

MACTEX OVERVIEW

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Part A: Binaries

1. INTRODUCTION AND HISTORY

This is the root document for a series of related documents which explain how to construct MacTeX.

Wendy McKay conceived the idea of a Macintosh install package which would provide everything needed to use TeX on a Macintosh. After advocating the idea at a couple of earlier TUG conferences, she organized a lunch for Macintosh users at the TUG Practical TeX Meeting, 2005, in Chapel Hill, North Carolina. At that lunch, she pointed to Jonathan Kew and assigned the construction of the installer to him (how could Jonathan refuse!). Jonathan had to leave the conference the next morning, and we expected that he would construct the package over several weeks after he returned to England. Instead, Jonathan stayed up all night and had a package the next morning. Over breakfast, he willed maintenance of it to me.

Originally, MacTeX installed a TeX Distribution created by Gerben Wierda, based on teTeX. But in 2006, Thomas Esser, the author of teTeX, announced that the project was ending and recommended that users switch to TeX Live. Gerben Wierda then began revising his distribution to contain a mixture of teTeX and TeX Live, announcing the new distribution, gwTeX, in November, 2006 at the annual TUG meeting in Marrakesh, Morocco. But at that same meeting, Gerben held up a sign containing the words “I quit” and announced that he would no longer support his distribution. I then constructed test versions of MacTeX, one using the old teTeX, one using gwTeX, and another using the full TeX Live. To my delight, the TUG authorities pushed for the package based on the full TeX Live, and since 2007, that is what MacTeX installs.

2. BINARIES

This document is provided inside a build tree for MacTeX. Do not rearrange folders in this tree. As MacTeX is constructed, these folders will gradually be filled with bits and pieces of the package, until finally the complete package is inside one of the folders. Some folders contain a subfolder named MiscDocs. This is extra material that might be useful, so I kept it but don't suggest reading it.

Date: February 27, 2023.

MacTeX supports the operating systems for which Apple is currently providing security patches. These are the current system and the two previous systems. Thus in 2023 we should support Big Sur, Monterey, and Ventura. Around September Apple will release the next operating system, and we always support that as well by working carefully with the beta release starting in June.

Since the first Arm machines ran Big Sur, we support all previous Arm systems in 2023. On Intel, we sometimes enlarge the range of supported systems, and in both 2022 and 2023 we will support Mojave and higher. Thus we support Mojave, Catalina, Big Sur, Monterey, and Ventura on Intel. But we do not promise support in the future for anything but the current system and the two previous systems.

Binaries must be compiled twice, once on an Arm machine (this year running Big Sur) and once on an Intel machine (this year running Mojave). They are then combined using lipo, signed, and zipped up to be sent to TeX Live. It is useful to do the construction step on the most recent system, even if the compiles were done on older systems. In 2023 all steps except compiling are done on an Arm system running Ventura.

The first step in creating MacTeX and TeX Live for a yearly update is to compile the TeX Live Macintosh binaries. All material for this step is contained in the folder named “Binary”. The initial steps of the process must be done twice, once on the Arm machine for Arm binaries, and once on the Intel machine for Intel binaries.

Inside the “Binary” folder is a TextEdit document named BuildStatus-2023. This contains the full instructions for making TeX Live binaries. It contains actual commands which can be copied and pasted into Terminal. The first step is to create an empty folder in your home directory named texlive2023dev. Then an rsync command in the document populates it with the current sources. This same command updates the directory when the sources change. The original step takes several minutes, but updating typically takes 30 seconds or less. Here is that command

```
cd
cd texlive2023dev
rsync -a --delete --exclude=.svn tug.org:tldevsrc/Build/source .
```

After the source is obtained, compiling is straightforward. But a few preliminary steps are required.

A small number of the binaries link with X11 libraries. They are pdfopen, pdfclose, xdvixaw, and xindy. Originally, Apple supported X11 on macOS with an install package named xQuartz. This package was only updated when new systems were introduced, and X11 users complained, so Apple abandoned the project and it became an independent open source project. The releases can be obtained at <https://www.xquartz.org>. TeX Live links a few programs with the X11 Library, so X11 must be installed but need not be running.

One program, xindy, requires Lisp. So before building binaries, it is necessary to obtain and compile Lisp. This is explained in the following section.

3. LISP

When xindy was added to the TeX Live toolchain, we were told to first compile clisp-2.49 and put it in a spot which could be called by the build system. This procedure worked.

Shortly afterward, we needed to support both PowerPC and Intel processors. Compiling xindy produces xindy and two support files named xindy.mem and xindy.run. It turned out xindy.mem depended on the processor. The author of Xindy had to modify the code to use the correct support file when run.

Later new versions CLisp were introduced, but did not work on some of our systems, so we continued using clisp-2.49. When Apple made the Arm transition, clisp-2.49 didn't compile on Arm, so for a couple of years we only produced Intel code, and Arm users needed to run it with Rosetta.

Then I received an email from Roberto Avanzi, roberto.avanzi@gmail.com. This email explained how to compile the modern version of CLisp on both Arm and Intel Macintosh machines. The last section of the document BuildStatus-2023 lists the url where CLisp source can be obtained, and the Avanzi instructions to compile it. Lisp is installed in your home directory, and compiling is very straightforward. This step must be done just once before compiling TeX Live.

4. COMPILING TeX LIVE

First go to /usr/local and temporarily rename the bin, lib, include, share, and texlive folders so the system will not accidentally use some other code on the machine.

Now you are ready to compile. On an Arm machine, execute

```
cd
cd texlive2023dev/source
export STRIP="strip -u -r"
./Build --disable-arm-neon --enable-xindy CLISP=/Users/koch/CLisp/bin/clisp
```

The flag about arm-neon is needed when compiling on Arm because libpng has arm assembly code, but it only works on 32 bit processors and the Apple processor has 64 bits. It is likely that libpng will be updated in the future and this flag may no longer be necessary.

If there is an error, then it must be reported to TeX Live and an unpleasant debugging session will commence. But if there is no error and the build passes all tests automatically done at the end, then there will be a folder in texlive2023dev/source/inst/bin with a name like aarch64-apple-darwin22.2.0. The numbers 22.2.0 will be different when compiling on Big Sur. Move the entire folder to the directory Binary/Binary2023/RawCode on the machine used for the final construction of MacTeX.

