Paper Augmented Digital Documents

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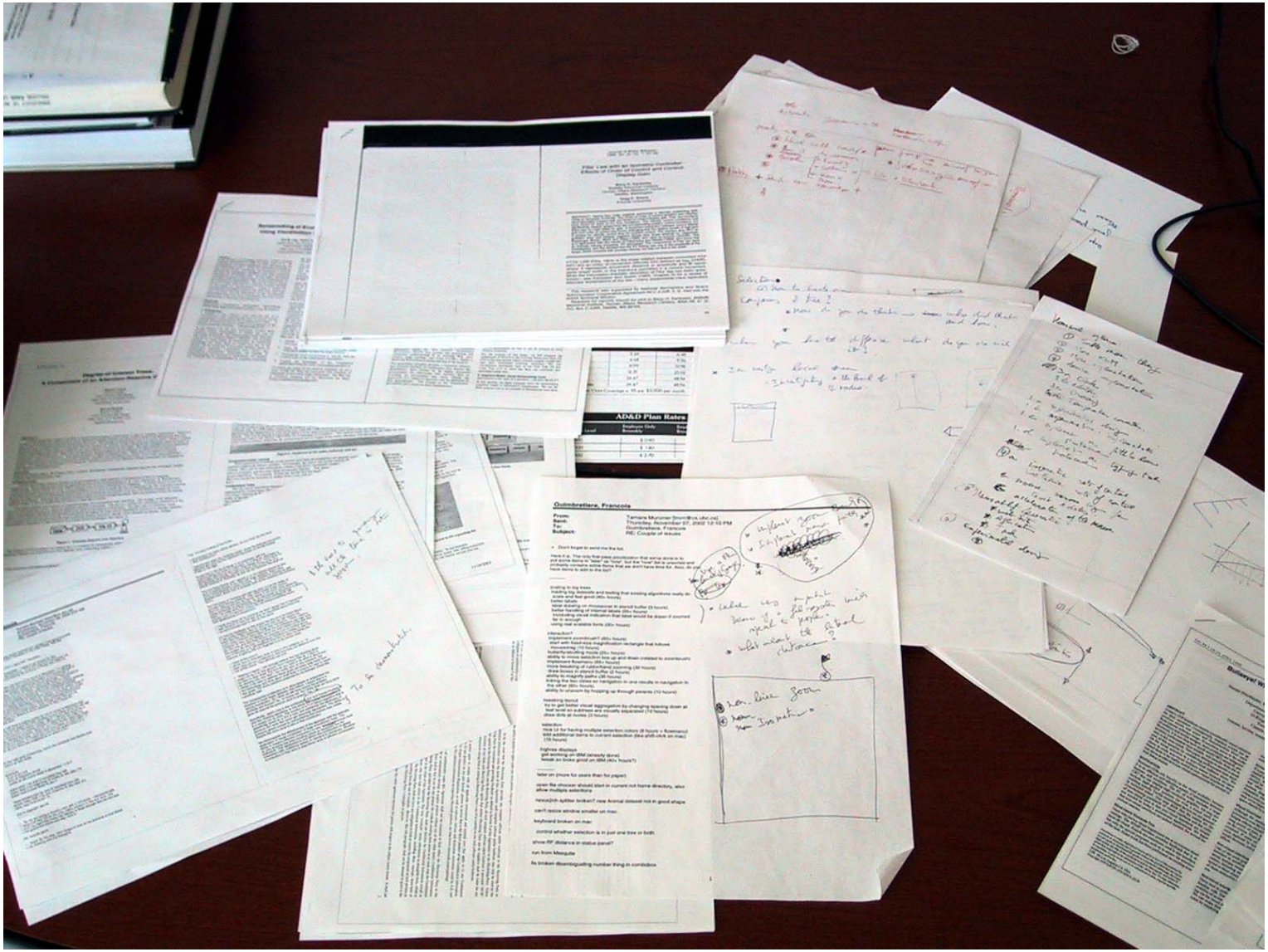
My desk



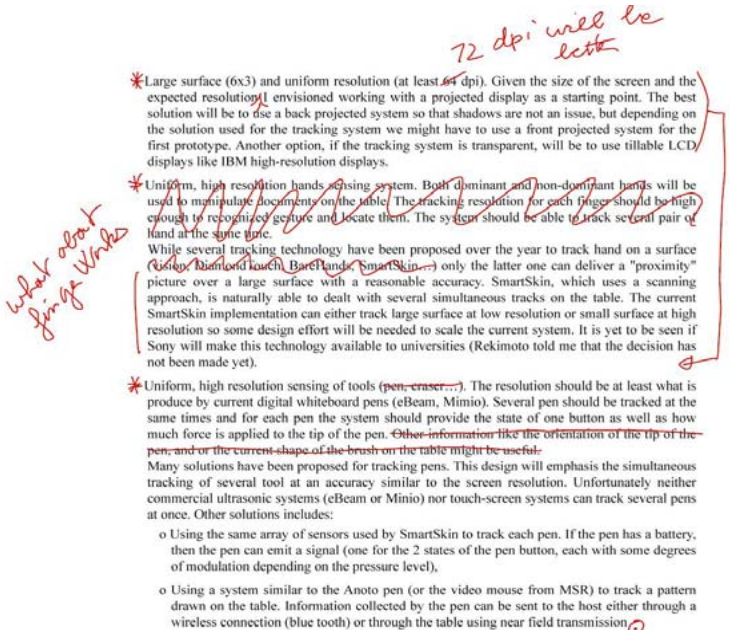
Affordances of paper documents [Sellen 01]

