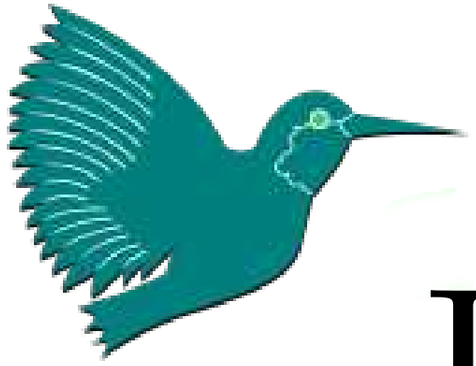

LaTeX

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Outline

Definitions and History

Definition of TEX

- An ASCII .tex file created with the help of a text editor shall be transformed to visually appealing document
- Idea: create qualitative layouts for read media on an arbitrary device with arbitrary operating system
- Focus on the document‘s structure for layout design
  - Optical markup: describes document‘s layout
  - Logical markup: captures document‘s structure, e. g. by setting titles

→ Mapping of the logical markup to the optical.

→ User can focus on the logical content instead of the visual appearance

→ Logical design by describing logical structure

Definition of TEX

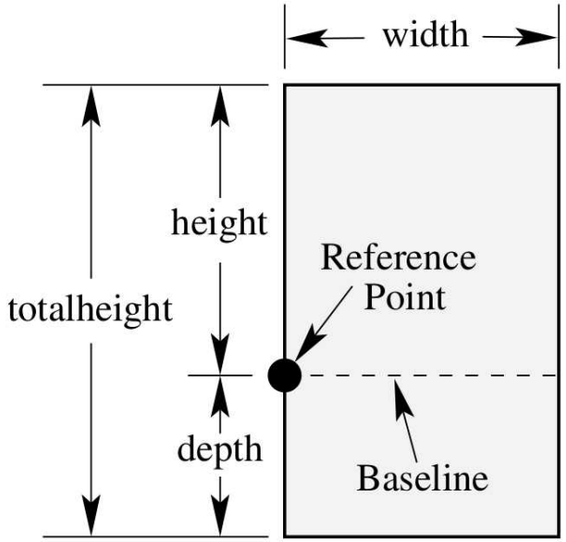


Figure 1: LaTeX box for graphic/ character [IV].

- Realization via typesetting:
  - Line and page breaks
  - Mathematical formulas
  - Writing direction, e. g. from bottom upwards, possible

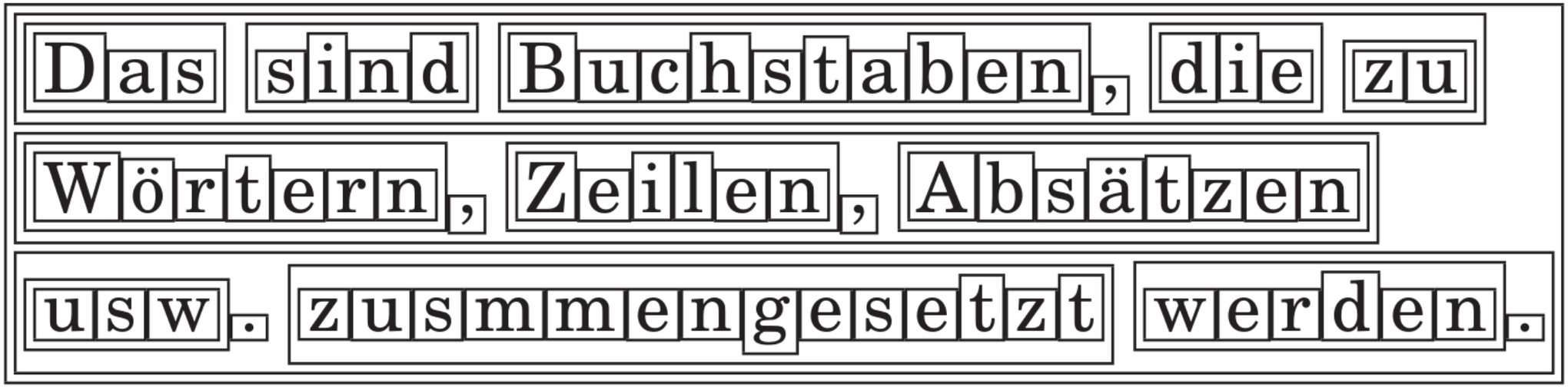


Figure 2: Typesetting TeX [II].

Definition of TEX

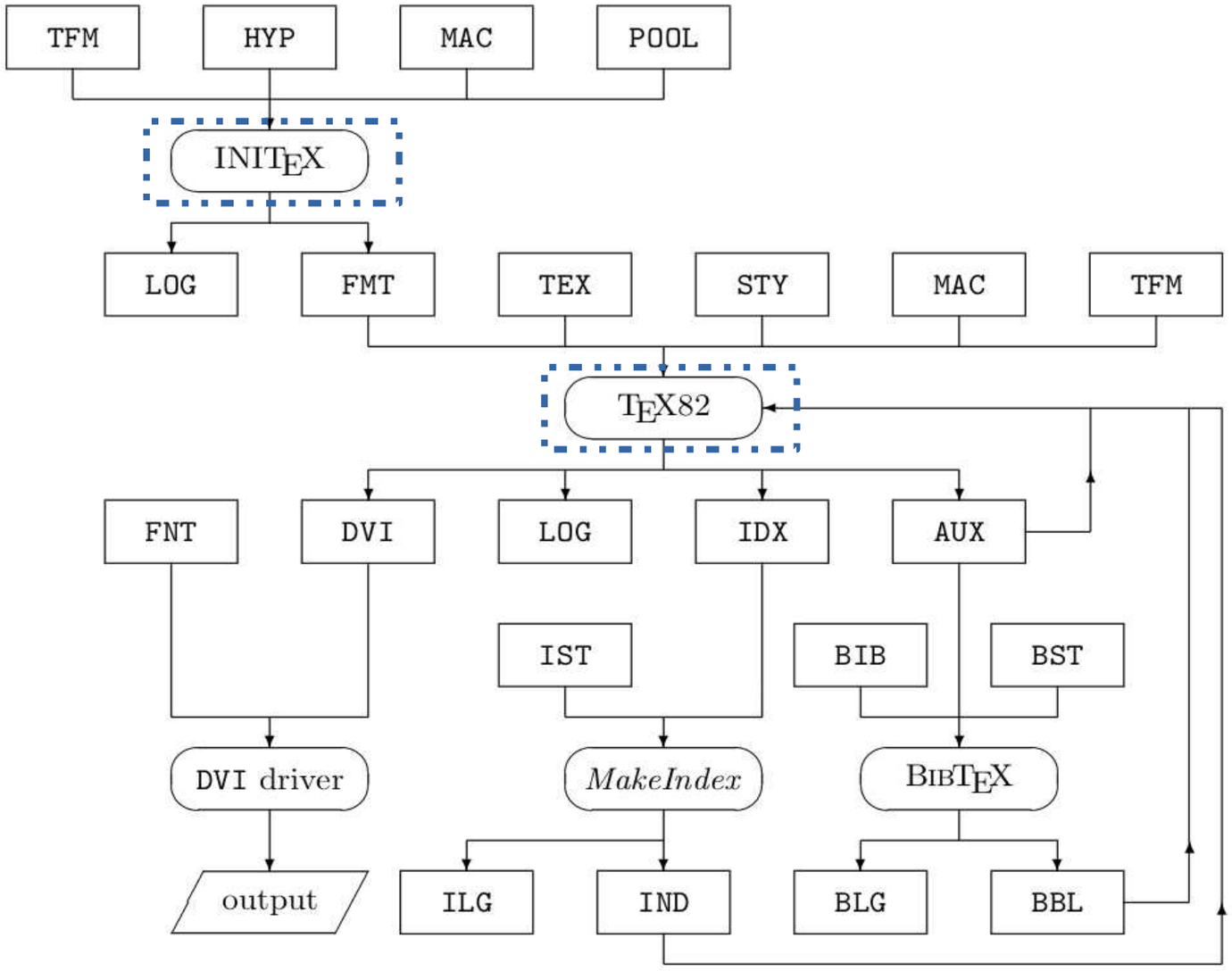


Figure 3: File tree [V].

- Written in documentation and developing language WEB.

  WEB-to-C source files enable the conversion into C lanugage.