On the Intel machine, the instruction to compile will be

```
cd
cd texlive2023dev/source
export STRIP="strip -u -r"
./Build --enable-xindy CLISP=/Users/koch//Users/koch/CLisp/bin/clisp
```

This command will produce a folder in `texlive2023dev/source/inst/bin` with a name like `x86_64-apple-darwin22.2.0`. Again the numbers 22.2.0 will be different when compiling on Mojave. Move this entire folder to the directory `Binary/Binary2023/RawCode`.

5. ASYMPOTOTE

One other binary requires special attention, `asy` or `Asymptote`. It is not compiled automatically by the build system used in the previous section.

There is a folder named `Asymptote` in the main TeX Live build folder. Create a copy of this folder in your home directory. The folder contains an instruction sheet, “`AsymptoteBuild-2023`”, and a `Sample` folder to test the final result. Follow the instructions in the instruction sheet. They will explain how to download and compile four libraries used by `asymptote`. This needs to be done only once a year. The libraries will be placed in the `Asymptote Folder` and thus will not modify `/usr/local`. The `asymptote` source itself is in the TeX Live source and obtained when you obtain that source. “`AsymptoteBuild-2023`” explains how to compile it. On Arm, rename the final binary “`asy-Arm`” and on Intel name it “`asy-Intel`”. Move these binaries to the machine used to create MacTeX and its `Binary/RawCode` folder.

6. PACKAGING UNIVERSAL-DARWIN

All remaining steps are done on the main computer, so in 2023 on an Arm machine running Ventura. After binaries are built on Arm and Intel machines, they are packaged to produce `universal-darwin.tar.xz`, which is sent to Karl Berry to add to TeX Live.

This will involve using some scripts in the MacTeX build system. The key scripts are named

```
lipounsignall.sh
lipocreateuniversaldarwin.sh
liposignuniversaldarwin.sh
liporebuild.sh
```

All of these scripts except `liposignuniversaldarwin.sh` contain the following two lines near the top:

```
ArmFiles=aarch64-apple-darwin22.2.0
IntelFiles=x86_64-apple-darwin22.2.0
```

Once each year, these scripts must be edited to replace these lines with the names created when compiling on the particular versions of macOS used to make Arm and Intel binaries. In 2023, these are

```
ArmFiles=aarch64-apple-darwin20.6.0
IntelFiles=x86_64-apple-darwin18.7.0
```

The scripts call the compression utility `xz`, which is not part of macOS. Therefore, the Binary folder must contain this binary.

To create the initial `universal-darwin.tar.xz` sent to TeX Live, run three of the four scripts in the following order:

```
sh lipounsignall.sh
sh lipocreateuniversaldarwin.sh
sh liposignuniversaldarwin.sh
```

What do these scripts do? The first script removes all developer signatures from the binaries in Raw Code. This is necessary because some versions of XCode, particularly on Arm, sign binaries automatically even when they are compiled on the command line. Experiments suggest that these signatures interfere with the `lipo` command.

The script `lipocreateuniversaldarwin` removes the `universal-darwin` directory its compressed file, if they exist, and then creates a new empty `universal-darwin` directory. Then it looks at all files in the Intel subdirectory of `RawCode`. If a file is not a symbolic link and is instead an executable, and if there is a corresponding Arm executable in the Arm directory, then the script creates a universal binary from these pieces and places it in `universal-darwin`. The script also copies Intel symbolic links and scripts directly into `universal-darwin`. Then it creates a universal binary from `asy-Intel` and `asy-Arm` and places it in `universal-darwin`. It creates a symbolic link `xasy` in `universal-darwin` related to `asy`. Finally, it renames `xindy.mem`, which was copied to `universal-darwin` from the Intel directory in `RawCode`, to `xindy-x86_64.mem`, and copies the corresponding Arm file in `RawCode` to `xindy-arm64.mem`.

After these steps, `universal-darwin` contains unsigned copies of the complete macOS TeX Live binaries.

The script `liposignuniversaldarwin` signs all of the binaries in `universal-darwin`, and adopts a hardened runtime for these binaries. A small number of binaries require exceptions. These binaries are signed again, this time with a hardened runtime allowing the required exceptions.

Then `liposignuniversaldarwin` creates `universal-darwin.tar`, and compresses it to `universal-darwin.tar.xz`. This final compression step takes a little time, because `xz` takes longer to compress but decompresses very rapidly.

The file `universal-darwin.tar.xz` should be sent to Karl Berry for inclusion in the initial TeX Live 2023 pretest.

7. MINOR DETAILS OF THE PREVIOUS PROCESS

Since the Macintosh does not come with a copy of `xz`, it is necessary to compile it and place a copy of the binary in the `Binary-2023` directory so the script can find it. We'll describe compiling `xz` in the next section.

Open the `lipocreateuniversaldarwin` script in an editor. You'll notice is that it uses the `file` command to determine whether a file is a link, a script, an Intel-only binary, or a universal binary. Only the last two types of files are signed.

Next notice that for Intel-only binaries like `xindy`, `file(xindy)` outputs `"xindy: Mach-O 64-bit executable x86_64"`. But for universal binaries like `tex`, `file(tex)` outputs a longer string which only starts with the script `"tex: Mach-O universal binary"` and then continues with text which we ignore.

These files are signed using the command

```
codesign -s "Developer ID Application: Richard Koch"
```

Another person running this script would have to pay Apple \$100 a year to become an Apple Developer. They would then obtain two licenses called `"Developer ID Application"` and `"Developer ID Installer"`. The first license is used for applications, and the second will be used soon for MacTeX and other install packages. When these licenses are obtained, information about them is stored in the computer's Keychain. This information is accessed to sign the code. Therefore as written, the script will only work for me, and another person will need to change to their own name and insure that the keychain has appropriate information from Apple. Incidentally, there is a fancy way to move developer keychain information from one computer to another. Thus if I buy and use a new machine, the scripts won't work until I move my keychain developer information using the fancy method.

