

# A Study of Digital Note Sharing in Nomadic Groups

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**Abstract.** We report on a study of an Anoto® digital pen and paper usage in three student project groups over three months. We have set up a system including a digital pen and paper, handwriting recognition software, and provided the conditions for wireless note sharing over Bluetooth, and thereafter we let the students use the technology as they went about their activities. Our goal was to evaluate the system's potential for student groups as usage naturally occurred and to assess how the participants integrated the technology in their work and whether it bridged the physical-digital gap. We found that even if the technology works well for individual use, collaborative use of digital pen and paper posed important issues, which we discuss in the light of our notion of nomadicity as a work condition, as well as in the light of the increasingly opportunistic nature of handwriting nowadays.

**Keywords:** digital pen, digital paper, sharing, nomadicity, student group, digital notes, handwriting, sketching, opportunistic

## 1 Introduction

While more and more documents exist in digital forms today, paper is still in wide use and its affordances still make it indispensable (Sellen and Harper, 2002). Handwriting and sketching by hand on paper or boards are still quick and inexpensive idea-sharing instruments during meetings. Bringing such writings or sketches into digital format, appears as a natural desire when designing groupware as that would get them closer to the wealth of digital documents that most ‘knowledge work’ groups employ nowadays. Various systems capable of capturing handwriting in digital format have emerged in the recent years. How can these systems help groups of knowledge workers merge their physical and digital realms?

While this question has been asked before (e.g. Luff et al. 2004) we approached it from a specific angle, that of nomadic groups, i.e. groups affected by variabilities in regard to work location, work session duration, group member attendance and technology support (Bogdan et al. 2006). In that context we have emphasized the importance of *discontinuities*: transitions of work artifacts or changes in the work setting that significantly affect the work. Our previous work with nomadic student project groups showed a lot of pen and paper usage during meetings for writing or drawing artifacts that were of shared interest: meeting minutes, design sketches, etc.

At the digital end, the groups always employed some form of repository of digital documents, or shared them via e-mail. We therefore became interested in the use of digital pen and paper in such settings, attempting to achieve an easy, hopefully seamless transition between the physical and the digital handwritten notes, for facile note sharing with the group members. In this paper, we report on a longitudinal study of digital note sharing in three student project groups. In terms of our nomadcity framework, our question is: can a digital pen and paper system bridge the physical-digital discontinuity in regard to handwritten notes and sketches?

## 2 Related work

Hinckley et al. (2007) developed a system for *active note taking*. They used digital features to go beyond to 'simple' note taking, which is described as moment-to-moment transcription. Their non paper-based system enabled "the combination of pen-and-ink note taking with searching, linking, collecting, and sense making activities".

Mackay (2003) argued the urge to replace all paper, and suggested to think about interactive paper, which maintains the ease-of-use of physical paper, while enabling us to benefit from the full spectrum of interactive computing. Following this, Miura et al. (2005) used in their study a system (AirTransNote) that did not change the natural way of note taking. Their participants were students who could share notes written on regular paper, using wireless communications. However, their system required many technical components which are harming the mobility of the technology.

Alexander and Dore (2006) evaluated various systems, among them digital pen and paper, for integrating document handling into electronic logistic systems used by truck drivers. When comparing the systems, the affordances of paper turned out to be ideal for these mobile workers and seemed therefore to be irreplaceable by other technology. Integrating a natural writing system into a digital workflow by using a digital pen was a success for these group of users, since "the pen is a familiar tool capable of making both fast, accurate selections and producing fast, accurate input". Differently from this study, we are evaluating the pens in a much less formal work environment. Apart from that we are more interested in the collaborative potential regarding digital note taking.

A setting more similar to ours is involved in a recent report (Mascord et al. 2007). It describes the use of digital pen and paper for management of paper-born materials produced through a range of research practices of a Integrative Biology community. This study showed that the use of digital pen and paper for this community could bring "significant benefits to the researcher who uses paper as a fundamental component of their research practice, for example, by providing a backup, facilitating sharing, making material easier to locate and offering opportunities for capturing information digitally in situations where a tablet or PDA is unavailable or cumbersome". However, this report suggests a more reliable handwriting recognition for scientific text and encouraging the company owning the technology (Anoto®) and its partners to open their file formats which are currently proprietary.

