a couple of gribouillis – those that have been uploaded the most recently. Because they change regularly, it is worth visiting the site on a daily basis.

When she has time, *Nicole* can use other services provided by the *Gribouilli Messaging System*. That is, she can browse through the entire collection. For instance, she can sort the gribouillis according to different criteria, and search for particular information. Also, she can annotate some of the gribouillis. This enables a reciprocal communication flow, and thus supports *mutual* awareness between *Olivier* and *Nicole*.

Task 4: Access via mobile appliances

Every day, Yuki goes to work by train – it is actually quite a long trip, during which there is nothing much to do. But Yuki has an i-mode mobile phone, which gives her wireless Internet access. Using this phone, she can connect to the *Gribouilli Messaging System* and see what is going on with *Olivier*. For that purpose, she connects to his personal site, where a section gives access to pages specially formatted for i-mode phones.

As shown in Figure 1, Yuki also owns a personal Web site. And because she has several friends who own a *Gribouilli Pad*, she can use it as a personal repository (adding a level of indirection in the system). Indeed, it is very easy for her to create a page, where the gribouillis published by several people are automatically integrated (she only has to embed HTML fragments in her own home page). As a result, instead of having to visit the sites of all of her friends, she just has to connect to her "personal gribouilli collection" page. Doing this, she instantly gets a snapshot of her social network.

3. SYSTEM ARCHITECTURE

In the previous section, we have given a general overview of the *Gribouilli Messaging System*. This section examines the system in more details. It first describes its hardware components, then its software components.

3.1. Hardware Components

There are four main hardware components in the *Gribouilli Messaging System*. Firstly, the *Gribouilli Pad* allows its users to compose notes. Secondly, the *Gribouilli Kiosk* provides network connectivity and interactive services. Thirdly, the *Internet* and the *WWW* provide the communication and storage infrastructure for the messages. Finally, *fixed and mobile Web-enabled appliances* are used to browse through gribouillis collections.

3.1.1. Gribouilli Pad

The *Gribouilli Pad*, shown in Figure 2, is composed of two elements. The first element is a CrossPad™ "hybrid" notepad. A special pen (equipped with a RF transmitter) is used to digitize strokes made on real paper. The second element of the *Gribouilli Pad* is a custom-made paper notepad, placed on top of the CrossPad™, which pages contain various graphical and typographic elements (see Figure 3).

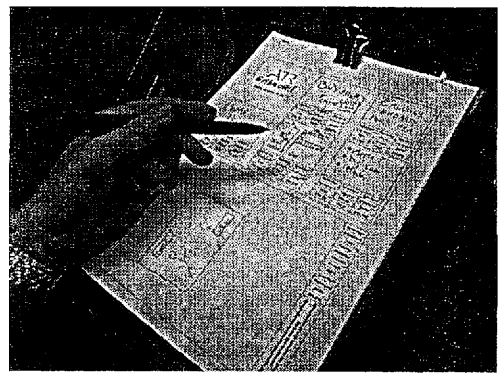

Figure 2. The Gribouilli Pad

These visual elements support some user interaction (asynchronously), and will be referred to as *Paper User Interface* (PUI) widgets. Some PUI widgets are used to capture information (equivalent to GUI input fields, checkboxes, radio buttons, etc). Others are used to trigger actions (equivalent to GUI push buttons). One page in the notepad, in other words one collection of PUI widgets, is referred to as a *PUI form*. In the first prototype, we have designed a unique and static PUI form. In other words, all the pages in the notepad are the same. However, we will explain later how we plan to extend the system by supporting the generation of dynamic and personalized PUI forms.

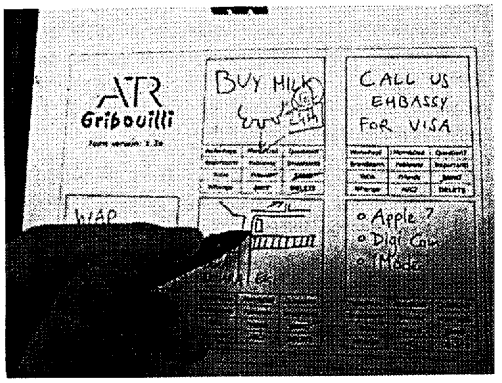

Figure 3. Close-up on the upper part of the PUI form

An overview of the form used in the first prototype is shown in Figure 4. There are six composite PUI widgets, named *Gribouilli Panels*. Five of them have the same size, the last one is about six times larger. As shown in Figure 5, every *Gribouilli Panel* contains the following PUI components:

- One *entry zone*, where the user can scribble notes and drawings.
- Four *checkboxes* used to specify the destination (on the *WWW*) for the content of the entry zone. The user has the choice between the following categories: "Home page", "Brainstorm", "To do" and "Nihongo". The last category is used to gather Japanese words and expressions heard by the user, e.g. during meetings or while watching television.
- Four *checkboxes* used to specify the recipients who should receive a copy of the gribouilli by *email*. Two of the choices correspond to *individuals*, the others correspond to *distribution lists* (friends and colleagues within the MIC2 department).
- Two *checkboxes* used to indicate the *nature* of the gribouilli, i.e. whether it contains a question, and whether it is important or not.
- Two *push buttons*. The "Send" button is used to validate the information captured in the panel. The "Delete" button is used to specify that the panel should be discarded, i.e. that the gribouilli should not be distributed.

Typically, the user starts by scribbling a note in one of the entry zone. He then makes a stroke in some of the checkboxes, and finally makes a stroke either within the "Send" or "Delete" push button. When a page is full, the user simply removes it from the notepad, to find a new one below.

The choice for the size and the number of the entry zones was motivated by the several factors. First, we have already said that the creation of a gribouilli is often impulsive, short, and that it encompasses one idea or concept. The size of the five small entry zones, similar to a Post-It™ note, seems appropriate for that purpose. Another factor is that some users access the gribouillis with mobile phones, which have small displays. It seems thus like a good idea to encourage the creation of rather small drawings.

On the other hand, only providing small areas would not be very practical. There are times where the user needs more space, for example when he takes notes in meetings. The larger entry zone in the lower part of the form was added for that purpose. The big advantage is that the Gribouilli Pad becomes the only notepad that the user needs to carry around.

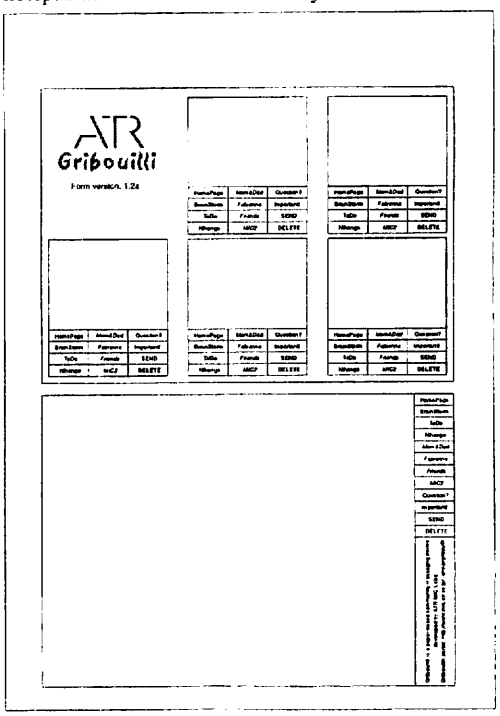

Figure 4. Static PUI form used in the first prototype

It is probably worth to point out at another device,

named the Decrio™. It uses the same technology for capturing strokes made on real paper (the CrossPad™ pen works with the Decrio™, and vice versa). However, the Decrio™ does not provide storage for the digitized strokes. Rather, it provides an IR connection, which is used to transfer the strokes to a nearby PalmPilot™ synchronously. The advantage is that this enables synchronous interaction. In other words, the user can receive an immediate feedback when he interacts with PUI widgets. A simple example would be to produce auditory notifications. We suspect that this might considerably enhance the usability of the device.