- Kernel/engine is formatting program TeX82 with two levels of features:
  - Text formatting, page/paragraph breaks, hyphenation
  - Out of ca. 300 primitive commands, macro commands can be formulated. Results into Plain TeX

  → So far, lack in index formulation, bibliography building, and graphic insertion

  → INITEX runs complete version of TeX82

- Process run:
  1) When new format, e. g. new language: run INITEX to create new format file which has the definitions of higher-level commands and hyphenation patterns
  2) Read format file
  3) Process user‘s source .tex file

- „TeX“ often means the TeX system with METAFONT, dvi drivers, TeX program, and so on

Definition of TEX

- ✔ Open source
- ✔ Robust
- ✔ Efficient in time and space
- ✔ Standard TeX has 75 font types produced by METAFONT but also fonts representing other languages like Chinese, Japanese

- ✗ struggles with foreign languages, non-US
- ✗ Difficult to set up several languages for one document
- ✗ Ill-considered and rapid typeset sequences of characters

History of TeX

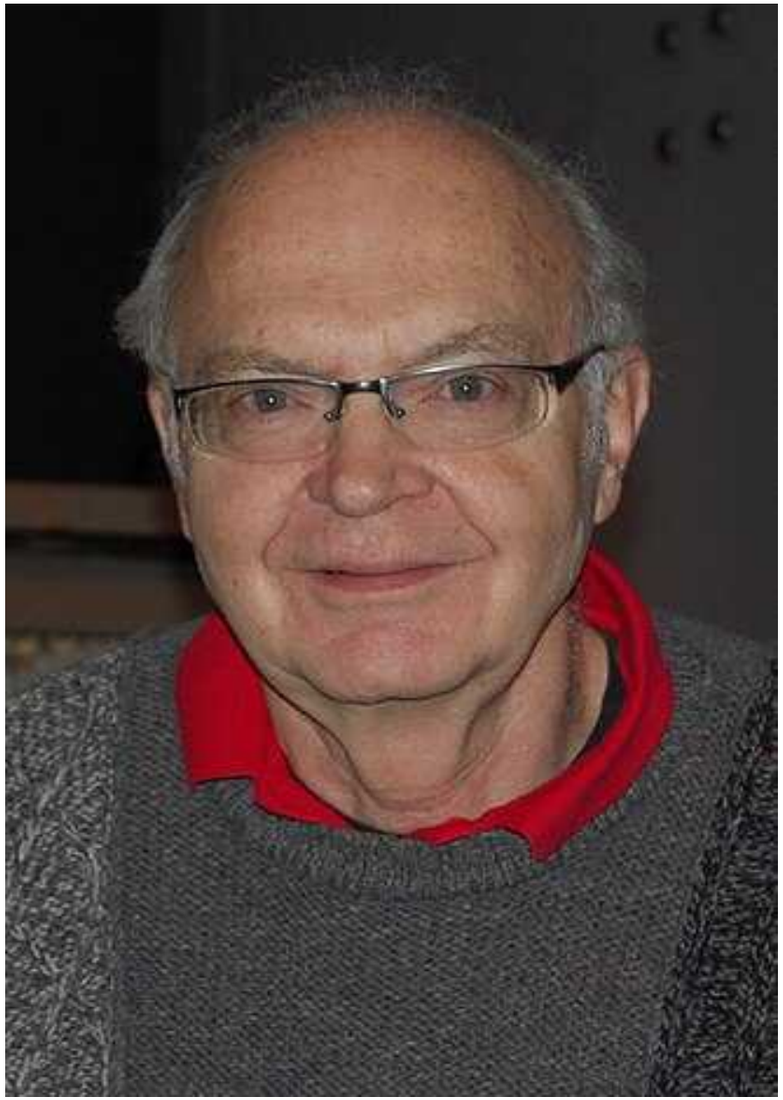


Figure 4: Prof. Dr. Donald Knuth [VII].

- 1978: TeX invented by Prof. Dr. Donald E. Knuth.

  Original aim: typesetting his own books

- 1980: foundation of the Tex Users Group (TUG):
  - cost-free organization, conferences, magazine, TeX distribution
  - TeX Directory Structure (TDS) for usage and installation
  - Comprehensive TeX Archive Network (CTAN) as web software archive
  - www.tug.org
- No changes of TeX but debugging
- 1989: expansion from 128 to 256 fonts to meet european font variety
- 1990: hyphenation for several languages, BUT still not guaranteed the right hyphenation by the usage of two different font encodings in the same paragraph
- Final TeX version 3.14 → No further developments
- Adoption by the American Mathematical Society (AMS) and other societies

Definition of PlainTeX

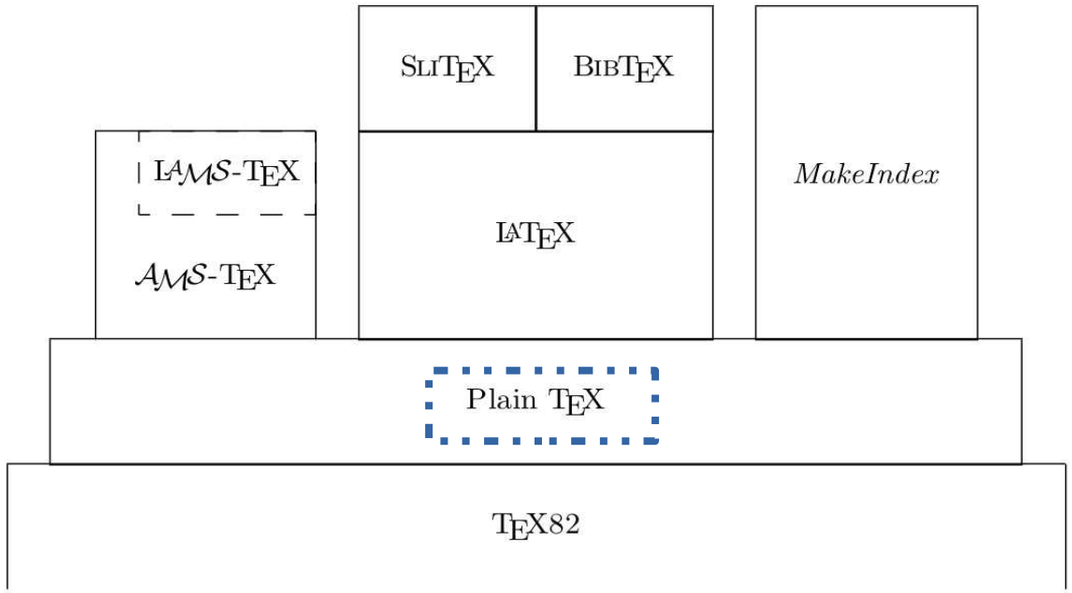


Figure 5: Development of TeX [VI].

- Command set to interact on a high level
  - → Basic macro package
  - → For optical markups
- The processing program is still TeX, meaning that Plain TeX parametrizes TeX82 typesetting machine
  - → Is not an engine but a format
  - → Is a TeX based language
- Basis of every other format

History of LaTeX

Figure 6: Dr. Leslie Lamport [l].

- Founder: Dr. Leslie Lamport
- Aims:
  - Overcome short-comings of TeX
  - Make it user friendly via high-level commands
  - User can concentrate on logical structure and less on formatting commands
- 1985: LaTeX 2.09
- 1992: LaTeX 2.09 frozen (nowadays obsolete)

  → Many incompatible extensions

  → 1994: LaTeX2e ($\LaTeX 2_\varepsilon$) to bring extensions to same format and use a better font system

  → Compatibility mode to run LaTeX 2.09 with LaTeX2e
- 1993: LaTeX3 project team:
  - Maintains LaTeX2e (finalized in 2003)
  - Original plan to develop LaTeX3 canceled
  - Improves LaTeX2e
- LaTeX2e used in scientific, academic and industrial areas

Definition of LaTeX

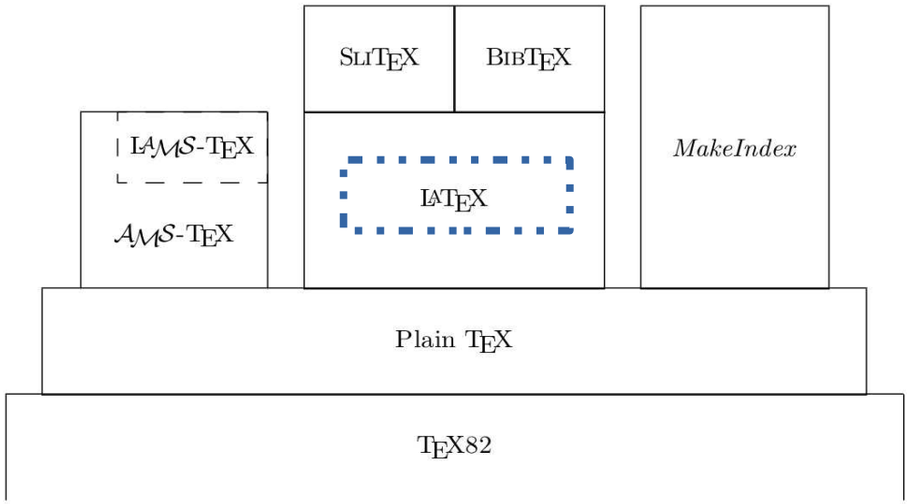


Figure 5: Development of TeX [VI].