Luff and Heath (1998) discuss how the replacement of an old paper allocation sheet (used to record the time spent by each worker on a given task at a building site) with an electronic notebook hindered some important collaborative aspects of the work carried out. When the mobile device was introduced, what used to be a quick handover of paper documents became a time consuming activity. The technology itself became the main discussion topic, thus hindering the communication between colleagues and the opportunity to deal with the current problems.

Close to such mobility concerns are our own nomadicity concerns (Bogdan et al. 2006). This is particularly the case with regard to *micro-mobility* (Luff and Heath, 1998), that is the mobility of artifacts and information between different places. In fact, the circulation of work resources and information is a relevant aspect to understand how students manage their collaborative activities at several places.

### **3 The study**

#### **3.1 Participants and Setting**

We introduced the digital pen and paper to eight students doing three-month course projects in three groups. We choose students studying Computer Science or Media Technology since they are more skillful in understanding new interface concepts and since they are more likely to pick up new technology. All the three groups had a highly nomadic character as they had to investigate the work process in a hospital through interviewing hospital employees, conducting surveys and observations in the field. Students moved constantly between their home, the hospital and the university. The course required the students to document and share their project findings via a Web-based project support tool on a regular basis.

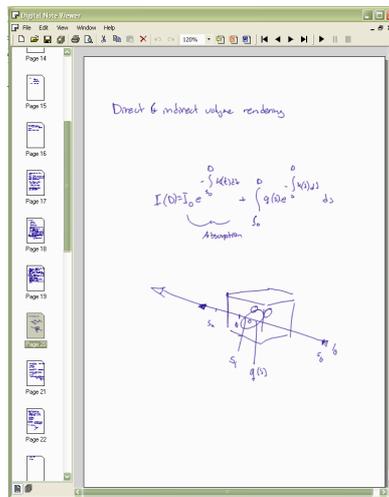
#### **3.2 Technology components.**

The Anoto® paper has a special dot pattern, enabling the pen store the handwriting information, including the exact position and exact paper sheet where it was written. As we were interested in sharing and handover of electronic notes, we chose a pen model that is capable of both sending its files to a computer over a USB cable as well as sending them to mobile phones and computers over wireless Bluetooth technology. Sending handwritten pages over Bluetooth is only possible when using a certain kind of paper, available only in A5 size, by tapping the pen on a box the corner of each page. We made an effort in supporting wireless Bluetooth sharing in order to create as many conditions as possible for sharing to take place between the students after the paper notes made it into the digital realm. All participants were also given an A4-sized notebook, even if it had less functionality as it was lacking the tapping box for Bluetooth sending.



**Fig. 1.** Possible sharing paths.

The digital pens could communicate with the participants' mobile phones, which all contained Bluetooth although they differed in graphical feedback, zoom possibility and storage possibilities. The participants who did not have an internal Bluetooth receiver for their computers were given an external Bluetooth "dongle".



**Fig. 2.** The 'Digital Note Viewer' automatically appears when pen data is synchronized.

The pen comes with a USB "docking station" and software for 'downloading' the notes and visualizing them. After synchronizing the pen via the docking station, one has a digital copy of all the notes, after which they can be exported to MS-Word, MS-PowerPoint and MS-Outlook, or be saved as BMP or JPEG files. It also comes with a play function which displays how the notes are being made like some sort of a movie.

As we wanted our participants having the opportunity to use handwriting recognition, so the physical-digital transition will be more efficient, we added the

Logitech IO2 software, enabling the participants to categorize the notes into different folders, modify the notes, add text and search within the notes. Since the digital pens we had were of an earlier version, the participants could only use the IO2 software after file conversion, which needed to be repeated after every single synchronization. A major drawback was that all software are Mac and Linux incompatible, which affected four students.

Two students could not install the software, and one could not use it frequently as it required computer restart, so they were left with Bluetooth sharing. Prior to using the pen, most of the students indicated that they took notes on paper on daily basis, two of them stressed that they seldom used paper, preferring a laptop for making notes. Except from one, all the students owned a laptop but only four indicated that they bring it frequently to the university. All students had Bluetooth phones, of which all except from one could display the digital note images.