- Easy to navigate
  - Two-handed interactions and tactile feedback
  - Reading across more than one document at once
- Easy to annotate
  - Directly on the document or on a nearby pad
- Well accepted during meetings
  - Socially accepted conventions

- Very difficult to modify
  - Printed documents are created and edited as digital documents
- Expensive to distribute and archive

Editing and proofreading documents

- IMF study [Sellen 01]
  - IMF has large IT resource
  - Still relies extensively on paper
    - *More convenient*
    - *Fosters better collaboration*



72 dpi will be lette

Large surface (6x3) and uniform resolution (at least ~~64~~ dpi). Given the size of the screen and the expected resolution I envisioned working with a projected display as a starting point. The best solution will be to use a back projected system so that shadows are not an issue, but depending on the solution used for the tracking system we might have to use a front projected system for the first prototype. Another option, if the tracking system is transparent, will be to use tillable LCD displays like IBM high-resolution displays.

Uniform, high resolution hands sensing system. Both dominant and non-dominant hands will be used to manipulate documents on the table. The tracking resolution for each finger should be high enough to recognized gesture and locate them. The system should be able to track several pair of hand at the same time.
While several tracking technology have been proposed over the year to track hand on a surface (Vision, Diamond touch, BarcFlands, SmartSkin, ...) only the latter one can deliver a "proximity" picture over a large surface with a reasonable accuracy. SmartSkin, which uses a scanning approach, is naturally able to dealt with several simultaneous tracks on the table. The current SmartSkin implementation can either track large surface at low resolution or small surface at high resolution so some design effort will be needed to scale the current system. It is yet to be seen if Sony will make this technology available to universities (Rekimoto told me that the decision has not been made yet).

what about finger work

Uniform, high resolution sensing of tools (~~pen, eraser...~~). The resolution should be at least what is produce by current digital whiteboard pens (eBeam, Mimio). Several pen should be tracked at the same times and for each pen the system should provide the state of one button as well as how much force is applied to the tip of the pen. ~~Other information like the orientation of the tip of the pen, and or the current shape of the brush on the table might be useful.~~
Many solutions have been proposed for tracking pens. This design will emphasis the simultaneous tracking of several tool at an accuracy similar to the screen resolution. Unfortunately neither commercial ultrasonic systems (eBeam or Minio) nor touch-screen systems can track several pens at once. Other solutions includes:

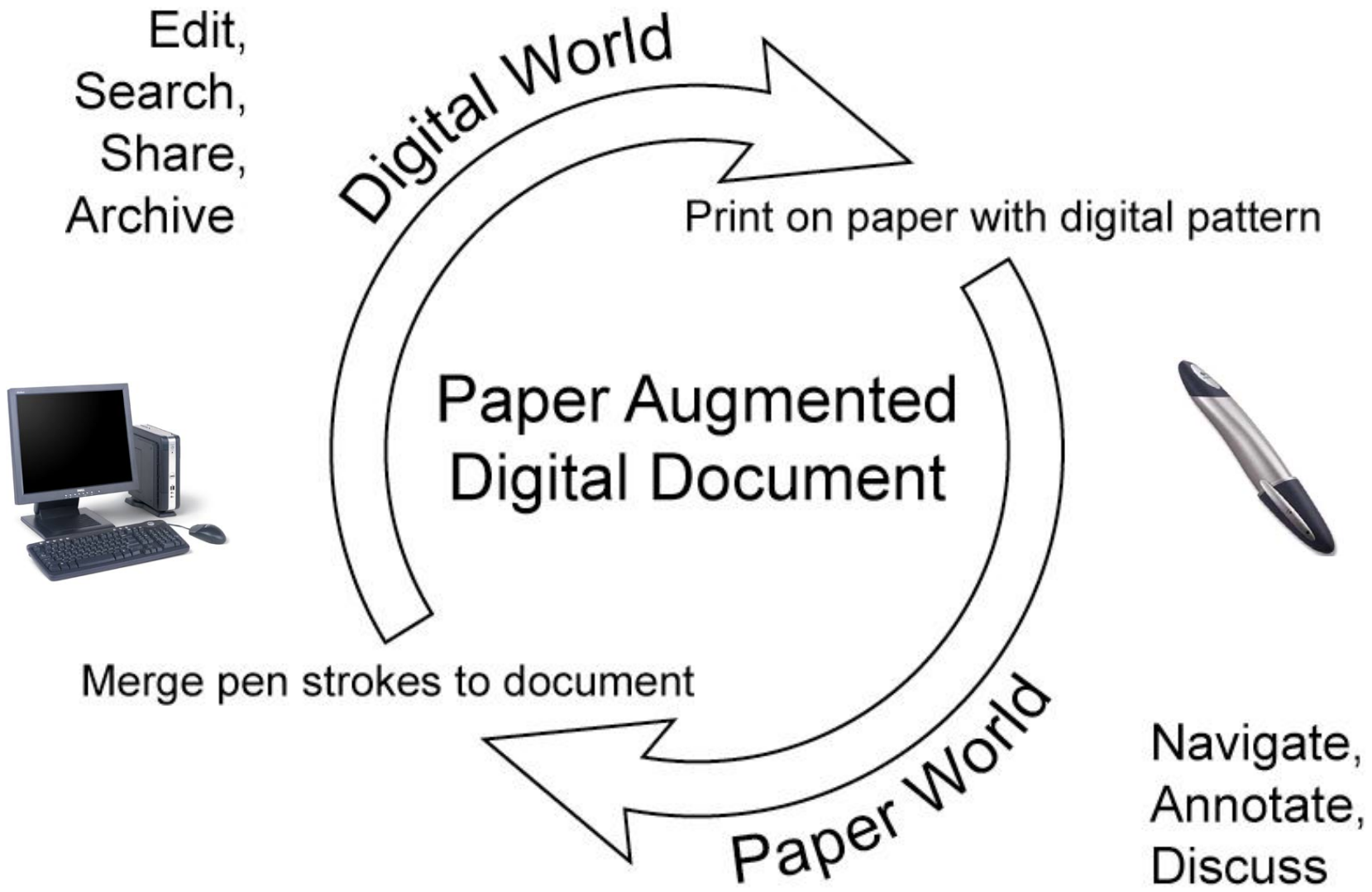
- o Using the same array of sensors used by SmartSkin to track each pen. If the pen has a battery, then the pen can emit a signal (one for the 2 states of the pen button, each with some degrees of modulation depending on the pressure level),
- o Using a system similar to the Anoto pen (or the video mouse from MSR) to track a pattern drawn on the table. Information collected by the pen can be sent to the host either through a wireless connection (blue tooth) or through the table using near field transmission.