Notice that the signing commands have a flag

```
--options=runtime
```

This flag causes the application to adopt Apple's `"hardened runtime."` Such an application is not allowed to perform certain dangerous tasks like accessing the camera, or the user's location, or the user's address book. The application also cannot link with a third party library, or execute JIT-compiled code. A full list of prohibited actions can be found in the document `"Hardened Runtime Entitlements"` in the `Binary/Exceptions` directory.

However, for each prohibition, the application can file an `"exception."` These exceptions are always automatically granted. So the idea is that Apple doesn't restrict programs in any way, but if a programmer doesn't intend to use a dangerous feature, they the programmer can make sure that even illegal code inserted by an attacker cannot use that feature.

After signing all binaries, the script `lipoharden` considers a few applications that require exceptions. These are signed again, and this time an additional flag `"-entitlements"` lists a file containing the required entitlements for that program. Three binaries (`mf`, `xdvi-xaw`,

and `dvisvgm`), link with an X11 library which is created by a third party, so they need an entitlement for that purpose. Four applications related to `luatex` require an entitlement to run JIT code.

8. xz

Certain portions of the TeX Live Unix Install Script, and the `tlmgr` code in TeX Live, use `wget` and `curl` to download code, and use `xz` to compress and decompress files. The Mac already has `curl`, so nothing has to be done about it. Since `curl` suffices, we do not provide `wget`. But early each year, before seriously working on the binaries, we must compile `xz` and send the resulting universal code to Karl. The folder `xz-code` in the Binary directory contains all scripts and tools to do this. We only use limited `xz` abilities, so the configure command disables many features.

To compile, search the internet for source code; we currently use `xz-5.2.5`. Uncompress the tar file and compile `xz` using the instructions

```
cd xz-5.2.5
./configure --disable-nls --disable-shared --disable-threads
make
strip src/xz/xz
cp src/xz/xz ../xz.Arm
```

On Intel, replace the last `xz.Arm` with `xz.Intel`. Place these two binaries in the `RawCode` directory. Run

```
sh lipoxz.sh
```

to produce `xz-universal-darwin` and `xz-universal-darwin.tar.xz`.

9. LZ4

Certain portions of `tlmgr` also use `lz4`, and Karl may ask for binaries for this program. They are produced exactly as the `xz` binaries.

To compile, search the internet for source code; we currently use `lz4-9.3`. Uncompress the tar file and compile `lz4` using the instructions

```
cd lz4-1.9.3
make
strip lz4
cp lz4 ../lz4.Arm
```

On Intel, replace the last `lz4.Arm` with `lz4.Intel`. Place these two binaries in the `RawCode` directory. Run

```
sh lipolz4.sh
```

to produce `lz4-universal-darwin` and `lz4-universal-darwin.tar.xz`.

10. UPDATING BINARIES

It will be necessary to update the TeX Live binaries several times during the pretest period as new code is installed and bugs are fixed. To do that, we recreate the full set of binaries as described earlier, and send this full set to Karl. But when he installs the set in the pretest, he only installs files which have been changed, so testers don't need to reinstall the full binary set. Unhappily, the lipo stage of our process changes the state of files and ruins this plan.

A modified process fixes this problem. When Karl asks for a rebuild, first rename the RawCode folder to RawCodeOld. If there is already a RawCodeOld folder, use the Date file inside to rename it RawCodeJan26 (or another date) and put it in RawCodeHistory.

Next uncompress the file universal-darwin.tar.xz in RawCodeOld.

Then compile and add files to RawCode as usual. But in the final stage, instead of running the three lipo files listed earlier, run

```
sh lipounsignall.sh
sh liporebuild.sh
```

The liporebuild script compares all Intel files in RawCode to the corresponding Intel files in RawCodeOld. If the two files are the same, then it copies the corresponding file from RawCodeOld/universal-darwin to the new universal-darwin folder begin constructed. Otherwise it creates a new file by using lipo as usual, and signs this file if necessary. Details can be seen by reading liporebuild. The end result is that if a file did not change, then the old file from the previous universal-darwin is sent to Karl, but otherwise a new file is sent.

The script also reports all changed files. This detail can be sent to Karl with the new universal-darwin, so he can check that the expected files were changed.

I hope this continues to work in the future, because liporebuild is the most complicated shell script I have ever written. (By Karl's standards, it was a triviality.)

11. LUAMETATEX

In the middle of the pretest for 2023, the ConTeXt team submitted a ConTeXt distribution with a single binary named `luametatex`. Unfortunately, this binary was created using `cmake`, which is not part of the TeX Live build system. As this paragraph is being written, it looks like the ConTeXt team will create their own binaries for all platforms and submit the binaries directly to TeX Live. This creates problems for MacTeX-2023 because those binaries would not be signed and thus could not be included in our install package.

I refused to install `cmake` on my systems because I maintain a plain vanilla system for the sake of TeXShop. But with important help of Mojca Miklavc, I discovered that it is easy to deal with `luametatex` and `cmake` without breaking this promise. The key point is that there is a CMake packaged as a macOS application. This application is self contained; it installs nothing in `/usr/local` or the XCode build system. The application can be pointed to the source code of a `cmake`-based project, and with a few simple steps it creates a make file for the platform on which it is running. After that, a simple “make” rapidly produces `luametatex`.

Here are the details. The application can be downloaded from <https://github.com/Kitware/CMake> and indeed the link <https://github.com/Kitware/CMake/releases/download/v3.25.2/cmake03.25.20macos-universal.dmg> produces a `dmg` file with the application. Place a copy of this program in the Application directory of all machines used to build `luametatex`.

The source code for `luametatex` was obtained from <https://github.com/texttextgarden/luametatex>. The ConTeXt people might provide a different location in a future year. This location ultimately produces a folder named `luametatex-main`. Add that folder to the Binary folder of the MacTeX build system.

Open the Application CMake. A dialog will appear with a number of fields. The top line of the dialog reads

Where is the source code:

Next to that field is a button named “Browse Source...”. Click it to bring up a Finder window and select the folder `luametatex-main` in this window. This will fill in the top line.

The next line, titled Preset, can be ignored. The following line is titled

Where to build the binaries:

Next to that field is a button named “Browser Build...”. Click it to bring up a Finder window pointed to the contents of `luametatex-main`. Create a new folder in this folder named “inst”.

