This tutorial will quickly get you up and running with the latest Tk from Python, Tcl, Ruby, and Perl on macOS, Windows, or Linux. It provides all the essentials about core Tk concepts, the various widgets, layout, events and more that you need for your application.

Previous | Contents | Single Page | Next

Introduction

This tutorial will help you quickly get up to speed and build mainstream desktop graphical user interfaces with Tk, in particular, Tk 8.5 and 8.6. Tk 8.5 was a milestone release. It marked a significant departure from older versions of Tk that most people know and ~~love~~ recognize.

The downside is that unless you know one or two crucial things, it's actually *not* that significant a release. In fact, it will seem like nothing has changed at all. Due to backward compatibility, unless existing programs make a few simple changes, they won't look any different. (Imagine if you just moved into a rustic and quirky historical home. You'd want someone to point out where they've hidden the light switches and power outlets, wouldn't you?)

If you're new to Tk or creating a new program, this tutorial will ensure you get started the right way. If you've used Tk before, it will help you bring your knowledge right up to date. And if you're updating code that may have been written years ago, you'll see step-by-step how to bring it into the modern age. It's a cliche, but I can't believe how much I've learned in writing this tutorial, and I've been using Tk for over twenty-five years.

The general state of Tk documentation (outside the Tcl-oriented reference documentation, which is excellent) is unfortunately not at a high point these days. This is particularly true for developers using Tk from languages other than Tcl or working on multiple platforms.

So this tutorial will, as much as possible, target developers on the three main platforms (Windows, macOS, Linux), and also be language-neutral. Initially, the tutorial will cover Tcl, Ruby, Perl and Python. Over time, additional languages may be added. Even if your own language isn't included, the chances are you'll still benefit; since all the languages use the same underlying Tk library, there's obviously a lot of overlap.

It's also not a reference guide. It's not going to cover everything, just the essentials you need in 95% of applications. The rest you can find in reference documentation.

Who This Tutorial Is For

This tutorial is designed for developers building tools and applications in Tk. It's also concerned with fairly mainstream graphical user interfaces, with buttons, lists, checkboxes, rich text editing, 2D graphics, etc. So if you're either looking to hack on Tk's internal C code or build the next great 3D immersive game interface, this is probably not the material for you.

This tutorial also doesn't teach you the underlying programming language (Tcl, Ruby, Perl, Python, etc.), so you should have a basic grasp of that already. Similarly, you should have a basic familiarity with desktop applications in general. While you don't have to be a user interface designer, some appreciation of GUI design is always helpful.

Modern Best Practices

This tutorial is all about building modern user interfaces using the current tools Tk has to offer. It's all about the best practices you need to know to do this.

For most tools, you wouldn't think you'd have to say something like that. But for Tk, that's not the case. Tk has had a very long evolution (see Tk Backgrounder), and any evolution tends to leave you with a bit of cruft. Couple that with how much graphical user interface platforms and standards have evolved in that time. You can see where keeping something as large and complex as a GUI library up to date (and backward compatible) may be challenging.

Tk has, for most of its lifetime, gotten a bad rap, to put it mildly. Some of this has been well deserved, most of it not so much. Like any GUI tool, you can create absolutely terrible-looking and outdated user interfaces with it. It can also be used to develop spectacularly good ones with the proper care and attention. Most people know about the crappy ones; most of the good ones people don't even know are done in Tk. In this tutorial, we're going to focus on what you need to build good user interfaces. Thankfully, this isn't nearly as hard as it used to be before Tk 8.5.

So, to sum up: modern desktop graphical user interfaces, using modern conventions and design sense, using the modern tools provided by Tk 8.5 and 8.6.

Tk Extensions

When it comes to modern best practices, Tk extensions deserve a special word of note. Over the years, developers have created all kinds of add-ons to Tk, for example, adding new widgets not available in the core (or at least not at the time). Some well-known and quite popular Tk extensions include BLT, Tix, iWidgets, BWidgets; there are many, many others.

Many of these extensions were created decades ago. Because core Tk has always been highly backward compatible, these extensions generally keep working with newer versions. However, they may not reflect current platform conventions or styles. They may "work" but can make your application appear extremely dated or out of place. In many cases, the facilities they provide have been obsoleted by newer and more modern facilities recently built into Tk itself.

If you decide to use Tk extensions, it's highly recommended to investigate and review your choices carefully.

The Better Way Forward

Tk gives you a lot of choices. There are at least six different ways to layout widgets on the screen. Multiple widgets can be used to accomplish the same thing, and that's before considering any Tk extensions. Tk emphasized backward compatibility, which is a double-edged sword. Most of these old ways of doing things still keep working, year after year. That doesn't mean you should keep using some of them.

So there are many in Tk, but frankly, all that choice gets in the way. If you want to learn and use Tk, you don't need to know ten different ways to accomplish the same thing. You shouldn't need to do all the research, explore all the options, and make a choice yourself. You need to know the *right* way to do things today. That's what this tutorial will give you. Think of it as the documentation equivalent of opinionated software.

So we'll often use different ways of doing things than you'd find in other documentation or examples. Usually, it's because when those were written, the better ways didn't even exist yet. (Here's a litmus test for Tk documentation: does it use the archaic `pack` instead of the modern `grid`?) Later on, once you're an expert and encounter some wacky situation where the typical choice doesn't fit, you can go hunt around for alternatives.

How to Use

While the tutorial is designed to be used linearly, feel free to jump around as you see fit. We'll often provide links to information, whether links to other documentation on this site, such as our "widget roundup" providing usage info on each Tk widget, or to external documentation, such as the full reference for a particular command.

The tutorial also lets you select what language (Tcl, Ruby, Perl or Python) to show. You can change this by the "Show:" popup menu which is located in the sidebar, near the top right of each page in the tutorial. But it also lets you see how Tk is used by all the different languages, which can itself be quite interesting and useful.

You can find a GitHub repository containing many of the larger examples at https://github.com/roseman/tkdocs.

Conventions

As is typically done, code listings, interpreter or shell commands, and responses will be indicated with a `fixed-width font`. When showing an interactive session with the interpreter, what you type will be in **`bold fixed-width`**.

When describing procedure or method calls, the literal parts (e.g., the method name) will be in a plain fixed-width font. Parameters, where you should fill in the actual value, will add italics, and optional parameters will be surrounded by '?', e.g., `set` *`variable`* *`?value?`*.

In general, when referring to these procedures or method calls in the text, we'll omit punctuation (brackets, parentheses, commas, equals, semicolons, etc.) that may be required by a specific language binding. Method names that consist of multiple words, (e.g., `selection_clear`) may look slightly different in different languages (e.g., `selection clear` in Tcl). In the text, we'll generally use the former notation with the underscore. Language-specific code snippets show the complete syntax, of course.

You'll see some paragraphs that are separated from the main text. These are used for several different things. Each is identified with a different icon, as follows:

This paragraph consists of material that is specific to the Python binding to Tk.

This paragraph will help point out common mistakes that people make or suggest helpful but not necessarily obvious solutions related to

the topic.

This indicates a new way of doing things in Tk 8.5 or Tk 8.6 that is very different from how things would have been done previously. People familiar with older versions of Tk (or working on programs developed with older versions of Tk) should pay close attention.

This paragraph provides some additional background information. It's not strictly necessary to learn the topic at hand, but that might clarify how or why things are done the way they are.

This highlights an area in Tk that could charitably be described as a "rough edge." It may indicate a faulty or missing API requiring you to use a workaround in your code. Because these things tend to get fixed up over time, it's worth marking them in your code with a "TODO." That way, you can remember to go back later and see if a newer API resolves the problem cleanly.

Installing Tk

In this chapter, you'll get Tk installed on your machine, verify it works, and then see a quick example of what a Tk program looks like.

Jump to Tk Install Instructions:

Python | Tcl | Ruby | Perl — macOS | Windows | Linux/X11 — Go!

Though pretty much all macOS and Linux machines come with Tk installed already, it's often an older version (typically 8.4.x or an early 8.5). You want to make sure you've got at least version 8.5 (preferably 8.6) to use the new widget set, so if that's not already there, you'll want to install the newer version.

You'll need both Tk and bindings for the language you're using it from. Sometimes these are bundled together, sometimes not. Though there are lots of ways to install Tk, often the easiest is to download and install one of the versions provided by ActiveState (www.activestate.com).

Users of recent Python versions can avoid this intermediate step. Starting with Python 3.7, the binary installers available at python.org now include everything you need to use Tk out of the box. If you're using an earlier Python version, or want to compile it yourself, you'll need to install Tcl/Tk on your system to do so. In this case, ActiveState's distributions are still the recommended way to go.

Remember, this tutorial assumes you're using Python 3, not Python 2. There are some significant differences between the two, including module naming, which is the first thing you'll encounter when trying Tkinter.

ActiveState is a company that sells professional developer tools for dynamic languages. They also provide (for free) quality-controlled distributions of some of these languages, and happen to employ a number of core developers of these languages.

Installing Tk on macOS

Install Tk for Python (Tkinter) on macOS

The Easy Way

As noted, the easiest way to get Tk and Tkinter installed on your system is using Python's binary installer, available at python.org. Thanks to work by Python core developer Ned Deily, binary installers starting with version 3.7 include Tcl and Tk.

Remember, we're using Python 3.x here, not 2.x. As of this writing, the latest 3.9 installer (3.9.0rc1) includes Tk 8.6.8.

If, however, you're compiling Python yourself, you'll have more work to do. Read on...

Installing Tcl/Tk

The Tkinter module is included with core Python, of course, but you'll need a version of Tcl/Tk on your system to compile it against. Do yourself a huge favor and get the most recent version.

Whatever you do, *do not rely on the Tk versions included in macOS!* Older versions included Tk 8.4.x. Even more recent macOS versions include an early 8.5 version (8.5.9, released in 2010), which has several serious bugs easily triggered by Tkinter.

While there are several ways to get Tcl and Tk onto your machine, the easiest and most recommended is to use the ActiveTcl distribution.

In your web browser, visit www.activestate.com/products/activetcl. Download ActiveTcl (as of this writing, it's version 8.6.9). Make sure to download an 8.6.x version, not something older! Note that you will need to create an account with ActiveState (no cost) to download it. After it's downloaded, run the installer to get Tcl and Tk loaded onto your machine.

> *If you're a masochist and want to read about other Tcl/Tk options and variations and how they interact with Python, see the Mac Tcl/Tk page at python.org If you want to compile Tcl/Tk from its source, see www.tcl.tk.*

Compiling Python

When compiling Python from source, you may need to tell it where to find the ActiveTcl (or other) distribution. Otherwise, it might not find any Tcl/Tk distribution (so Tkinter won't work), or it could find the (ancient and broken) version of Tcl/Tk supplied with macOS.

If you're using Python 3.9 or newer, the build system will look in `/Library/Frameworks`, where ActiveState and other custom builds are typically installed.

```
% ./configure
% make
```

> *The initial "%" is the Unix shell prompt; you don't have to type it. The rest of it should all go on one line without adding line breaks.*

When compiling Python versions prior to 3.9, you will need to add two new command-line options to the initial `./configure` in the Python build process. The first provides the locations of the Tcl and Tk include files, and the second provides the locations of the Tcl and Tk libraries. These are usually found in two different locations (i.e., `Tcl.framework` and `Tk.framework`). You need to provide both locations for the include files and both for the libraries. Note the location of the quotes in the command below and the spaces separating the Tcl and Tk paths.

```
% ./configure --with-tcltk-includes="-I/Library/Frameworks/Tcl.framework/Headers -I/Library/Frameworks/Tk.framework/Headers" --with-tcltk-libs="/Library/Frameworks/Tcl.framework/Tcl /Library/Frameworks/Tk.framework/Tk"
% make
```

> *If you have multiple versions of Tcl/Tk installed on your system (and in the same frameworks), you may need to check inside the framework to ensure the most recent version is marked as the current one. If not, you may need to adjust your paths to point to the specific version (i.e., `Versions/8.x/`) within each framework.*

When everything is built, be sure to test it out. Start Python from your terminal, e.g.

```
% ./python.exe
```

This should give you the Python command prompt. From the prompt, enter these two commands:

```
>>> import tkinter
>>> tkinter._test()
```

This should pop up a small window; the first line at the top of the window should say, "This is Tcl/Tk version 8.6"; make sure it is not 8.4 or 8.5!

> *Get an error saying `"No module named tkinter"`? You're probably using Python 2. This tutorial assumes Python 3.*

You can also get the exact version of Tcl/Tk that is being used with:

```
>>> tkinter.Tcl().eval('info patchlevel')
```

It should return something like '8.6.9'.

> *Verified install using ActiveTcl 8.6.9.8609.2 and Python 3.90rc1 source code from python.org on macOS 10.15.6.*

Installing Tk on Windows

Install Tk for Python (Tkinter) on Windows

Tkinter (and, since Python 3.1, ttk, the interface to the newer themed widgets) is included in the Python standard library. We highly recommend installing Python using the standard binary distributions from python.org. These will automatically install Tcl/Tk, which of course, is needed by Tkinter.

If you're instead building Python from source code, the Visual Studio projects included in the "PCbuild" directory can automatically fetch and compile Tcl/Tk on your system.

Once you've installed or compiled Python, test it out to make sure Tkinter works. From the Python prompt, enter these two commands:

```
>>> import tkinter
>>> tkinter._test()
```

This should pop up a small window; the first line at the top of the window should say, "This is Tcl/Tk version 8.6"; make sure it is not 8.4 or 8.5!

Get an error saying `"No module named tkinter"`? You're probably using Python 2. This tutorial assumes Python 3.

You can also get the exact version of Tcl/Tk that is being used with:

```
>>> tkinter.Tcl().eval('info patchlevel')
```

It should return something like '8.6.9'.

Verified using Python 3.9.0rc1 binary installer from python.org (containing Tcl/Tk 8.6.9) on Windows 10 version 1809.

Installing Tk on Linux

Install Tk for Python (Tkinter) on Linux/X11

Tkinter (and, since Python 3.1, ttk, the interface to the newer themed widgets) is included in the Python standard library. It relies on Tcl/Tk being installed on your system. Depending on how you install Python, this may not happen automatically.

Remember, we're using Python 3.x here, not 2.x.

You have several different options to get Python and Tkinter onto your machine. We'll show you two, using your distro's package manager, or compiling from source.

Option 1. Your Linux Distribution's Package Manager

Currently supported Linux distributions usually install a recent version of Python 3.x by default. If not, they have a package (.deb, .rpm, etc.) that you can install using their package manager. This is usually the easiest way to install Python.

However, after you're done installing Python, you should verify that Tkinter works correctly. Start a Python shell (e.g., `/usr/bin/python3`) and verify the install (see below).

You may find that when you try to `import tkinter` that you get an error. Sometimes it will tell you that you need to install another package. If so, follow the instructions, and try again. It may also just give you Python's standard error message: `"ModuleNotFoundError: No module named 'tkinter'"`.

If you're getting an error saying `"No module named tkinter"` (without the single quotes around the module name), you're probably using Python 2. This tutorial assumes Python 3.

Sometimes Linux distributions separate out their Tkinter support into a separate package. That saves installing the Tcl/Tk libraries for people who are using Python but not Tkinter. If so, you'll need to find and install this package, which will also ensure that appropriate versions of the Tcl/Tk libraries are installed on your system.

For example, running Ubuntu 20.04LTS, Python 3.8.2 is already installed. However, to use Tkinter, you need to install a separate package, named `python3-tk`:

```
% sudo apt-get install python3-tk
```

In this case, that package provides Tcl/Tk 8.6.x libraries to be used with Python.

Option 2. Install Tcl/Tk and Compile the Standard Python Distribution

If you'd like to use the standard source distribution from python.org, you can certainly do that.

But to do so, you'll need to get the Tcl and Tk include files and libraries loaded on your machine first. Again, while there are several ways to do *that*, the easiest is to download and install ActiveTcl.

Another option would be to install the Tk development package, e.g., `tk8.6-dev`, via your package manager.

In your web browser, go to www.activestate.com/products/activetcl. Download the latest version of ActiveTcl for Linux. Make sure you're downloading an 8.6 or newer version. Note that you will need to create an account with ActiveState (no cost) to download it. After it's downloaded, unpack it, run the installer (`sudo ./install.sh`), and follow along. You'll end up with a fresh install of ActiveTcl, located in, e.g., `/opt/ActiveTcl-8.6`.

Next, download the current Python 3.x source distribution from python.org, and unpack it. On your configure line, you'll need to tell it how to find the version of Tcl/Tk you installed. Then build as usual:

```
% ./configure --with-tcltk-includes='-I/opt/ActiveTcl-8.6/include'
       --with-tcltk-libs='/opt/ActiveTcl-8.6/lib/libtcl8.6.so /opt/ActiveTcl-8.6/lib/libtk8.6.so'
% make
% make install
```

If you installed `tk8.6-dev` via your package manager instead of using ActiveTcl, the include files should be found in `/usr/include/tcl8.6`, and the libraries `libtcl8.6.so` and `libtk8.6.so` should be in `/usr/lib/x86_64-linux-gnu`.

Make sure to verify your install (see below).

Didn't work? There may have been an error compiling Python's tkinter code. To check, from the main Python source directory, try `touch Modules/_tkinter.c` (note the underscore) and then `make` to recompile it. Watch closely for error messages.

The most common thing is that the way you specified the Tcl/Tk include and libraries needs to be changed somehow. If you get messages that certain include files can't be found (e.g., `X11/Xlib.h`), you may need to install additional packages on your Linux distribution (e.g., `apt-get install libx11-dev`). Once you get it to compile without errors, don't forget to `make install`.

Verifying your Install

At the Python command prompt, enter these two commands:

```
>>> import tkinter
>>> tkinter._test()
```

This should pop up a small window; the first line at the top of the window should say, "This is Tcl/Tk version 8.6"; make sure it is not 8.4!

If it gives you an error when you try to `import tkinter` (e.g., "If this fails your Python may not be configured for Tk"), something hasn't been set up correctly. If you compiled Python yourself, see above to check for compile errors.

Get an error saying `"No module named tkinter"`? You're probably using Python 2. This tutorial assumes Python 3.

You can also get the exact version of Tcl/Tk that is being used with:

```
>>> tkinter.Tcl().eval('info patchlevel')
```

It should return something like '8.6.9'.

Verified install using ActiveTcl 8.6.9.8609.2 and Python 3.90rc1 source code from python.org on Ubuntu 20.04LTS.