- Macro package for logical markup built on top of Plain TeX
- Wrapper around TeX
  - → TeX for typesetting and processing of source file to final output
  - → No engine but format

- ✔ structure document without considering too many details of formatting, e. g. distances, font style, sizes, …
- ✔ No knowledge about object formatting, like graphics, needed
- ✔ Easy to create footnotes, tables, registers
- ✔ Pre-defined layouts
- ✔ Stronger mathematical formula collection

- ✔ Better typographical quality
- ✔ Complex documents can be generated with higher-level commands
- ✔ Easier to handle
- ✔ Better font system
- ✔ BibTeX to create a bibliography
- ✔ One document several languages

Definition of LaTeX

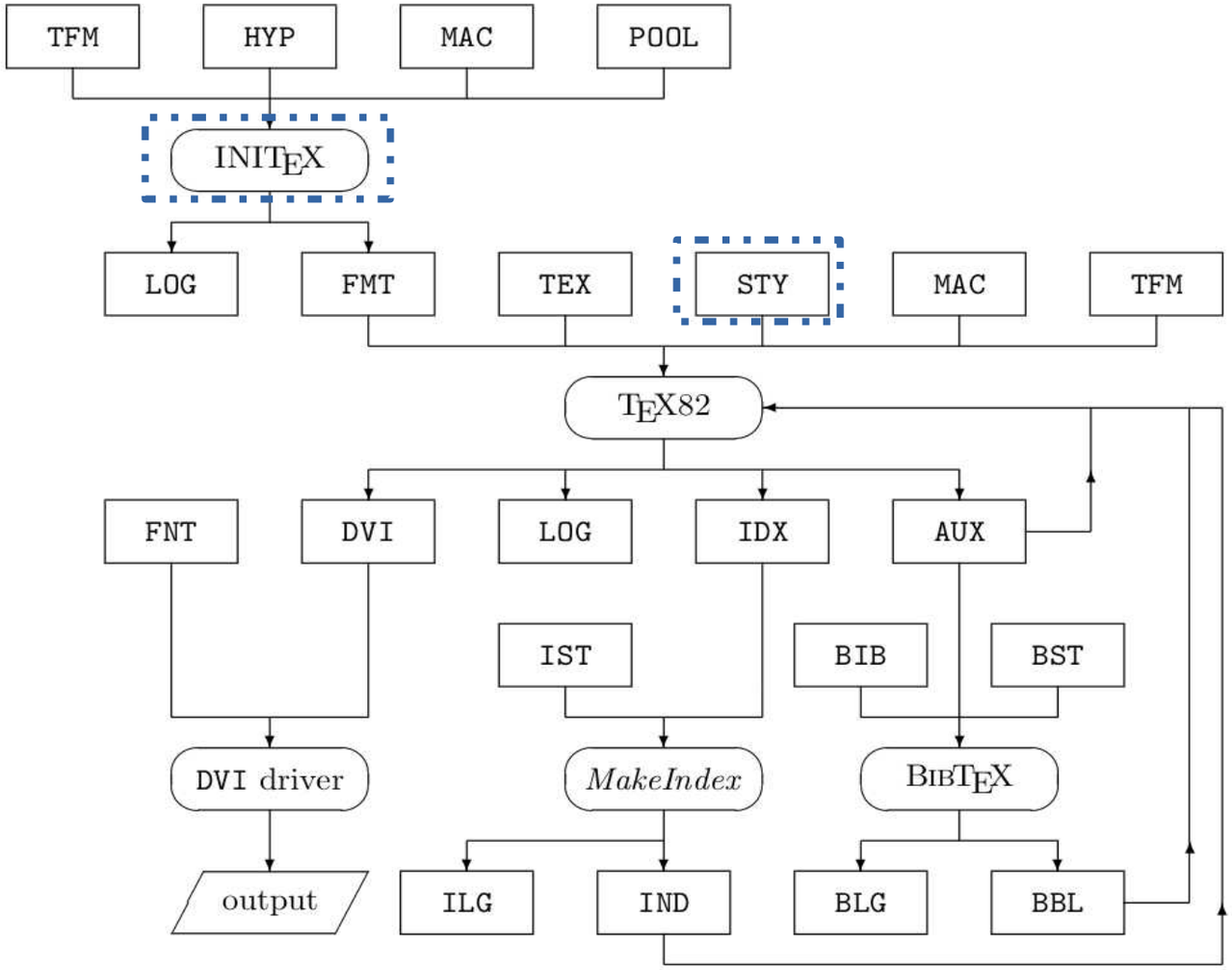


Figure 3: File tree [V].

- Macro packages for new functionalities consist of:
  - **.dtx**: documented source files
  - **.ins**: run LaTeX to it to get a source code file **.sty**
- set of **.dtx** files: source and documentation files to create classes, packets, and others.
  - **Unpacking with INITEX** gives, e. g.:
    - **.cls**: class file, overall format of document, e. g. article
    - **.clo**: class option file; coding for certain options
    - **.sty**: package file extending LaTeX command collection, importable in .tex files
    - **latex.ltx**:
      - Case latex.cfg exists: load this file to enable final format configuration for local conditions, e. g. hyphenation patterns, pre-load fonts
      - Case no latex.cfg exists: load .cfg files, then run latex.ltx to produce LaTeX format **latex.fmt** which gives basic instructions code for quick loading
  - Run with **DocStrip** program for documentation and code management gives, e. g.:
    - **.fd**: New Font Selection Scheme (NFSS) commands linking external font names with font attributes; font description files
    - **.ltx**: as input of INITEX to generate **latex.fmt**

Definition of LaTeX

- **TeX:** METAFONT‘s generated Computer Modern Fonts:
  - Type 3/pixel fonts
  - ensuring same output on every printer
  - bitmap fonts stored as **.pk** files containing images of font characters in binary format. The filename contains font family and resolution

    → No independent attribute selection possible, e. g. only Italic OR bold
- **LaTeX:** New Font Selection Scheme (NFSS):
  - Type 1/outline fonts: mathematical curves describe contours of characters
  - select attributes independently:

Encoding as **.def** files: storage of characters‘ font positions, e. g. ASCII, UTF-8

l in T1 *l in TS1*

Series

series **series**

m *b*

Size → linearly scalable!

argument 1: 12 *argument 1: 22*

Family

family family

cmr *cmss*

Shape

shape *shape*

it *sl*

argument 2: 6 *argument 2: 26*

Syntax of LaTeX

Syntax LaTeX: basic file

- A **.tex** document:
  - Created with text editor
  - Contains commands and textual content

    → Information for final output layout
  - Consists of a preamble and body, shortest document:

```
\documentclass{article}

\begin{document}
text
\end{document}
```

→ **preamble:** global processing parameters for upcoming text, e. g. paper format

body:
- text content
- commands applied to text parts

pdflatex filename

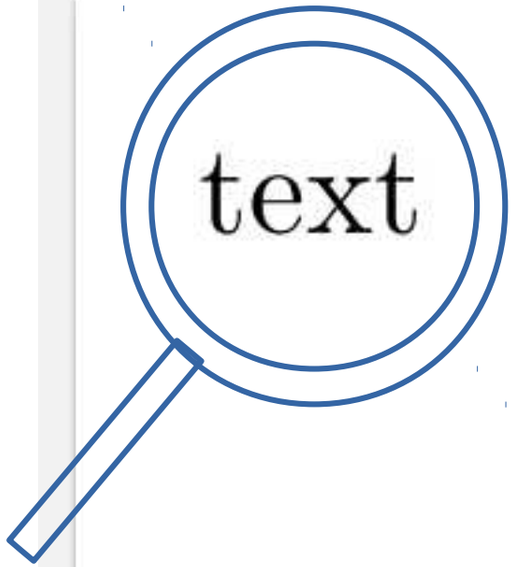
Öffnen star... ~/Sch... Speichern

```
\documentclass{article}
\begin{document}
text
\end{document}
```

Tabulatorbreite: 8 Z. 3, Sp. 5 EINF

pdflatex filename

1 von 1 star... 70%



Syntax LaTeX: command structure

- Command structure:

  \command[optional argument1, optional arugment2]{needed argument}

- Define own new command:

  \renewcommand{command_name}[1-9, e. g. 2]{content of command: arbitrary text #1, #2}

  Call command:

  \command_name{first_input}{second_input}

- Redefine existing command
- Symbols interpreted as commands: $ & % # _ ^ ~ { } \

  → Use \ to treat it like text, e. g. \$
- next line: \\
- comment: %

Syntax LaTeX: environment

- Apply commands only to parts of text:

  \begin{env_name}{argument1}{argument2}

  text

  \begin{inner_env_name}

  other text

  \end{inner_env_name}

  \end{env_name}

- Define own new environment:

  \renewenvironment{env_name}[1-9]{begin definition, commands which are activated first}{end definition}

- Redefine existing environment

Öffnen star... ~/Sch... Speichern

```
\documentclass{article}

\begin{document}

\begin{itemize}

\item my first item
\item my second item

\end{itemize}

\end{document}
```