### **3.3 Method and data collection**

All participating students were interviewed using semi-structured interviews at the beginning and midway through their project. The first interview was also an occasion to get the technology installed and give the students a tutorial of the hardware and software. Throughout the study we kept track of the students by informal talks, email support and field work observations. The study ended with a focus group where the students reflected on the experience and thought about their possible improvements together with us. A digital copy of all the student's notes at the end of the study completed our data corpus.

## **4 Results**

The amount of pages that we received from seven of the eight informants in digital format at the end of the study is as follows: 29 (4 shared with others), 14 (3), 62 (17), 18 (1), 6 (0) and 20 (16), resulting in a total of 128 pages out of which 41 were shared with the peers. We were especially interested in the nature of note sharing, as that for us is a matter of discontinuity bridging. We expected a relatively large number of notes to be taken due to the nature of the project tasks such as field and meeting notes, typically spanning over multiple pages. As field notes and meeting notes were inherent to the project assignments, we will comment mostly on the other notes that the participants chose to make.

We have seen examples of shopping lists, dance steps, to-do lists, brainstorming notes, drawings and personal messages, etc. Since we have a digital copy of all the notes that were once written with the digital pens (unless individual notes were being deleted manually by using the software), it is interesting to mention that this was not always understood by the participants.

Hej Jonas dm gamla starka  
 Hej Jonas  
 Den här lektionen är långsam...  
 tändtråd bomull  
 DARLING!

Fig. 3. Personal message notes: “Hello J you old scoundrel, regards, M”, and “Hello J. [change of color] this lecture is slow”, and one personal message combined with a shopping list: “dental floss, cotton, Darling”

2 cm 2cs  
 Isabella Spök men här  
 Rebecca Spök men här  
 Johanna  
 Johanna  
 Marcus  
 Alexandra  
 Sofie  
 Madeleine  
 Simon  
 Björn  
 Frasse  
 Niklas  
 Mattias

1 kg potatis  
 500g fryst spenat  
 1 l mjölk  
 0,5 dl grädde  
 4 port  
 potatismas m. spenat

500g kött - eller korvfil  
 2 l vitlökskrydda  
 1 buk kikärt, urade  
 2 stik  
 2 mask kaffepulv  
 1/2 dl kokad potatis  
 1 kg  
 1 buk kikärt  
 1 buk vitlagopulv  
 1/2 lime  
 1 st  
 4 port  
 köttbullar

Havanna  
 Cancun  
 Alektolet Bay-steg  
 Mexico City  
 Seattle  
 Dallas

7  
 4  
 1  
 5  
 2  
 4  
 24  
 29  
 31  
 24  
 3 21 / 5 4 10

Fig. 4. Attendance list, recipe and reflection sketch

SLT  
 G  
 U  
 S  
 N

koordinatör bestämmer ämnen för ingång  
 BK  
 VPL  
 SP1 Mo  
 BTS  
 Fördjupningsfjädröster

alla ser samma bild av patienten  
 patienten öpp på  
 VPL

Testar person TESTA  
 Testar om alla föregående rudda?  
 Step 1 h v  
 jump change 123, 123 point hop back  
 h h v h v h h v h  
 123 → into side step f h f h 123  
 v h v h v h h h v h

Step 2 h v  
 jump change 123 f h and down, f h and  
 h h v h h v h h v h  
 h h v h h v h h v h  
 h h v h h v h h v h  
 f h f h 123  
 h h v h

DDP - step 1 (red)  
 d to and out side toe stand 10/12 → jump  
 v h h  
 d to and toe and toe and toe  
 v h h h v h  
 d to d to d to hop to hop back

Fig. 5. Two sketches and a dancing steps’ note (“dancing recipe”)

The misconception that a removal of the physical note made by the digital pen on the special paper does not imply a removal of the digital copy being stored in the pen became apparent by the embarrassment of one participant about some graphical

content within the notes. Although the informant decided in the end that it is all right for us to have the sensitive data, we do not show it here for privacy reasons.

We have seen a number of instances of both planned *sharing of digital handwriting* (e.g. uploading them to the project support tool) and impromptu sharing which confirmed somewhat our initial expectations about Bluetooth sharing. For an example of impromptu note handover, one student explains why she had sent some notes via Bluetooth to other students' mobile phones

We were going to meet our teacher the day after and going to tell her what we were going to do, on the interview the day after that. And I wasn't going to the meeting with our teacher. And I was the one taking notes on the meeting, about what the purpose was and about the things that we were going to tell her. So they needed it, and I didn't need it really.

