Instant Preview and the TeX daemon

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Abstract

Instant Preview is a new package, for use with Emacs and `xdvi`, that allows the user to preview instantly the file being edited. At normal typing speed, and on a 225MHz machine, it refreshes the preview screen with every keystroke.

Instant Preview uses a new program, `dvichop`, that allows TeX to process small files over 20 times quicker than usual. It avoids the overhead of starting TeX. This combination of TeX and `dvichop` is the TeX daemon.

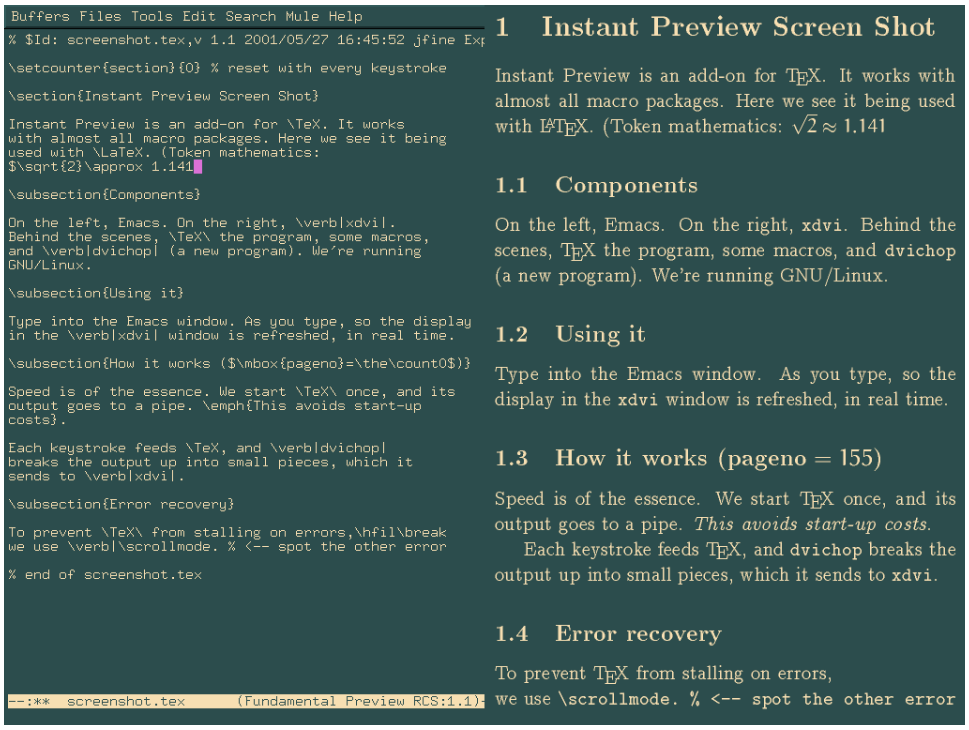
One instance of the TeX daemon can serve many programs. It can make TeX available as a callable function. It can be used as the formatting engine of a WYSIWYG editor.

This paper will demonstrate Instant Preview, describe its implementation, discuss its use with LaTeX, sketch the architecture of a WYSIWYG TeX, and call for volunteers to take the project forward.

Instant Preview at present is known to run only under GNU/Linux, and is released under the GPL. It is available at: `http://www.activetex.org`.

Instant Preview

TeX is traditionally thought of as a batch program that converts text files into typeset pages. This article describes an add-on for TeX, that in favourable circumstances can compile a file in a twentieth of



```
% $Id: screenshot.tex,v 1.1 2001/05/27 16:45:52 jfine Exp

\setcounter{section}{0} % reset with every keystroke

\section{Instant Preview Screen Shot}

Instant Preview is an add-on for \TeX. It works
with almost all macro packages. Here we see it being
used with \LaTeX. (Token mathematics:
$\sqrt{2}\approx 1.141

\subsection{Components}

On the left, Emacs. On the right, \verb|xdvi|.
Behind the scenes, \TeX\ the program, some macros,
and \verb|dvichop| (a new program). We're running
GNU/Linux.

\subsection{Using it}

Type into the Emacs window. As you type, so the display
in the \verb|xdvi| window is refreshed, in real time.

\subsection{How it works ($\mbox{pageno}=\the\count0$)}

Speed is of the essence. We start \TeX\ once, and its
output goes to a pipe. \emph{This avoids start-up
costs}.

Each keystroke feeds \TeX, and \verb|dvichop|
breaks the output up into small pieces, which it
sends to \verb|xdvi|.

\subsection{Error recovery}

To prevent \TeX\ from stalling on errors,\hfil\break
we use \verb|\scrollmode. % <-- spot the other error

% end of screenshot.tex

--:**  screenshot.tex      (Fundamental Preview RCS:1.1)-
```