The Obligatory First Program

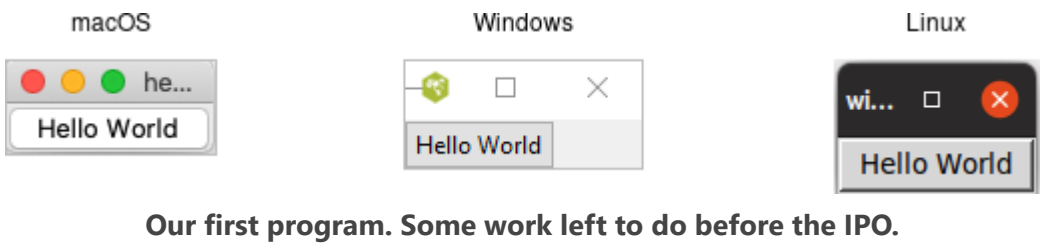
To make sure that everything actually did work, let's try to run a "Hello World" program in Tk. While for something this short, you could just type it in directly to the interpreter, instead use your favorite text editor to put it in a file.

```
from tkinter import *
from tkinter import ttk
root = Tk()
ttk.Button(root, text="Hello World").grid()
root.mainloop()
```

Save this to a file named "hello.py". From a command prompt, type:

```
% python hello.py
```

Couldn't find hello.py? You might be looking in the wrong directory. Try providing the full path to hello.py.



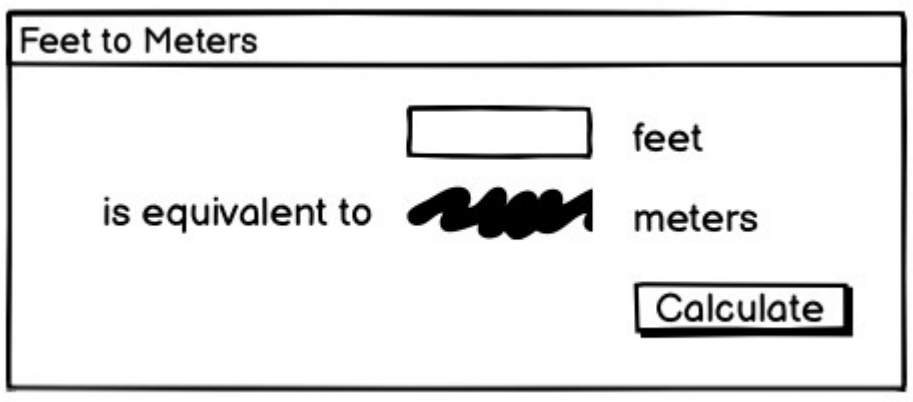
Our first program. Some work left to do before the IPO.

A First (Real) Example

With that out of the way, let's try a slightly more substantial example, which will give you an initial feel for what the code behind a real Tk program looks like.

Design

We'll create a simple GUI tool to convert a distance in feet to the equivalent distance in meters. If we were to sketch this out, it might look something like this:



A sketch of our feet to meters conversion program.

So it looks like we have a short text entry widget that will let us type in the number of feet. A "Calculate" button will get the value out of that entry, perform the calculation, and put the result in a label below the entry. We've also got three static labels ("feet," "is equivalent to," and "meters"), which help our user figure out how to work the application.

The next thing we need to do is look at the layout. The widgets we've included seem to be naturally divided into a grid with three columns and three rows. In terms of layout, things seem to naturally divide into three columns and three rows, as illustrated below:

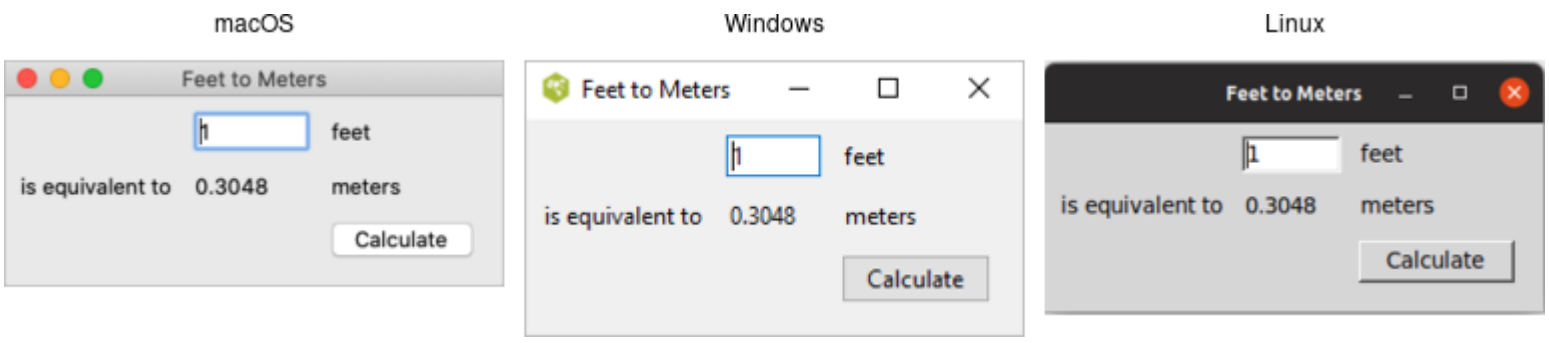
The layout of our user interface, which follows a 3 x 3 grid.

Code

Now here is the Python code needed to create this entire application using Tkinter.

```
from tkinter import *
from tkinter import ttk

def calculate(*args):
    try:
        value = float(feet.get())
        meters.set(int(0.3048 * value * 10000.0 + 0.5)/10000.0)
    except ValueError:
        pass

root = Tk()
root.title("Feet to Meters")

mainframe = ttk.Frame(root, padding="3 3 12 12")
mainframe.grid(column=0, row=0, sticky=(N, W, E, S))
root.columnconfigure(0, weight=1)
root.rowconfigure(0, weight=1)

feet = StringVar()
feet_entry = ttk.Entry(mainframe, width=7, textvariable=feet)
feet_entry.grid(column=2, row=1, sticky=(W, E))

meters = StringVar()
ttk.Label(mainframe, textvariable=meters).grid(column=2, row=2, sticky=(W, E))

ttk.Button(mainframe, text="Calculate", command=calculate).grid(column=3, row=3, sticky=W)

ttk.Label(mainframe, text="feet").grid(column=3, row=1, sticky=W)
ttk.Label(mainframe, text="is equivalent to").grid(column=1, row=2, sticky=E)
ttk.Label(mainframe, text="meters").grid(column=3, row=2, sticky=W)

for child in mainframe.winfo_children():
    child.grid_configure(padx=5, pady=5)

feet_entry.focus()
root.bind("<Return>", calculate)

root.mainloop()
```

And the resulting user interface:



Screenshot of our completed feet to meters user interface.

A Note on Coding Style

Each of the languages included in this tutorial has a variety of coding styles and conventions available to choose from, which help determine conventions for variable and function naming, procedural, functional or object-oriented styles, and so on.

Because the focus on this tutorial is Tk, this tutorial will keep things as simple as possible, generally using a very direct coding style, rather than wrapping up most of our code in procedures, modules, objects, classes and so on. As much as possible, you'll also see the same names for objects, variables, etc. used across the languages for each example.

Step-by-Step Walkthrough

Let's take a closer look at that code, piece by piece. For now, all we're trying to do is get a basic understanding of the types of things we need to do to create a user interface in Tk and roughly what those things look like. We'll go into details later.

Incorporating Tk

Our program starts by incorporating Tk.

```
from tkinter import *
from tkinter import ttk
```

These two lines tell Python that our program needs two modules. The first, `tkinter`, is the standard binding to Tk. When imported, it loads the Tk library on your system. The second, `ttk`, is a submodule of `tkinter`. It implements Python's binding to the newer "themed widgets" that were added to Tk in 8.5.

Notice that we've imported everything (`*`) from the tkinter module. That way, we can call tkinter functions, etc., without prefixing them with the module name. This is standard Tkinter practice.

However, because we've imported just `ttk` itself, we'll need to prefix anything inside that submodule. For example, calling `Entry(...)` would refer to the `Entry` class inside the `tkinter` module (classic widgets). We'd need `ttk.Entry(...)` to use the `Entry` class inside `ttk` (themed widgets).

As you'll see, several classes are defined in both modules. Sometimes you will need one or the other, depending on the context. Explicitly requiring the `ttk` prefix facilitates this and will be the style used in this tutorial.

One of the first things you'll find if you're migrating Python 2.x code is that the name of the Tkinter module is now lowercase, i.e., `tkinter`, rather than `Tkinter`. In Python 2.x, `Ttk` was also its own module, not a sub-module of `Tkinter`.

Setting up the Main Application Window

Next, the following code sets up the main application window, giving it the title "Feet to Meters."

```
root = Tk()
root.title("Feet to Meters")
```

Yes, the `calculate` function appeared before this. We'll describe it below but need to include it near the start because we reference it in other parts of the program.

Creating a Content Frame

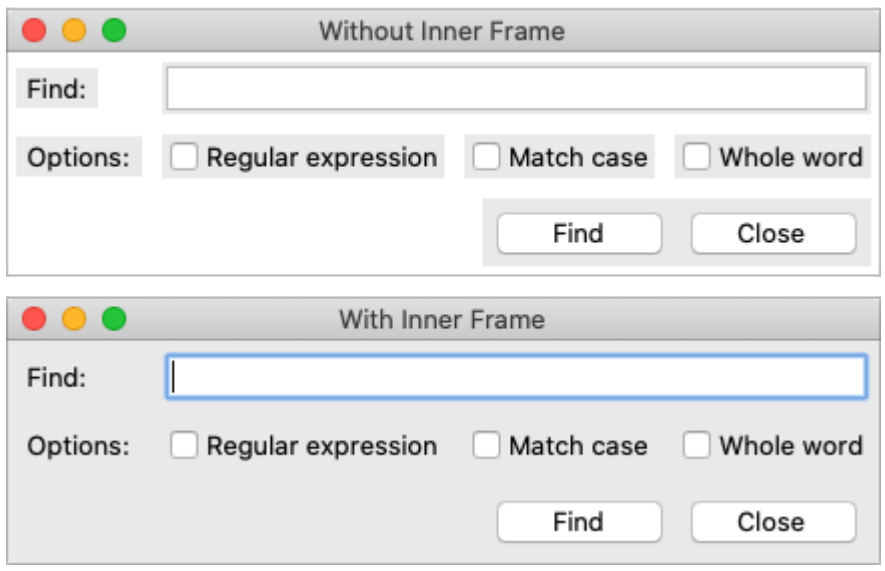
Next, we create a frame widget, which will hold the contents of our user interface.

```
mainframe = ttk.Frame(root, padding="3 3 12 12")
mainframe.grid(column=0, row=0, sticky=(N, W, E, S))
root.columnconfigure(0, weight=1)
root.rowconfigure(0, weight=1)
```

After the frame is created, `grid` places it directly inside our main application window. The `columnconfigure/rowconfigure` bits tell Tk that the frame should expand to fill any extra space if the window is resized.

Why do we put a frame inside the main window? Strictly speaking, we could just put the other widgets in our interface directly into the main application window without the intervening content frame. That's what you'll see in older Tk programs.

However, the main window isn't itself part of the newer "themed" widgets. Its background color doesn't match the themed widgets we will put inside it. Using a "themed" frame widget to hold the content ensures that the background is correct. This is illustrated below.



Placing a themed frame inside a window.

On macOS, where this problem is most prominent, you can also set the window's background color (via its `background` configuration option) to the predefined color `systemWindowHeaderBackground`.

Creating the Entry Widget

The first widget we'll create is the entry to input the number of feet to convert.

```
feet = StringVar()
feet_entry = ttk.Entry(mainframe, width=7, textvariable=feet)
feet_entry.grid(column=2, row=1, sticky=(W, E))
```

We need to do two things: create the widget itself and then place it onscreen.

When we create a widget, we need to specify its *parent*. That is the widget that the new widget will be placed inside. In this case, we want our entry placed inside the content frame. Our entry, and other widgets we'll create shortly, are said to be *children* of the content frame. In Tcl and Perl, the widget name is used to specify the parent-child relationship, i.e. `.c.feet` is a child of `.c`. In Python and Ruby, the *`parent`* is passed as the first parameter when instantiating a widget object.

When we create a widget, we can optionally provide it with certain *configuration options*. Here, we specify how wide we want the entry to appear, i.e., 7 characters. We also assign it a mysterious `textvariable`; we'll see what that does shortly.

When widgets are created, they don't automatically appear on the screen; Tk doesn't know where you want them placed relative to other widgets. That's what the `grid` part does. Remember the layout grid when we sketched out our application? Widgets are placed in the appropriate column (1, 2, or 3) and row (also 1, 2, or 3).

The `sticky` option to grid describes how the widget should line up within the grid cell, using compass directions. So `w` (west) means to anchor the widget to the left side of the cell, `we` (west-east) means to attach it to both the left and right sides, and so on. Python also defines constants for these directional strings, which you can provide as a list, e.g. `W` or `(W, E)`.

Creating the Remaining Widgets

We then do exactly the same thing for the remaining widgets. We have one label that will display the resulting number of meters that we calculate. We have a "Calculate" button that is pressed to perform the calculation. Finally, we have three static text labels to make it clear how to use the application. For each of these widgets, we first create it and then place it onscreen in the appropriate cell in the grid.

```
meters = StringVar()
ttk.Label(mainframe, textvariable=meters).grid(column=2, row=2, sticky=(W, E))

ttk.Button(mainframe, text="Calculate", command=calculate).grid(column=3, row=3, sticky=W)

ttk.Label(mainframe, text="feet").grid(column=3, row=1, sticky=W)
ttk.Label(mainframe, text="is equivalent to").grid(column=1, row=2, sticky=E)
ttk.Label(mainframe, text="meters").grid(column=3, row=2, sticky=W)
```

Adding Some Polish

We then put a few finishing touches on our user interface.

```
for child in mainframe.winfo_children():
    child.grid_configure(padx=5, pady=5)
feet_entry.focus()
root.bind("<Return>", calculate)
```

The first part walks through all of the widgets contained within our content frame and adds a little bit of padding around each so they aren't so scrunched together. (We could have added these options to each `grid` call when we first put the widgets onscreen, but this is a nice shortcut.)

The second part tells Tk to put the focus on our entry widget. That way, the cursor will start in that field, so users don't have to click on it before starting to type.

The third line tells Tk that if a user presses the Return key (Enter on Windows), it should call our calculate routine, the same as if they pressed the Calculate button.

Performing the Calculation

Speaking of which, here we define our calculate procedure. It's called when a user presses the Calculate button or hits the Return key. It performs the feet to meters calculation.

```
def calculate(*args):
    try:
        value = float(feet.get())
        meters.set(int(0.3048 * value * 10000.0 + 0.5)/10000.0)
    except ValueError:
        pass
```

As you can clearly see, this routine takes the number of feet from our entry widget, does the calculation, and places the result in our label widget.

Say what? It doesn't look like we're doing anything with those widgets! Here's where the magic `textvariable` options we specified when creating the widgets come into play. We specified the global variable `feet` as the textvariable for the entry. Whenever the entry changes, Tk will *automatically* update the global variable `feet`. Similarly, if we explicitly change the value of a textvariable associated with a widget (as we're doing for `meters` which is attached to our label), the widget will automatically be updated with the current contents of the variable. For Python, the only caveat is that these variables must be an instance of the `StringVar` class. Slick.

The multiplying and dividing by 10000.0 is to avoid the rounding problems inherent in floating-point math. A simple calculation, e.g., `0.3048*1.5`, could result in a number like `0.45720000000000005`, which would neither be correct or visually appealing when displayed. There are other ways to do this. of course.

Start the Event Loop

Finally, we need to tell Tk to enter its event loop, which is necessary for everything to appear onscreen and allow users to interact with it.

```
root.mainloop()
```

What's Missing

We've now seen how to create widgets, put them onscreen, and respond to users interacting with them. It's certainly not fancy, could probably do with some error checking, but it's a fully functional GUI application.

It's also worth examining what we *didn't* have to include in our Tk program to make it work. For example:

- we didn't have to worry about redrawing the screen as things changed
- we didn't have to worry about parsing and dispatching events, hit detection, or handling events on each widget
- we didn't have to provide a lot of options when we created widgets; the defaults seemed to take care of most things, and so we only had to change things like the text the button displayed
- we didn't have to write complex code to get and set the values of simple widgets; we just attached them to variables
- we didn't have to worry about what happens when users close the window or resizes it
- we didn't need to write extra code to get this all to work cross-platform

One More Thing...

As this tutorial emphasizes Tkinter, our examples use standalone script code, global variables, and simple functions. In practice, you'll likely organize anything beyond the simplest scripts in functions or classes. There are different ways to do this: using modules, creating classes for different parts of the user interface, inheriting from Tkinter classes, etc.

Often though, you just want to do something simple to encapsulate your data rather than putting everything into the global variable space. Here is the feet to meters example, rewritten to encapsulate the main code into a class. Note the use of `self` on callbacks (which execute at the global scope) and `StringVar`'s.

```
from tkinter import *
from tkinter import ttk

class FeetToMeters:

    def __init__(self, root):

        root.title("Feet to Meters")

        mainframe = ttk.Frame(root, padding="3 3 12 12")
        mainframe.grid(column=0, row=0, sticky=(N, W, E, S))
        root.columnconfigure(0, weight=1)
        root.rowconfigure(0, weight=1)

        self.feet = StringVar()
        feet_entry = ttk.Entry(mainframe, width=7, textvariable=self.feet)
        feet_entry.grid(column=2, row=1, sticky=(W, E))
        self.meters = StringVar()

        ttk.Label(mainframe, textvariable=self.meters).grid(column=2, row=2, sticky=(W, E))
        ttk.Button(mainframe, text="Calculate", command=self.calculate).grid(column=3, row=3, sticky=W)

        ttk.Label(mainframe, text="feet").grid(column=3, row=1, sticky=W)
        ttk.Label(mainframe, text="is equivalent to").grid(column=1, row=2, sticky=E)
        ttk.Label(mainframe, text="meters").grid(column=3, row=2, sticky=W)

        for child in mainframe.winfo_children():
            child.grid_configure(padx=5, pady=5)

        feet_entry.focus()
        root.bind("<Return>", self.calculate)

    def calculate(self, *args):
        try:
            value = float(self.feet.get())
            self.meters.set(int(0.3048 * value * 10000.0 + 0.5)/10000.0)
        except ValueError:
            pass

root = Tk()
FeetToMeters(root)
root.mainloop()
```

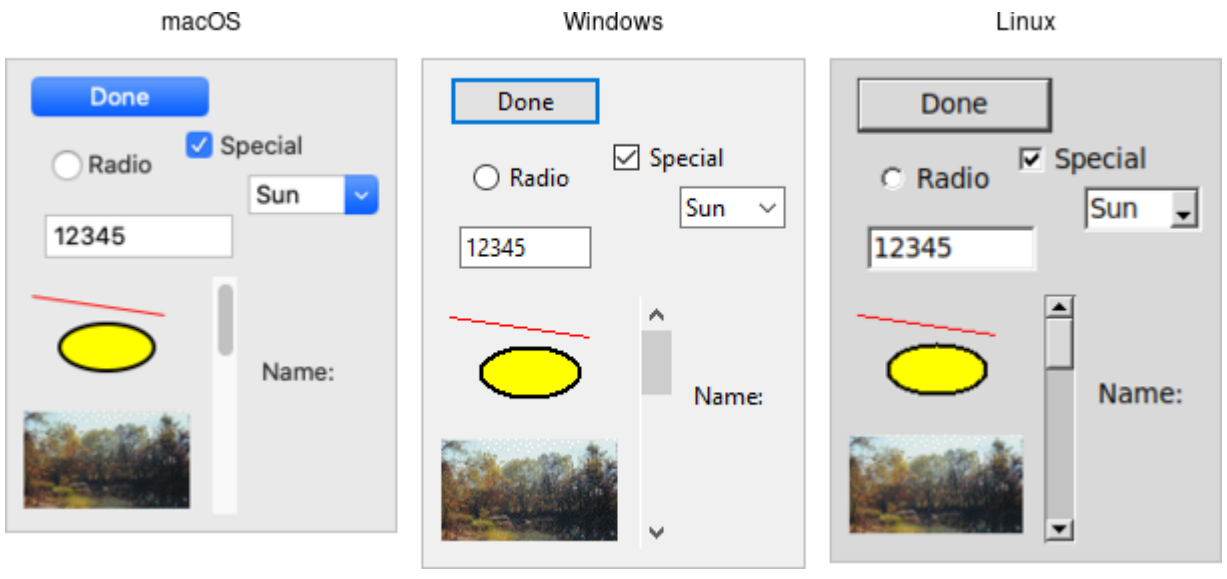
Tk Concepts

With your first example behind you, you now have a basic idea of what a Tk program looks like and the type of code you need to write to make it work. This chapter will step back and look at three broad concepts required to understand Tk: widgets, geometry management, and event handling.