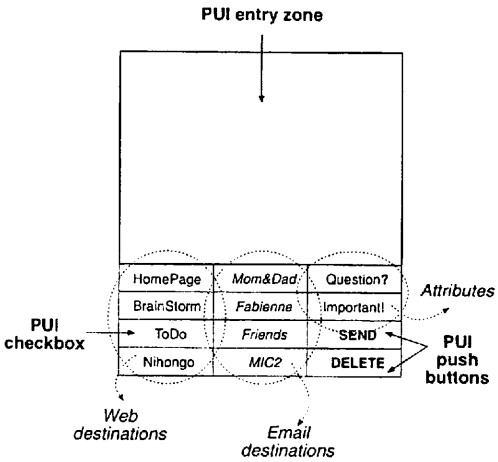

Figure 5. Gribouilli Panel PUI widget

3.1.2. Gribouilli Kiosk

In order to share the gribouillis captured by the *Gribouilli Pad*, the user needs to connect it to a *Gribouilli Kiosk*. As we have already mentioned, this component offers network connectivity. Also, it provides interactive validation services, through which the user can verify that his input has been correctly interpreted. The *Gribouilli Kiosk* essentially is a networked personal computer. The *Gribouilli Pad* is connected to this computer via a serial cable.

3.1.3 The Internet and the WWW

Of course, the *Gribouilli Messaging System* requires an infrastructure for *distributing* and *storing* the notes composed by authors. The Internet provides the communication infrastructure, which is now interfaced with wireless networks. The HTTP and SMTP protocols are used to send messages over this infrastructure. Of course, it is possible to use the system on any TCP/IP network, for instance on an Intranet. One might think of applications where notes captured on paper notepads would be shared among workgroup members. However, our focus is on domestic settings, and the Internet seems therefore a more relevant choice.

When gribouillis are sent by email, thus distributed directly to their recipients, the system does not need to provide any storage capabilities. However, the system also supports the creation of repositories, in which gribouillis are stored persistently. Readers can then access these repositories asynchronously, pulling information out of them. Web servers offer a natural and flexible solution for that purpose. In our current design, the gribouillis are first uploaded to a Web server that plays the role of central repository (shared by several users). Other Web servers can then be used to gather and integrate gribouillis from different sources, with one level of indirection.

3.1.4. Clients: fixed and mobile Web terminals

The clients used to access shared gribouillis simply are Web terminals. Of course, personal computers and workstations can be used for that purpose. Their displays make it easy to browse through large collections and complex HTML pages.

But one goal of the system is to be ubiquitously accessible, at any time and in any place (in order to take advantage of users idle time). This is indeed possible, thanks to Web-enabled mobile phones. Figure 6 shows how a note captured on the Gribouilli Pad is displayed on an i-mode phone. The Gribouilli Messaging System supports both i-mode and WAP terminals.

Figure 6. The i-mode Gribouilli client

3.2. Software Components

The *Gribouilli Messaging System* integrates three main software components. Firstly, the *Gribouilli API* is a collection of Java classes that facilitates the implementation of "semi-interactive" applications with the CrossPad™. Secondly, the *Gribouilli Kiosk* is an application implemented on top of the *Gribouilli API*, which main goal is to validate and complete the distribution of gribouillis. Finally, the *Gribouilli Web Services* are HTML templates and server-side scripts that provide an interface for accessing and navigating gribouilli collections.

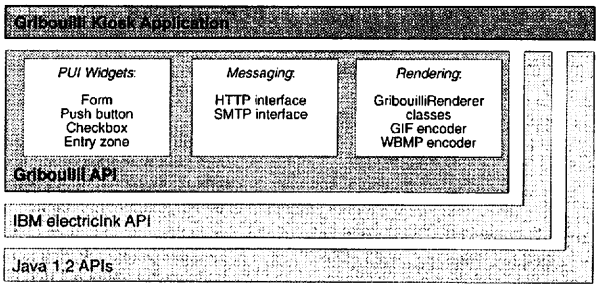

Figure 7. The Gribouilli API

3.2.1. Gribouilli API

Strokes captured by the CrossPad™ are stored in special files (ink files), which can be uploaded to a personal computer via a serial connection. An application running on the host can parse ink files to retrieve the strokes. The IBM Ink Manager™ is the application used by most CrossPad™ users, since it is distributed with the device. It supports the creation of personal notebooks, but is not oriented towards interpersonal communication. Moreover, custom applications can be implemented with the IBM Ink SDK, developed by IBM Research. The API is available in two flavors, C++ and Java. It integrates components for accessing and manipulating pages, scribbles and strokes. As shown in Figure 7, we implemented the *Gribouilli API* on top of the IBM Ink API. The main functions supported by the *Gribouilli API* are: i) a paper user interface architecture, ii) messaging and iii) graphical rendering and encoding.