- Transfer back to the digital world is expensive

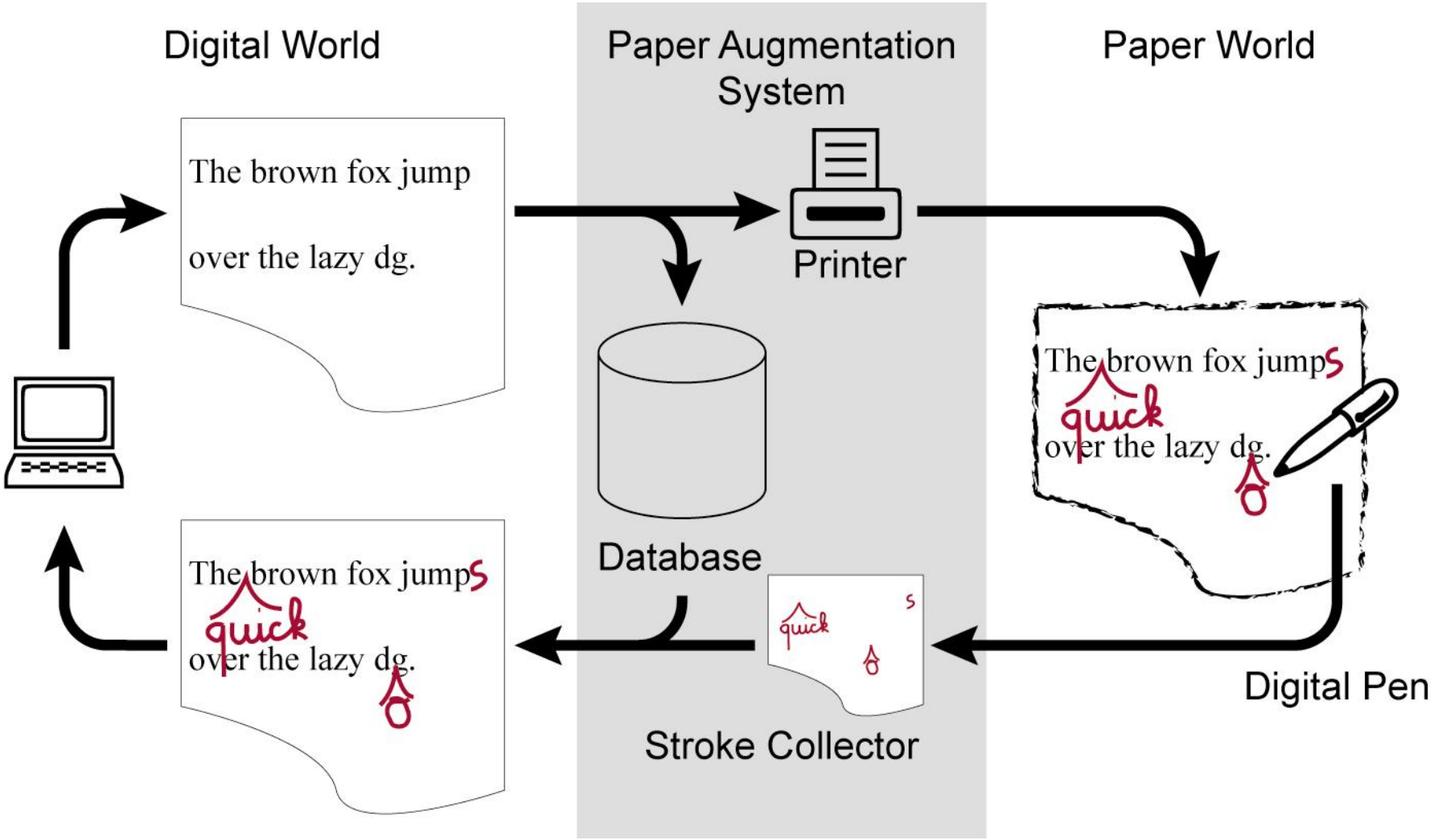
Bridging the gap: previous work

- Digital emulation
  - FreeStyle system [Wang 89]
  - MATE [Hardock 93]
  - XLibris [Schilit 98], [Golovchinsky 02]
- Tight coupling
  - DigitalDesk [Wellner 93], Ariel [Mackay 95]
  - A-Book [Mackay 02]
  - PaperLink [Arai 97]
  - Intelligent Paper [Dymetman 98]
- Paper as input device
  - Xax [Johnson 93]
  - Anoto
  - Paper PDA [Heiner 99], [Avrahami 01]

Cohabitation

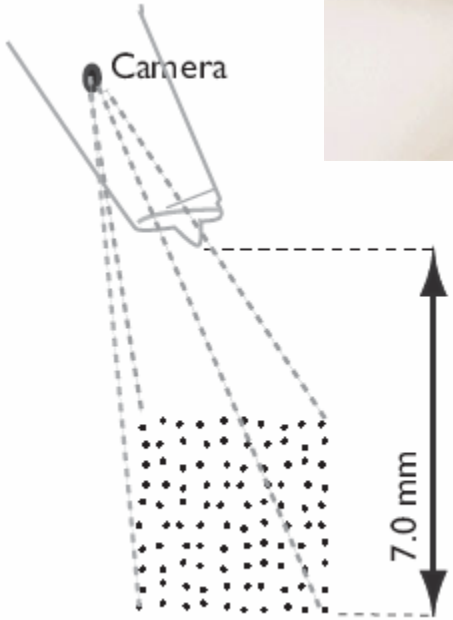


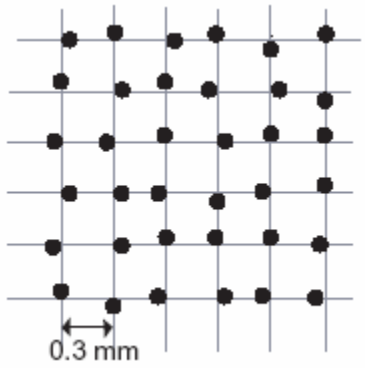
System architecture



Stroke capture

- Requirement
  - Stroke coordinates on the page
  - Page ID
  - Large address space
- Possible technologies
  - Anoto
  - DataGlyphs [Hecht 94]
  - MEMO pen [Nabeshima 95]





From Anoto documentation

Printing user content

- Pen camera use IR light
  - Pattern should be printed using IR absorbing inks
  - User content should be printed with IR transparent ink
    - *C, M, Y are IR transparent*
    - *Black should be printed as C+M+Y not K*

- Pattern is time consuming to print
  - Use pre-printed paper
  - Use new fast (but expensive) color printer

Stroke recovery

- Recover strokes from pen
  - When users synchronize their pen

Stroke recovery

- Recover strokes from pen
  - When users synchronize their pen
- Find the corresponding digital document
  - Paper documents can be exchanged between users
    - *Requires a distributed directory system*

From paper to document space

Paper Augmented Digital Documents

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ABSTRACT