Tabulatorbreite: 8 Z. 15, Sp. 1 EINF

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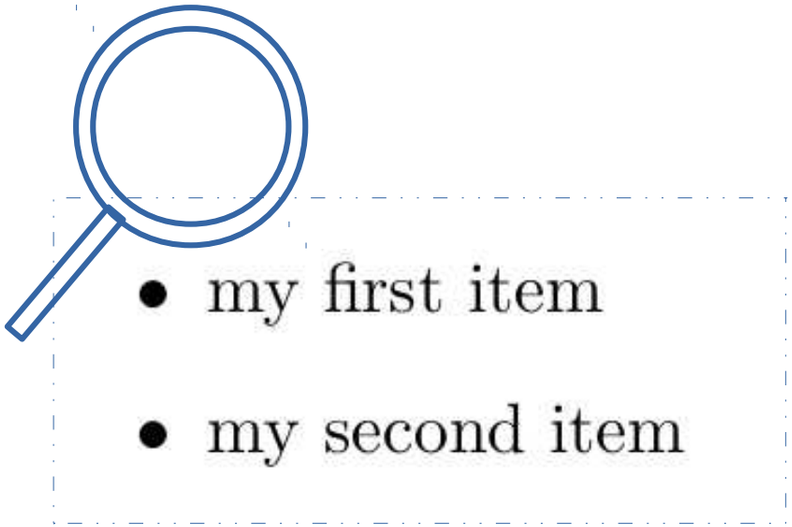


1 von 1 star... 70%

- my first item
- my second item

1

Öffnen star... Speichern

```
\begin{abstract}

The short summary of the content in form
of an abstract.

\end{abstract}

The text after the abstract.

\end{document}
```

Tabulatorbreite: 8 Z. 7, Sp. 58 EINF

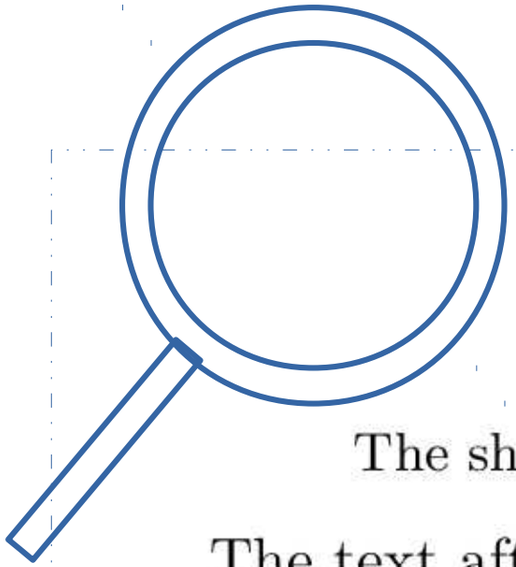
pdflatex filename

1 von 1 star... 70,68%

Abstract

The short summary of the content in form of an abstract.

The text after the abstract.



Abstract

The short summary of the content in form of an abstract.

The text after the abstract.

Syntax LaTeX: group

- Format only small text parts
- Implementation:

```
{}
```

- Font characteristics, like:
  - Font size:

\tiny	→ 5 pt	\large	→ 12 pt
\scriptsize	→ 7 pt	\Large	→ 14.4 pt
\footnotesize	→ 8 pt	\LARGE	→ 17.28 pt
\small	→ 9 pt	\huge	→ 20.74 pt
\normalsize	→ 10 pt	\Huge	→ 24.88 pt

  - Font color:

```
\usepackage{xcolor}
{\textcolor{green}}
```

- Several commands for one group possible {\command1 \command2}

Öffnen star... ~/Sch... Speichern

```
\documentclass{article}
\begin{document}

{\itshape This text is recursive in this
group area of \{ \}.}
Here is the non-impacted text outside the
group.

\end{document}
```

Tabulatorbreite: 8 Z. 8, Sp. 1 EINF

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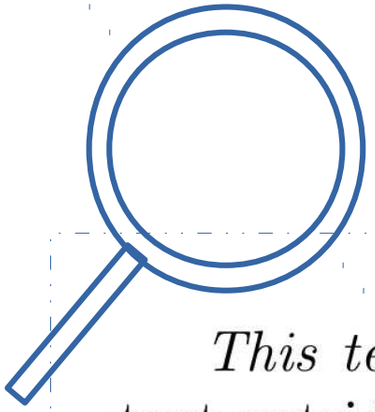
1 von 1 star... 70%

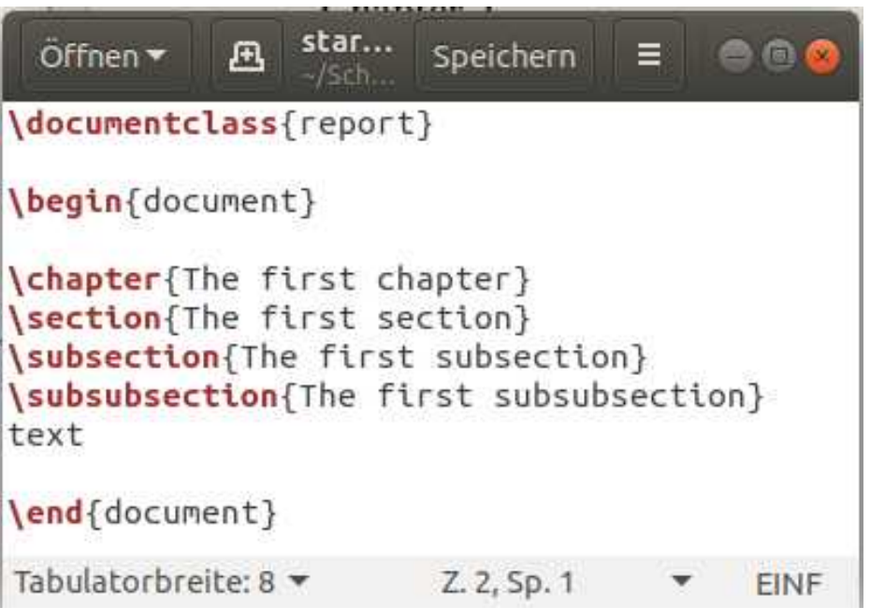
This text is recursive in this group area of { }. Here is the non-impacted text outside the group.



This text is recursive in this group area of { }. Here is the non-impacted text outside the group.

Syntax LaTeX: document subdivision

- Possible commands:
  - \part
  - \chapter
  - \section
  - \subsection
  - \subsubsection
  - \paragraph
  - \subparagraph