Widgets

Widgets are all the things that you see onscreen. Our example had a button, an entry, a few labels, and a frame. Checkboxes, tree views, scrollbars, and text areas are examples of other widgets. Widgets are often referred to as "controls." You'll also sometimes see them referred to as "windows," particularly in Tk's documentation. This is a holdover from its X11 roots (under that terminology, both your toplevel application window and a button would be called windows).

Here is an example showing some of Tk's widgets, which we'll cover individually shortly.



Several Tk Widgets.

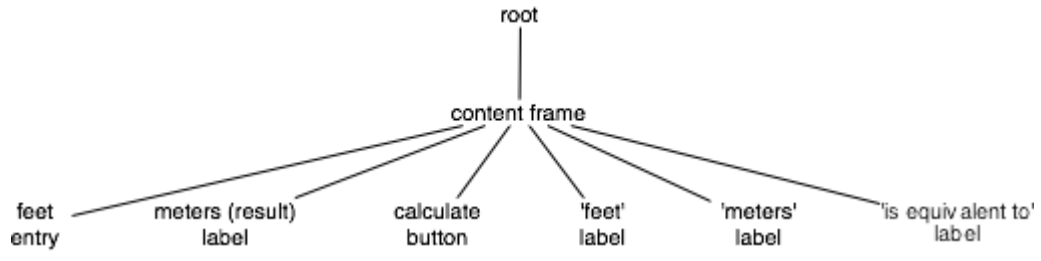
Widget Classes

Widgets are objects, instances of classes that represent buttons, frames, and so on. When you want to create a widget, the first thing you'll need to do is identify the specific class of the widget you'd like to instantiate. This tutorial and the widget roundup will help with that.

Widget Hierarchy

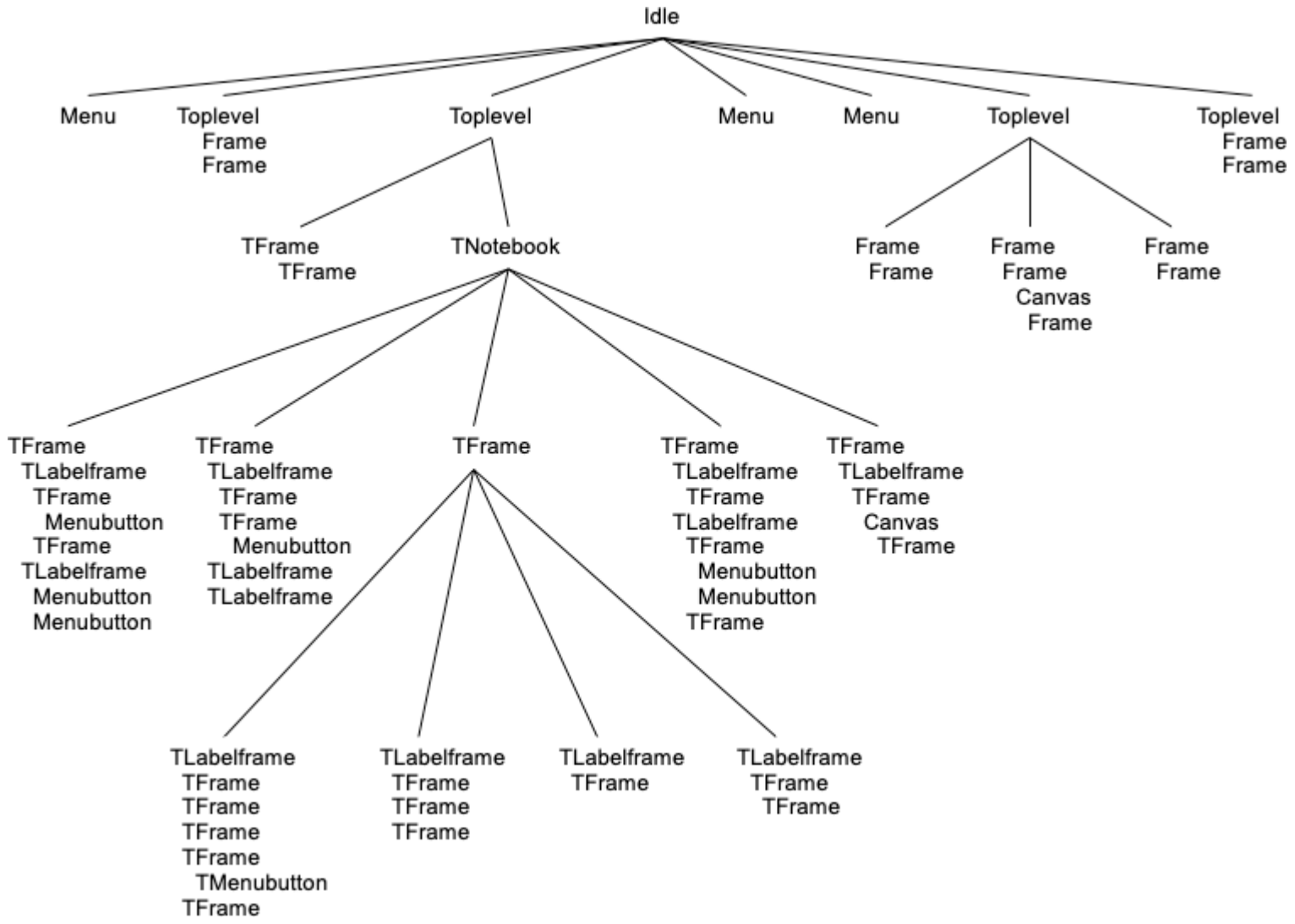
Besides the widget class, you'll need one other piece of information to create it: its *parent*. Widgets don't float off in space. Instead, they're contained within something else, like a window. In Tk, all widgets are part of a *widget (or window) hierarchy*, with a single root at the top of the hierarchy.

In our metric conversion example, we created a single frame as a child of the root window, and that frame had all the other controls as children. The root window was a *container* for the frame and was, therefore, the frame's *parent*. The complete hierarchy for the example looked like this:



The widget hierarchy of the metric conversion example.

This hierarchy can be arbitrarily deep, so you might have a button in a frame in another frame within the root window. Even a new window in your application (often called a *toplevel*) is part of that same hierarchy. That window and all its contents form a subtree of the overall widget hierarchy.



Hierarchy of a more substantial application. Leaf nodes (buttons, labels, etc.) omitted.

Creating Widgets

Each separate widget is a Python object. When instantiating a widget, you must pass its parent as a parameter to the widget class. The *only* exception is the "root" window, the toplevel window containing everything else. That is automatically created when you instantiate `Tk`. It does not have a parent. For example:

```
root = Tk()
content = ttk.Frame(root)
button = ttk.Button(content)
```

Whether or not you save the widget object in a variable is entirely up to you, depending on whether you'll need to refer to it later. Because the object is inserted into the widget hierarchy, it won't be garbage collected even if you don't keep your own reference to it.

If you sneak a peek at how Tcl manages widgets, you'll see each widget has a specific pathname; you'll also see this pathname referred to in Tk reference documentation. Tkinter chooses and manages all these pathnames for you behind the scenes, so you should never have to worry about them. If you do, you can get the pathname from a widget by calling `str(widget)`.

Configuration Options

All widgets have several *configuration options* that control how the widget is displayed or how it behaves.

The available options for a widget depend upon the widget class, of course. There is a lot of consistency between different widget classes, so options that do similar things tend to be named the same. For example, both a button and a label have a `text` option to adjust the text that the widget displays, while a scrollbar would not have a `text` option since it's not needed. Similarly, the button has a `command` option telling it what to do when pushed, while a label, which holds just static text, does not.

Configuration options can be set when the widget is first created by specifying their names and values as optional parameters. Later, you can retrieve the current values of those options, and with a tiny number of exceptions, change them at any time.

If you're unsure what configuration options a widget supports, you can ask the widget to describe them. This gives you a long list of all its options.

This is all best illustrated with the following interactive dialog with the interpreter.

```
% python
>>> from tkinter import *
>>> from tkinter import ttk
>>> root = Tk()
create a button, passing two options:
>>> button = ttk.Button(root, text="Hello", command="buttonpressed")
>>> button.grid()
check the current value of the text option:
>>> button['text']
'Hello'
change the value of the text option:
>>> button['text'] = 'goodbye'
another way to do the same thing:
>>> button.configure(text='goodbye')
check the current value of the text option:
>>> button['text']
'goodbye'
get all information about the text option:
>>> button.configure('text')
('text', 'text', 'Text', '', 'goodbye')
get information on all options for this widget:
>>> button.configure()
{'cursor': ('cursor', 'cursor', 'Cursor', '', ''), 'style': ('style', 'style', 'Style', '', ''),
'default': ('default', 'default', 'Default', <index object at 0x00DFFD10>, <index object at 0x00DFFD10>),
'text': ('text', 'text', 'Text', '', 'goodbye'), 'image': ('image', 'image', 'Image', '', ''),
'class': ('class', '', '', '', ''), 'padding': ('padding', 'padding', 'Pad', '', ''),
'width': ('width', 'width', 'Width', '', ''),
'state': ('state', 'state', 'State', <index object at 0x0167FA20>, <index object at 0x0167FA20>),
'command': ('command', 'command' , 'Command', '', 'buttonpressed'),
'textvariable': ('textvariable', 'textVariable', 'Variable', '', ''),
'compound': ('compound', 'compound', 'Compound', <index object at 0x0167FA08>, <index object at 0x0167FA08>),
'underline': ('underline', 'underline', 'Underline', -1, -1),
'takefocus': ('takefocus', 'takeFocus', 'TakeFocus', '', 'ttk::takefocus')}
```

As you can see, for each option, Tk will show you the name of the option and its current value (along with three other attributes which you can usually ignore).

Ok, if you really want to know, here are the details on the five pieces of data provided for each configuration option. The most useful are the first, the option's name, and the fifth, which is the option's current value. The fourth is the default value of the option, or in other words, the value it would have if you didn't change it. The other two relate to something called the option database. We'll touch on it when we discuss menus, but it's not used in modern applications. The second item is the option's name in the database, and the third is its class.

Widget Introspection

Tk exposes a treasure trove of information about each and every widget that your application can take advantage of. Much of it is available via the `winfo` facility; see the `winfo` command reference for full details.

This short example traverses the widget hierarchy, using each widget's `winfo_children` method to identify child widgets that need to be examined. For each widget, we print some basic information, including its class (button, frame, etc.), width, height, and position relative to its parent.

```
def print_hierarchy(w, depth=0):
    print('  '*depth + w.winfo_class() + ' w=' + str(w.winfo_width()) + ' h=' + str(w.winfo_height()) + ' x=' + str(w.winfo_x()) + ' y=' +
str(w.winfo_y()))
    for i in w.winfo_children():
        print_hierarchy(i, depth+1)

print_hierarchy(root)
```

The following are some of the most useful methods:

`winfo_class`
: a class identifying the type of widget, e.g., `TButton` for a themed button

`winfo_children`
: a list of widgets that are the direct children of a widget in the hierarchy

`winfo_parent`
: parent of the widget in the hierarchy

`winfo_toplevel`

the toplevel window containing this widget

`winfo_width, winfo_height`
current width and height of the widget; not accurate until it appears onscreen

`winfo_reqwidth, winfo_reqheight`
the width and height that the widget requests of the geometry manager (more on this shortly)

`winfo_x, winfo_y`
the position of the top-left corner of the widget relative to its parent

`winfo_rootx, winfo_rooty`
the position of the top-left corner of the widget relative to the entire screen

`winfo_vieweable`
whether the widget is displayed or hidden (all its ancestors in the hierarchy must be viewable for it to be viewable)

Geometry Management

If you've been running code interactively, you've probably noticed that widgets don't appear on the screen just by creating them. Placing widgets on the screen (and precisely *where* they are placed) is a separate step called *geometry management*.

In our example, positioning each widget was accomplished by the `grid` command. We specified the column and row we wanted each widget to go in, how things were aligned within the grid, etc. Grid is an example of a *geometry manager* (of which there are several in Tk, grid being the most useful). For now, we'll look at geometry management in general; we'll talk about grid in a later chapter.

A geometry manager's job is to figure out exactly where those widgets are going to be put. This turns out to be a complex optimization problem, and a good geometry manager relies on quite sophisticated algorithms. A good geometry manager provides the flexibility, power, and ease of use that makes programmers happy. It also makes it easy to create appealing user interface layouts without needing to jump through hoops. Tk's `grid` is, without a doubt, one of the absolute best. A poor geometry manager... well, all the Java programmers who have suffered through "GridBagLayout" please raise their hands.

We'll go into more detail in a later chapter, but `grid` was introduced several years after Tk became popular. Before that, an older geometry manager named `pack` was most commonly used. It's equally powerful but much harder to use, making it onerous to create layouts that look appealing today. Unfortunately, much of the example Tk code and documentation out there uses `pack` instead of `grid` (a good clue to how current it is). The widespread use of `pack` is a leading reason that so many Tk user interfaces look terrible. Start new code with `grid`, and upgrade old code when you can.

The Problem

The problem for a geometry manager is to take all the different widgets the program creates, plus the program's instructions for where in the window each should go (explicitly, or more often, relative to other widgets), and then actually position them in the window.

In doing so, the geometry manager has to balance multiple constraints. Consider these situations:

- The widgets may have a *natural* size, e.g., the natural width of a label would depend on the text it displays and the font used to display it. What if the application window containing all these different widgets isn't big enough to accommodate them? The geometry manager must decide which widgets to shrink to fit, by how much, etc.
- If the application window is bigger than the natural size of all the widgets, how is the extra space used? Is extra space placed between each widget, and if so, how is that space distributed? Is it used to make certain widgets larger than they usually are, such as a text entry growing to fill a wider window? Which widgets should grow?
- If the application window is resized, how does the size and position of each widget inside it change? Will certain areas (e.g., a text entry area) expand or shrink while other parts stay the same size, or is the area distributed differently? Do certain widgets have a minimum size that you want to avoid going below? A maximum size? Does the window itself have a minimum or maximum size?
- How can widgets in different parts of the user interface be aligned with each other? How much space should be left between them? This is needed to present a clean layout and comply with platform-specific user interface guidelines.
- For a complex user interface, which may have many frames nested in other frames nested in the window (etc.), how can all the above be accomplished, trading off the conflicting demands of different parts of the entire user interface?

How it Works

Geometry management in Tk relies on the concept of *master* and *slave* widgets. A master is a widget, typically a toplevel application window or a frame. It contains other widgets, called slaves. You can think of a geometry manager taking control of the master widget and deciding how all the slave widgets will be displayed within.

The computing community has embraced the more general societal trend towards more diversity, sensitivity, and awareness about the impacts of language. As a result, the Tk core will slowly adopt a more inclusive set of terminology. For example, where it makes sense, "parent" and "child" will be preferred over "master" and "slave." The current terminology will not disappear to preserve backward compatibility. This is something to be aware of for the future. For more details, see TIP #581.

Your program tells the geometry manager what slaves to manage within the master, i.e., via calling `grid`. Your program also provides hints as to how it would like each slave to be displayed, e.g., via the `column` and `row` options. You can also provide other things to the geometry manager. For example, we used `columnconfigure` and `rowconfigure` to indicate the columns and rows we'd like to expand if extra space is available in the window. It's worth noting that all these parameters and hints are specific to `grid`; other geometry managers would use different ones.

The geometry manager collects information about the slaves in the master and the total size of the master. It asks each slave widget for its natural size, i.e., how large it would ideally be displayed. The geometry manager's internal algorithm calculates the area each slave will be allocated (if any!). The slave is then responsible for rendering itself within that particular rectangle. And of course, we repeat the whole thing whenever the size of the master changes (e.g., because the toplevel window was resized), the natural size of a slave changes (e.g., because we've changed the text in a label), or any geometry manager parameters change (e.g., like `row`, `column`, or `sticky`).

This all works recursively as well. In our example, we had a content frame inside the toplevel application window and then several other widgets inside the content frame. We, therefore, had to manage the geometry for two different masters. At the outer level, the toplevel window was the master, and the content frame was its slave. At the inner level, the content frame was the master, with each of the other widgets being slaves. Notice that the same widget, e.g., the content frame, can be both a master and a slave! As we saw previously, this widget hierarchy can be nested much more deeply.

While each master can be managed by only one geometry manager (e.g., `grid`), different masters can have different geometry managers. While `grid` is the right choice most of the time, others may make sense for a particular layout used in one part of your user interface. Other Tk geometry managers include `pack`, which we've mentioned, and `place`, which leaves all layout decisions entirely up to you. Some complex widgets like `canvas` and `text` let you embed other widgets, making them de facto geometry managers.

Finally, we've been assuming that slave widgets are the immediate children of their master in the widget hierarchy. While this is usually the case, and mostly there's no good reason to do it any other way, it's also possible (with some restrictions) to get around this.

Event Handling

As with most user interface toolkits, Tk runs an *event loop* that receives events from the operating system. These are things like button presses, keystrokes, mouse movement, window resizing, and so on.

Generally, Tk takes care of managing this event loop for you. It will figure out what widget the event applies to (did a user click on this button? if a key was pressed, which textbox had the focus?), and dispatch it accordingly. Individual widgets know how to respond to events; for example, a button might change color when the mouse moves over it and revert back when the mouse leaves.