Paper Augmented Digital Documents (PADDs) are digital documents that can be manipulated either on a computer screen or on paper. PADDs, and the infrastructure supporting them, can be seen as a bridge between the digital and the paper worlds. As digital documents, PADDs are easy to edit, distribute and archive; as paper documents, PADDs are easy to navigate, annotate and well accepted in social settings. The chimeric nature of PADDs make them well suited for many tasks such as proofreading, editing, and annotation of large format document like blueprints.

We are presenting an architecture which supports the seamless manipulation of PADDs using today's technologies and reports on the lessons we learned while implementing the first PADD system.

Keywords: Paper Augmented Digital Document, PADD, Anoto, Paper based user interface, Digital pen.

INTRODUCTION
For several decades, experts have predicted that the advent of more powerful and compact computers will result in the creation of paperless offices. Yet, as pointed out by Sellen et al. in "The Myth of the Paperless Office" [28], the consumption of paper is on the rise, and with few exceptions, office work still relies heavily on paper. Sellen et al. provided a careful analysis of the reason of this state of affairs, pointing out the wide gap between paper affordances, such as ease of navigation and annotation, high information density display, and digital document affordances, such as ease of distribution, archival and search.

Many systems have been proposed as solutions to narrow this gap. Some, such as the DigitalDesk [30], and Ariel [18], proposed bringing digital resources to paper. Others, such as Xax [13], Intelligent Paper [7], Audio Notebook [29] and Anoto [4], used paper as an input medium. Others still, such as the Freestyle system [15] or XLibris [27], explored how paper affordances could be provided on tablet computers, such as the recent Tablet PC.