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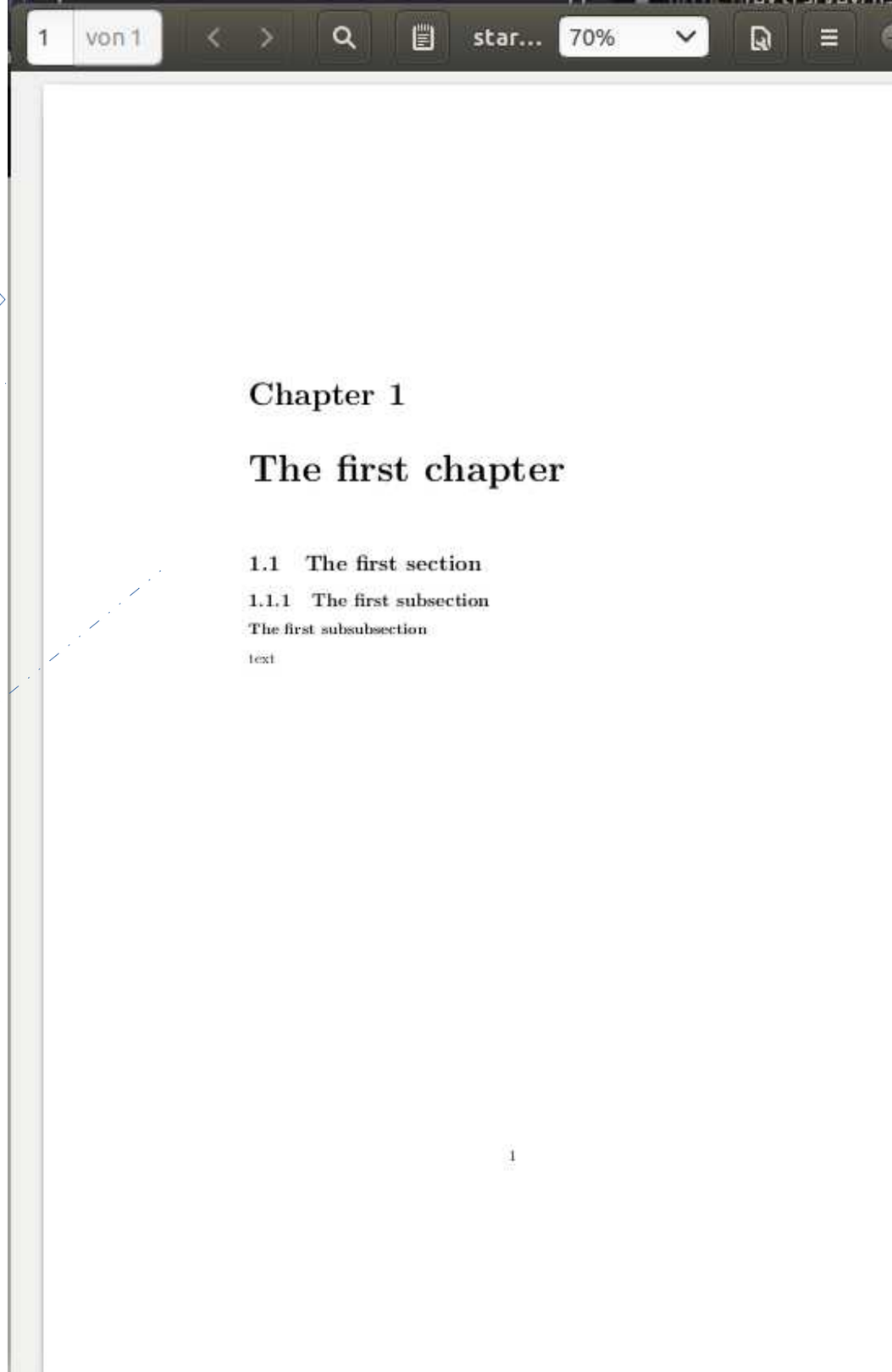
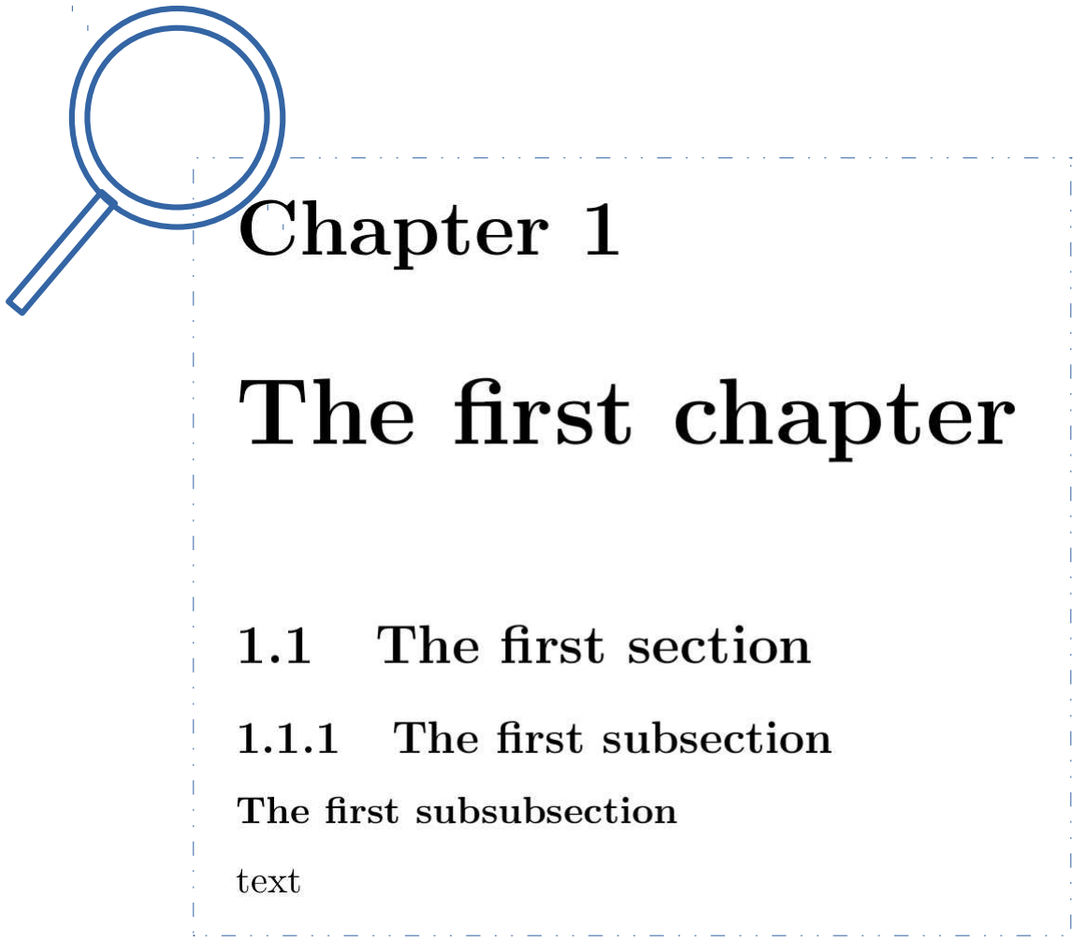




Syntax LaTeX: packages

- Preamble: make use of **.sty** packages:

  \usepackage[options]{package_name}

- different package types sorted by developer‘s party:
  - core: integral part of the LaTeX basic distribution
  - tools: LaTeX3 team created them, also in installation
  - graphics: integrate graphics from other programs, same level as tools
  - AMS-LaTeX: American Mathematical Society
  - contributed: LaTeX user written
- Run **latex209.def** with LaTeX2e by:

  \usepackage{oldlfont}

Öffnen star... Speichern

```
\documentclass{report}

\usepackage{xcolor}

\begin{document}

\textcolor{red}{text}

\end{document}
```

Tabulatorbreite: 8 Z. 3, Sp. 20 EINF

pdflatex filename

1 von 1 star... 70%

Öffnen star... ~/Sch... Speichern

```
\documentclass{report}

\usepackage{graphicx}

\begin{document}

\includegraphics[scale=0.5, angle=45]
{picture}


\begin{figure}[h]
\includegraphics{picture}
\caption{Retrieved from https://www.latex-
project.org/}
\label{piclabel}
\end{figure}

This is a reference to figure
\ref{piclabel}.

\end{document}
```

Tabulatorbreite: 8 Z. 10, Sp. 17 EINF

picture.png

pdflatex filename

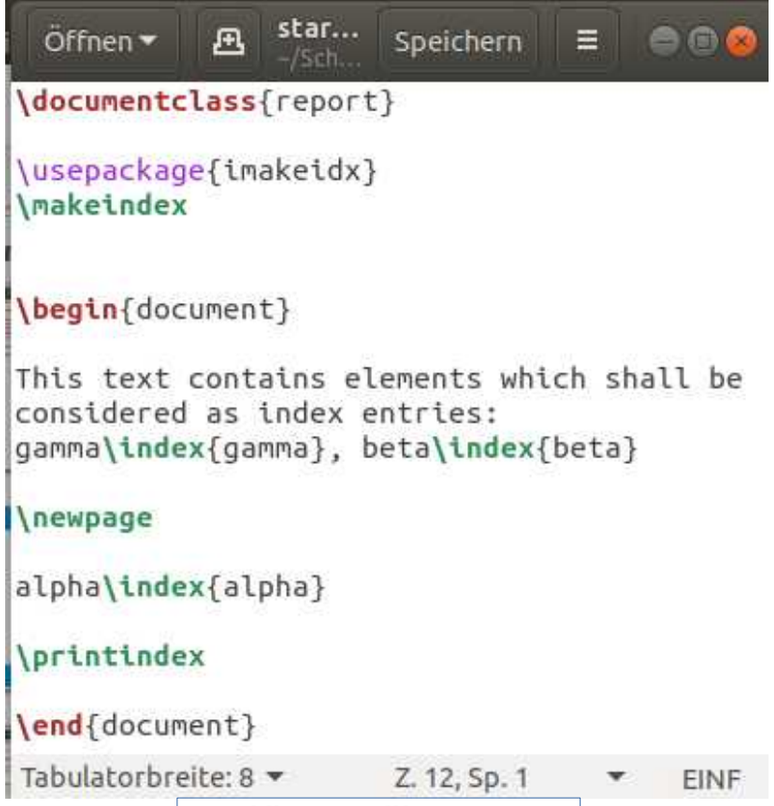
1 von 1 star... 70%

Figure 1: Retrieved from https://www.latex-project.org/

This is a reference to figure 1.

Figure 1: Retrieved from https://www.latex-project.org/

This is a reference to figure 1.