Paper User Interface (PUI) Widgets

In the same way that GUI widgets are the building blocks of a Graphical User Interface, PUI widgets are the building blocks of a Paper User Interface. There are buttons, input fields, checkboxes, etc. But instead of responding to keyboard and mouse events, they react to stroke events, made on paper. PUI widgets can be assembled and interfaced with application logic, enabling the processing of a flow of strokes. From the developer's point of view, developing a PUI with the Gribouilli API is very similar to developing a GUI with the Java AWT – there are components, events, event listeners, etc.

Messaging

The API includes classes that make the distribution of gribouillis extremely easy for the developer. High-level interfaces are provided both for HTTP and SMTP.

Graphical rendering and encoding

A gribouilli is a set of strokes, which are in turn collections of points. It is of course very useful to be able to change the way a gribouilli is rendered. For instance, its size should accommodate the display on which it is shown (workstation vs. mobile phone). Also, it is sometimes interesting to add information within the gribouilli bounding box (such as the creation time or author name). Finally, it can be interesting to apply various visual effects to the strokes, for example to make them more aesthetically appealing. The Gribouilli API includes a GribouilliRenderer abstract class, which can be specialized to change the appearance of gribouillis. Moreover, the API includes classes for encoding gribouillis in several graphical formats, such as GIF or WBMP (the bitmap format used on WAP mobile phones).

3.2.2. Gribouilli Kiosk Application

We have already explained why it was necessary to ask for the confirmation of authors before distributing their gribouillis. The *Gribouilli Kiosk Application* was developed for that purpose. It is an interactive application, implemented on top of the *Gribouilli API*. When the user presses the "Upload" button on the CrossPad™, an ink file is transferred to the *Gribouilli Kiosk* and the *Gribouilli Kiosk Application* is launched automatically. The strokes are parsed and processed by the PUI widgets corresponding to the active zones on the paper form. As a result, a grid is presented in a window, where each cell corresponds to a gribouilli. The gribouilli is drawn on the screen, and the destinations specified by the user are presented in GUI checkboxes. It is thus possible for the user to change these parameters, before finally deciding to either send or discard the gribouilli.

3.2.3. Gribouilli Web Services

Once gribouillis have been transferred from the *Gribouilli Kiosk Application* to a *Gribouilli Web repository*, it is possible for readers to access them with a browser. The *Gribouilli Web Services* are HTML templates and server-side scripts, which support functions such as browsing, searching, and annotating. Some services target browsers running on

personal computers, others target browsers running on mobile terminals. The output of some services consists of *pages* encoded in a markup language (such as HTML, cHTML or WML). The output of other services consists of *images* (GIF or WBMP), and can thus be incorporated in other Web pages.

5. RELATED WORK

The *Gribouilli Messaging System* is related to two different categories of systems. On one hand, it shares common goals with several CSCW systems. Some of these systems support the exchange of notes [1, 17, 18], while others encourage lightweight interactions and group awareness by other means [2, 5, 10, 13].

On the other hand, several systems have integrated paper as part of their user interface. An early example is the augmented desk described in [12]. Also, the idea of a "paper user interface" was proposed in [6] and illustrated with an OCR system. The Paper PDA [4] adds semi-interactive functions to a paper organizer and synchronizes physical and digital worlds through a continuous "scanning-printing" loop.

6. CONCLUSION

The goal of the *Gribouilli Messaging System* is to facilitate interpersonal communication, by making it less constraining and more impulsive. To achieve this goal, the system integrates the *Gribouilli Pad*, a device that allows its users to quickly compose brief messages (gribouillis) on real paper. The goal of the system is not to *replace* email, which is more appropriate for having focused discussions. Rather, it is to *complement* email with more affective and lightweight interaction mechanisms.

In this paper, we have described the first prototype built to experiment our ideas. While it already provides useful services, it is only an initial step towards the system we intend to build. For instance, the *Web services* currently implemented are still very basic, and need to be improved. Also, *awareness mechanisms* such as those described in [10, 11] will be incorporated in the system. They will make it possible for the authors to be notified when their notes are accessed, and to get feedback from their relatives and friends.

Finally, our goal is also to address the problem of *creativity* faced by many users of CMC technologies (e.g. the problem of coming up with good content for emails). For that purpose, the next prototype will support the dynamic generation of paper forms. These forms will prompt user input by displaying *questions* coming from various sources. This will add a number of interesting issues to tackle.

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