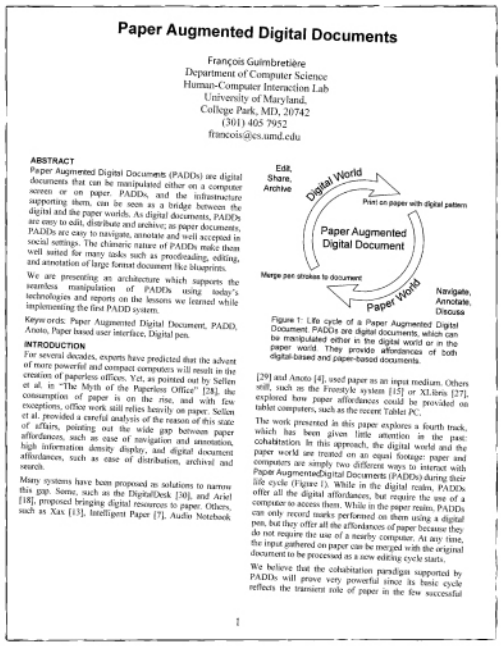
The work presented in this paper explores a fourth track, which has been given little attention in the past: cohabitation. In this approach, the digital world and the paper world are treated on an equal footage: paper and computers are simply two different ways to interact with Paper Augmented Digital Documents (PADDs) during their life cycle (Figure 1). While in the digital realm, PADDs offer all the digital affordances, but require the use of a computer to access them. While in the paper realm, PADDs can only record marks performed on them using a digital pen, but they offer all the affordances of paper because they do not require the use of a nearby computer. At any time, the input gathered on paper can be merged with the original document to be processed as a new editing cycle starts.

We believe that the cohabitation paradigm supported by PADDs will prove very powerful since its basic cycle reflects the transient role of paper in the few successful

Figure 1: Life cycle of a Paper Augmented Digital Document. PADDs are digital documents, which can be manipulated either in the digital world or in the paper world. They provide affordances of both digital-based and paper-based documents.

Printing

Calibration



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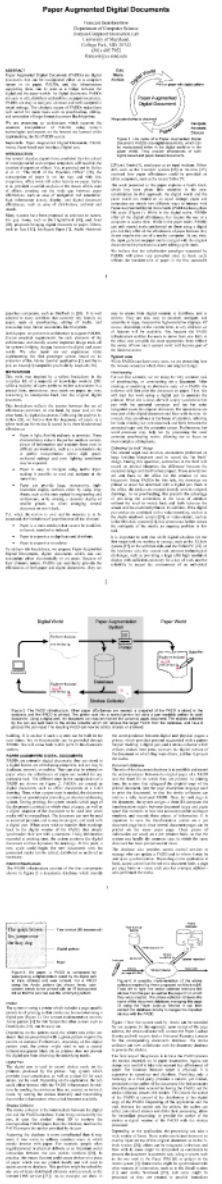
1