Page 1: This text contains elements which shall be considered as index entries: gamma, beta

Page 2: alpha

Page 3:

Index

Öffnen star... Speichern

```
\documentclass{report}

\usepackage[TS1, T1]{fontenc}

\begin{document}

\fontencoding{TS1}
\fontfamily{cmr}
\fontseries{wt_wth}
\fontshape{it}
\fontsize{22}{22}
\selectfont

l \\


{

\fontencoding{T1}
\fontsize{52}{22}
\selectfont

l

}

\end{document}
```

Tabulatorbreite: 8 Z. 2, Sp. 1 EINF

pdflatex filename

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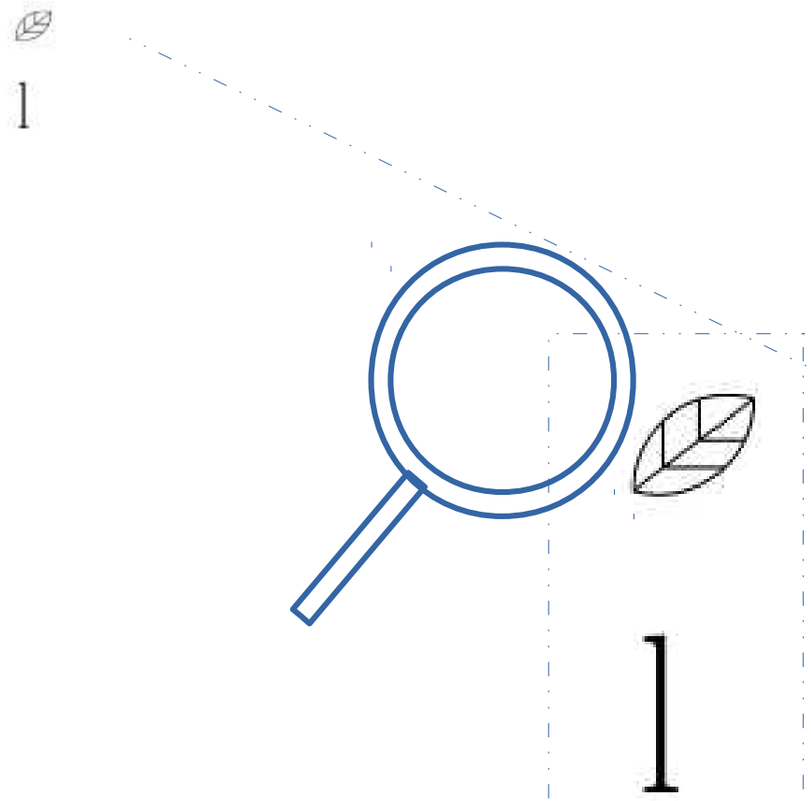


1

\usepackage[encoding]{encoding_scheme}

→ encoding sheme as

- mapping between input character and output character (glyph)
- effect on representation style of glyph

Syntax LaTeX: math section

Mathematical environments:

- Inline:
  - \(\)
  - \begin{math} \end{math}
  - $ $
- detachted from text:
  - \[\]
  - \begin{equation} \end{equation}
  - \begin{displaymath} \end{displaymath}
  - $$ $$

Syntax LaTeX: math section

\exists	$\exists$	\top	$\top$	\vdash	$\vdash$	\ne	$\neq$
\nexists	$\nexists$	\bot	$\bot$	\dashv	$\dashv$	\ge	$\geq$
\forall	$\forall$	\cap	$\cap$	\models	$\models$	\le	$\leq$
\setminus	$\setminus$	\cup	$\cup$			\approxeq	$\approxeq$
		\wedge	$\wedge$	\rightarrow	$\rightarrow$	\approx	$\approx$
		\vee	$\vee$	\leftarrow	$\leftarrow$	\propto	$\propto$
\in	$\in$	\oplus	$\oplus$	\leftrightarrow	$\leftrightarrow$		
\notin	$\notin$			\equiv	$\equiv$	\Omega	Ω
\ni	$\ni$					\mho	$\mho$
\subset	$\subset$	\bigcap	$\bigcap$	\sum	$\sum$	\Psi	Ψ
\supset	$\supset$	\bigcup	$\bigcup$	\prod	$\prod$	\Phi	Φ
\subseteq	$\subseteq$	\bigwedge	$\bigwedge$	\int	$\int$	\Theta	Θ
\supseteq	$\supseteq$	\bigvee	$\bigvee$			\Lambda	Λ
\emptyset	$\emptyset$			\triangle	$\triangle$		
				\nabla	∇	\cdots	$\cdots$
				\Delta	Δ	\Box	$\Box$

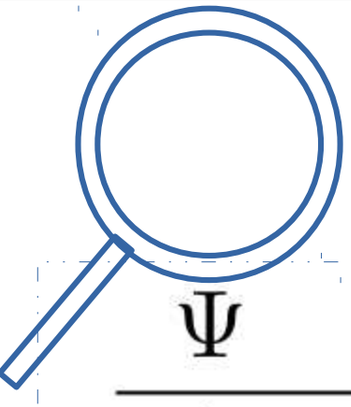
Öffnen start.tex Speichern

```latex
\documentclass{report}

\begin{document}

\begin{tabular}{c c | c c}
$\Psi$ & $\Phi$ & $(\Psi \wedge \Phi)$ & $(\Psi \vee \Phi)$ \\
\hline
1 & 1 & 1 & 1 \\
1 & 0 & 0 & 1 \\
0 & 1 & 0 & 1 \\
0 & 0 & 0 & 0 \\
\end{tabular}

\end{document}
```

LaTeX Tabulatorbreite: 8 Z. 13, Sp. 1 EINF

pdflatex filename

von 1 star... 70%



Ψ	Φ	$(\Psi \wedge \Phi)$	$(\Psi \vee \Phi)$
1	1	1	1
1	0	0	1
0	1	0	1
0	0	0	0

Ψ	Φ	$(\Psi \wedge \Phi)$	$(\Psi \vee \Phi)$
1	1	1	1
1	0	0	1
0	1	0	1
0	0	0	0

.tex to output file convertion

.tex to output file convertion: Processing LaTeX

How are the .tex files above converted to an approriate output file?

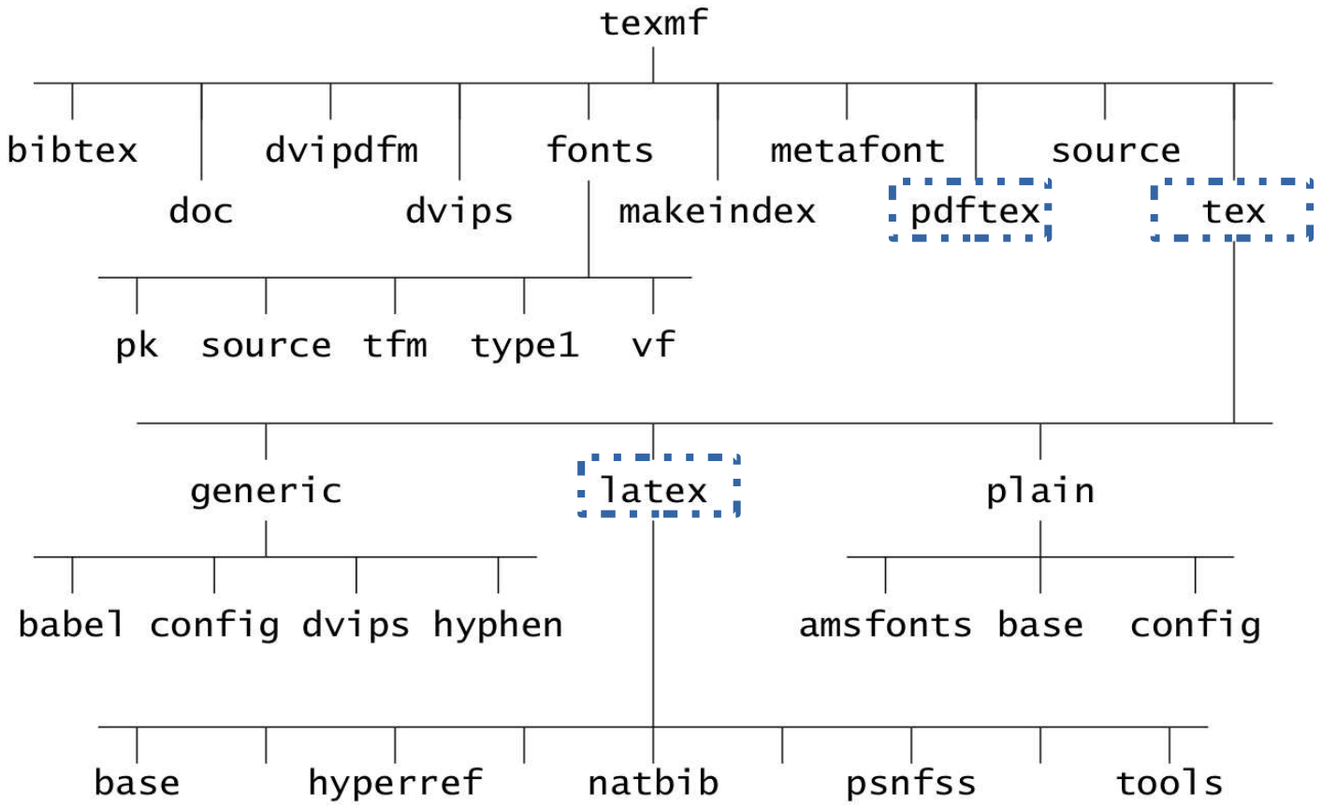


Figure 7: TeX Directory Structure (TDS) directory tree for usage and installation [III].