1 Instant Preview Screen Shot

Instant Preview is an add-on for TEX. It works with almost all macro packages. Here we see it being used with LATEX. (Token mathematics: $\sqrt{2} \approx 1.141$

1.1 Components

On the left, Emacs. On the right, **xdvi**. Behind the scenes, TEX the program, some macros, and **dvichop** (a new program). We're running GNU/Linux.

1.2 Using it

Type into the Emacs window. As you type, so the display in the **xdvi** window is refreshed, in real time.

1.3 How it works (pageno = 155)

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Each keystroke feeds TEX, and **dvichop** breaks the output up into small pieces, which it sends to **xdvi**.

1.4 Error recovery

To prevent TEX from stalling on errors,
we use `\scrollmode. % <-- spot the other error`

Figure 1: Screen shot of Instant Preview.

the normal time. This allows TEX to be used in interactive programs. This section describes Instant Preview. See figure 1 for a screen-shot.

Types of users Almost all users of TEX are familiar with the edit-compile-preview cycle that is part of the customary way of using TEX. Previewing is very useful. It helps avoid wasting paper, and it saves time. In the early days, it could take several seconds to compile and preview a file, and perhaps minutes to print it. Today it takes perhaps about a quarter of a second to compile and preview a file.

Many of today's newcomers to computing, and most users of WYSIWYG word processors, expect to have instant feedback, when they are editing a document. Users of TEX expect the same instant feedback, when they are editing a source file in a text editor. Because they have absorbed the meaning of the markup codes, they can usually imagine without difficulty the printed form of the document. They know when the markup is right.

Beginners tend to compile the document frequently, because they are uncertain, and wish to have the positive reinforcement of success. Instant Preview, again under favourable circumstances, can reduce to a twentieth the time take to compile and preview a file. This makes it practical to offer preview after every keystroke. Beginners will be able to see their failures and successes as they happen.

Experienced users do not need such a high level of feedback, and prefer to devote the whole screen to the document being edited. However, even experts have the same need for positive reinforcement, when they use a package that is new to them.

Modus operandi Here we describe three possible ways of using Instant Preview. At the time of writing, only the last has been implemented. We assume that the document is in the editing stage of its life cycle, or in other words the location of page breaks and the like is not of interest.

The expert needs only occasionally to preview the source document. She will select the region of interest, and ask for it to be previewed. Instant Preview here may provide a quick and convenient interface, but the operation is uncommon and so the functionality should be unobtrusive.

When doing something tricky, the user might wish to focus on a part of the document, and for this part have Instant Preview after every keystroke. The tuning of math spacing in a formula is an example. Few if any users invariably know, without looking, what tuning should be applied to a moderately complicated formula. This applies particularly to displayed equations wider than the measure, multi-line equations, and commutative diagrams. It also applies to the picture environment (for which the special tool TEXcad was written).

For the beginner, everything is tricky, even straight text. The beginner hardly knows that `\{}#^_%$` are all special characters, and that ` `` ` and `''` are the way to get open and close double quotes. Even experts, who know full well the rules for spaces after control sequences, sometimes make a mistake[1]. The absolute beginner is likely to want Instant Preview of everything, absolutely all the time. Later, with experience, the training wheels can be removed.

Implementation Instant Preview has been implemented using Emacs and `xdvi`. There seems to be no reason why another editor and previewer should not be used, provided the editor is sufficiently programmable, and the previewer can be told to refresh the file it is previewing.