Near the bottom of the dialog is a button named "Configure". Push this, and notice that the terminal window at the bottom shows the resulting action. In the end, CMake will create some items in the middle portion named

```
CMAKE-BUILD_TYPE
CMAKE-INSTALL_PREFIX    /usr/local
CMAKE_OSX_ARCHITECTURES
CMAKE_OSX_DEPLOYMENT_TARGET
CMAKE_OSX_SYSROOT       /Applications/Xcode.app/Contents/Developer/Pi...
```

These items will appear in red so the user can edit them, but editing is not needed. For instance the second item determines where luametateX will be installed if we type "sudo make install" but we will never do that.

At the bottom of the dialog, push "Generate". This item will create some files in luametateX-main/inst. The most important is named "Makefile".

Using Terminal, change directory to luametateX-main/inst and type "make". The project will be built in the usual way and the binary luametateX will appear in luametateX-main/inst.

Move this to the folder RawCodeConTeXt the Binary directory of the computer used for final construction of MacTeX-2023. Rename the two binaries luametateX-Arm and luametateX-Intel.

Part B: BasicTeX

12. INSTALL PACKAGES

A glance at the MacTeX-2023 directory reveals that most folders install one or another version of TeX, or a piece of the full MacTeX. All of these folders are constructed in the same way, so it suffices to describe the specifics in a single case. Let us concentrate on BasicTeX-2023.

The folder for this item contains a directory named “root”. This directory will eventually contain a duplicate of part of the Mac file tree, containing exactly the new material to be installed on that machine. For example, the root folder for BasicTeX-2023 will contain `root/usr/local/texlive/2023basic/...` and the string of dots will be the full contents of BasicTeX. The BasicTeX subfolder of MacTeX-Doc-2023 contains scripts which construct this root folder, and then scripts which create the install package from this root, and finally scripts which sign and notarize this package.

To create the root folder, we will install BasicTeX on our machine using the TeX Live Unix Install Script. This script is available at <https://tug.org/texlive/acquire-netinstall.html> by clicking the link titled “install-tl-unx.tar.gz”. The pretest of Tex Live contains a similar script. This script, when run, downloads a large number of packages over the internet and installs them on the local machine.

However, it is much more convenient to download the full set of install packages once and for all and keep them on our local machine, since many different installs will be done from the collection. We place this full set in the directory `~/texlive2023pretest`.

Even before the pretest is available, it is useful to remake everything using the previous year’s packages. The following command will populate `~/texlive2023pretest` from the CTAN repository in Utah. Here the two backslashes should be removed and the last two lines combined into one line.

```
cd
cd texlive2023pretest
rsync -a --delete --exclude="mactex*" \\  
    rsync://ctan.math.utah.edu/CTAN/systems/texlive/tlnet .
```

When the pretest becomes available, the following command downloads the pretest directly from the Utah mirror server in the same way.

```
cd
cd texlive2023pretest
rsync -a --delete --exclude="mactex*" ftp.math.utah.edu::tlpretest .
```

It is also possible to download the pretest directly from TUG’s server, but this loads the server and should usually be avoided. Also, it may create an extra folder between `texlive2023pretest` and the contents downloaded, changing some later scripts.

```
cd
cd texlive2023pretest
rsync -a --delete --exclude="mactex*" ftp.tug.org::texlive/tlpretest .
```

Both are large downloads that initially take around an hour. But the same commands also update `~/texlive2023pretest` after changes are made, and these commands take only a couple of minutes.

13. BASIC_{TEX}-2023

We now turn to the BasicTeX-2023 folder. Essentially the same steps we describe here hold work all other install folders.

To create BasicTeX-2023, we first install BasicTeX and then construct the “root” folder from this installation. Begin by deactivating key elements of `/usr/local`:

```
cd /usr/local
sudo mv bin bin-temp
sudo mv lib lib-temp
sudo mv share share-temp
sudo mv texlive texlive-temp
```

Next run the texlive install script in `~/texlive2023pretest`:

```
cd
cd texlive2023pretest
sudo ./install-tl
```

The following text will appear in Terminal:

```
<B> set binary platforms: 1 out of 16

<S> set installation scheme: scheme-full

<C> set installation collections:
    40 collections out of 41, disk space required: 7189 MB

<D> set directories:
    TEXDIR (the main TeX directory):
        /usr/local/texlive/2023
    TEXMFLOCAL (directory for site-wide local files):
        /usr/local/texlive/texmf-local
    TEXMFSYSVAR (directory for variable and automatically generated data):
        /usr/local/texlive/2023/texmf-var
    TEXMFCONFIG (directory for local config):
        /usr/local/texlive/2023/texmf-config
    TEXMFVAR (personal directory for variable and automatically generated data):
        ~/Library/texlive/2023/texmf-var
    TEXMFCONFIG (personal directory for local config):
        ~/Library/texlive/2023/texmf-config
    TEXMFHOME (directory for user-specific files):
        ~/Library/texmf

<O> options:
    [ ] use letter size instead of A4 by default
    [X] allow execution of restricted list of programs via \write18
    [X] create all format files
    [X] install macro/font doc tree
    [X] install macro/font source tree
    [ ] create symlinks to standard directories

<V> set up for portable installation

Actions:
<I> start installation to hard disk
<P> save installation profile to 'texlive.profile' and exit
<Q> quit
```

Enter command:

We first change any default answers that are wrong for us. After that, the installation proceeds without further help. It downloads and installs a large number of packages over the network, or directly finds these packages in `texlive2023pretest`.

The TeX Live authors have been kind to the Macintosh, and most default answers are already correct. Let us look at the questions and answers. The install script will pick the binaries suitable for the machine being used. In 2023 it will pick `universal-darwin`. Using the first set of options, we can add additional binary sets to the installation, but we won't.