It's critical in event-driven applications that the event loop not be blocked. The event loop should run continuously, normally executing dozens of steps per second. At every step, it processes an event. If your program is performing a long operation, it can potentially block the event loop. In that case, no events would be processed, no drawing would be done, and it would appear as if your application is frozen. There are many ways to avoid this happening, mostly related to the structure of your application. We'll discuss this in more detail in a later chapter.

Command Callbacks

You often want your program to handle some event in a particular way, e.g., do something when a button is pushed. For those events that are most frequently customized (what good is a button without something happening when you press it?), the widget will allow you to specify a *callback* as a widget configuration option. We saw this in the example with the `command` option of the button.

```
def calculate(*args):
    ...

ttk.Button(mainframe, text="Calculate", command=calculate)
```

Callbacks in Tk tend to be simpler than in user interface toolkits used with compiled languages (where a callback must be a procedure with a certain set of parameters or an object method with a certain signature). Instead, the callback is just an ordinary bit of code that the interpreter evaluates. While it can be as complicated as you want to make it, most of the time, you'll just want your callback to call some other procedure.

Binding to Events

For events that don't have a widget-specific command callback associated with them, you can use Tk's `bind` to capture any event and then (like with callbacks) execute an arbitrary piece of code.

Here's a (silly) example showing a label responding to different events. When an event occurs, a description of the event is displayed in the label.

```
from tkinter import *
from tkinter import ttk
root = Tk()
l =ttk.Label(root, text="Starting...")
l.grid()
l.bind('<Enter>', lambda e: l.configure(text='Moved mouse inside'))
l.bind('<Leave>', lambda e: l.configure(text='Moved mouse outside'))
l.bind('<ButtonPress-1>', lambda e: l.configure(text='Clicked left mouse button'))
l.bind('<3>', lambda e: l.configure(text='Clicked right mouse button'))
l.bind('<Double-1>', lambda e: l.configure(text='Double clicked'))
l.bind('<B3-Motion>', lambda e: l.configure(text='right button drag to %d,%d' % (e.x, e.y)))
root.mainloop()
```

The first two bindings are pretty straightforward, just watching for simple events. An `<Enter>` event means the mouse has moved over top the widget, while the `<Leave>` event is generated when the mouse moves outside the widget to a different one.

The next binding looks for a mouse click, specifically a `<ButtonPress-1>` event. Here, the `<ButtonPress>` is the actual event, but the `-1` is an *event detail* specifying the left (main) mouse button on the mouse. The binding will only trigger when a `<ButtonPress>` event is generated involving the main mouse button. If another mouse button was clicked, this binding would ignore it.

This next binding looks for a `<3>` event. This is actually a shorthand for `<ButtonPress-3>`. It will respond to events generated when the right mouse button is clicked. The next binding, `<Double-1>` (shorthand for `<Double-ButtonPress-1>`) adds another modifier, `Double`, and so will respond to the left mouse button being double-clicked.

The last binding also uses a modifier: capture mouse movement (`Motion`), but only when the right mouse button (`B3`) is held down. This binding also shows an example of how to use *event parameters*. Many events carry additional information, e.g., the position of the mouse when it's clicked. Tk provides access to these parameters in Tcl callback scripts through the use of *percent substitutions*. These percent substitutions let you capture them so they can be used in your script.

Tkinter abstracts away these percent substitutions and instead encapsulates all the event parameters in an *event object*. Above, we used the `x` and `y` fields to retrieve the mouse position. We'll see percent substitutions used later in another context, entry widget validation.

What's with the `lambda` expressions? Tkinter expects you to provide a function as the event callback, whose first argument is an event object representing the event that triggered the callback. It's sometimes not worth the bother of defining regular named functions for one-off trivial callbacks, such as in this example. Instead, we've just used Python's anonymous functions via `lambda`. In real applications, you'll almost always use a regular function, such as the `calculate` function in our feet to meters example, or a method of an object.

Multiple Bindings for an Event

We've just seen how event bindings can be set up for an individual widget. When a matching event is received by that widget, the binding will trigger. But that's not all you can do.

Your binding can capture not only a single event but a short sequence of events. The `<Double-1>` binding triggers when two mouse clicks occur in a short time. You can do the same thing to capture two keys pressed in a row, e.g., `<KeyPress-A><KeyPress-B>` or simply `<ab>`.

You can also set up an event binding on a toplevel window. When a matching event occurs anywhere in that window, the binding will be triggered. In our example, we set up a binding for the Return key on the main application toplevel window. If the Return key was pressed when any widget in the toplevel window had the focus, that binding would fire.

Less commonly, you can create event bindings triggered when a matching event occurs anywhere in the application or even for events received by any widget of a given class, e.g., all buttons.

More than one binding can fire for an event. This keeps event handlers concise and limited in scope, meaning more modular code. For example, the behavior of each widget class in Tk is itself defined with script-level event bindings. These stay separate from event bindings in your application. Event bindings can also be changed or deleted. They can be modified to alter event handling for widgets of a certain class or parts of your application. You can reorder, extend, or change the sequence of event bindings that will be triggered for each widget; see the `bindtags` command reference if you're curious.

Available Events

The most commonly used events are described below, along with the circumstances when they are generated. Some are generated on some platforms and not others. For a complete description of all the different event names, modifiers, and the different event parameters that are available with each, the best place to look is the `bind` command reference.

`<Activate>`
Window has become active.

`<Deactivate>`
Window has been deactivated.

`<MouseWheel>`
Scroll wheel on mouse has been moved.

`<KeyPress>`
Key on keyboard has been pressed down.

`<KeyRelease>`
Key has been released.

`<ButtonPress>`
A mouse button has been pressed.

`<ButtonRelease>`
A mouse button has been released.

`<Motion>`
Mouse has been moved.

`<Configure>`
Widget has changed size or position.

`<Destroy>`
Widget is being destroyed.

`<FocusIn>`
Widget has been given keyboard focus.

`<FocusOut>`
Widget has lost keyboard focus.

`<Enter>`
Mouse pointer enters widget.

`<Leave>`
Mouse pointer leaves widget.

Event detail for mouse events is the button that was pressed, e.g., `1`, `2`, or `3`. For keyboard events, it's the specific key, e.g., `A`, `9`, `space`, `plus`, `comma`, `equal`. A complete list can be found in the `keysyms` command reference.

Event modifiers can include, e.g., `B1` or `Button1` to signify the main mouse button being held down, `Double` or `Triple` for sequences of the same event. Key modifiers for when keys on the keyboard are held down inline `Control`, `Shift`, `Alt`, `Option`, and `Command`.

Virtual Events

The events we've seen so far are low-level operating system events like mouse clicks and window resizes. Many widgets also generate higher-level, semantic events called *virtual events*. These are indicated by double angle brackets around the event name, e.g., `<<foo>>`.

For example, a listbox widget will generate a `<<ListboxSelect>>` virtual event whenever its selection changes. The same virtual event is generated whether a user clicked on an item, moved to it using the arrow keys, or another way. Virtual events avoid the problem of setting up multiple, possibly platform-specific event bindings to capture common changes. The available virtual events for a widget will be listed in the documentation for the widget class.

Tk also defines virtual events for common operations that are triggered in different ways for different platforms. These include `<<Cut>>`, `<<Copy>>` and `<<Paste>>`.

You can define your own virtual events, which can be specific to your application. This can be a useful way to keep platform-specific details isolated in a single module while using the virtual event throughout your application. Your own code can generate virtual events that work in exactly the same way that virtual events generated by Tk do.

```
root.event_generate("<<MyOwnEvent>>")
```

Basic Widgets

This chapter introduces the basic Tk widgets that you'll find in just about any user interface: frames, labels, buttons, checkbuttons, radiobuttons, entries, and comboboxes. By the end, you'll know how to use all the widgets you'd ever need for a typical fill-in-the-form type of user interface.

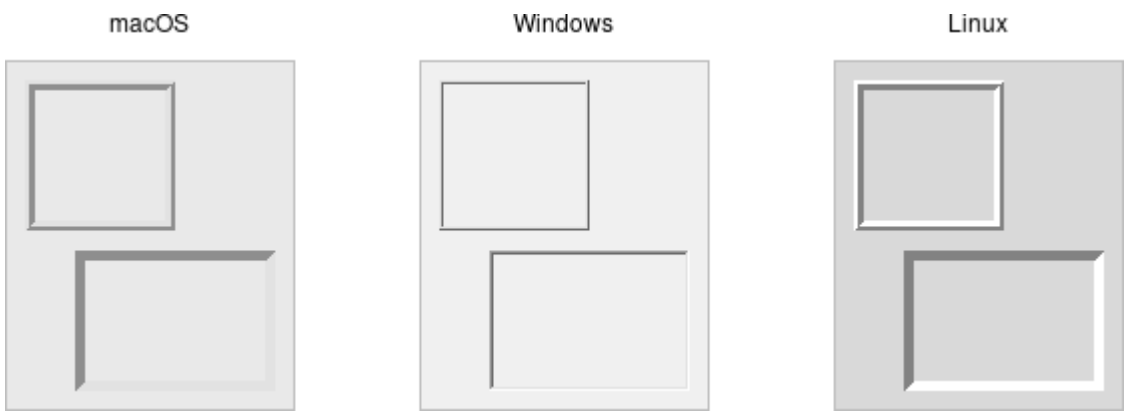
You'll find it easiest to read this chapter (and those following that discuss more widgets) in order. Because there is so much commonality between many widgets, we'll introduce certain concepts when describing one widget that will also apply to a widget we describe later. Rather than going over the same ground multiple times, we'll refer back to when the concept was first introduced.

As each widget is introduced, we'll refer to the widget roundup page for the specific widget, as well as the Tk reference manual page. As a reminder, this tutorial highlights the *most useful parts* of Tk and how to use them to build effective modern user interfaces. The reference documentation, which details *everything* that can be done in Tk, serves a very different purpose.

Frame

- Widget Roundup
- Reference Manual

A **frame** is a widget that displays as a simple rectangle. Frames help to organize your user interface, often both visually and at the coding level. Frames often act as master widgets for a geometry manager like `grid`, which manages the slave widgets contained within the frame.



Frame widgets.

Frames are created using the `ttk.Frame` class:

```
frame = ttk.Frame(parent)
```

Frames can take several different configuration options, which can alter how they are displayed.

Requested Size

Typically, the size of a frame is determined by the size and layout of any widgets within it. In turn, this is controlled by the geometry manager that manages the contents of the frame itself.

If, for some reason, you want an empty frame that does not contain other widgets, you can instead explicitly set its size using the `width` and/or `height` configuration options (otherwise, you'll end up with a very small frame indeed).

Screen distances such as width and height are usually specified as a number of pixels. You can also specify them via one of several suffixes. For example, `350` means 350 pixels, `350c` means 350 centimeters, `350m` means 350 millimeters, `350i` means 350 inches, and `350p` means 350 printer's points (1/72 inch).

> *Remember, you can request a given size for a frame (or any widget), but the geometry manager has the final say. If things aren't showing up the way you want them, make sure to check there too.*

Padding

The `padding` configuration option is used to request extra space around the inside of the widget. If you're putting other widgets inside the frame, there will be a margin all the way around. You can specify the same padding for all sides, different horizontal and vertical padding, or padding for each side separately.

```
f['padding'] = 5           # 5 pixels on all sides
f['padding'] = (5,10)      # 5 on left and right, 10 on top and bottom
f['padding'] = (5,7,10,12) # left: 5, top: 7, right: 10, bottom: 12
```

Borders

You can display a border around a frame widget to visually separate it from its surroundings. You'll see this often used to make a part of the user interface look sunken or raised. To do this, you need to set the `borderwidth` configuration option (which defaults to 0, i.e., no border) and the `relief` option, which specifies the visual appearance of the border. This can be one of: `flat` (default), `raised`, `sunken`, `solid`, `ridge`, or `groove`.

```
frame['borderwidth'] = 2
frame['relief'] = 'sunken'
```

Changing Styles

Frames have a `style` configuration option, which is common to all of the themed widgets. This lets you control many other aspects of their appearance or behavior. This is a bit more advanced, so we won't go into it in too much detail right now. But here's a quick example of creating a "Danger" frame with a red background and a raised border.

```
s = ttk.Style()
s.configure('Danger.TFrame', background='red', borderwidth=5, relief='raised')
ttk.Frame(root, width=200, height=200, style='Danger.TFrame').grid()
```

What elements of widgets can be changed by styles vary by widget and platform. On Windows and Linux, it does what you'd expect. On current macOS, the frame will have a red raised border, but the background will remain the default grey. Much more on why this is in a later chapter.

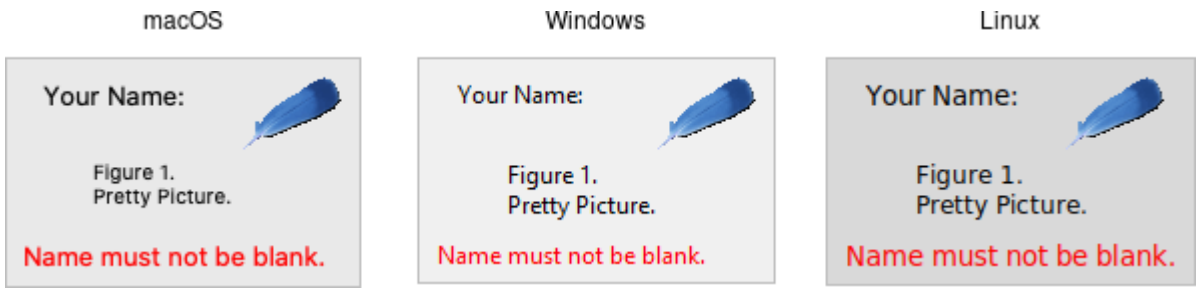
Styles mark a sharp departure from how most aspects of a widget's visual appearance were changed in the "classic" Tk widgets. In classic Tk, you could provide a wide range of options to finely control every aspect of an individual widget's behavior, e.g., foreground color, background color, font, highlight thickness, selected foreground color, and padding. When using the new themed widgets, these changes are made by modifying styles, not adding options to each widget.

As such, many options you may be familiar with in certain classic widgets are not present in their themed version. However, overuse of such options was a key factor undermining the appearance of Tk applications, especially when used across different platforms. Transitioning from classic to themed widgets provides an opportune time to review and refine how (and if!) such appearance changes are made.

Label

- Widget Roundup
- Reference Manual

A **label** is a widget that displays text or images, typically that users will just view but not otherwise interact with. Labels are used to identify controls or other parts of the user interface, provide textual feedback or results, etc.



Label widgets.

Labels are created using the **`ttk.Label`** class. Often, the text or image the label will display are specified via configuration options at the same time:

```
label = ttk.Label(parent, text='Full name:')
```

Like frames, labels can take several different configuration options, which can alter how they are displayed.

Displaying Text

The `text` configuration option (shown above when creating the label) is the most commonly used, particularly when the label is purely decorative or explanatory. You can change what text is displayed by modifying this configuration option. This can be done at any time, not only when first creating the label.

You can also have the widget monitor a variable in your script. Anytime the variable changes, the label will display the new value of the variable. This is done with the `textvariable` option:

```
resultsContents = StringVar()
label['textvariable'] = resultsContents
resultsContents.set('New value to display')
```

Tkinter only allows you to attach widgets to an instance of the `StringVar` class but not arbitrary Python variables. This class contains all the logic to watch for changes and communicate them back and forth between the variable and Tk. Use the `get` and `set` methods to read or write the current value of the variable.

Displaying Images

Labels can also display an image instead of text. If you just want an image displayed in your user interface, this is normally the way to do it. We'll go into images in more detail in a later chapter, but for now, let's assume you want to display a GIF stored in a file on disk. This is a two-step process. First, you will create an image "object." Then, you can tell the label to use that object via its `image` configuration option:

```
image = PhotoImage(file='myimage.gif')
label['image'] = image
```

Labels can also display both an image and text at the same time. You'll often see this in toolbar buttons. To do so, use the `compound` configuration option. The default value is `none`, meaning display only the image if present; if there is no image, display the text specified by the `text` or `textvariable` options. Other possible values for the `compound` option are `text` (text only), `image` (image only), `center` (text in the center of image), `top` (image above text), `left`, `bottom`, and `right`.

Fonts, Colors, and More

Like with frames, you normally don't want to change things like fonts and colors directly. If you need to change them (e.g., to create a special type of label), the preferred method would be to create a new style, which is then used by the widget with the `style` option.

Unlike most themed widgets, the label widget also provides explicit widget-specific configuration options as an alternative. Again, you should use these only in special one-off cases when using a style doesn't necessarily make sense.

You can specify the font used to display the label's text using the `font` configuration option. While we'll go into fonts in more detail in a later chapter, here are the names of some predefined fonts you can use:

`TkDefaultFont`
Default for all GUI items not otherwise specified.

`TkTextFont`
Used for entry widgets, listboxes, etc.

`TkFixedFont`
A standard fixed-width font.

`TkMenuFont`
The font used for menu items.

`TkHeadingFont`
A font for column headings in lists and tables.

`TkCaptionFont`
A font for window and dialog caption bars.

`TkSmallCaptionFont`
Smaller captions for subwindows or tool dialogs.

`TkIconFont`
A font for icon captions.

`TkTooltipFont`
A font for tooltips.

Because font choices are platform-specific, be careful of hardcoding specifics (font families, sizes, etc.). This is something else you'll see in many older Tk programs that can make them look ugly.

```
label['font'] = "TkDefaultFont"
```

The foreground (text) and background color of the label can also be changed via the `foreground` and `background` configuration options. Colors are covered in detail later, but you can specify them as either color names (e.g., `red`) or hex RGB codes (e.g., `#ff340a`).

Labels also accept the `relief` configuration option discussed for frames to make them appear sunken or raised.

Layout

The geometry manager determines the overall layout of the label (i.e., where it is positioned within the user interface and how large it is). Yet, several options can help you control how the label is displayed within the rectangle the geometry manager gives it.

If the box given to the label is larger than the label requires for its contents, you can use the `anchor` option to specify what edge or corner the label should be attached to, which would leave any empty space in the opposite edge or corner. Possible values are specified as compass directions: `n` (north, or top edge), `ne`, (north-east, or top right corner), `e`, `se`, `s`, `sw`, `w`, `nw` or `center`.

Things not appearing where you think they should? The position and size of the overall label widget may not be what you think it is. They can be affected by various widget and geometry manager options. For example, if you're using `grid`, you may need to adjust the `sticky` options. Options on one widget can affect the placement of another, as the geometry manager juggles space to fit all the widgets together. When debugging, it can help to change the background color of each widget so you know exactly where each is positioned. This is a good example of those "one-off" cases we just mentioned where you might use configuration options rather than styles to modify appearance.