- **LaTeX:**
  - wrapper around TeX
    - → TeX processes
    - → Implementation of LaTeX format
  - .tex to **.dvi**
- **pdfLaTeX:**
  - adding LaTeX macros to pdfTeX results in pdfLaTeX
  - Wrapper around pdfTeX
    - → pdfTeX processes
    - → Implementation of LaTeX format
  - .tex to **.pdf**

Processing a LaTeX file

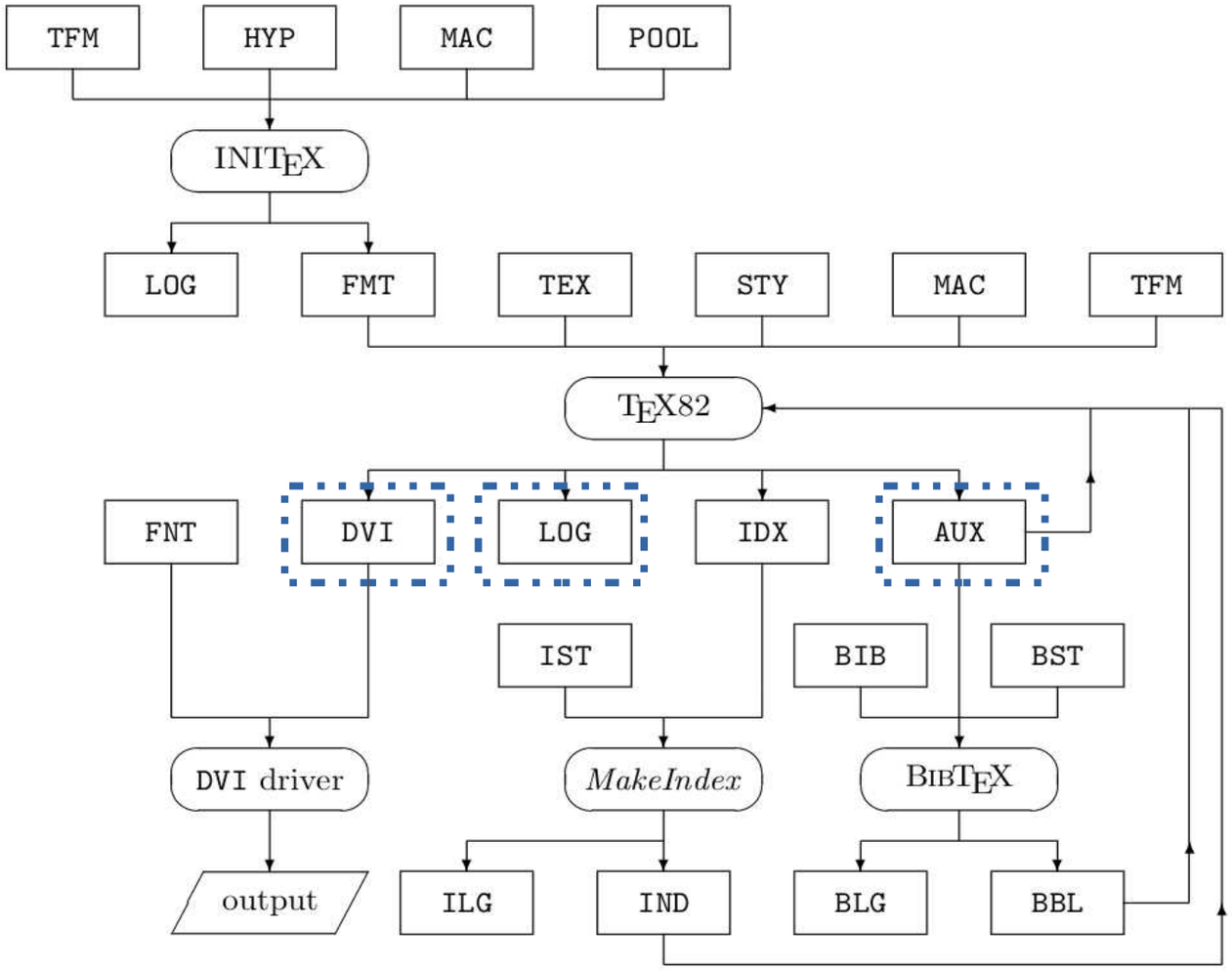


Figure 3: File tree [V].

- Create a .dvi/.pdf, .log, and .aux file when running LaTeX/pdfLaTeX
  - **.log**: information, warnings, errors
  - **.aux**: commands for table of contents and other lists, information for cross-references
- Several runs for one output, e. g.:
  - First run: .toc created containing table of contents;

    second run: integrate this in output
- Output .dvi file is processed then by the printer‘s driver

Processing a LaTeX file

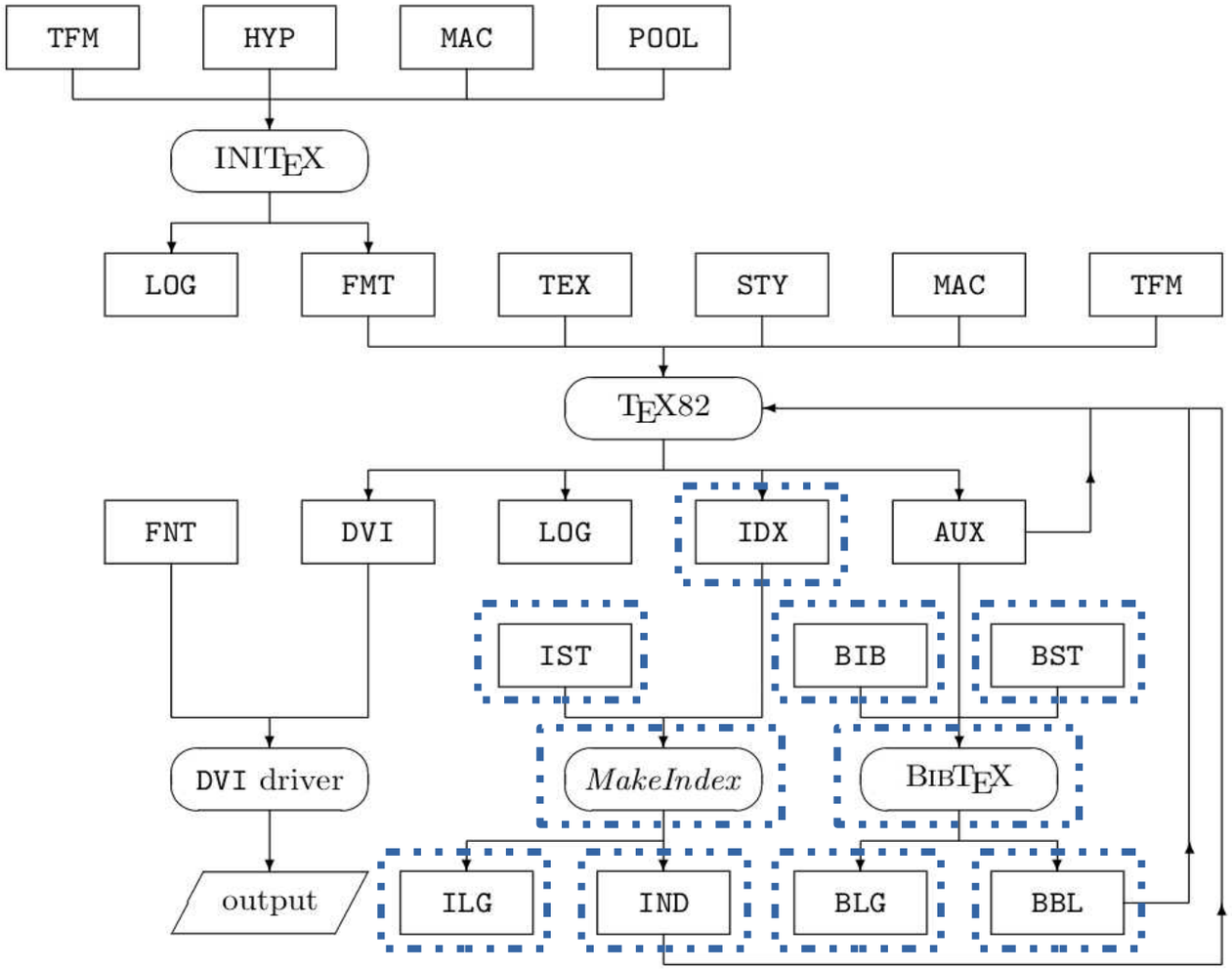


Figure 3: File tree [V].