The second "S" choice picks an installation scheme. By default, everything is installed and that is what MacTeX will do. But for BasicTeX we select a smaller set of packages. So type S and push return and the display will change to the following:

Select scheme:

```
a [X] full scheme (everything)
b [ ] medium scheme (small + more packages and languages)
c [ ] small scheme (basic + xetex, metapost, a few languages)
d [ ] basic scheme (plain and latex)
e [ ] minimal scheme (plain only)
f [ ] ConTeXt scheme
g [ ] GUST TeX Live scheme
h [ ] infrastructure-only scheme (no TeX at all)
i [ ] teTeX scheme (more than medium, but nowhere near full)
j [ ] custom selection of collections
```

Actions: (disk space required: 7189 MB)

```
<R> return to main menu
<Q> quit
```

Enter letter to select scheme:

Type "c" to pick the small scheme, which gives Basic TeX. As a matter of fact, Basic TeX came first in the Macintosh world, and then TeX Live copied our choices to form this scheme. Then push "R" to return to the main choices.

The next question can be ignored. But we need to change some of the directory choices. Actually the TeX Live people have again been kind to the Macintosh and the default choices in our list are the correct ones for the full MacTeX.

I won't show the choice dialog, but will walk our way through it. The first directory is the location where TeX will be installed. MacTeX installs in a directory named `2023`, but BasicTeX installs in a directory named `2023basic` so both installations can coexist. So change the first option to `/usr/local/texlive/2023basic`. The script automatically changes several

other names. But we must change options 5 and 6 from “ /Library/texlive/2023/texmf-var” to “ /Library/texlive/2023basic/texmf-var” and from “ /Library/texlive/2023/texmf-config” to “ /Library/texlive/2023basic/texmf-config”.

Next we change the ”options”. Select “use letter size instead of A4 by default” and “allow execution of restricted list of programs via write18”. Deselect all other options.

Now start the installation. When it completes, a message will be printed asking you to set up a symbolic link to the binaries. Ignore that message.

We now have BasicTeX and we want to move it to the “root” directory and then prepare that location to be used by our install package. This is done by running one script:

```
sudo sh buildPackage.sh
```

At this point, the root folder is complete and it is time to make the install package. That will be explained in a future section.

But first, let us discuss revising the script buildPackage.sh for a future year. This is easy. The only needed change is the name of the distribution, so use Find/Replace to change “2023basic” to “2024basic” or whatever in the entire document.

WARNING: I have always run “sh buildPackage.sh” using sudo. But in 2023 I discovered that this step with the GUI-Applications package causes the package to be rejected because of problems with TeX Live Utility. These problems disappear if the “sudo” is omitted. So temporarily, we use sudo on all packages except the GUI-Applications package.

14. IMPORTANT NOTE ON BUILDPACKAGE SCRIPT

The TeX binary directory for Macintosh contains a symbolic link

```
man --> ../../texmf-dist/doc/man
```

That is because man packages on the Mac use a heuristic to find some such pages: look for a man entry in the directory containing the actual binary.

In 2019 and 2020, the configuration software which created BasicTeX and MacTeX added a third entry to texmf-dist/doc/man. This third entry was a symbolic link ”man” which again pointed to ../../texmf-dist/doc/man. There is no such location.

This spurious entry was probably created by trying to add a new ”man link” to the binary directory, but in such a way that the existing link was followed and a new link was added to its end. Therefore, after TeX is installed and before root is created, check to see if there is an existing man link. If there is, check to make sure buildPackage does not add another. Otherwise add a step in buildPackage to create that link.

In January, 2023, the TeX Live install script adds this man link automatically and thus none of the scripts for BasicTeX-2023 adds or modifies it. But in the future, check this point.

15. INSTALL PACKAGES PART 2

Now we need to create the Basic TeX install package using the “root” directory we have just prepared. It turns out that the techniques we use for BasicTeX work the same way for all other packages. So this section explains the final steps once and for all for everything.

In the BasicTeX-2023 folder, find the subfolder CreateInstallPackage. Creating an install package from root is very simple; just change to the CreateInstallPackage folder and run three scripts as follows:

```
sh pkgbuildscript.sh
sh productbuildscript.sh
signPackage.sh
```

The first line creates BasicTeX-2023-Start.pkg, the second creates BasicTeX-2023-Temp.pkg, and the final line creates BasicTeX-2023.pkg. This third item will be the release package after it is notarized.

These scripts must be edited for each new year, but the editing is mainly changing 2022 to 2023 using a search and replace.

Examine the three scripts. The final script is completely straightforward. The first script is also mostly straightforward. It locates the root folder and the Scripts folder, and identifies the package with a reverse-url, in this case org.tug.mactex.basictex2023. This url must change each year and serves to keep various yearly updates separate.

The more complicated script is productbuildscript. It builds an unsigned copy of the final install package, locates the startup text in MyResources, and uses requirement.xml and distribution.xml to “design the structure of the package.” So we need to talk about these two xml files.

The file requirement.xml lists the lowest system on which the package can be installed. In 2023, that is Mojave and the file lists 10.14

The file distribution.xml gives the detailed structure of the distribution and will become more complicated when we deal with MacTeX, which is built from several subpackages. Because distribution.xml is complicated, there is a script named create-distribution.sh which can create a skeleton from the information in the Start package. This need only be run when packages are first created; later it is easiest just to edit distribution.xml. Read this file. The purpose of most lines will be clear, and other lines can just be copied and retained without full understanding (!!).

The CreateInstallPackage folder contains two important subfolders: MyResources and scripts. The first folder contains pages of text which the installer displays at the start of an install process. The second folder contains the postinstall script which runs at the end, and possibly auxiliary files used by this script. So both folders need editing at the start of each new year. In both cases, this is mainly or entirely a matter of changing dates using search and replace.

The files in MyResources are very simple. But the file postinstall in scripts is complicated because it installs the TeX Distribution Data Structure created by Jerome Laurens and Gerben Wierda. We will not discuss that structure here; read postinstall if you need to know the details.

16. NOTARIZING

The final step sends the install package to Apple. It is not touched by human hands there, but it is searched for viruses and checked to make sure all included binaries are signed and have adopted a hardened runtime. If the package passes these tests, then an official “notarization” is “stapled” to the package, which can then be released.

Notice that install packages are flat files which have already been compressed, so no compression is needed. The file can be placed directly on a server. Notarization is straightforward. Change to the directory NotarizePackage and issue the following commands:

```
sh notarytool.sh
sh stapleresult.sh
```

The file being sent is the signed install package in CreateInstallPackage, BasicTeX-2023.pkg. If this file passes notarization, the staple command adds notarization to it. So in the end, BasicTeX-2023.pkg in CreateInstallPackage will be the package released to the public.