Multi-line Labels

Labels can display more than one line of text. To do so, embed carriage returns (`\n`) in the `text` (or `textvariable`) string. Labels can also automatically wrap your text into multiple lines via the `wraplength` option, which specifies the maximum length of a line (in pixels, centimeters, etc.).

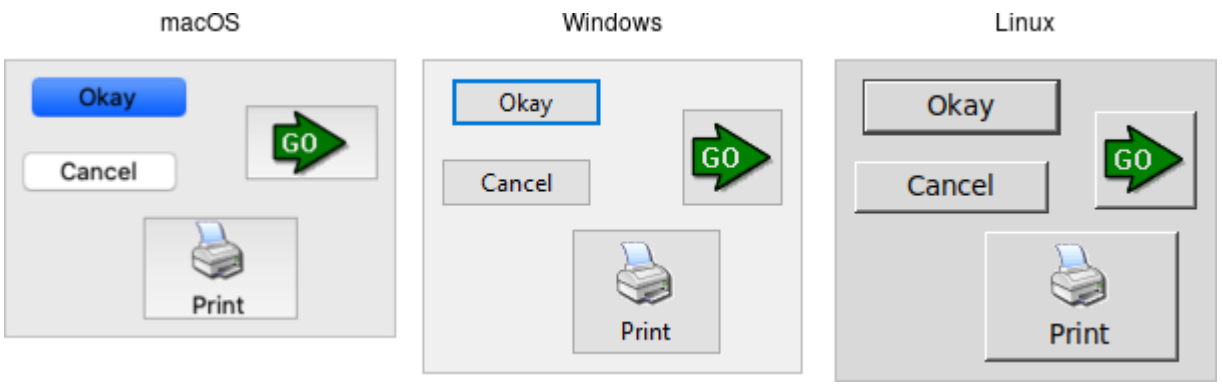
Multi-line labels are a replacement for the older `message` widgets in classic Tk.

You can also control how the text is justified via the `justify` option. It can have the values `left`, `center`, or `right`. If you have only a single line of text, you probably want the `anchor` option instead.

Button

- Widget Roundup
- Reference Manual

A **button**, unlike a frame or label, is very much there to interact with. Users press a button to perform an action. Like labels, they can display text or images but accept additional options to change their behavior.



Button widgets.

Buttons are created using the **`ttk.Button`** class:

```
button = ttk.Button(parent, text='Okay', command=submitForm)
```

Typically, their contents and command callback are specified at the same time the button is created. As with other widgets, buttons accept several configuration options to alter their appearance and behavior, including the standard `style` option.

Text or Image

Buttons take the same `text`, `textvariable` (rarely used), `image`, and `compound` configuration options as labels. These control whether the button displays text and/or an image.

Buttons have a `default` configuration option. If specified as `active`, this tells Tk that the button is the default button in the user interface; otherwise, it is `normal`. Default buttons are invoked if users hit the Return or Enter key. Some platforms and styles will draw this default button with a different border or highlight. Note that setting this option doesn't create an event binding that will make the Return or Enter key activate the button; you have to do that yourself.

The Command Callback

The `command` option connects the button's action and your application. When a user presses the button, the script provided by the option is evaluated by the interpreter.

You can also ask the button to invoke the command callback from your application. That way, you don't need to repeat the command to be invoked several times in your program. If you change the command attached to the button, you don't need to change it elsewhere too. Sounds like a useful way to add that event binding on our default button, doesn't it?

```
action = ttk.Button(root, text="Action", default="active", command=myaction)
root.bind('<Return>', lambda e: action.invoke())
```

Standard behavior for dialog boxes and many other windows on most platforms is to set up a binding on the window for the Return key (`<Return>` or `<Key-Return>`) to invoke the active button if it exists, as we've done here. If there is a "Close" or "Cancel" button, create a binding to the Escape key (`<Key-Escape>`). On macOS, you should additionally bind the Enter key on the keyboard (`<KP_Enter>`) to the active button and Command-period (`<Command-.>`) to the close or cancel button.

Button State

Buttons and many other widgets start off in a normal state. A button will respond to mouse movements, can be pressed, and will invoke its command callback. Buttons can also be put into a disabled state, where the button is greyed out, does not respond to mouse movements, and cannot be pressed. Your program would disable the button when its command is not applicable at a given point in time.

All themed widgets maintain an internal state, represented as a series of binary flags. Each flag can either be set (on) or cleared (off). You can set or clear these different flags, and check the current setting using the `state` and `instate` methods. Buttons make use of the `disabled` flag to control whether or not users can press the button. For example:

```
b.state(['disabled'])          # set the disabled flag
b.state(['!disabled'])         # clear the disabled flag
b.instate(['disabled'])        # true if disabled, else false
b.instate(['!disabled'])       # true if not disabled, else false
b.instate(['!disabled'], cmd)  # execute 'cmd' if not disabled
```

*Note that these commands accept an **array** of state flags as their argument.*

The full list of state flags available to themed widgets is: `active`, `disabled`, `focus`, `pressed`, `selected`, `background`, `readonly`, `alternate`, and `invalid`. These are described in the themed widget reference. While all widgets have the same set of state flags, not all states are meaningful for all widgets. It's also possible to get fancy in the `state` and `instate` methods and specify multiple state flags at the same time.

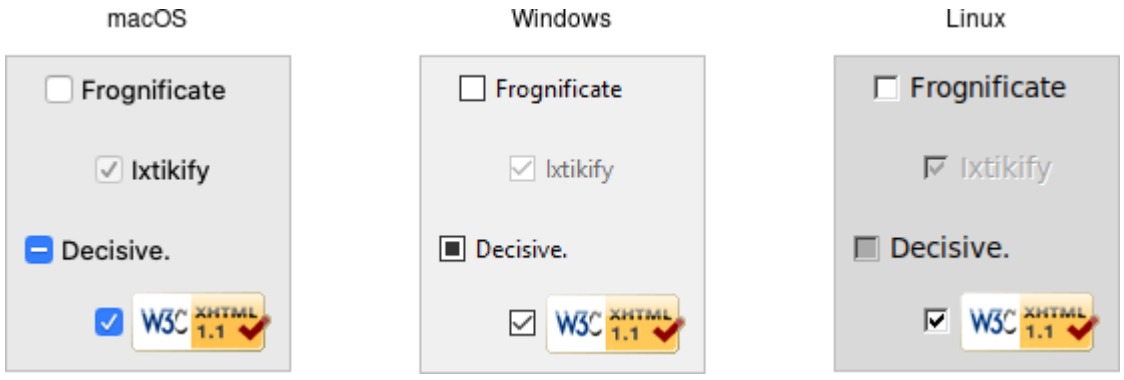
The `state` and `instate` methods replace the older `state` configuration option (which took the values `normal` or `disabled`).

That configuration option is actually still available for themed widgets in Tk 8.5, but "write-only," which means that changing the option calls the appropriate `state` command. It's mainly intended as a convenience, so you can specify a widget should be disabled when you first create it. However, any changes made using the new `state` command do not update the configuration option. To avoid confusion, update your code to use the state flags for all themed widgets.

Checkbutton

- Widget Roundup
- Reference Manual

A **checkbutton** widget is like a regular button that also holds a binary value of some kind (i.e., a toggle). When pressed, a checkbutton flips the toggle and then invokes its callback. Checkbutton widgets are frequently used to allow users to turn an option on or off.



Checkbutton widgets.

Checkbuttons are created using the **`ttk.Checkbutton`** class. Typically, their contents and behavior are specified at the same time:

```
measureSystem = StringVar()
check = ttk.Checkbutton(parent, text='Use Metric',
            command=metricChanged, variable=measureSystem,
            onvalue='metric', offvalue='imperial')
```

Checkbuttons use many of the same options as regular buttons but add a few more. The `text`, `textvariable`, `image`, and `compound` configuration options control the display of the label (next to the checkbox itself). Similarly, the `command` option lets you specify a command to be called every time a user toggles the checkbutton; and the `invoke` method will also execute the same command. The `state` and `instate` methods allow you to manipulate the `disabled` state flag to enable or disable the checkbutton.

Widget Value

Unlike regular buttons, checkbuttons also hold a value. We've seen how the `textvariable` option links the label of a widget to a variable. The `variable` option for checkbuttons behaves similarly, except it links a variable to the widget's current value. The variable is updated whenever the widget is toggled. By default, checkbuttons use a value of `1` when checked and `0` when not checked. These can be changed to something else using the `onvalue` and `offvalue` options.

A checkbutton doesn't automatically set (or create) the linked variable. Therefore, your program needs to initialize it to the appropriate starting value.

What happens when the linked variable contains neither the `onvalue` or the `offvalue` (or even doesn't exist)? In that case, the checkbutton is put into a special "tristate" or indeterminate mode. The checkbox might display a single dash in this mode instead of being empty or holding a checkmark. Internally, the state flag `alternate` is set, which you can inspect via the `instate` method:

```
check.instate(['alternate'])
```

While we've been using an instance of the `StringVar` class, Tkinter provides other variable classes that can hold booleans, integers, or floating-point numbers. You can always use a `StringVar` (because the Tcl API that Tkinter uses is string-based) but can choose one of the others if the data stored in it fits the type. All are subclasses of the base class `Variable`.

In the feet to meters example, we saw that you can call the `get` method of a `Variable` to retrieve its value or the `set` method to provide a new value. You can also supply an initial value when you instantiate it.

```
s = StringVar(value="abc")    # default value is ''
b = BooleanVar(value=True)    # default is False
i = IntVar(value=10)          # default is 0
d = DoubleVar(value=10.5)     # default is 0.0
```

Radiobutton

- Widget Roundup
- Reference Manual

A **radiobutton** widget lets you choose between one of several mutually exclusive choices. Unlike a checkbutton, they are not limited to just two options. Radiobuttons are always used together in a set, where multiple radiobutton widgets are tied to a single choice or preference. They are appropriate to use when the number of options is relatively small, e.g., 3-5.

Radiobutton widgets.

Radiobuttons are created using the **`ttk.Radiobutton`** class. Typically, you'll create and initialize several of them at once:

```
phone = StringVar()
home = ttk.Radiobutton(parent, text='Home', variable=phone, value='home')
office = ttk.Radiobutton(parent, text='Office', variable=phone, value='office')
cell = ttk.Radiobutton(parent, text='Mobile', variable=phone, value='cell')
```

Radiobuttons share most of the same configuration options as checkbuttons. One exception is that the `onvalue` and `offvalue` options are replaced with a single `value` option. Each radiobutton in the set will have the same linked variable but a different value. When the variable holds the matching value, that radiobutton will visually indicate it is selected. If it doesn't match, the radiobutton will be unselected. If the linked variable doesn't exist, or you don't specify one with the `variable` option, radiobuttons also display as "tristate" or indeterminate. This can be checked via the `alternate` state flag.

Entry

- Widget Roundup
- Reference Manual

An **entry** widget presents users with a single-line text field where they can type in a string value. These can be just about anything: a name, a city, a password, social security number, etc.

Entry widgets.

Entries are created using the **`ttk.Entry`** class:

```
username = StringVar()
name = ttk.Entry(parent, textvariable=username)
```

A `width` configuration option may be specified to provide the number of characters wide the entry should be. This allows you, for example, to display a shorter entry for a zip or postal code.

Entry Contents

We've seen how checkbutton and radiobutton widgets have a value associated with them. Entries do as well, and that value is usually accessed through a linked variable specified by the `textvariable` configuration option.

> *Unlike the various buttons, entries don't have a text or image beside them to identify them. Use a separate label widget for that.*

You can also get or change the value of the entry widget without going through the linked variable. The `get` method returns the current value, and the `delete` and `insert` methods let you change the contents, e.g.

```
print('current value is %s' % name.get())
name.delete(0,'end')          # delete between two indices, 0-based
name.insert(0, 'your name')   # insert new text at a given index
```

Watching for Changes

Entry widgets don't have a `command` option to invoke a callback whenever the entry is changed. To watch for changes, you should watch for changes to the linked variable. See also "Validation" below.

```
def it_has_been_written(*args):
    ...
username.trace_add("write", it_has_been_written)
```

You'll be fine if you stick with simple uses of `trace_add` like that shown above. You might want to know that this is a small part of a much more complex system for observing variables and invoking callbacks when they are read, written, or deleted. You can trigger multiple callbacks, add or delete them (`trace_remove`), and introspect them (`trace_info`).

These methods also replace a now-deprecated set of older methods (`trace`, `trace_variable`, `trace_vdelete`, and `trace_vinfo`) that should not be used.

Tkinter allows you to watch for changes on a `StringVar` (or any subclass of `Variable`). Both the older and newer tracing tools are a very thin (and not terribly Pythonic) front end to Tcl's `trace` command.

Passwords

Entries can be used for passwords, where the actual contents are displayed as a bullet or other symbol. To do this, set the `show` configuration option to the character you'd like to display.

```
passwd = ttk.Entry(parent, textvariable=password, show="*")
```

Widget States

Like the various buttons, entries can also be put into a disabled state via the `state` command (and queried with `instate`). Entries can also use the state flag `readonly`; if set, users cannot change the entry, though they can still select the text in it (and copy it to the clipboard). There is also an `invalid` state, set if the entry widget fails validation, which leads us to...

Validation

Users can type any text they like into an entry widget. However, if you'd like to restrict what they can type into the entry, you can do so with *validation*. For example, an entry might only accept an integer or a valid zip or postal code.

Your program can specify what makes an entry valid or invalid, as well as when to check its validity. As we'll see soon, the two are related. We'll start with a simple example, an entry that can only hold an integer up to five digits long.

The validation criteria are specified via an entry's `validatecommand` configuration option. You supply a piece of code whose job is to validate the entry. It functions like a widget callback or event binding, except that it returns a value (whether or not the entry is valid). We'll validate the entry on every keystroke; this is specified by providing a value of `key` to the `validate` configuration option.

```
import re
def check_num(newval):
    return re.match('^[0-9]*$', newval) is not None and len(newval) <= 5
check_num_wrapper = (root.register(check_num), '%P')

num = StringVar()
e = ttk.Entry(root, textvariable=num, validate='key', validatecommand=check_num_wrapper)
e.grid(column=0, row=0, sticky='we')
```

A few things are worth noting. First, as with event bindings, we can access more information about the conditions that triggered the validation via *percent substitutions*. We used one of these here: `%P` is the new value of the entry *if* the validation passes. We'll use a simple regular expression and a length check to determine if the change is valid. To reject the change, our validation command can return a false value, leaving the entry unchanged.

Taking advantage of these percent substitutions requires some gymnastics. You'll recall that Tkinter abstracts away percent substitutions in event binding callbacks. All event parameters are wrapped into an event object that is passed to the callback. There's no equivalent abstraction for validation callbacks. Instead, we have to choose which percent substitutions we're interested in. The `register` method (which can be called on any widget, not just `root`) creates a Tcl procedure which will call our Python function. The percent substitutions we've chosen will be passed to it as parameters.

Let's extend our example so that the entry will accept a US zip code, formatted as "#####" or "#####-####" ("#" can be any digit). We'll still do some validation on each keystroke (only allowing entry of numbers or a hyphen). However, We can no longer fully validate the entry on every keystroke; if they've just typed the first digit, it's not valid yet. So full validation will only happen when the entry loses focus (e.g., a user tabs away from it). Tk refers to this as *revalidation*, in contrast with *prevalidation* (accepting changes on each keystroke).

How should we respond to errors? Let's add a message reminding users of the format. It will appear if they type a wrong key or tab away from the entry when it's not holding a valid zip code. We'll remove the message when they return to the entry or type a valid key. We'll also add a (dummy) button to "process" the zip code, which will be disabled unless the zip entry is valid. Finally, we'll also add a "name" entry so you can

tab away from the zip entry.

```
import re
errmsg = StringVar()
formatmsg = "Zip should be ##### or #####-####"

def check_zip(newval, op):
    errmsg.set('')
    valid = re.match('^[0-9]{5}(\-[0-9]{4})?$', newval) is not None
    btn.state(['!disabled'] if valid else ['disabled'])
    if op=='key':
        ok_so_far = re.match('^[0-9\-]*$', newval) is not None and len(newval) <= 10
        if not ok_so_far:
            errmsg.set(formatmsg)
        return ok_so_far
    elif op=='focusout':
        if not valid:
            errmsg.set(formatmsg)
    return valid
check_zip_wrapper = (root.register(check_zip), '%P', '%V')

zip = StringVar()
f = ttk.Frame(root)
f.grid(column=0, row=0)
ttk.Label(f, text='Name:').grid(column=0, row=0, padx=5, pady=5)
ttk.Entry(f).grid(column=1, row=0, padx=5, pady=5)
ttk.Label(f, text='Zip:').grid(column=0, row=1, padx=5, pady=5)
e = ttk.Entry(f, textvariable=zip, validate='all', validatecommand=check_zip_wrapper)
e.grid(column=1, row=1, padx=5, pady=5)
btn = ttk.Button(f, text="Process")
btn.grid(column=2, row=1, padx=5, pady=5)
btn.state(['disabled'])
msg = ttk.Label(f, font='TkSmallCaptionFont', foreground='red', textvariable=errmsg)
msg.grid(column=1, row=2, padx=5, pady=5, sticky='w')
```

Notice that the `validate` configuration option has been changed from `key` to `all`. That arranges for the `validatecommand` callback to be invoked on not only keystrokes but other triggers. The trigger is passed to the callback using the `%V` percent substitution. The callback differentiated between `key` and `focusout` triggers (you can also check for `focusin`).

There are a few more things to know about validation. First, if your `validatecommand` ever generates an error (or doesn't return a boolean), validation will be disabled for that widget. Your callback can modify the entry, e.g., change its textvariable. You can ask the widget to validate at any time by calling its `validate` method, which returns true if validation passes (the `%V` substitution is set to `forced`).

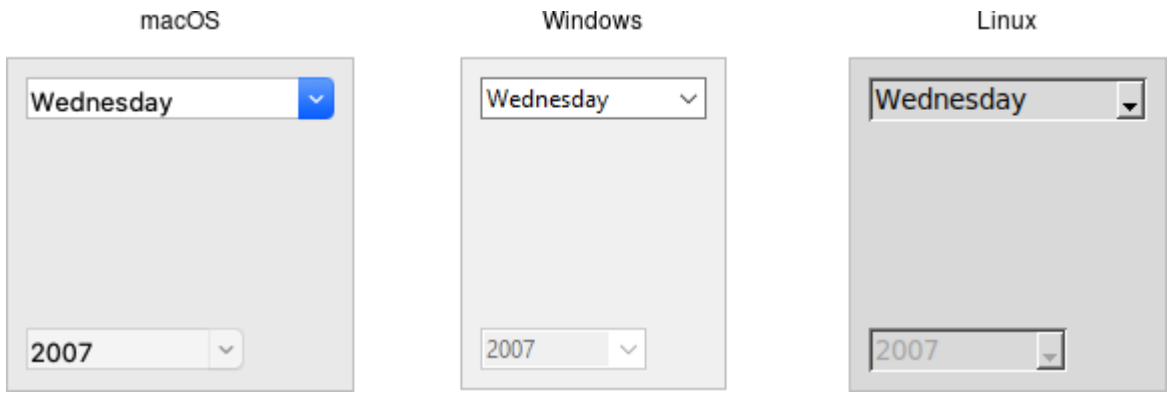
There is an `invalidcommand` configuration option (which works like `validatecommand`) that is called whenever validation fails. You can use it to accomplish nasty things like forcing the focus back on the widget that didn't validate. In practice, it's rarely used. As mentioned earlier, the entry's `invalid` state flag (which can be checked via the `instate invalid` method) is automatically updated as validation succeeds or fails.