- **BibTeX:**
  1) **.bst** defines format style of bibliography
  2) **.bib**: bibliographic database; user stores all the (potentially) used sources here with information about author, title, ...
  3) Reading **.bib** and **.aux** to get sorted bibiliography **.bbl**
  4) **.bbl** is read in next latex process step via command \bibliography in the **.tex** file
  5) **.blg** as the logfile
- **MakeIndex:**
  1) **.ist** defines format style
  2) reads **.idx** file containing entries and page numbers
  3) sorting **.idx** entries and writing them in **.ind** file
  4) **.ind** is used by **.tex**
  5) **.ilg** as the logfile

.tex to output file convertion: pdfTEX

Definition of pdfTeX

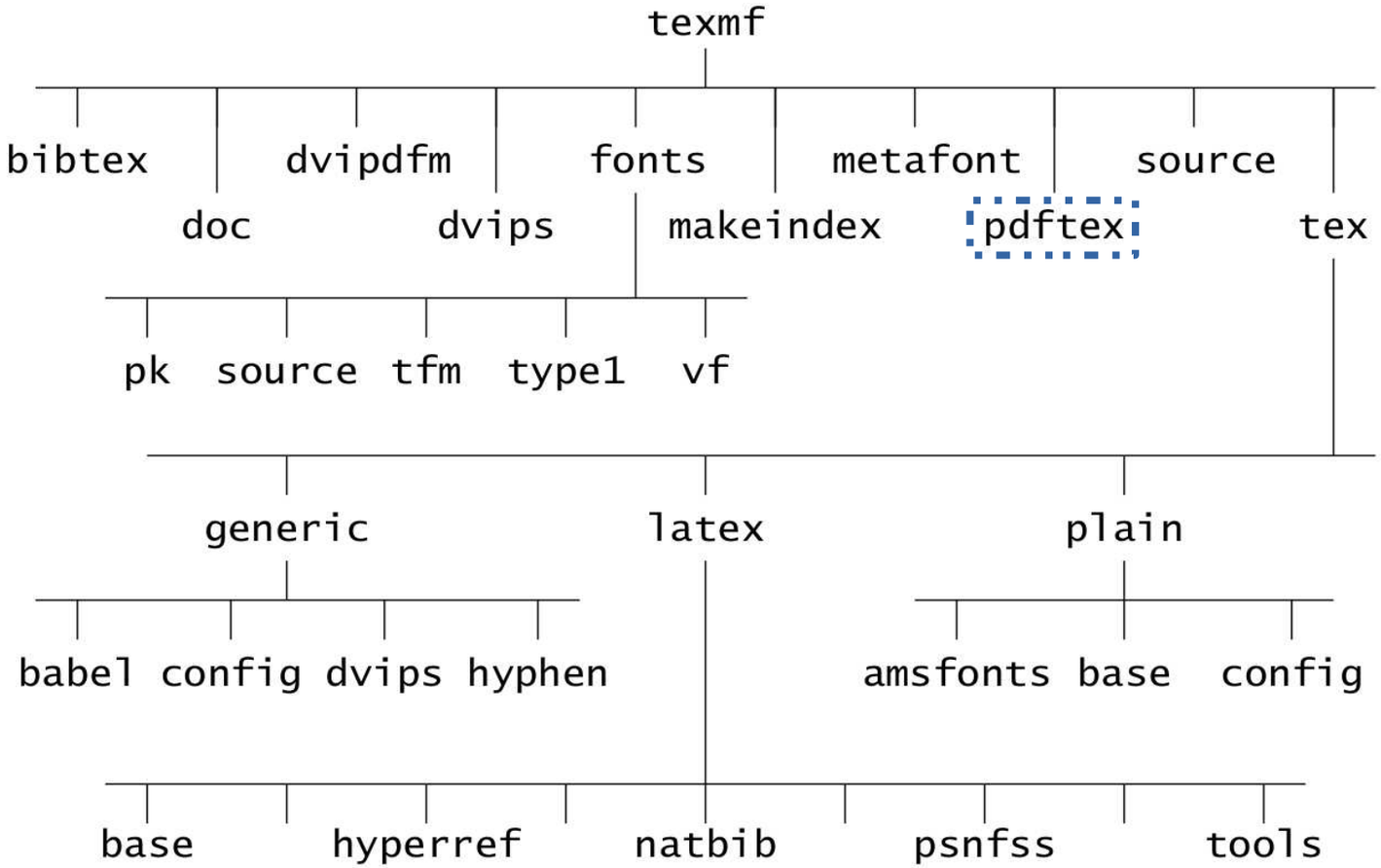


Figure 7: TeX Directory Structure (TDS) directory tree for usage and installation [III].

- Modification of TeX using TeX‘s source code

  → Same doings as TeX but with the ability to directly write the output to **.pdf** instead of .dvi file

  → The .dvi files of TeX and pdfTeX are identical

  → LaTeX commands identical for TeX and pdfTeX

- Engine; has driver

pdfTeX graphics

- **pdfTeX (pdfLaTeX)** can handle following graphic formats:
  - ✔ JPEG
  - ✔ PNG
  - ✔ PDF
  - ✔ MetaPost
  - ✗ Encapuslated PostScript (EPS): no direct import but in pdfLaTeX usable via epstopdf program
- **TeX (LaTeX)**: only supports EPS to include it in **.ps** PostScript files.

  However, non-EPS graphics convertable to EPS.

Graphics driver

- Tells the graphics package how to process imported graphic
- **graphics.cfg** in LaTeX:
  - Configuration file
  - Chooses the driver
  - Determines whether LaTeX or pdfLaTeX.
    - **LaTeX** → **dvips.def** as definition file for graphic rules (in general also for definition of special encoding and LaTeX 2.09 compatibility mode)
    - **pdfLaTeX** → **pdftex.def**
  - Override its driver by:

    \documentclass

    - Override \documentclass and graphics.cfg by:

      \usepackage[e. g. dvips which is already default]{graphics}

.tex to output file convertion: dvips

.dvi as output

- Output of TeX
- **dev**ice **i**ndependent
- Type and postion on page for each character specified, not the character/glyph layouts!
- Coded description of final printed page in binary style
- Convertable into ps, html, xml, pdf, …

→ **TeX only needs to know about a .tfm metric file containing shape independent character information. Glyph files describing character‘s shape aren‘t needed.**

.ps PostScript

- .dvi directly usable for printer‘s drivers, alternative: convert to .ps file
- **.ps**:
  - Instructs printer how to typeset document when transforming it into ink to paper.
  - Typeset example of S:
    1) ps interpreters use ASCII → S as 83
    2) ps font dictionary as encoding vector for that font → Goes to position 83 to get ps name /S
    3) Type 1 font interpreter looks at key /S in dictionary CharStrings to draw S by commands, curveto, lineto, fill, …
  - METAPOST creates ps figures
  - Device and operating system independent
  - Printer has .ps interpreter with definitions of ps fonts (e. g. binary .pfb, ASCII .pfa).

    Different TeX and ps font encodings

    → Solution: create a new font encoding with the character at wanted position
  - Command to **create .ps** out of .dvi:

    dvips filename

dvips driver

- dvips uses own Afm2tfm converter which converts ps fonts into .tfm and .vf
  - **.afm**: adobe font metric file about font information, height, width, depth, kerning, …
  - **.tfm**: → What TeX and LaTeX need
    - TeX font metric files
    - Font information, height, width, depth, kerning, …
    - No information about character‘s look
    - Each file has corresponding .vf file
  - **.vf**: → Relevant in LaTeX
    - Virtual fonts
    - Instructions to driver
    - Replaces .pk file
    - Read in fonts
    - Make it possible to use ps fonts in LaTeX documents
    - Rearrange and synthesize new character from extracted exsiting one
  - **.pk**: → Relevant in TeX
    - Information about character‘s look
    - Paked pixel or bitmap files
    - Glyph file

dvips driver

- **convert .dvi into .ps**; dvips steps:

  1) **config.proto** with memory allocation, resolution, font type, … → Default

  2) Read the user‘s **config.ps** for additional configuration settings → Overrides 1)

  3) If env var DVIPSRC set in terminal: user configuration specification of **.dvipsrc** dvips startup file, e. g. paper format

     Else: Default startup file in **$HOME/.dvipsrc**

  4) Command line

     dvips filename

     is read.

     If printing device command Pdevice: **config.device** is loaded which is a printer configuration which can override 1) and 2).

  5) If env var PRINTER set in terminal: When **config.$PRINTER** exists, then load it; config.printer relies on the individual printer

  6) If env var TEXCONFIG set in terminal: User‘s own printer-specific configuration

Glimpse into the project: DeltaDebug LaTeX Documents

Description

- Aim: Finding error positions within one LaTeX document by using the Minimizing Delta Debugging Algorithm (ddmin)
- Idea of ddmin:

  1) Split up the document into atoms
  2) Combine the atoms by putting them together to .tex documents
  3) Test the created .tex documents
     - If error: go back to 1) with the current combination
     - Else if the # splits < # all atoms: go back to 1) with all atoms and increase number of splits
     - Else: done

  → Results in getting the error code snippet excluding working code

Implementation

1) Load .tex file to check on
2) Parsing with pylatexenc.latexwalker; split .tex file into preamble, body, and rest parts.
3) ddmin;

   create new files by considering the single atomic commands and embedding them into the preamble and body to get valid .tex file;

   the .log file created by pdfLaTeX informs about the error to search

Docker for creating out of the original file a filesystem containing the results of ddmin.

→ Multithreading becomes possible

Thank you for your attention!

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