When notarytool runs, it first checks that the package has a reasonable form. Then it prints a submission-id. This number should immediately be copied and pasted to the file submission-id.tex, because it will be needed to retrieve error information if notarization fails. Meanwhile, notarytool will be uploading the install package to Apple and printing a progress report. Uploading can take a long time for the full MacTeX package. When it is complete, notarytool will print a “processing message”, and finally a short message reporting that notarization was successful, or that there were errors.

If notarization was successful, immediately issue the “stapleresult” command and the entire process is complete.

If notarization fails, open the log.sh file and notice that the script reads

```
xcrun notarytool log "132de0cd-4584-4e0e-ab39-04f5402eebfe" --apple-id ...
```

The item in quotations should be the submission-id which notarytool printed when it started. Replace the existing string with this submission-id. Then issue the command

```
sh log.sh
```

Apple will return a long and very detailed log of notarization, clearly explaining any errors. Fix them and try again.

The good news is that notarization usually works. It only fails at the start of a "season" when errors are made revising the build process for a new year.

17. MORE ABOUT NOTARIZATION

A few years ago I wrote a short TugBoat article about notarization. However, in 2021 Apple revised the notarization tools, so the article is already out of date. Notarization in MacTeX for 2023 is done using the new tools. These tools require a developer account at Apple, which costs \$99 a year. Another developer doing notarization will need to modify the scripts notarytool and log, because they currently refer to my account.

A glance at the scripts notarytool and log shows that each begins with the code

```
xcrun notarytool ...
```

Thus a command "xcrun" is going to run another command "notarytool" which communicates with the Apple Developer Site. For security reasons, communication with this developer site requires 2-factor authentication. However, 2-factor authentication is not convenient when running shell scripts, so Apple invented an alternative security method. A developer wishing to run a tool (in this case notarytool) which communicates with the Developer Site can log onto the site and request a password designed for that particular developer and that particular tool. Then the script can pass that password to Apple when the tool is used.

Consequently a new developer using the tool needs to log into <https://appleid.apple.com>, signing in with their developer-id and password. This will require 2-factor authentication. Then a page appears clearly listing several tasks, and one is labeled App-Specific Passwords. Select this item and a list of applications which already have a password will be shown. Add "notarytool". Apple will print a password. Immediately copy it down!. Then log out.

Now look at the text of the shell commands notarytool and log. Each contains straightforward parameters and flags, together with three crucial items:

```
--apple-id "...."
--password "... "
--team-id "... "
```

Change these to your own developer values. Recall that your apple-id is just an email address; if you log onto the developer site, the site will list your team-id.

This ends the description of BasicTeX-2023, and thus the description of most install packages in MacTeX. In the remaining documentation, we describe unusual features of the remaining folders and packages, and these descriptions will be easy reading.

Part C: Other Packages

18. MINIMALTEX-2023

MinimalTeX was requested by Vafa Khalighi. It is based on the "minimal" TeX Live scheme. I make it available on my web site, but do not upload it to TUG or CTAN.

MinimalTeX is installed in `/usr/local/texlive/2023minimal`. It contains the TeX Live "minimal" scheme.

19. TEXDIST-2023

Some users install TeX Live using the Unix install script. This includes users installing from the DVD, and users installing Mojca Miklavc's x86_64-darwinlegacy binaries for older versions of macOS. These users do not get the TeX Dist structure and cannot configure their machines to look in `/Library/TeX/texbin` for binaries.

For these users we constructed a very small install package which adds the missing TeX Dist structure. This package is called TeXDist-2023. It is provided on the DVD and available from the MacTeX web page. Construction is easy, but follows the usual pattern established by BasicTeX-2023.

20. GUI-APPLICATIONS

This package installs `BibDesk.app`, `LaTeXiT.app`, `TeX Live Utility.app`, and `TeXShop.app` in `/Applications/TeX`. In the past, it also installed a folder containing various pieces of documentation. In 2023, this folder will be replaced by a single file `READ ME FIRST.pdf`, for users who install TeX but have no idea how to use it.

Just before we made MacTeX-2023, it was decided to add Martin Ruckert's `hintview` to the package so users could view `HINT` files. The package also contains a very short one page description of `hintview`.

Although this package works like previous packages, there is one tricky piece. In reality, the five applications are folders containing a large number of parts. So there is an extra step if the contents of the package change from one year to the next. In the folder `CreateInstallPackage`, there is a file named `dist.plist` which the software uses automatically to construct the package. This file must be created, and that is done automatically using the contents of `root`, by running

```
sh createdistplist.sh
```

However, the resulting `dist.plist` has one flaw. It marks each application as relocatable. In practice that means that the installer is allowed to search the user's entire machine for an old copy of each app, and then update that app. We certainly do not want that. So after creating `dist.plist`, it must be edited by hand. Search the document for keys named "BundleIsRelocatable". There should be five such keys. Each will be followed with a value `<true>`. Change each of the five values to `<false>`.

In both 2022 and 2023, there were problems notarizing the package due to TeX Live Utility. The author of TeX Live Utility, Adam Maxwell, has a developer account, so the program is notarized. But when we added his notarized copy to the full GUI-Applications, Apple would no longer notarize the entire package.

With great effort, particularly from Bruno Voisin, we managed to discover a work around. This requires four small changes to the usual procedure of creating GUI-Applications.

- Instead of updating TLU with Sparkle to get the latest version, update by going directly to Adam Maxwell's site. This step is probably not necessary, but I'm too busy to check.
- In the script **buildPackage.sh**, comment out the following lines:

```
# Get TeX Live Utility
echo "Getting TeX Live Utility"
ditto ${WORK}/apps/"TeX Live Utility.app" ${WORK}/root/Applications/TeX/"TeX Live
```

- Run this script without using “sudo”.
- The result will be a **root** folder which does not contain TeX Live Utility. Now drag and drop TeX Live Utility into this folder to the spot root/Applications/TeX.

We suspect that the command line program **ditto** breaks the notarization information in TeX Live Utility, and these modifications avoid that program.