Instant Preview works by writing the region to be previewed, together with suitable preamble and postamble, to a special place. From there, the TEX daemon picks it up, typesets it, and writes it out as a `dvi` file. Once written, the previewer is told to refresh its view of the `dvi` file.

The main difference between the three modes is what is written out, and when. Absolute beginner mode writes out the whole buffer, after every keystroke. Confident expert mode writes out a selected region, but only on demand.

At the time of writing (mid-June 2001), only absolute beginner mode has been implemented. Further progress requires above all clear goals and Emacs programming skills.

The `dvichop` program

For interactive programs, speed is of the essence. Therefore, we will look at TEX's performance. The author's computer has a 225MHz Cyrix CPU. So that we have a definite figure, we will say that on this machine a response time of 1/10 seconds is acceptable.

Typesetting `story.tex` There is a file, `story.tex`, that is part of every TEX distribution. It is described in *The TEXbook*. On the author's computer, the command

```
time tex ./story \\end
```

[1] In the first draft, the allegedly expert author forgot that `&` is also special, and also that `\verb` cannot be used in a LaTeX footnote.

Mode	seconds
Console, output to `/dev/null`	.492
Console, output to screen	.507
X-windows, output to `/dev/null`	.497
X-windows, output to screen	.837

Table 1: Time taken to typeset `story.tex` 100 times

takes .245 seconds to execute[2]. This seems to make Instant Preview impossible.

However, the command

```
time tex \\end
```

takes only .240 seconds to execute. Therefore, it takes TEX almost 1/4 of a second to load and exit, while typesetting the two short paragraphs in `story.tex` can be done about 20 times in the target time of a tenth of a second.

Thus, provided the overhead of loading (and exiting) TEX can be avoided, Instant Preview is possible.

Remarks on performance The simple tests earlier in this article show that it takes TEX about 0.005 seconds to typeset the file `story.tex`. This subsection gives a more precise result. It also show some of the factors that can influence apparent performance.

The file `100story.tex` is as below.

```
\def\0{\input ./story }
\def\1{\0\0\0\0\0\0\0\0\0\0}
\def\2{\1\1\1\1\1\1\1\1\1\1}
\2 \end
```

Table 1 gives the time taken to process this file, in the various modes. It shows that on the author's machine and in the best conditions, it takes about $0.0025 \approx (0.492 - 0.240)/100$ seconds to process `story.tex` once.

Note that the time taken can be quite sensitive to the mode, particularly X-windows. We also note that using `\input story` (so that kpathsea looks for the file) adds about 0.025 seconds to the total time taken.

Starting TEX once The solution is to start TEX once, and use it to typeset multiple documents. Once TEX has typeset a page, it uses the `\shipout` command to write it to the `dvi` file. The new page now exists on the file system, and can be used by other programs. Actually, this is not always true.

[2] To avoid the overhead of X-windows, this command was executed in a virtual console. The same goes for the other timing data. The input file is placed in the current directory to reduce kpathsea overheads.

To improve performance, the system dependent part of TEX usually buffers the output `dvi` stream. However, this can be turned off. We assume that `dvi` output is unbuffered.

Most dvi-reading applications are unable to process such an ill-formed `dvi` file. For example, most immediately seek to the end of the file, to obtain a list of fonts used. To bridge this gap, and thereby enable Instant Preview, the author wrote a utility program called `dvichop`.

This program takes as input a `dvi` file, perhaps of thousands of pages, and produces from it perhaps thousands of tiny `dvi` files. The little files are the ones that the previewer is asked to reload.

More exactly, `dvichop` looks for special *marker pages* in the output dvi-stream produced by TEX the program. The marker pages delimit the material that is to be written to the small `dvi` files. The marker pages also control where the output of `dvichop` is to be written, and which process is to be informed once the output page is ready.

Implementation The program `dvichop` is written in the *C* programming language. It occupies about 800 lines of code, and calls in a header file `dviop.h` to define the opcodes. A shell program `texd` starts TEX and sends its `dvi` output to `dvichop`. More exactly, TEX writes to a named pipe (a FIFO), which is then read by `dvichop`.