Digital Document

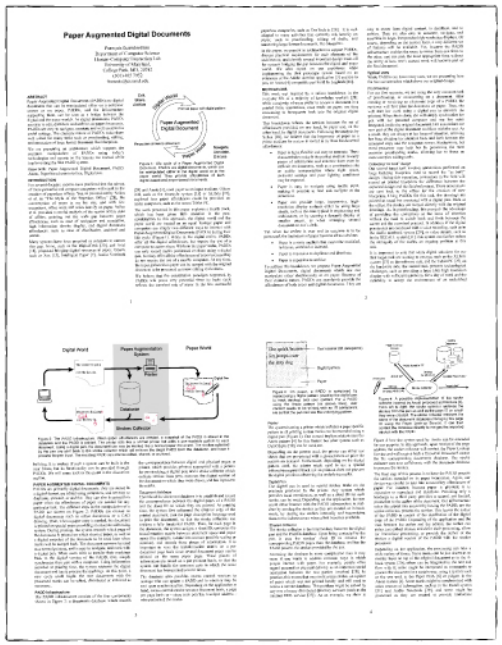
Printout

Multi-page printing



Printing

Calibration,
Mapping



Digital Document

Printout

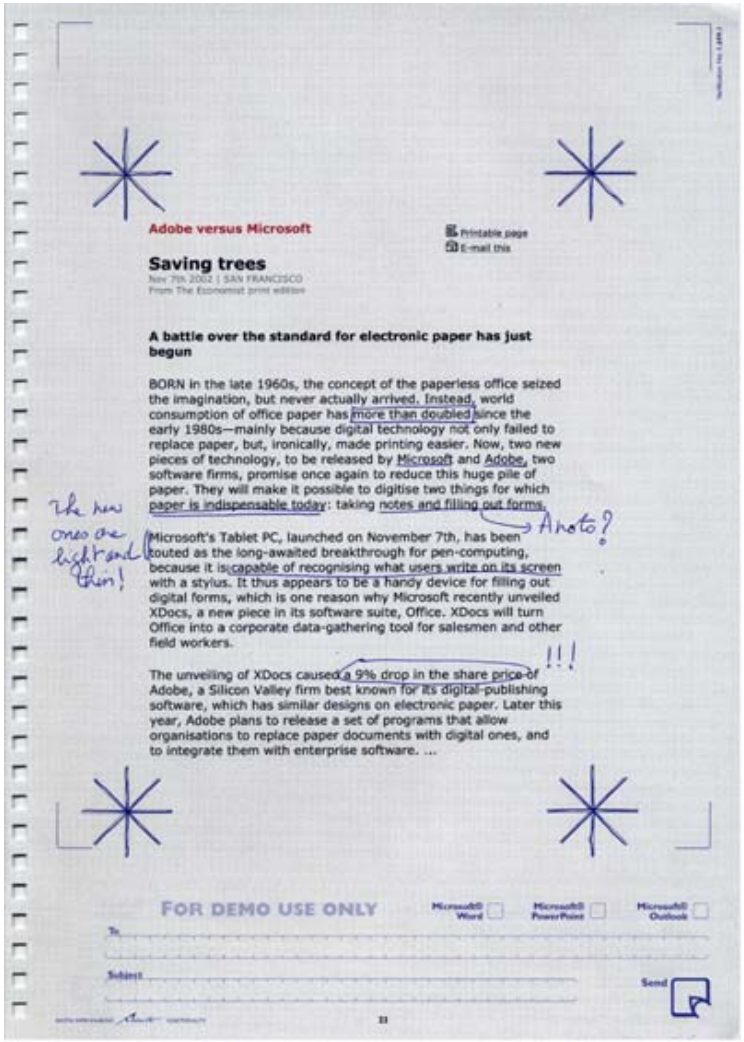
Stroke recovery

- Recover strokes from pen
  - When users synchronize their pen
- Find the corresponding digital document
  - Paper documents can be exchanged between users
    - *Requires a distributed directory system*
- Processing the strokes
  - From a simple overlay to application dependent processing
  - Printed documents are expensive to duplicate
    - *Stroke processing near the database*
    - *Need for access control*
      - Per documents, pages, or pen ID

PADD prototype as an Acrobat plug-in

- Feasibility study focusing on calibration problems
  - Use pre-printed paper
  - HP 5550 with black cartridge removed
    - *Automatically use CMY to emulate black*
  - Document acts as its own database
    - *Personal use only*
    - *Only one out-standing copy per document*
    - *Strokes are simply overlaid on top of the document*

PADD Acrobat plug-in



Adobe versus Microsoft

Printable page
E-mail this

Saving trees

Nov 7th 2002 | SAN FRANCISCO
From The Economist print edition

A battle over the standard for electronic paper has just begun

BORN in the late 1960s, the concept of the paperless office seized the imagination, but never actually arrived. Instead, world consumption of office paper has more than doubled since the early 1980s—mainly because digital technology not only failed to replace paper, but, ironically, made printing easier. Now, two new pieces of technology, to be released by Microsoft and Adobe, two software firms, promise once again to reduce this huge pile of paper. They will make it possible to digitise two things for which paper is indispensable today: taking notes and filling out forms.

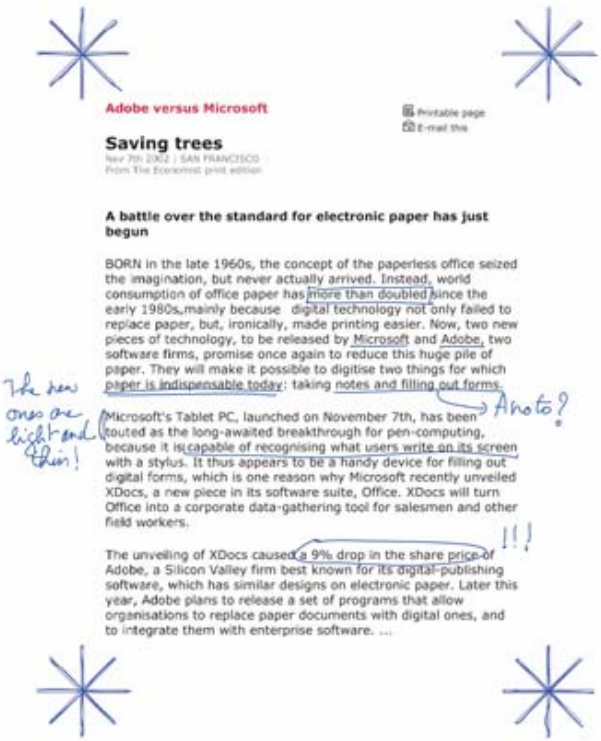
Microsoft's Tablet PC, launched on November 7th, has been touted as the long-awaited breakthrough for pen-computing, because it is capable of recognising what users write on its screen with a stylus. It thus appears to be a handy device for filling out digital forms, which is one reason why Microsoft recently unveiled XDocs, a new piece in its software suite, Office. XDocs will turn Office into a corporate data-gathering tool for salesmen and other field workers.

The unveiling of XDocs caused a 9% drop in the share price of Adobe, a Silicon Valley firm best known for its digital-publishing software, which has similar designs on electronic paper. Later this year, Adobe plans to release a set of programs that allow organisations to replace paper documents with digital ones, and to integrate them with enterprise software. ...