Now proceed as usual.

21. MACTEX-FOR-DVD

The TeX Live DVD does not have room for two full copies of the TeX Live distribution. So instead it installs TeX Live using the TeX Live Unix install script. This small folder contains the Macintosh portion of the DVD. This portion contains three install packages: Ghostscript-10.00-Full.pkg, GUI-Applications.pkg, and TeXDist-2023.pkg. It also contains a text document, MacTeX Install Parts 1 and 2, explaining how to install everything from the DVD to a Macintosh. After the folder is constructed here, it is copied to the folder DVD.

22. DVD

This folder contains a folder named “mactex” which will eventually appear on the TeX Live DVD as the Macintosh portion of that product.

The “mactex” folder is initially constructed by Herbert Schulz and contains MacTeXtures, a collection of files and folders with Documentation, extra Front Ends, Utilities, etc. In 2023, Schulz is revising “mactex” to contain lists of web links rather than actual binary applications. This will save space and lead the user to up-to-date versions of the programs. So I do not yet know exactly what the contents of the folder will look like.

When the folder is ready, Schulz will send an email with a link to the contents. Usually the link points to

```
http://tug.org/~herbs/mactex.zip
http://tug.org/~herbs/mactex.zip.md5
```

To create the full Mac content of the DVD, unzip the file to recreate the folder, and then add a copy of MacTeX-Install to the folder. Then run the command

```
zip -r --symlinks mactex.zip mactex/ -x "*.DS_Store"
```

This creates a file named mactex.zip inside the DVD folder. Send this to Manfred Lotz, who creates the DVD for TUG. The usual way to do send the file is to upload it to your TUG site, place it in the public_html folder so it is available from the web, and send an appropriate link address to manfred@dante.de.

When the full DVD is ready, Manfred makes it available for testing. This involves downloading the contents, burning a DVD with the contents, and using it to install on several different systems.

In the past, burning a DVD was tricky for me, so I wrote the following instructions. Note that I have an external DVD player.

Download texcol2023.iso and do not worry about capitolization.

Plug in the external Apple DVD using a USB to Thunderbolt 3 Converter. Connect directly to the computer, not to the monitor.

Right click on texcol2023.iso. One way is to hold down the Control key while clicking. A contextual menu will appear. Select "Burn Disc Image "texcol2023.iso" to Disk.

Insert an empty double-sided DVD + R DL, white side up, when asked. The computer will then burn, verify, and eject the disk.

Occasionally, the GUI-Applications install package cannot be notarized because one or more applications are not properly signed. These applications must then be omitted from MacTeX-2023 because it is crucial to notarize this package. But there is not a problem on the DVD. Just replace GUI-Applications.pkg by the four individual GUI programs and ask the user to drag their icons to /Applications.

23. PACKAGES WITH MULTIPLE PIECES

It is possible to create install packages with multiple pieces. The Ghostscript package has two pieces: one installs Ghostscript and one installs the library libs. The MacTeX-2023 packages has four pieces: one installs GUI-Applications, one installs Ghostscript, one installs the library libs, and one installs the full TeX Live 2023 distribution.

When a package has multiple pieces, the install dialog presents an “Options” button which allows users to select which pieces to install. A user might already have up to date GUI applications, or might have a Ghostscript obtained from macports. Such a users could decide to install only the full TeX Live 2023 distribution.

If a package has multiple pieces, the developers can select the pieces which are installed by default, and the pieces which are only installed using the “Options” method.

A package with multiple pieces is constructed by first constructing install packages for each of the pieces. Then the pieces are merged together to form a single final product. This merging process is very simple. To understand how it works, look at the MacTeX-2023 subfolder. Notice that there is no buildPackage.sh and no root folder inside, because the full package will just install the roots from its various pieces. But there is still a CreateInstallPackage subfolder.

This folder contains the “Start” folders for the various pieces:

```
GUI-Applications-Start
Ghostscript-10.00-Start
Ghostscript-10.00-libgs-Start
TeXLive-2023-Start
```

Each of these pieces was constructed by running pkgbuildscript.sh, but the additional steps

```
productbuildscript.sh
signPackage.sh
notarytool.sh
```

are irrelevant. These three scripts will be run on the final package, but not on its pieces.

In particular, TeXLive-2023 is an enormous package because it contains the full TeX-Live distribution. So making a second copy with productbuildscript.sh takes time and disk space and is completely unnecessary. And notarizing would involve a long, long upload to Apple, and again be completely unnecessary.

The CreateInstallPackage folder contains a MyResources subfolder because the installer will display Welcome and ReadMe panels for the entire package, not for the individual pieces. But it does not contain a scripts folder because the scripts folders of the individual subpanels are used instead. It does not contain a pkgbuildscript.sh because the various parts have already been made, but it contains a productbuildscript.sh to put together the full install package. Notarization works as before.

With this background, we finish the construction of TeXLive-2023 and of the full MacTeX-2023. We are leaving Ghostscript until the end because it is made on an entirely different schedule determined by the Ghostscript release schedule, rather than the TeX Live release schedule.

24. TEXLIVE-2023

To prepare for this package

```
cd /usr/local
sudo mv bin bin-temp
sudo mv lib lib-temp
sudo mv share share-temp
sudo mv texlive texlive-temp
```

Now install TeX Live using the TeX Live Unix install script. Call the script in the following fancy manner. Remove the `\` symbol and type the last two lines as one line.

```
TEXLIVE_INSTALL_NO_CONTEXT_CACHE=1
export TEXLIVE_INSTALL_NO_CONTEXT_CACHE
cd
cd texlive2023pretest
sudo env TEXLIVE_INSTALL_NO_CONTEXT_CACHE=$TEXLIVE_INSTALL_NO_CONTEXT_CACHE \
./install-tl
```

All default options will be correct for the Macintosh except the page size option. Select “letter size”.

After installation is complete,

```
sudo sh buildPackage.sh
```

That step creates a new root file. Then go to `/usr/local` and restore the folders there.

Incidentally, the `buildPackage.sh` script does not create a link to man pages, since I believe TeX Live now does that automatically. It is useful to check this point.