More on performance In the abstract it is claimed that TEX together with `dvichop` is over 20 times quicker that ordinary TEX, when applied to small files. Here is some test data to support this bold claim.

Normally, `dvichop` is run using a pipe. To simplify matters, we will create the input stream as a ordinary file. The plain input file listed below does this. It also illustrates the interface to `dvichop`.

```
% 100chop.tex
\newcount\dvicount
\def\0{
\begingroup % begin chop marker page
  \global\advance\dvicount 1
  \count0\maxdimen \count1 3
  \count2 \dvicount \shipout\hbox{}
\endgroup
\input ./story % typeset the story
\begingroup % end chop marker page
  \count0\maxdimen \count1 4
  \count2 0 \shipout\hbox{}
\endgroup
}
\def\1{\0\0\0\0\0\0\0\0\0\0}
\def\2{\1\1\1\1\1\1\1\1\1\1}

\begingroup % say hello to dvichop
  \count0\maxdimen \count1 1
  \count2 1 \shipout\hbox{}
\endgroup
\2 % ask dvichop to produce 100 files
\begingroup % say goodbye to dvichop
  \count0\maxdimen \count1 2
  \count2 0 \shipout\hbox{}
\endgroup
\end
```

Typesetting `story.tex` 100 times in the conventional way takes approximately 24.5 seconds. Running TEX on `100chop.tex` takes about 0.510 seconds. This typesets the story for us 100 times. Running `dvichop` on the output file `100chop.dvi` takes 0.135 seconds. Its execution creates files `1.dvi` through to `100.dvi` that are for practical purposes identical to those obtained in the conventional way. The conventional route takes 24.5 seconds. The `dvichop` route took $0.510 + 0.135 = 0.645$ seconds.

This indicates that on `story.tex` using `dvichop` is $24.5/0.635 \approx 38$ times quicker. Some qualifying remarks are in order. In practice, using the pipeline will add overhead, but this seems to be less than 0.01 seconds. On the other hand, the present version of `dvichop` is not optimised.

The TEX daemon

A this point we assume the reader has some basic familiarity with client-server architecture. A server is a program that is running more or less continually, waiting for requests from clients. Clients can come and go, but servers are expected to persist. An operating system is a classic example of a server, while an application is a client.

Thanks for the memory Normally, TEX is run as an application or client program. It is loaded into memory to do its job, it does its job, and then it exits. In the mid-1980s, when the author started using a personal computer, having more than a megabyte of memory was uncommon. TEX is uncomfortable on less than 512Kb of memory. Thus running TEX as a server would consume perhaps half of the available memory. For all but the most rabid TEX-ophile, this is clearly not an option.

Today TEX requires perhaps 2Mb of memory, and personal computers typically have at least 32Mb of memory. Letting TEX remain in memory on a more or less permanent basis, much as Emacs and other programs remain loaded even when not used, is clearly practical. However, even today, for most users there is probably not room to have more than a handful of instances of TEX resident in memory.

Sockets The present implementation of Instant Preview uses a named pipe. Sockets provide a more reliable and flexible interface. In particular, sockets can handle contention (requests to the same server from several clients). Applications communicate to the X-server provided by X-windows by means of a socket.

Providing a socket interface to the TEX daemon will greatly increase its usefulness. The author hopes that by the end of the year he or someone else will have done this.

TEX as a callable function Over the years, many people have complained that the batch nature of TEX makes it unsuitable for today's new computing world. They have wanted TEX to be a callable function. However, to make TEX a callable function, all that is required is a suitable wrapper, that communicates with the TEX daemon.

At present the TEX daemon is capable of returning only a `dvi` file. To do this, it must parse the output `dvi` stream. Suppose, for example, that the caller wants to convert the output `dvi` into a bitmap, say for inclusion in an HTML page. The present set-up would result in the `dvi` pages being parsed twice. Although this is not expensive, compared to starting up a whole new TEX process, it is still far from optimal.

If the TEX daemon could be made to load page-handling modules, then the calling function could then ask for the bitmap conversion module to handle the pages produced by the function call. This would be more efficient. However, as we shall soon see, premature optimisation can be a source of problems.