FOR DEMO USE ONLY

Microsoft® Word
Microsoft® PowerPoint
Microsoft® Outlook

To
Subject
Send



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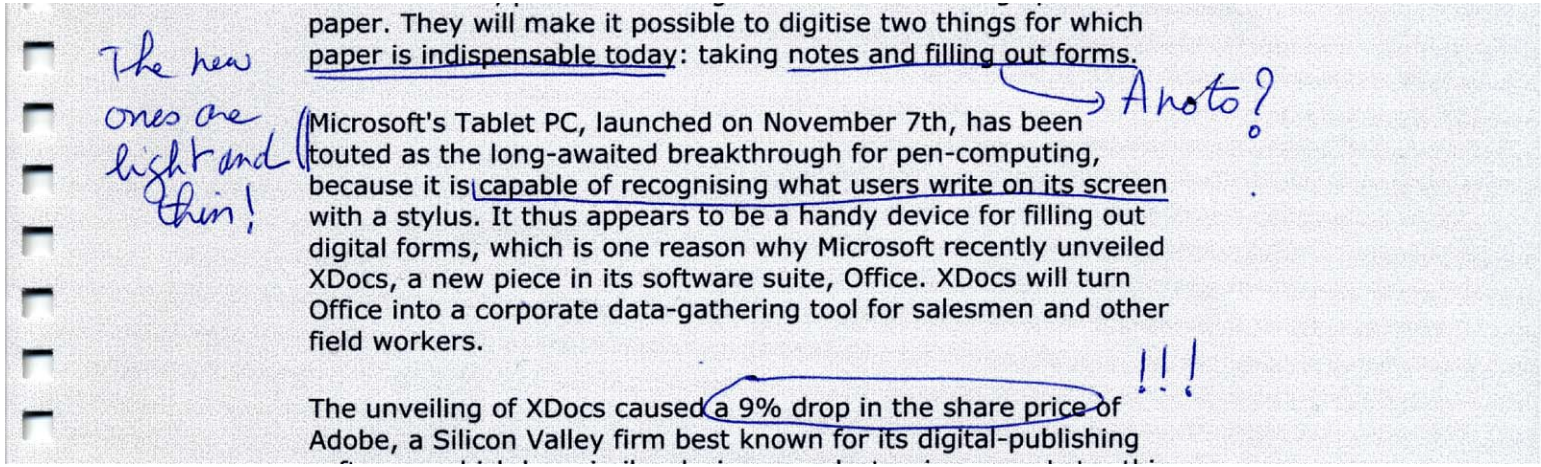
Paper