Other percent substitutions allow you to get the entry's contents prior to editing (`%s`), differentiate between insert and delete (`%d`), where an insert or delete occurs (`%i`), what is being inserted or deleted (`%S`), the current setting of the `validate` option (`%v`) and the name of the widget (`%W`).

Combobox

- Widget Roundup
- Reference Manual

A **combobox** widget combines an entry with a list of choices. This lets users either choose from a set of values you've provided (e.g., typical settings), but also put in their own value (e.g., for less common cases).



Combobox widgets.

Comboboxes are created using the **`ttk.Combobox`** class:

```
countryvar = StringVar()
country = ttk.Combobox(parent, textvariable=countryvar)
```

Like entries, the `textvariable` option links a variable in your program to the current value of the combobox. As with other widgets, you should initialize the linked variable in your own code.

A combobox will generate a `<<ComboboxSelected>>` virtual event that you can bind to whenever its value changes. (You could also trace changes on the `textvariable`, as we've seen in the previous few widgets we covered. Binding to the event is more straightforward, and so tends to be our preferred choice.)

```
country.bind('<<ComboboxSelected>>', function)
```

Predefined Values

You can provide a list of values that users can choose from using the `values` configuration option:

```
country['values'] = ('USA', 'Canada', 'Australia')
```

If set, the `readonly` state flag will restrict users to making choices only from the list of predefined values but not be able to enter their own (though if the current value of the combobox is not in the list, it won't be changed).

```
country.state(["readonly"])
```

If you're using the combobox in `readonly` mode, I'd recommend that when the value changes (i.e., on a `<<ComboboxSelected>>` event), that you call the `selection_clear` method. It looks a bit odd visually without doing that.

You can also get the current value using the `get` method and change the current value using the `set` method (which takes a single argument, the new value).

To complement the `get` and `set` methods, you can also use the `current` method to determine which item in the predefined values list is selected. Call `current` with no arguments; it will return a 0-based index into the list or -1 if the current value is not in the list. You can select an item in the list by calling `current` with a single 0-based index argument.

Want to associate some other value with each item in the list so that your program can use one value internally, but it gets displayed in the combobox as something else? You'll want to have a look at the section entitled "Keeping Extra Item Data" when we get to the discussion of listboxes in a couple of chapters from now.

The Grid Geometry Manager

We'll take a bit of a break from talking about different widgets (what to put onscreen) and focus instead on geometry management (where to put those widgets). We introduced the general idea of geometry management in the "Tk Concepts" chapter. Here, we focus on one specific geometry manager: `grid`.

As we've seen, `grid` lets you layout widgets in columns and rows. If you're familiar with using HTML tables for layout, you'll feel right at home here. This chapter illustrates the various ways you can tweak grid to give you all the control you need for your user interface.

Grid is one of several geometry managers available in Tk, but its mix of power, flexibility, and ease of use make it the best choice for general use. Its constraint model is a natural fit with today's layouts that rely on the alignment of widgets. There are other geometry managers in Tk: `pack` is also quite powerful but harder to use and understand, while `place` gives you complete control of positioning each element. Even widgets like paned windows, notebooks, canvas, and text that we'll explore later can act as geometry managers.

It's worth noting that `grid` was first introduced to Tk in 1996, several years after Tk became popular, and it took a while to catch on. Before that, developers had always used `pack` to do constraint-based geometry management. When `grid` came out, many developers kept using `pack`, and you'll still find it used in many Tk programs and documentation. While there's nothing technically wrong with `pack`, the

algorithm's behavior is often hard to understand. More importantly, because the order that widgets are packed is significant in determining layout, modifying existing layouts can be more difficult. Aligning widgets in different parts of the user interface is also much trickier.

Grid has all the power of pack, produces nicer layouts (that align widgets both horizontally and vertically), and is easier to learn and use. Because of that, grid is the right choice for most developers most of the time. Start your new programs using grid, and switch old ones to grid as you make changes to an existing user interface.

The reference documentation for grid provides an exhaustive description of grid, its behaviors, and all options.

Columns and Rows

In grid, widgets are assigned a `column` number and a `row` number. These indicate each widget's position relative to other widgets. Widgets in the same column are above or below each other. Those in the same row are to the left or right of each other.

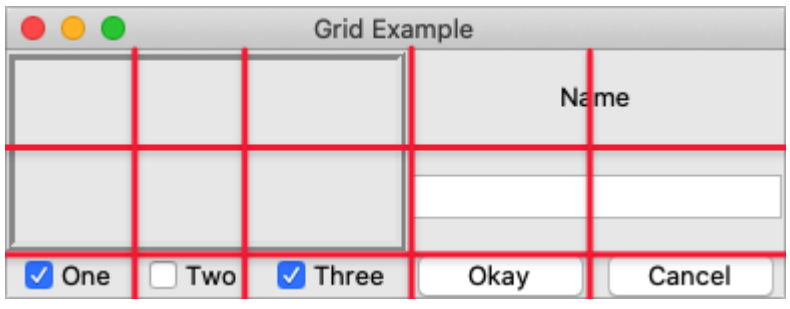
Column and row numbers must be positive integers (i.e., 0, 1, 2, ...). You don't have to start at 0 and can leave gaps in column and row numbers (e.g., column 1, 2, 10, 11, 12, 20, 21). This is useful if you plan to add more widgets in the middle of the user interface later.

The width of each column will vary depending on the width of the widgets contained within the column. Ditto for the height of each row. This means when sketching out your user interface and dividing it into rows and columns, you don't need to worry about each column or row being equal width.

Spanning Multiple Cells

Widgets can take up more than a single cell in the grid; to do this, we'll use the `columnspan` and `rowspan` options when gridding the widget. These are analogous to the "colspan" and "rowspan" attributes of HTML tables.

Here is an example of creating a user interface with multiple widgets, some that take up more than a single cell.



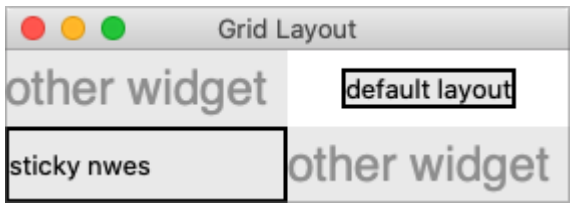
Gridding multiple widgets.

```
from tkinter import *
from tkinter import ttk

root = Tk()

content = ttk.Frame(root)
frame = ttk.Frame(content, borderwidth=5, relief="ridge", width=200, height=100)
namelbl = ttk.Label(content, text="Name")
name = ttk.Entry(content)

onevar = BooleanVar(value=True)
twovar = BooleanVar(value=False)
threevar = BooleanVar(value=True)

one = ttk.Checkbutton(content, text="One", variable=onevar, onvalue=True)
two = ttk.Checkbutton(content, text="Two", variable=twovar, onvalue=True)
three = ttk.Checkbutton(content, text="Three", variable=threevar, onvalue=True)
ok = ttk.Button(content, text="Okay")
cancel = ttk.Button(content, text="Cancel")

content.grid(column=0, row=0)
frame.grid(column=0, row=0, columnspan=3, rowspan=2)
namelbl.grid(column=3, row=0, columnspan=2)
name.grid(column=3, row=1, columnspan=2)
one.grid(column=0, row=3)
two.grid(column=1, row=3)
three.grid(column=2, row=3)
ok.grid(column=3, row=3)
cancel.grid(column=4, row=3)

root.mainloop()
```

Layout within the Cell

The width of a column (and height of a row) depends on all the widgets contained in it. That means some widgets could be smaller than the cells they are placed in. If so, where exactly should they be put within their cells?

By default, if a cell is larger than the widget contained in it, the widget will be centered within it, both horizontally and vertically. The master's background color will display in the empty space around the widget. In the figure below, the widget in the top right is smaller than the cell allocated to it. The (white) background of the master fills the rest of the cell.



Layout within the cell and the 'sticky' option.

The `sticky` option can change this default behavior. Its value is a string of 0 or more of the compass directions `nsew`, specifying which edges of the cell the widget should be "stuck" to. For example, a value of `n` (north) will jam the widget up against the top side, with any extra vertical space on the bottom; the widget will still be centered horizontally. A value of `nw` (north-west) means the widget will be stuck to the top left corner, with extra space on the bottom and right.

In Tkinter, you can also specify this as a list containing any of `N`, `S`, `E`, and `W`. It's a stylistic choice, and we'll tend to use the list format in this book.

Specifying two opposite edges, such as `we` (west, east), means the widget will be stretched. In this case, it will be stuck to both the left and right edges of the cell. So the widget will be wider than its "ideal" size.

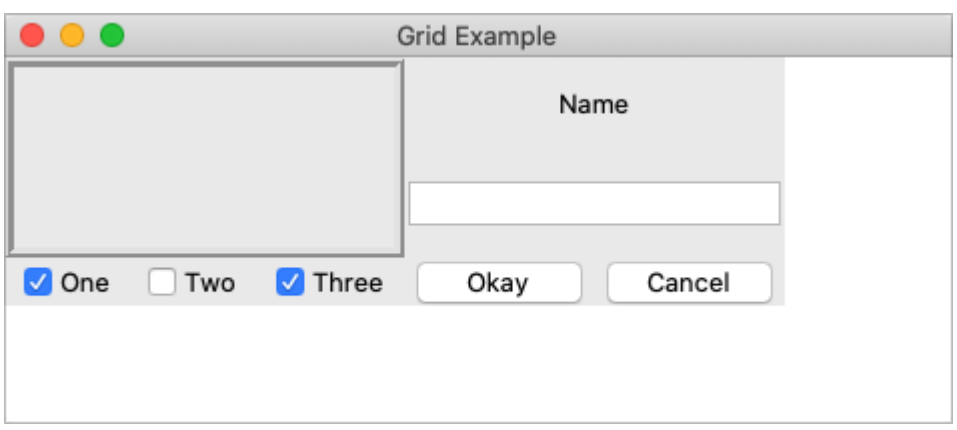
If you want the widget to expand to fill up the entire cell, grid it with a sticky value of `nsew` (north, south, east, west), meaning it will stick to every side. This is shown in the bottom left widget in the above figure.

Most widgets have options that can control how they are displayed if they are larger than needed. For example, a label widget has an `anchor` option that controls where the label's text will be positioned within the widget's boundaries. The bottom left label in the figure above uses the default anchor (`w`, i.e., left side, vertically centered).

If you're having trouble getting things to line up the way you want them to, first make sure you know how large the widget is. As discussed with the `label` widget in the previous chapter, changing the widget's background or border can help.

Handling Resize

If you've tried to resize the example, you'll notice that nothing moves at all, as shown below.



Resizing the window.

Even if you took a peek below and added the extra `sticky` options to our example, you'd still see the same thing. It looks like `sticky` may tell Tk *how* to react if the cell's row or column does resize but doesn't actually say that the row or columns *should* resize if any extra room becomes available. Let's fix that.

Every column and row in the grid has a `weight` option associated with it. This tells `grid` how much the column or row should grow if there is extra room in the master to fill. By default, the weight of each column or row is 0, meaning it won't expand to fill any extra space.

For the user interface to resize, we'll need to specify a positive weight to the columns and rows that we'd like to expand. You must provide weights for at least one column and one row. This is done using the `columnconfigure` and `rowconfigure` methods of `grid`. This weight is relative. If two columns have the same weight, they'll expand at the same rate. In our example, we'll give the three leftmost columns (holding the checkbuttons) weights of 3 and the two rightmost columns weights of 1. For every one pixel the right columns grow, the left columns will grow by three pixels. So as the window grows larger, most of the extra space will go to the left side.

Resizing the window after adding weights.

Both `columnconfigure` and `rowconfigure` also take a `minsize` grid option, which specifies a minimum size you really don't want the column or row to shrink beyond.

Padding

Normally, each column or row will be directly adjacent to the next so that widgets will be right next to each other. This is sometimes what you want (think of a listbox and its scrollbar), but often you want some space between widgets. In Tk, this is called padding, and there are several ways you can choose to add it.

We've already actually seen one way, and that is using a widget's own options to add the extra space around it. Not all widgets have this, but one that does is a frame; this is useful because frames are most often used as the master to grid other widgets. The frame's `padding` option lets you specify a bit of extra padding inside the frame, whether the same amount for each of the four sides or even different for each.

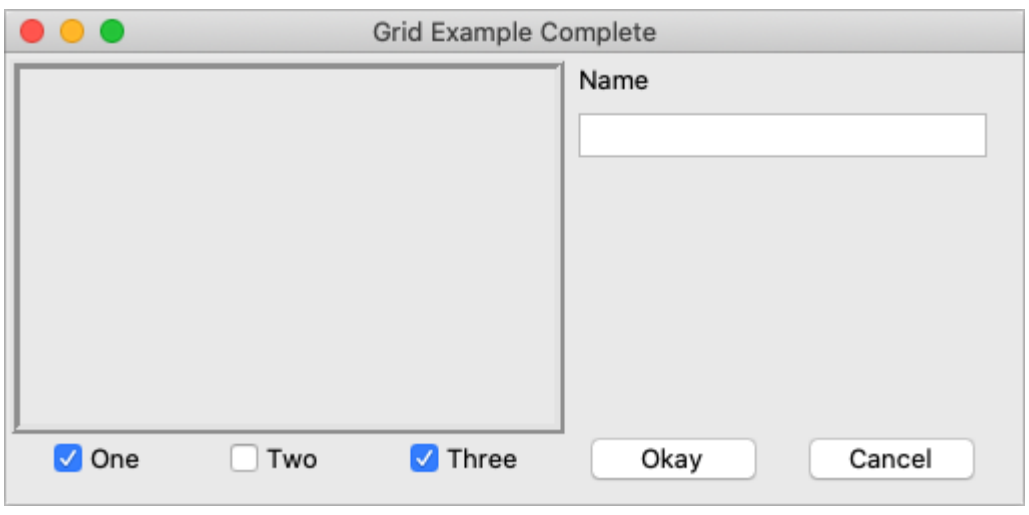
A second way is using the `padx` and `pady` grid options when adding the widget. As you'd expect, `padx` puts a bit of extra space to the left and right, while `pady` adds extra space top and bottom. A single value for the option puts the same padding on both left and right (or top and bottom), while a two-value list lets you put different amounts on left and right (or top and bottom). Note that this extra padding is within the grid cell containing the widget.

If you want to add padding around an entire row or column, the `columnconfigure` and `rowconfigure` methods accept a `pad` option, which will do this for you.

Let's add the extra sticky, resizing, and padding behavior to our example (additions in bold).

```
from tkinter import *
from tkinter import ttk

root = Tk()

content = ttk.Frame(root, padding=(3,3,12,12))
frame = ttk.Frame(content, borderwidth=5, relief="ridge", width=200, height=100)
namelbl = ttk.Label(content, text="Name")
name = ttk.Entry(content)

onevar = BooleanVar()
twovar = BooleanVar()
threevar = BooleanVar()
onevar.set(True)
twovar.set(False)
threevar.set(True)

one = ttk.Checkbutton(content, text="One", variable=onevar, onvalue=True)
two = ttk.Checkbutton(content, text="Two", variable=twovar, onvalue=True)
three = ttk.Checkbutton(content, text="Three", variable=threevar, onvalue=True)
ok = ttk.Button(content, text="Okay")
cancel = ttk.Button(content, text="Cancel")

content.grid(column=0, row=0, sticky=(N, S, E, W))
frame.grid(column=0, row=0, columnspan=3, rowspan=2, sticky=(N, S, E, W))
namelbl.grid(column=3, row=0, columnspan=2, sticky=(N, W), padx=5)
name.grid(column=3, row=1, columnspan=2, sticky=(N,E,W), pady=5, padx=5)
one.grid(column=0, row=3)
two.grid(column=1, row=3)
three.grid(column=2, row=3)
ok.grid(column=3, row=3)
cancel.grid(column=4, row=3)

root.columnconfigure(0, weight=1)
root.rowconfigure(0, weight=1)
content.columnconfigure(0, weight=3)
content.columnconfigure(1, weight=3)
content.columnconfigure(2, weight=3)
content.columnconfigure(3, weight=1)
content.columnconfigure(4, weight=1)
content.rowconfigure(1, weight=1)

root.mainloop()
```

This looks more promising. Play around with the example to get a feel for the resize behavior.



Grid example, handling in-cell layout and resize.

Additional Grid Features

If you look at the reference documentation for `grid`, you'll see many other things you can do with grid. Here are a few of the more useful ones.

Querying and Changing Grid Options

Like widgets themselves, it's easy to introspect the various grid options or change them. Setting options when you first grid the widget is certainly convenient, but you can change them anytime you'd like.

The `slaves` method will tell you all the widgets that have been gridded inside a master, or optionally those within just a certain column or row. The `info` method will return a list of all the grid options for a widget and their values. Finally, the `configure` method lets you change one or more grid options on a widget.

These are illustrated in this interactive session:

```
>>> content.grid_slaves()
[<tkinter.ttk.Button object .!frame.!button2>, <tkinter.ttk.Button object .!frame.!button>,
<tkinter.ttk.Checkbutton object .!frame.!checkbutton3>, <tkinter.ttk.Checkbutton object .!frame.!checkbutton2>,
<tkinter.ttk.Checkbutton object .!frame.!checkbutton>, <tkinter.ttk.Entry object .!frame.!entry>,
<tkinter.ttk.Label object .!frame.!label>, <tkinter.ttk.Frame object .!frame.!frame>]
>>> for w in content.grid_slaves(): print(w)
...
.!frame.!button2
.!frame.!button
.!frame.!checkbutton3
.!frame.!checkbutton2
.!frame.!checkbutton
.!frame.!entry
.!frame.!label
.!frame.!frame
>>> for w in content.grid_slaves(row=3): print(w)
...
.!frame.!button2
.!frame.!button
.!frame.!checkbutton3
.!frame.!checkbutton2
.!frame.!checkbutton
>>> for w in content.grid_slaves(column=0): print(w)
...
.!frame.!checkbutton
.!frame.!frame
>>> namelbl.grid_info()
{'in': <tkinter.ttk.Frame object .!frame>, 'column': 3, 'row': 0, 'columnspan': 2, 'rowspan': 1,
'ipadx': 0, 'ipady': 0, 'padx': 5, 'pady': 0, 'sticky': 'nw'}
>>> namelbl.grid_configure(sticky=(E,W))
>>> namelbl.grid_info()
{'in': <tkinter.ttk.Frame object .!frame>, 'column': 3, 'row': 0, 'columnspan': 2, 'rowspan': 1,
'ipadx': 0, 'ipady': 0, 'padx': 5, 'pady': 0, 'sticky': 'ew'}
```

Internal Padding

You saw how the `padx` and `pady` grid options added extra space around the outside of a widget. There's also a less used type of padding called "internal padding" controlled by the grid options `ipadx` and `ipady`.