Another reason for Bluetooth sharing was often convenience. Although one needs to go through the process of pairing before sending via Bluetooth, getting a copy using the docking station was often seen as a time consuming process. A participant is explaining about the preference of Bluetooth sharing

Uh.. convenience. I didn't have to.. cause for those I didn't feel the need to have a OCR. And this was much faster for me to just sync it via Bluetooth and then email it, instead of using the docking station and then going to the software and then getting a copy of it, and then copying it back to my Mac again and then send it and so on.. so it was convenience.

Even when students went through the whole process to finally perform the *handwriting recognition* the results were mostly disappointing. Participants explained that they still needed to modify the converted text by a large extend.

I added a lot of words, wordlists and things. And this is all about hospital, so I don't know.. all weird words. But it is a lot more time consuming than if I just type it in from the.. you know manually. I just thought this was a lot of work.

Apart from the estimated success rate for handwriting recognition, expectations about the content of the 'to be written' pages could have influenced the use of the special paper. Participants indicated that in some cases the importance of the notes was considered in advance before *using the dot-pattern notebooks*.

It's a luxury paper. You can't use it to [just] anything. But if I want to make a note, that I feel like this is not very necessary. Then I take normal paper because it feels expensive to me. It's a feeling even though I haven't paid anything, it's just something...

An aspect that was criticized often by the participants was *the need for special pen and the special paper*, which is non-ubiquitous and therefore the participants had to be aware that they had to bring along this extra technology.

But with normal pen and paper, you can use this paper [pointing at a pile of normal blank paper sheets] or some other paper. This special paper, I think that's the most hard thing to remember. That you need this special paper with you. It's not possible to just take the pen, like M2 said in that room, that you just take the pen and grab some paper when you arrived in the room. You need to have both pen and paper with you.

Since most of the students of the course project groups were participants of our study they had the opportunity to rely on their colleagues' note taking equipment.

A: I wrote down a to-do list, what I was supposed to do for the next meeting.

B: And you didn't have any paper. So you borrowed my book. And then we transferred it to your phone.

A: Yes. So I had it in my phone. So I used the note from my cell phone.

Not only the paper was borrowed, also the digital pen. Which lead to bigger problem because one 'has to' synchronize the borrowed pen with one's own mobile phone or computer, or one has to remember to ask the pen's owner to send the file later on.

I had a note in my notebook, which was important for our group. But at that moment, I couldn't find my pen. So I used A's pen, and she emailed me this page, digital. And at first I thought it was unnecessary to email me the page... but it was lucky that she could send it.

In another example a participant tells about handing over the digital pen to others in order to work on a common sketch surface. This was later shared with the other members.

We were taking some drawings about the future living room.[] And we were planning on how to put things in the living room, so everybody was using my pen to put their things in this room. And afterwards we shared it to everybody's phone so that everybody could write text to this picture.

In a situation with normal pen and paper, the collaborators could have used each their own pens. However, in order to get an accurate digital representation of the physically drawn sketch the users involved had to pass on a certain digital pen (so all the sketch data is stored in it), taking turns using it, which made them aware that they are not working with a regular pen.

As part of the *focus group discussion* on possible pen technology improvements, one group of participants discussed the idea to make the digital pen easier to explore and more transparent. In this regard, our informants would like the pen to function just like an *external hard-drive or memory stick*. This is very different from the software existing today, based on a notebook synchronization approach, whereby the pen sends to the computer all strokes that have not yet been sent. The “memory stick” approach:

makes it easier to pick out some pages, instead of loading all pages to your computer. ...

And we would like these pages to be seen as an XML-file, so it would be readable by all kind of programs to pick out some sort of information.

Following up on the file system metaphor, informants expressed the need for metadata about the files, so that it is possible to see at *which date and time the note has been written*. We as researchers had this problem: we have our informants' notes but had a hard time interpreting them without time information.

Bluetooth connectivity was seen as important for informants as it provides a *standard form of connection* with a variety of devices, e.g. whatever type of phone the colleague happens to have. It is also proposed as a vehicle for universal “note file” transfer between pen and computer (or another device).