TEX forever An errant application does not bring down the operating system. Strange keystrokes and mouse movements do not freeze X-windows. In the same way, applications should never be able to kill the TEX daemon. To achieve this level of reliability is something of a programming problem.

One thing is clear: The application cannot be allowed to send arbitrary raw TEX to the TEX daemon. TEX is much too sensitive. All it takes is something like

```
\global\let\def\undefined
```

and the TEX daemon will be rendered useless.

A more subtle form of this problem is when a client's call to the daemon results in an unintended, unwelcome, and not readily reversible change of state. For example, the LATEX macro `\maketitle` executes

```
\global\let\maketitle\relax
```

which is an example of such a command. (Doing this frees tokens from TEX's main memory. When TEX, macros and all, is shoe-horned into 512Kb, this may be a good idea.)

Protecting TEX TEX can be made a callable function by providing an interface to the TEX daemon. Most applications will want an interface that is safe to use. In other words, input syntax errors are reported before they get to TEX, and it is not possible to accidentally kill the TEX daemon. To provide this, the interface must be well defined. For example, the input might be an XML-document (say as a string) together with style parameters, and the output would be say a `dvi` file. Alternatively, the input might be a pointer to an already parsed data structure.

In the long run, this interface is probably best implemented using compiled code, rather than TEX macros. Once a function is used to translate source document into TEX input, there is far less need for developers to write complicated macros whose main purpose is to provide users with a comfortable input syntax. Instead, the interface function can do this.

When carried out in a systematic manner, this will remove the problem that in general LATEX is the only program that can understand a LATEX input file. The same holds for other TEX macros formats, of course. Note that Don Knuth's `WEAVE` (part of his literate programming system) is similarly compiled code that avoids the need to write complicated TEX macros.

Visual TEX

This article uses the term visual TEX to mean programs and other resources that allow the user to interact with a document through a formatted representation, typically a previewed `dvi` file. We use it in preference to WYSIWYG (what you see is what you get) for two reasons. The first is today many documents are formatted only for screen, and never get printed. Help files and web pages are examples of this. The second is that even when editing a document for print, the user may prefer a representation that is not WYSIWYG.

In most cases the author will benefit from interacting with a suitably formatted view of the underlying document. The benefits of readability and use of space that typesetting provides in print also manifest on the screen. But to insist on WYSIWYG is to ignore the differences between the two media. Hence our use of the term Visual TEX.

Whatever term is used, the technical problems are much the same, which is how to enable user interaction with the `dvi` file.

Richer `dvi` files In Visual TEX, the resulting `dvi` file is a view on the underlying document. For it to be possible to edit the document through the view, the view must allow the access to the underlying document. Editing changes applied to the view, such as insertion and deletion, can then be applied to the document.

Placing large numbers of `\special` commands in the `dvi` file is probably the best (and perhaps the only) way to make this work. Doing this is the responsibility of the macro package (here taken to include the input filter function described in the previous section). It is unlikely that any existing macro package, used in its intended manner, will support the generation of such enriched `dvi` files. The author's Active TEX macro package[2] is designed to allow this.

Better `dvi` previewers Most `dvi` previewers convert the `dvi` into a graphics file, such as a bitmap. Some retain information about the font and position of each glyph. A text editor or word processor has a cursor (called point in Emacs), and by moving the cursor text can be marked. This is a basic property of such programs. So far as the author knows, no `dvi` previewer allows such marking of text.

Further reading This section is based on the author's article [1].

The Lyx editor for LATEX adopts a visual approach to the generation of files that can be typeset using LATEX. It does not support WYSIWYG interaction. Understanding the capabilities and limitations of Lyx is probably a good way to learn more about this area.

The next steps

This section discusses some of the opportunities and problems in this general area, likely to present themselves over the next year or two.

Applications Two areas are likely to be the focus of development in the next year or so. The first is the refinement of Instant Preview, as a tool for use with existing TEX formats. Part of this is the creation of material for interactive (La)TEX training. Instant Preview provides an attractive showcase for the abilities of TEX and its various macro packages.