Digital

PADD: detail I



The new ones are light and thin!
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Anoto?
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!!!
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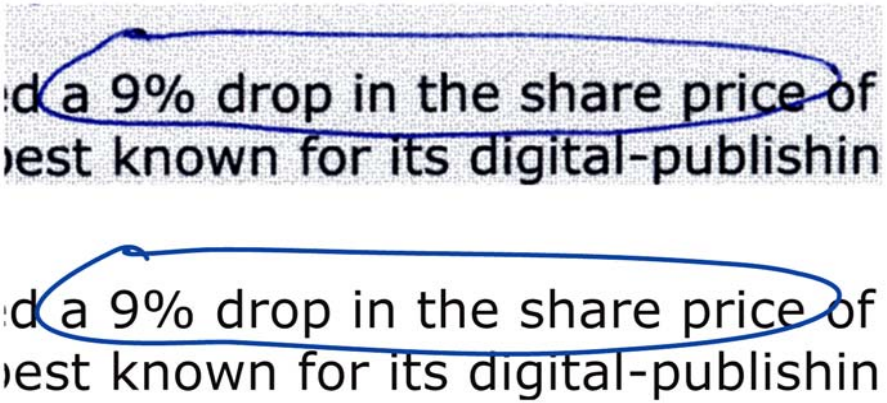
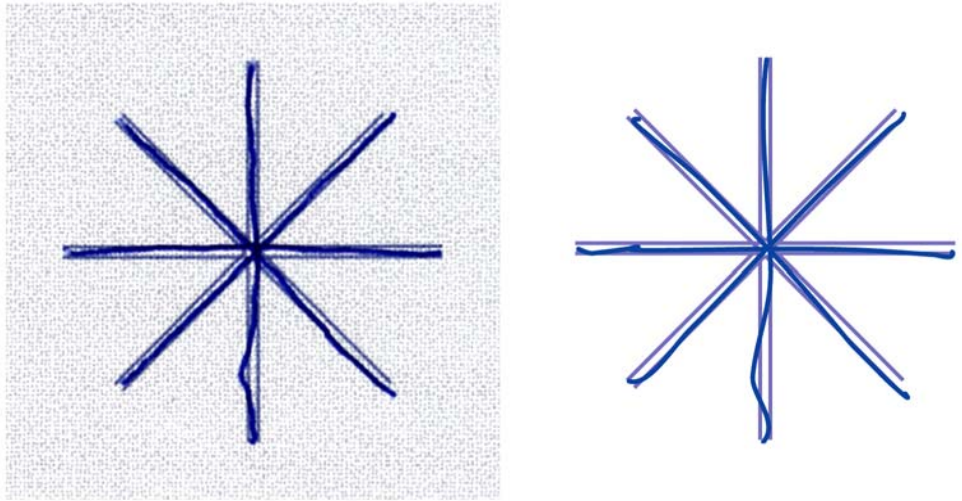
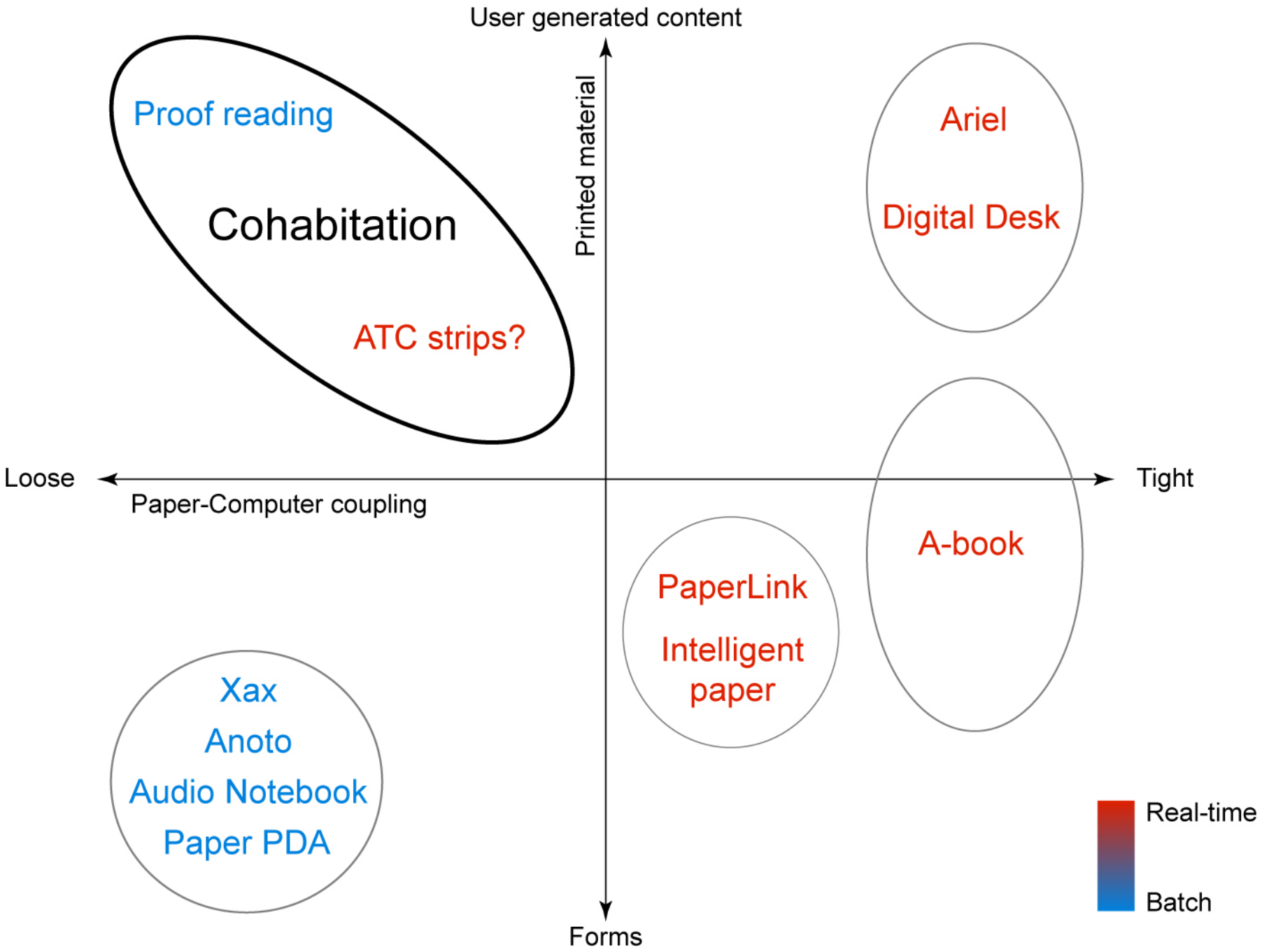
Original text from the Economist

PADD detail II






User generated content
Printed material
Forms
Loose
Tight
Paper-Computer coupling
Proof reading
Cohabitation
ATC strips?
Ariel
Digital Desk
A-book
PaperLink
Intelligent paper
Xax
Anoto
Audio Notebook
Paper PDA
Real-time
Batch

TabletPC?

- Ease of navigation and annotation
  - Paper is easy to navigate
  - Paper is easy to annotate
- Display size
  - Digital high-resolution engineering drawing?
  - Multi-document interactions?
- Practical issues
  - Paper is low cost
  - Paper is resilient
  - Paper does not have batteries (but the pen does!)

Future work

- Full infrastructure
  - First for workgroup
  - Then for larger group
- Better, more powerful stroke processing
  - Transparent insertion of marks inside word processor documents
    - *Marks should reflow and resize with the text*
  - Other application specific processing
- Detailed access to document life cycle
  - Ethnographic studies
    - *Beyond self-report on paper usage*

Conclusion

- Paper Augmented Digital Documents
  - Cohabitation: paper and computer on an equal footing
- Design framework
  - Understanding the design space of paper-computer interactions
  - Proposed architecture
- Prototype demonstrating feasibility
  - Printing and calibration possible using available technology

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- Corinna Löckenhoff

- Anoto
- Logitech