## 5 Discussion

The patterns of digital pen usage inspired us to believe that handwriting and sketching are *increasingly brief and opportunistic*: as digital and portable technologies are increasingly ubiquitous, handwriting is less and less employed. Some participants reported having to get used to write by hand again. Lecture or meeting notes are increasingly taken directly on the laptop, or other portable devices. Even us, as computer-tied researchers, when testing the technology, we felt characteristic signs (such as tiredness of the hand) of not being used to long handwriting sessions any longer. We do not claim that handwriting is going to disappear soon, yet it is obvious that there are “handwriting genres” (like lecture notes) that are seriously being diminished by modern technologies, especially as technologies are increasingly

cheaper and portable, and people get to know them at an earlier age. Some other handwritten genres on the other hand, seem to be more resilient in the face of technology: the shopping list, the recipe, the to-do list, the brainstorming notes, the graphical sketch, and the personal message note (though increasingly cannibalized by the SMS message). Apart from another genre requiring pen and paper (the field notes), all these genres are *brief* and *opportunistic*: they are typically not planned (many are created when ideas happen to come) and are usually limited in size, to one page or even less (cf. the size of post-it notes). The opportunistic character of today's handwriting is, we believe, fueled by the nomadic character of one's activity, which is important in the context of our research setting. Furthermore, many of the opportunistic and brief pen-paper genres are often collaborative in nature; even seemingly personal writings like the shopping list, to-do list or the recipe may be done for or with somebody else.

Supporting brief, opportunistic and collaborative handwriting is then, for us, an essential design requirement for a digital pen and paper system, especially in a highly nomadic setting where brevity and opportunism are inherent. This requirement is then essential for bridging the physical-digital discontinuity, the subject of our research question. We will now argue that there are significant difficulties for the Anoto® system to support these requirements and to bridge this discontinuity, due to *metaphor breakdowns* and what we will call *additional-operation discontinuities*. In other words, the physical-digital bridging, although it works technically, is often likely to be *not seamless* in a nomadic setting.

Like many information technologies today the digital pen bears a metaphor: it builds on the familiarity with traditional pen and paper to add new functionality. In our longitudinal study in a real-life setting we have encountered cases where the metaphor has broken down, and the breakdowns have important consequences for our research question. *First is the page rip-off problem*: with traditional pen and paper, the information remains on paper and can be spatially associated with it. This has important implications when it comes to confidential or private information, or simply to moving or extracting information. The digital pen breaks the familiar paper spatiality, because not only is the information more dependent on the pen than it is on the paper (your pen will capture everything you write, no matter on which dot-pattern paper you do it) but "ripping it off" from the pen is not a easily-accessible operation, unlike ripping the paper off, or disposing of it. This lead to an important misunderstanding of how the pen works.

*Second is the forgetting and borrowing problem*. With traditional pen and paper, we can easily borrow a pen or a paper or both from somebody else, and we stand a high chance to get one. With the Anoto® system, one has to be careful to remember to bring along both the pen and the paper, which comes in conflict with the increasingly opportunistic nature of handwriting. Failing to remember to bring their personal pen or paper, one has to be careful to borrow both somebody else's pen *and* their paper, otherwise superimposition may result in the digital format. Furthermore, since the information does not travel with the paper, but with the pen, additional sharing operations are needed to get the digital format of the writing from the pen-and-paper lender.

*Third is the sketching together problem*. When several users use their pens to sketch something together on a paper, each pen will record just its part of the sketch

and with the current technology the partial sketches are impossible to put together in the digital realm, although they are perfectly combined in the physical! Instead, the users have to be careful to (less naturally) pass one pen from one user to the other. This issue is somewhat alleviated in more modern pens which record time information for each written stroke, however, even there putting together the sketch pieces drawn at approximately the same time, would require an additional, concerted operation from all the involved users, with a dedicated tool.

*Fourth, the work unit detection problem:* the digital system does not represent, in the current set-up, what constitutes *one* sketch or one note. The “work artifacts” recorded in the pen are notebook-based: everything that is written in a notebook is one object, with only the pages being marked within that object. Notes unfolding over several pages, or interrelated sketches on multiple pages, or separated sketches on one page are not detected by the system. This clearly impedes sharing, unless the user is careful to write or draw exactly one note on one page (which may not fit for long texts like field notes) or one sketch on one page. This problem also hinders single-user pen data management, as our informants have suggested with their file-system-like design. Adding time information to the pen strokes can help a long way towards solving this problem, since a period of pen activity on contiguous pages, taking place between two periods of pen “silence” most probably means that the pen strokes made during that activity period compose a work unit. Such work unit detection would permit the realization of a file-system (or work-unit-system) pen storage as designed by our informants.