By the time binaries reach the TeX Live pretest, they have been signed and hardened. However, a small number of files in TeX Live confuse the Apple Notarization Machinery. The shell script `fix-for-notarization.sh` fixes these issues. The script is short and fully commented; read it for a detailed explanation of the issues and fixes. Then issue the command

```
sudo sh fix-for-notarization.sh
```

Now create `TeXLive-2023-Start.pkg` as usual by calling

```
sh pkgbuildscript.sh
```

as usual. Recall that it is not necessary to do remaining steps because we only use `TeXLive-2023-Start` to make `MacTeX-2023`.

The TeXLive-2023 folder contains a folder named History with further information about notarization. in the past.

25. MACTEX-2023

Add to the CreateInstallPackage folder the following packages from other folders:

```
GUI-Applications-Start
Ghostscript-10.00-Start
Ghostscript-10.00-libgs-Start
TeXLive-2023-Start
```

Everything else is straightforward.

26. COMPILING GHOSTSCRIPT

The Ghostscript work in MacTeX was heavily influenced by Bruno Voisin, a Ghostscript expert. I'll describe what to do, but almost every instruction comes from him.

Begin by getting the latest Ghostscript sources from <http://ghostscript.com>. In the middle of the resulting page, a link leads to <https://www.ghostscript.com/releases/gsdnld.html>. Several versions are available; get the “Ghostscript 10.0.0 Source” specified by “Ghostscript AGPL Release”. This will download the file ghostscript-10.0.0.tar.

In 2023 we create Intel binaries on an Intel machine running Mojave, and Arm binaries on an Arm machine running Big Sur.

On each of the two machines, uncompress the source tar file. Change directory to /usr/local and move bin to bin-temp and share to share-temp. Be sure X11 is available on both machines; it need not be running. Compile ghostscript twice, once with X11 available and once with it disabled.

With X11 active, build using the commands

```
make clean
./configure --disable-compile-inits
make
```

Find the resulting binary gs in the ghostscript-10.0.0 directory and rename it gs-X11-intel or gs-X11-arm as appropriate. Next issue the command

```
make so
```

When this completes, go to the sobin directory in ghostscript-10.0.0 and find a library file and two symbolic links. Rename the library file libgs.dylib.10.00.intel or libgs.dylib.10.00.arm as appropriate.

Next disable X11 by changing /opt/X11 to /opt/X11-temp. Compile ghostscript again using the above commands and rename the resulting gs file to gs-noX11.intel or gs-noX11.arm as appropriate. In this mode ignore the library.

Finally on each of the two machines move `/opt/X11-temp` back to `/opt/X11` and move `/usr/local/bin-temp` back to `/usr/local/bin` and move `/usr/local/share-temp` back to `/usr/local/share`.

So in the end, the Intel machine has produced `gs-X11-intel`, `gs-noX11-intel` and `libgs.dylib.10.00.intel`. The Arm machine has produced `gs-X11-arm` and `gs-noX11-arm` and `libgs.dylib.10.00.arm`.

Move these six files back to the main machine used to construct MacTeX. In 2023 this was an Arm portable running Ventura. Place the Arm files in the build directory in Ghostscript-10.00/Binaries/Arm, which will have `gs-X11-arm`, `gs-noX11-arm`, and `libgs.dylib.arm`. Place the Intel files in the build directory in Ghostscript-10.0.0/Intel, which will have `gs-X11-intel`, `gs-noX11-intel`, and `libgs.dylib.intel`.

Finally in the Ghostscript-10.00/Binaries directory, issue the following commands:

```
sh unsignall.sh
sh liposcript.sh
sh liposcriptsign.sh
```

The end result will be a new folder named Universal-Binaries, containing hardened and signed universal binaries and a library: `gs-X11`, `gs-noX11`, `libgs.dylib.10.00`.

27. GHOSTSCRIPT-10.00-LIBGS

Move the file `libgs.dylib.10.00` from Ghostscript-10.00/Binaries/Universal-Binaries to Ghostscript-10.00-libgs/Binaries. Then

```
sudo sh buildPackage.sh
```

Finally, build the package in the usual way.

28. GHOSTSCRIPT-10.00

We have already compiled the ghostscript binaries, but the final Ghostscript package also needs the many support files which are part of Ghostscript. These files will ultimately be placed in the “root” file. Moreover, the Ghostscript package will contain symbolic links to important TeX Live fonts, a feature designed by Bruno Voisin.

Begin by making sure the latest TeX Live distribution is installed and active. Also make sure X11 is installed. It need not be running. Then issue the command

```
buildTeXfonts.sh
```

This builds a new copy of the folder TeXfonts, which will become part of the Ghostscript package.

Next disable pieces of `/usr/local` temporarily via

```
cd /usr/local
sudo mv bin bin-temp
sudo mv share share-temp
```

Then go to the ghostscript source file and compile as earlier, but this time install the result in `/usr/local`:

```
make clean
./configure --disable-compile-inits
make
sudo make install
```

Now issue the command

```
buildPackage.sh
```

This creates the root folder, making adjustments in the standard distribution designed by Bruno Voisin, and adding `gs-X11` and `gs-noX11` to the `/usr/local/bin` directory of the package. When this package is later installed, the postinstall script will test whether X11 is available on the install machine and create a link `gs` to either `gs-X11` or `gs-noX11` as appropriate.

Finally clean up `/usr/local`:

```
cd /usr/local
sudo rm -R bin
sudo rm -R share
sudo mv bin-temp bin
sudo mv share-temp share
```

Now create the install packages from this root in the standard manner.

29. GHOSTSCRIPT-10.00-FULL

Place `Ghostscript-10.00-Start.pkg` and `Ghostscript-10.00-libgs-Start.pkg` in `Ghostscript-10.00-Full/CreateInstallPackage` and proceed as usual.

30. XMACTEXDOC-2023

This folder contains the instructions needed to create MacTeX and related packages. It has this READ-ME document, together with a skeleton of the full build file tree. The skeleton contains scripts (with passwords removed), but omits large files created during the build process.

After revising this folder,

```
sh compress.sh
```

The result will be a file named `mactexdoc-2023.tar.xz`. Send this file to Karl Berry, who will install it in the Master/Source directory.