The difference can be subtle. Let's say you have a frame that's 20x20, and specify normal (external) padding of 5 pixels on each side. The frame will request a 20x20 rectangle (its natural size) from the geometry manager. Normally, that's what it will be granted, so it'll get a 20x20 rectangle for the frame, surrounded by a 5-pixel border.

With internal padding, the geometry manager will effectively add the extra padding to the widget when figuring out its natural size, as if the widget has requested a 30x30 rectangle. If the frame is centered or attached to a single side or corner (using `sticky`), we'll end up with a 20x20 frame with extra space around it. If, however, the frame is set to stretch (i.e., a `sticky` value of `we`, `ns`, or `nwes`), it will fill the extra space, resulting in a 30x30 frame with no border.

Forget and Remove

The `forget` method of grid removes slaves from the grid they're currently part of. It takes a list of one or more slave widgets as arguments. This does not destroy the widget altogether but takes it off the screen as if it had not been gridded in the first place. You can grid it again later, though any grid options you'd originally assigned will have been lost.

The `remove` method of grid works the same, except that the grid options will be remembered if you `grid` it again later.

Nested Layouts

As your user interface gets more complicated, the grid that organizes all your widgets can get increasingly complicated. This can make changing and maintaining your program very difficult.

Luckily, you don't have to manage your entire user interface with a single grid. If you have one area of your user interface that is fairly independent of others, create a new frame and grid the widgets in the area within that frame. For example, if you were building a graphics editor with multiple palettes, toolbars, etc., each one of those areas might be a candidate for putting in its own frame.

In theory, these frames, each with its own grid, can be nested arbitrarily deep, though, in practice, this usually doesn't go beyond a few levels. This can be a big help in modularizing your program. If, for example, you have a palette of drawing tools, you can create the whole thing in a separate function or class. It would be responsible for creating all the component widgets, gridding them together, setting up event bindings, etc. The details of how things work inside that palette can be contained in that one piece of code. Your main program only needs to know about the single frame widget containing your palette.

Our examples have shown just a hint of this: a content frame was gridded into the main window, and then all the other widgets gridded into the content frame.

As your own programs grow, you'll likely run into situations where changing the layout of one part of your interface requires code changes to the layout of another part. That may be a clue to reconsider how you're using `grid` and if splitting out components into separate frames would help.

More Widgets

This chapter introduces several more widgets: listbox, scrollbar, text, scale, spinbox, and progressbar. Some of these are starting to be a bit more powerful than the basic ones we looked at before. Here we'll also see a few instances of using the classic Tk widgets in cases where there isn't (or there isn't a need for) a themed counterpart.

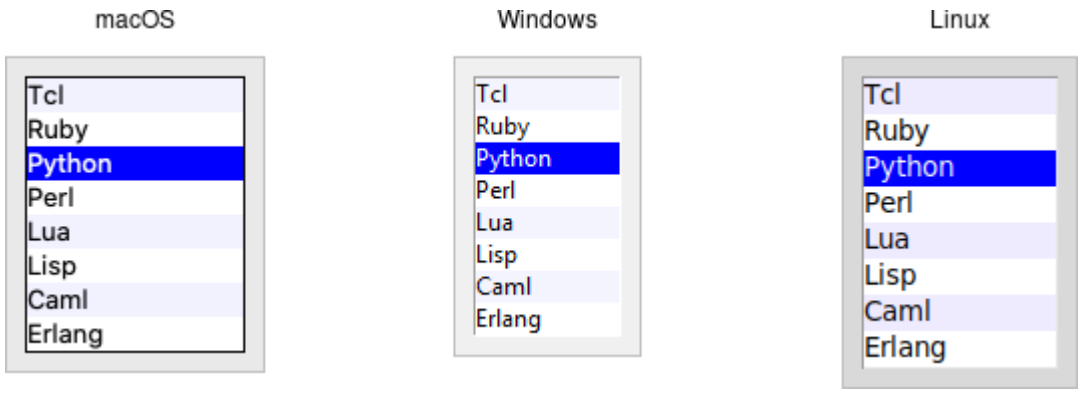
Listbox

- Widget Roundup
- Reference Manual

A **listbox** widget displays a list of single-line text items, usually lengthy, and allows users to browse through the list, selecting one or more.

Listboxes are part of the classic Tk widgets; there is not presently a listbox in the themed Tk widget set.

> *Tk's treeview widget (which is themed) can also be used as a listbox (a one-level deep tree), allowing you to use icons and styles with the list. It's also likely that a multi-column (table) list widget will make it into Tk at some point, whether based on treeview or one of the available extensions.*



Listbox widgets.

Listboxes are created using the `Listbox` class. A height configuration option can specify the number of lines the listbox will display at a time without scrolling:

```
l = Listbox(parent, height=10)
```

Populating the Listbox Items

There's an easy way and a hard way to populate and manage all the items in the listbox.

Here's the easy way. Each listbox has a `listvariable` configuration option, which allows you to link a variable (which must hold a list) to the listbox. Each element of this list is a string representing one item in the listbox. To add, remove, or rearrange items in the listbox, you can simply modify this variable as you would any other list. Similarly, to find out, e.g., which item is on the third line of the listbox, just look at the third element of the list variable.

It's actually not quite *that* easy. Tkinter doesn't allow you to link regular Python lists to a `listbox`. As we saw with widgets like `entry`, we need to use a `StringVar` as an intermediary. It provides a mapping between Python's lists and a string representation that the underlying Tk widgets can use. It also means that anytime we change the list, we need to update the `StringVar`.

```
choices = ["apple", "orange", "banana"]
choicesvar = StringVar(value=choices)
l = Listbox(parent, listvariable=choicesvar)
...
choices.append("peach")
choicesvar.set(choices)
```

The older, harder way is to use a set of methods that are part of the listbox widget itself. They operate on the (internal) list of items maintained by the widget:

- The `insert` *`idx item ?item...?`* method is used to add one or more items to the list; *`idx`* is a 0-based index indicating the position of the item before which the item(s) should be added; specify `end` to put the new items at the end of the list.
- Use the `delete` *`first ?last?`* method to delete one or more items from the list; *`first`* and *`last`* are indices as per the `insert` method.
- Use the `get` *`first ?last?`* method to return the contents of a single item at the given position, or a list of the items between *`first`* and *`last`*.
- The `size` method returns the number of items in the list.

The reason there is a hard way at all is because the `listvariable` option was only introduced in Tk 8.3. Before that, you were stuck with the hard way. Because using the list variable lets you use all the standard list operations, it provides a much simpler API. It's certainly an upgrade worth considering if you have listboxes doing things the older way.

Selecting Items

You can choose whether users can select only a single item at a time from the `listbox` or if multiple items can simultaneously be selected. This is controlled by the `selectmode` option: the default is only being able to select a single item (`browse`), while a `selectmode` of `extended` allows users to select multiple items.

*The names `browse` and `extended`, again for backward compatibility reasons, are truly awful. This is made worse by the fact that there are two other modes, `single` and `multiple`, which you **should not use** (they use an old interaction style that is inconsistent with modern user interface and platform conventions).*

To find out which item or items in the listbox are currently selected, use the `curselection` method. It returns a list of indices of all items currently selected; this may be an empty list. For lists with a `selectmode` of `browse`, it will never be longer than one item. You can also use the `selection_includes` *`index`* method to check if the item with the given index is currently selected.

```
if lbox.selection_includes(2): ...
```

To programmatically change the selection, you can use the `selection_clear` *`first ?last?`* method to deselect either a single item or any within the range of indices specified. To select an item or all items in a range, use the `selection_set` *`first ?last?`* method. Both of these will not touch the selection of any items outside the range specified.

If you change the selection, you should also ensure that the newly selected item is visible (i.e., it is not scrolled out of view). To do this, use the `see` *`index`* method.

```
lbox.selection_set(idx)
lbox.see(idx)
```

When a user changes the selection, a `<<ListboxSelect>>` virtual event is generated. You can bind to this to take any action you need. Depending on your application, you may also want to bind to a double-click `<Double-1>` event and use it to invoke an action with the currently selected item.

```
lbox.bind("<<ListboxSelect>>", lambda e: updateDetails(lbox.curselection()))
lbox.bind("<Double-1>", lambda e: invokeAction(lbox.curselection()))
```

Stylizing the List

Like most of the "classic" Tk widgets, you have immense flexibility in modifying the appearance of a listbox. As described in the reference manual, you can modify the font the listbox items are displayed in, the foreground (text) and background colors for items in their normal state, when selected, when the widget is disabled, etc. There is also an `itemconfigure` method that allows you to change the foreground and background colors of individual items.

As is often the case, restraint is useful. Generally, the default values will be entirely suitable and a good match for platform conventions. In the example we'll get to momentarily, we'll show how restrained use of these options can be put to good effect, in this case displaying alternate lines of the listbox in slightly different colors.

Keeping Extra Item Data

The `listvariable` (or the internal list, if you're managing things the old way) holds the strings that will be shown in the listbox. It's often the case, though, that each string you're displaying is associated with some other data item. This might be an internal object meaningful to your program but not meant to be displayed to users. In other words, what you're really interested in is not so much the string displayed in the listbox but the associated data item. For example, a listbox may display a list of names to users, but your program is really interested in the underlying user object (or id number) for each one, not the particular name.

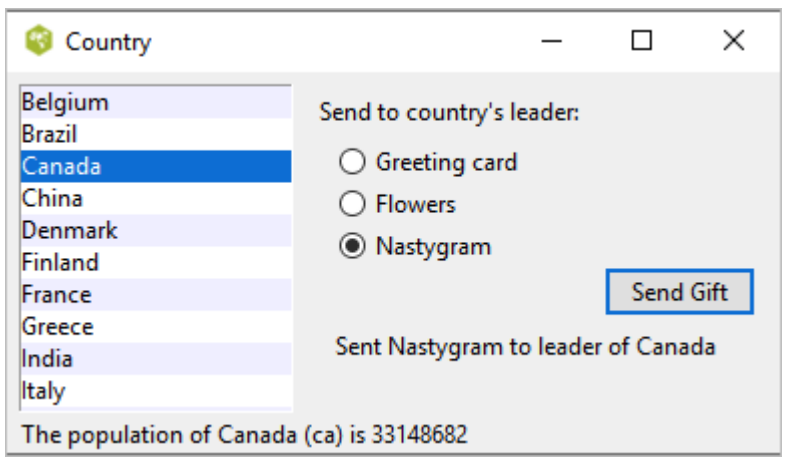
How can we associate this underlying value with the name that is displayed? Unfortunately, the listbox widget itself doesn't offer any facilities, so it's something we'll have to manage separately. There are a couple of obvious approaches. First, if the displayed strings are guaranteed unique, you could use a hash table to map each name to its associated underlying object. This wouldn't work well for peoples' names, where duplicates are possible, but could work for countries, which are unique.

A second approach is to keep a second list parallel to the list of strings displayed in the listbox. This second list will hold the underlying object associated with each item that is displayed. So the first item in the displayed strings list corresponds to the first item in the underlying objects list, the second to the second, etc. Any changes that you make in one list (insert, delete, reorder), you must make in the other. You can then easily map from the displayed list item to the underlying object based on their position in the list.

Example

Here is a silly example showing several of these listbox techniques. We'll have a list of countries displayed. We'll be able to select only a single country at a time. As we do so, a status bar will display the population of the country. You can press a button to send one of several gifts to the selected country's head of state (well, not really, but use your imagination). Sending a gift can also be triggered by double-clicking the list or hitting the Return key.

Behind the scenes, we maintain two lists in parallel. The first is a list of two-letter country codes. The other is the corresponding name for each country that we will display in the listbox. We also have a simple hash table that contains the population of each country, indexed by the two-letter country code.



Country selector listbox example.

```
from tkinter import *
from tkinter import ttk
root = Tk()

# Initialize our country "databases":
#  - the list of country codes (a subset anyway)
#  - parallel list of country names, same order as the country codes
#  - a hash table mapping country code to population
countrycodes = ('ar', 'au', 'be', 'br', 'ca', 'cn', 'dk', 'fi', 'fr', 'gr', 'in', 'it', 'jp', 'mx', 'nl', 'no', 'es', 'se', 'ch')
countrynames = ('Argentina', 'Australia', 'Belgium', 'Brazil', 'Canada', 'China', 'Denmark', \
        'Finland', 'France', 'Greece', 'India', 'Italy', 'Japan', 'Mexico', 'Netherlands', 'Norway', 'Spain', \
        'Sweden', 'Switzerland')
cnames = StringVar(value=countrynames)
populations = {'ar':41000000, 'au':21179211, 'be':10584534, 'br':185971537, \
        'ca':33148682, 'cn':1323128240, 'dk':5457415, 'fi':5302000, 'fr':64102140, 'gr':11147000, \
        'in':1131043000, 'it':59206382, 'jp':127718000, 'mx':106535000, 'nl':16402414, \
        'no':4738085, 'es':45116894, 'se':9174082, 'ch':7508700}

# Names of the gifts we can send
gifts = { 'card':'Greeting card', 'flowers':'Flowers', 'nastygram':'Nastygram'}

# State variables
gift = StringVar()
sentmsg = StringVar()
statusmsg = StringVar()

# Called when the selection in the listbox changes; figure out
# which country is currently selected, and then lookup its country
# code, and from that, its population.  Update the status message
# with the new population.  As well, clear the message about the
# gift being sent, so it doesn't stick around after we start doing
# other things.
def showPopulation(*args):
    idxs = lbox.curselection()
    if len(idxs)==1:
        idx = int(idxs[0])
        code = countrycodes[idx]
        name = countrynames[idx]
        popn = populations[code]
        statusmsg.set("The population of %s (%s) is %d" % (name, code, popn))
    sentmsg.set('')

# Called when the user double clicks an item in the listbox, presses
# the "Send Gift" button, or presses the Return key.  In case the selected
# item is scrolled out of view, make sure it is visible.
#
# Figure out which country is selected, which gift is selected with the
# radiobuttons, "send the gift", and provide feedback that it was sent.
def sendGift(*args):
    idxs = lbox.curselection()
    if len(idxs)==1:
        idx = int(idxs[0])
        lbox.see(idx)
        name = countrynames[idx]
        # Gift sending left as an exercise to the reader
        sentmsg.set("Sent %s to leader of %s" % (gifts[gift.get()], name))

# Create and grid the outer content frame
c = ttk.Frame(root, padding=(5, 5, 12, 0))
c.grid(column=0, row=0, sticky=(N,W,E,S))
root.grid_columnconfigure(0, weight=1)
root.grid_rowconfigure(0,weight=1)

# Create the different widgets; note the variables that many
# of them are bound to, as well as the button callback.
# We're using the StringVar() 'cnames', constructed from 'countrynames'
lbox = Listbox(c, listvariable=cnames, height=5)
lbl = ttk.Label(c, text="Send to country's leader:")
g1 = ttk.Radiobutton(c, text=gifts['card'], variable=gift, value='card')
g2 = ttk.Radiobutton(c, text=gifts['flowers'], variable=gift, value='flowers')
g3 = ttk.Radiobutton(c, text=gifts['nastygram'], variable=gift, value='nastygram')
send = ttk.Button(c, text='Send Gift', command=sendGift, default='active')
sentlbl = ttk.Label(c, textvariable=sentmsg, anchor='center')
status = ttk.Label(c, textvariable=statusmsg, anchor=W)

# Grid all the widgets
lbox.grid(column=0, row=0, rowspan=6, sticky=(N,S,E,W))
lbl.grid(column=1, row=0, padx=10, pady=5)
```

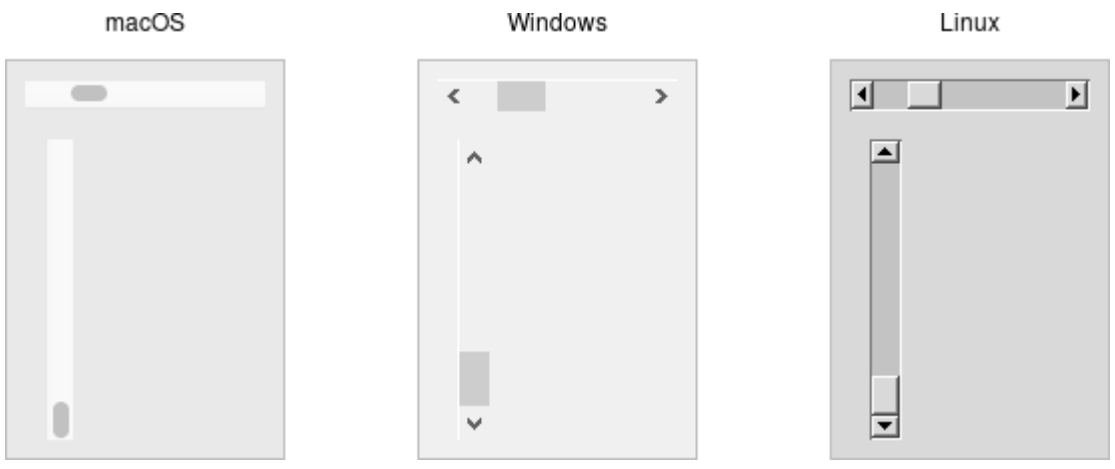
```
g1.grid(column=1, row=1, sticky=W, padx=20)
g2.grid(column=1, row=2, sticky=W, padx=20)
g3.grid(column=1, row=3, sticky=W, padx=20)
send.grid(column=2, row=4, sticky=E)
sentlbl.grid(column=1, row=5, columnspan=2, sticky=N, pady=5, padx=5)
status.grid(column=0, row=6, columnspan=2, sticky=(W,E))
c.grid_columnconfigure(0, weight=1)
c.grid_rowconfigure(5, weight=1)

# Set event bindings for when the selection in the listbox changes,
# when the user double clicks the list, and when they hit the Return key
lbox.bind('<<ListboxSelect>>', showPopulation)
lbox.bind('<Double-1>', sendGift)
root.bind('<Return>', sendGift)

# Colorize alternating lines of the listbox
for i in range(0,len(countrynames),2):
    lbox.itemconfigure(i, background='#f0f0ff')

# Set the starting state of the interface, including selecting the
# default gift to send, and clearing the messages.  Select the first
# country in the list; because the <<ListboxSelect>> event is only
# fired when users makes a change, we explicitly call showPopulation.
gift.set('card')
sentmsg.set('')
statusmsg.set('')
lbox.selection_set(0)
showPopulation()

root.mainloop()
```

One obvious thing missing from this example was that while the list of countries could be quite long, only part of it fits on the screen at once. To show countries further down in the list, you had to either drag with your mouse or use the down arrow key. A scrollbar would have been nice. Let's fix that.