While the above issues may be regarded as exceptional, incidental, or simply rare, and difficult to generalize from, we will now argue that they have important consequences for our research question: “can the digital pen bridge the physical-digital discontinuity in a nomadic group?” The reason for these consequences is that it is precisely at the opportunistic and often brief “points of group collaboration” where the pen metaphor is likely to break down. While one person writing in one single notebook can use the pen relatively seamlessly, and get an accurate digital copy of their notes (though without work unit separation), the above-illustrated issues begin to occur when there are more users who wish to share their work artifacts or when users wish to share artifacts *with only some people* and not with anybody else, and would like to rip artifacts off from the digital realm, in a way familiar with the physical paper ripping-off.

The metaphor breakdowns are even more important as many of them imply additional operations to go around. On the surface, the digital pen itself is a bridge between the physical and digital worlds, so it apparently does bridge the discontinuity. However, the work needed to extract the hand stroke information from the pen into a computer, and from there to digital text or digital shapes, along with the “discipline work” needed to circumvent the collaboration issues above, can be classified as another type of discontinuity which in effect leads to the paper-digital realms not being bridged effectively: the *additional operation discontinuity*. Each additional required operation may lead users to give up on using a technology. For example one can refrain from doing work on a computer terminal because they have to log in, and prefer to postpone it and subsequently they may forget about it, or do it with some other technology set-up. For us this is part of understanding a discontinuity, which is almost always implied by such an additional operation.

Besides the important issues in regard to support for opportunistic writing in collaborative settings, it is interesting to reflect on the recent technology evolutions in the digital pen and paper area, and compare them to our results and our informants' designs. There is a stark contrast between the kinds of future digital pen evolutions proposed by our informants after three months of digital pen usage, and the actual evolutions in the industry and research. Many current digital pen implementations and their developments tend to lead to complex systems with multiple interconnected server modules, specialized for e-mail routing, multimedia processing, form circulation, etc. The same is true for research prototypes like Paper++ (Luff et al. 2004). Our data lead us to believe that, at least for a nomadic knowledge work setting, reducing the number of system components, thereby simplifying the work to make the digital pen system work (cf. Bowers, 1994), is an important alternative way to go. Our informants wanted as much functionality as possible to be pushed into the digital pen, to the extent allowed by current state of the art, making sure that the data is easily accessible, not on some remote computer which is part of a complex system. Instead of complex multi-tier applications with a pre-determined data flow, our nomadic students preferred to have the pen data accessible via generic, familiar, folder-like structures, from a variety of devices (not just PCs) via standard connections such as Bluetooth, in open formats like XML (cf. Mascord, 2007), and to choose for themselves the type of processing they want to pursue by combining these technological ingredients.

Part of our informants' desires is being met with the latest developments in the digital pen industry. The Pulse Smartpen has embedded time information along with audio recording, meeting our informants wish for meta-data. Epos technologies meets the need to see the pen as a 'memory stick' where one can view and take out individual notes. Both these products will be commercially available soon, leading to possible future work for us.

Still, given the metaphor breakdowns that we have found, there is an important comparison to be made between the digital pen (not available to students today) and digital photography (ubiquitous today in mobile phones) as physical-digital transfer technologies. While the apparent seamlessness of the digital pen would apparently make it preferable to digital photography, the additional operation discontinuities that we have found are comparable to the additional operation of actually taking the digital photograph. This comes to emphasize once more the importance of such discontinuities in designing support for highly-nomadic work.

## **6 Conclusion**

We have found that even if the Anoto® system is probably the most mobile today, and resembles best the pen and paper metaphor, it still poses important issues in supporting nomadic student groups, due to shortcomings that arise at the "points of collaboration" when supporting opportunistic handwriting, such as metaphor breakdowns and additional-operation discontinuities. Some of such shortcomings may be addressed by recent technology that records time information of handwritten strokes.

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