The second is TEX as a callable function. This is required for Visual TEX. One of the important missing components are libraries that allow rich interaction with `dvi` files. This will lay the foundation for TEX being embedded in desktop applications.

Licence The work described this article is at present released under the General Public Licence of the Free Software Foundation (the GPL). Roughly speaking, this means that any derived work that contains say the author's implementation of the TEX daemon must also be released under the GPL.

However, the TEX daemon is the basis for TEX as a callable function, and for good reason library functions are usually released under the Lesser (or Library) General Public Licence (the LGPL), or something similar. This means that the library as is can be linked into proprietary programs, but that any enhancement to the library must be released under the LGPL.

Porting TEX runs on almost all computers, and where it runs, it gives essentially identical results. The same applies, of course, to TEX macros. By and large, it is desirable that the tools used with TEX run can be made to run identically on all platforms. This is not to say that the special features of any particular platform should be ignored. Nor is it to say that advances (such as Instant Preview itself) should not first manifest on a more suitable platform.

Cross-platform portability is one of the great strengths of TEX. What is desirable is that programs that run with TEX have a similar portability. Many people cannot freely choose their computing platform. If TEX and friends are available everywhere, this make TEX a more attractive choice.

In the 1980s, in the early days of TEX, many pioneers ported TEX to diverse platforms. This work established deep roots that even today continue to nourish the community. Although Instant Preview, even when fully developed, is not on the same scale as TEX, it being ported will similarly nourish the community.

TEX macros Visual TEX requires a stable TEX daemon, which in turn will require a macro package (or a pre-loaded format). This new use of TEX places new demands on the macros. Here, we include in macros any input filter functions used to protect the TEX daemon from errant applications.

These new demands include protection against change of state, reporting and recovery from errors, ability to typeset document fragments, support for rich `dvi` file, and the ability for a single daemon to support round-robin processing of multiple documents. Once tools are in place, much of the input is likely to be XML, and much of the output will be for screen rather than paper.

The existing macros packages (such as plain, LaTeX and ConTeXT) were not written with these new requirements in mind. Although they are useful now, in the longer term it may be better to write a new macro package from scratch, for use in conjunction with suitable input filters.

Summary

By running TeX within a client-server architecture, many of the problems traditionally associated with it are removed. At the same time, new demands are placed on macro packages, device drivers (such as `dvichop` and `xdvi`) and a new category of software, input filters (such as `WEAVE`).

This new architecture allows Instant Preview, and opens the door to Visual TeX. All this is possible without making any changes to TeX the program, other than in the system dependent part.

Don Knuth In 1990, when he told us [4] that his work on developing TeX had come to an end, Don Knuth went on to say:

> Of course I do not claim to have found the best solution to every problem. I simply claim that it is a great advantage to have a fixed point as a building block. Improved macro packages can be added on the input side; improved device drivers can be added on the output side.

The work described in this article has taken its direction from this statement. One of the most obvious characteristics of today's computer monitors (not to be confused with the chalk monitor in classrooms of old) is their widespread use of colour. TeX is clumsy with colour. TeX was not designed with Visual TeX in mind. However, we still have our hands full making the best of what we have with TeX. If our labours bear fruit, then in time a place and a need for a successor will arise.

Again, this possibility was foretold by Don Knuth [3]:

> Of course I don't mean to imply that all problems of computational typography have been solved. Far from it! There are still countless important issues to be studied, relating especially to the many classes of documents that go far beyond what I ever intended TeX to handle.

References

[1] Jonathan Fine, Editing `.dvi` files, or Visual TeX, *TUGboat*, **17** (3) (1996), 255–259.

[2] ———, Active TeX and the `DOT` input syntax, *TUGboat*, **20** (3) (1999), 248–261

[3] Donald E. Knuth, The Errors of TeX, *Software—Practice & Experience*, **19** (1989) 607–685 (reprinted in *Literate Programming*)

[4] ———, The future of TeX and METAFONT, *TUGboat*, **11** (4) (1990), 489 (reprinted in *Digital Typography*)

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