Scrollbar

- Widget Roundup
- Reference Manual

A **scrollbar** widget helps users see all parts of another widget, whose content is typically much larger than what can be shown in the available screen space.



Scrollbar widgets.

Scrollbars are created using the **`ttk.Scrollbar`** class:

```
s = ttk.Scrollbar( parent, orient=VERTICAL, command=listbox.yview)
listbox.configure(yscrollcommand=s.set)
```

Unlike in some user interface toolkits, Tk scrollbars are not a part of another widget (e.g., a listbox) but are a separate widget altogether. Instead, scrollbars communicate with the *scrolled widget* by calling methods on the scrolled widget; as it turns out, the scrolled widget also needs to call methods on the scrollbar.

> *If you're using a recent Linux distribution, you've probably noticed that the scrollbars you see in many applications have changed to look more like what you'd see on macOS. This newer look isn't supported on Linux by any of the default themes included with Tk. However, some third-party themes do support it.*

The `orient` configuration option determines whether the scrollbar will scroll the scrolled widget in the `horizontal` or `vertical` dimension. You then need to use the `command` configuration option to specify how to communicate with the scrolled widget. This is the method to call on the scrolled widget when the scrollbar moves.

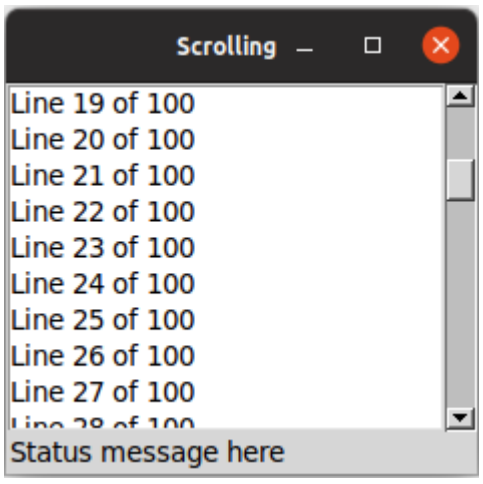
Every widget that can be scrolled vertically includes a method named `yview`, while those that can be scrolled horizontally have a method named `xview`). As long as this method is present, the scrollbar doesn't need to know anything else about the scrolled widget. When the scrollbar is manipulated, it appends several parameters to the method call, indicating how it was scrolled, to what position, etc.

The scrolled widget also needs to communicate back to the scrollbar, telling it what percentage of the entire content area is now visible. Besides the `yview` and/or `xview` methods, every scrollable widget also has a `yscrollcommand` and/or `xscrollcommand` configuration option. This is used to specify a method call, which must be the scrollbar's `set` method. Again, additional parameters will be automatically tacked onto the method call.

If you want to move the scrollbar to a particular position from within your program, you can call the `set first last` method yourself. Pass it two floating-point values (between 0 and 1) indicating the start and end percentage of the content area that is visible.

Example

Listboxes are one of several types of widgets that are scrollable. Here, we'll build a very simple user interface consisting of a vertically scrollable listbox that takes up the entire window, with just a status line at the bottom.



Scrolling a listbox.

```
from tkinter import *
from tkinter import ttk

root = Tk()
l = Listbox(root, height=5)
l.grid(column=0, row=0, sticky=(N,W,E,S))
s = ttk.Scrollbar(root, orient=VERTICAL, command=l.yview)
s.grid(column=1, row=0, sticky=(N,S))
l['yscrollcommand'] = s.set
ttk.Label(root, text="Status message here", anchor=(W)).grid(column=0, columnspan=2, row=1, sticky=(W,E))
root.grid_columnconfigure(0, weight=1)
root.grid_rowconfigure(0, weight=1)
for i in range(1,101):
    l.insert('end', 'Line %d of 100' % i)
root.mainloop()
```

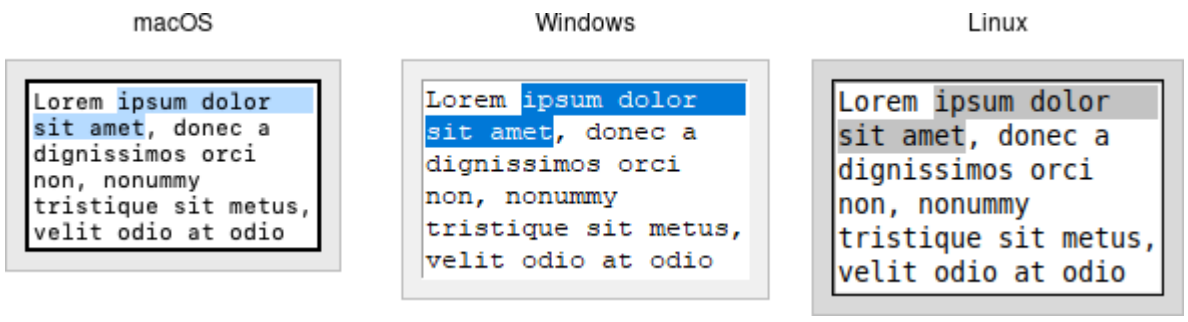
If you've seen an earlier version of this tutorial, you might recall that at this point, we introduced a `sizegrip` widget. It placed a small handle at the bottom right of the window, allowing users to resize the window by dragging the handle. This was commonly seen on some platforms, including older versions of macOS. Some older versions of Tk even automatically added this handle to the window for you.

Platform conventions tend to evolve faster than long-lived open source GUI toolkits. Mac OS X 10.7 did away with the size grip in the corner in favor of allowing resizing from any window edge, finally catching up with the rest of the world. Unless there's a pressing need to be visually compatible with 10+ year old operating systems, if you have a `sizegrip` in your application, it's probably best to remove it.

Text

- Widget Roundup
- Reference Manual

A **text** widget provides users with an area so that they can enter multiple lines of text. Text widgets are part of the classic Tk widgets, not the themed Tk widgets.



Text widgets.

> *Tk's text widget is, along with the canvas widget, one of two uber-powerful widgets that provide amazingly deep but easily programmed features. Text widgets have formed the basis for full word processors, outliners, web browsers, and more. We'll get into some of the advanced stuff in a later chapter. Here, we'll show you how to use the text widget to capture fairly simple, multi-line text input.*

Text widgets are created using the `Text` class:

```
t = Text(parent, width=40, height=10)
```

The `width` and `height` options specify the requested screen size of the text widget, in characters and rows, respectively. The contents of the text can be arbitrarily large. You can use the `wrap` configuration option to control how line wrapping is handled: values are `none` (no wrapping, text may horizontally scroll), `char` (wrap at any character), and `word` (wrapping will only occur at word boundaries).

A text widget can be disabled so that no editing can occur. Because text is not a themed widget, the usual `state` and `instate` methods are not available. Instead, use the configuration option `state`, setting it to either `disabled` or `normal`.

```
txt['state'] = 'disabled'
```

Scrolling works the same way as in listboxes. The `xscrollcommand` and `yscrollcommand` configuration options attach the text widget to horizontal and/or vertical scrollbars, and the `xview` and `yview` methods are called from scrollbars. To ensure that a given line is visible (i.e., not scrolled out of view), you can use the `see` *`index`* method, where *`index`* is in the form *`Linenum.charnum`*, e.g., `5.0` for the first (0-based) character of line 5 (1-based).

Contents

Text widgets do not have a linked variable associated with them like, for example, entry widgets do. To retrieve the contents of the entire text widget, call the method `get 1.0 end`; the `1.0` is an index into the text and means the first character of the first line, and `end` is a shortcut for the index of the last character in the last line. Other indices could be provided to retrieve smaller ranges of text if needed.

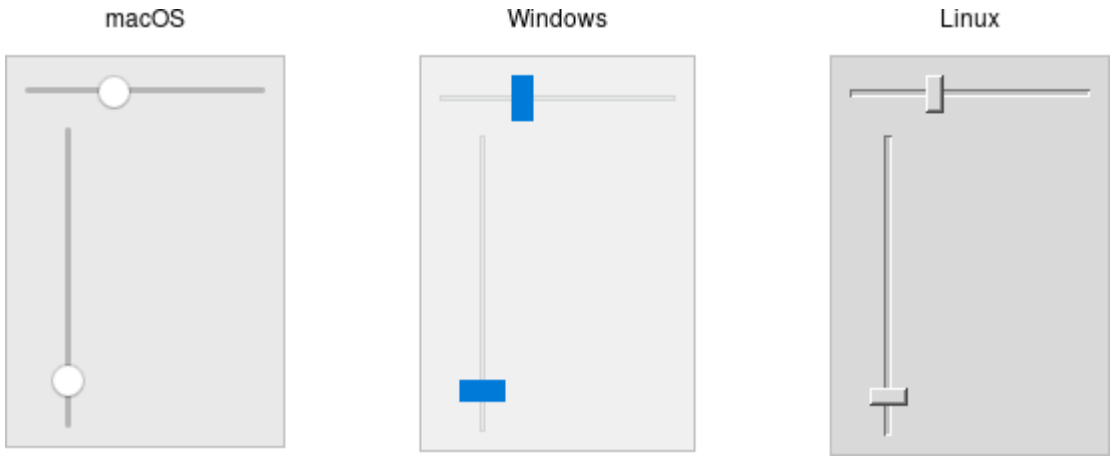
Text can be added to the widget using the `insert` *`index string`* method; again *`index`* is in the form *`line.char`* and marks the character before which text is inserted; use `end` to add text to the end of the widget. You can delete a range of text using the `delete` *`start end`* method, where both *`start`* and *`end`* are text indices as already described.

We'll get into the text widget's many additional advanced features in a later chapter.

Scale

- Widget Roundup
- Reference Manual

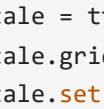
A **scale** widget allows users to choose a numeric value through direct manipulation.



Scale widgets.

Scale widgets are created using the **`ttk.Scale`** class:

```
s = ttk.Scale(parent, orient=HORIZONTAL, length=200, from_=1.0, to=100.0)
```



Because 'from' is a reserved keyword in Python, we need to add a trailing underscore when using it as a configuration option.

The `orient` option may be either `horizontal` or `vertical`. The `length` option, which represents the longer axis of either horizontal or vertical scales, is specified in screen units (e.g., pixels). You should also define the range of the number that the scale allows users to choose; to do this, set a floating-point number for each of the `from` and `to` configuration options.

There are several different ways you can set the current value of the scale (which must be a floating-point value between the `from` and `to` values). You can set (or read, to get the current value) the scale's `value` configuration option. You can link the scale to a variable using the `variable` option. Or, you can call the scale's `set value` method to change the value or the `get` method to read the current value.

A `command` configuration option lets you specify a script to call whenever the scale is changed. Tk will append the current value of the scale as a parameter each time it calls this script (we saw a similar thing with extra parameters being added to scrollbar callbacks).

```
# label tied to the same variable as the scale, so auto-updates
num = StringVar()
ttk.Label(root, textvariable=num).grid(column=0, row=0, sticky='we')

# label that we'll manually update via the scale's command callback
manual = ttk.Label(root)
manual.grid(column=0, row=1, sticky='we')

def update_lbl(val):
   manual['text'] = "Scale at " + val

scale = ttk.Scale(root, orient='horizontal', length=200, from_=1.0, to=100.0, variable=num, command=update_lbl)
scale.grid(column=0, row=2, sticky='we')
scale.set(20)
```

As with other themed widgets, you can use the `state disabled`, `state !disabled`, and `instate disabled` methods to prevent users from modifying the scale.

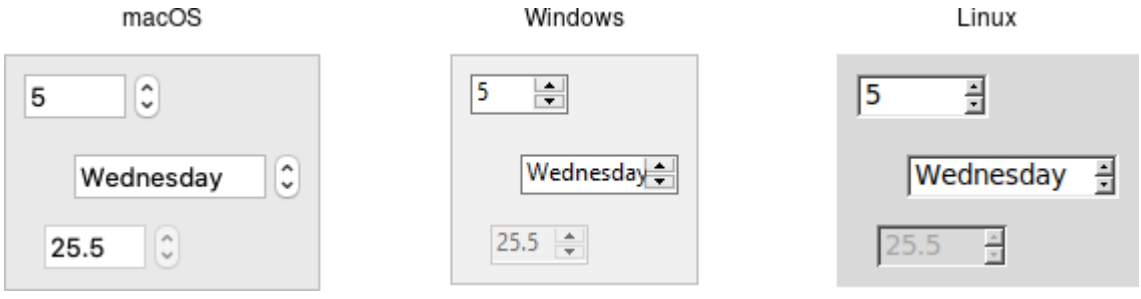
As the scale widget does not display the actual values, you may want to add those separately, e.g., using label widgets.

Spinbox

- Widget Roundup
- Reference Manual

A **spinbox** widget allows users to choose numbers (or, in fact, items from an arbitrary list). It does this by combining an entry-like widget showing the current value with a pair of small up/down arrows, which can be used to step through the range of possible choices.

The themed spinbox was added in Tk 8.5.9 (released in 2010). If you must run an older version, there is a spinbox in the classic Tk widgets, though with a slightly different API.



Spinbox widgets.

Spinbox widgets are created using the **`ttk.Spinbox`** class:

```
spinval = StringVar()
s = ttk.Spinbox(parent, from_=1.0, to=100.0, textvariable=spinval)
```

Like scale widgets, spinboxes let users choose a number between a certain range (specified using the `from` and `to` configuration options), though through a very different user interface. You can also specify an `increment`, which controls how much the value changes every time you click the up or down button.

Like a listbox or combobox, spinboxes can also be used to let users choose an item from an arbitrary list of strings; these can be specified using the `values` configuration option. This works in the same way it does for comboboxes; specifying a list of values will override to `from` and `to` settings.

In their default state, spinboxes allow users to select values either via the up and down buttons or by typing them directly into the entry area that displays the current value. If you'd like to disable the latter feature so that only the up and down buttons are available, you can set the `readonly` state flag.

```
s.state(['readonly'])
```

Like other themed widgets, you can also disable spinboxes via the `disabled` state flag or check the state via the `instate` method. Spinboxes also support validation in the same manner as entry widgets, using the `validate` and `validatecommand` configuration options.

> *You might be puzzled about when to choose a scale, listbox, combobox, entry, or a spinbox. Often, several of these can be used for the same types of data. The answer really depends on what you want users to select, platform user interface conventions, and the role the value plays in your user interface.*
>
> *For example, both a combobox and a spinbox take up fairly small amounts of space compared with a listbox. They might make sense for a more peripheral setting. A more primary and prominent choice in a user interface may warrant the extra space a listbox occupies. Spinboxes don't make much sense when items don't have a natural and obvious ordering to them. Be careful about putting too many items in both comboboxes and spinboxes. This can make it more time-consuming to select an item.*

There is a boolean `wrap` option that determines whether the value should wrap around when it goes beyond the starting or ending values. You can also specify a `width` for the entry holding the current value of the spinbox.

Again there are choices as to how to set or get the current value in the spinbox. Normally, you would specify a linked variable with the `textvariable` configuration option. As usual, any changes to the variable are reflected in the spinbox, while any changes in the spinbox are reflected in the linked variable. As well, the `set` *`value`* and `get` methods allow you to set or get the value directly.

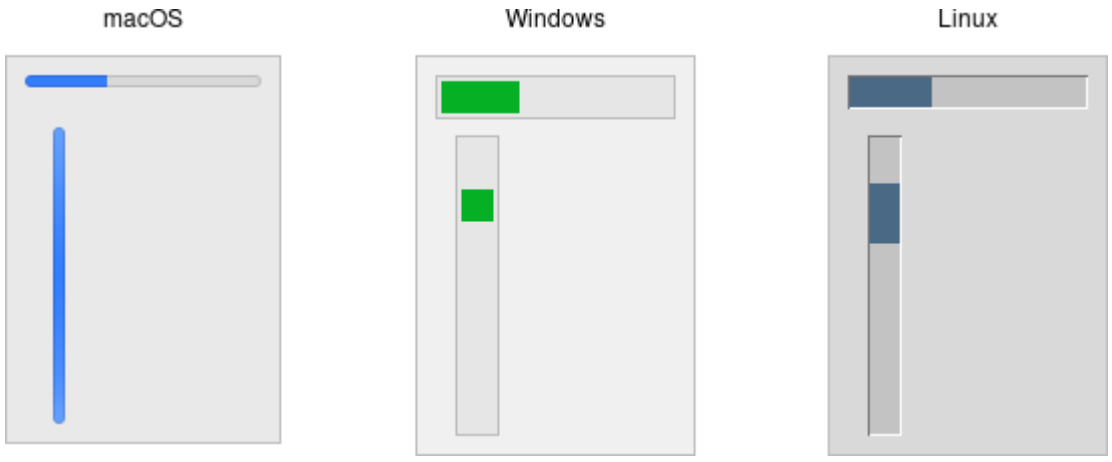
Spinboxes generate virtual events when users press up (`<<Increment>>`) or down (`<<Decrement>>`). A `command` configuration option allows you to provide a callback that is invoked on any changes.

Progressbar

- Widget Roundup
- Reference Manual

A **progressbar** widget provides feedback to users about the progress of a lengthy operation.

In situations where you can estimate how long the operation will take to complete, you can display what fraction has already been completed. Otherwise, you can indicate the operation is continuing, but without suggesting how much longer it will take.



Progressbar widgets.

Progressbar widgets are created using the **`ttk.Progressbar`** class:

```
p = ttk.Progressbar(parent, orient=HORIZONTAL, length=200, mode='determinate')
```

As with scale widgets, they should be given an orientation (`horizontal` or `vertical`) with the `orient` configuration option and can be given an optional `length`. The `mode` configuration option can be set to either `determinate`, where the progressbar will indicate relative progress towards completion, or `indeterminate`, where it shows that the operation is still continuing but without showing relative progress.

Determinate Progress

To use determinate mode, estimate the total number of "steps" the operation will take to complete. This could be an amount of time but doesn't need to be. Provide this to the progressbar using the `maximum` configuration option. It should be a floating-point number and defaults to `100.0` (i.e., each step is 1%).

As you proceed through the operation, tell the progressbar how far along you are with the `value` configuration option. So this would start at 0 and then count upwards to the maximum value you have set.

> *There are two slight variations on this. First, you can just store the current value for the progressbar in a variable linked to it by the progressbar's `variable` configuration option; that way, when you change the variable, the progressbar will update. The other alternative is to call the progressbar's `step` `?amount?` method. This increments the value by the given `amount` (defaults to 1.0).*

Indeterminate Progress

Use indeterminate mode when you can't easily estimate how far along in a long-running task you actually are. However, you still want to provide feedback that the operation is continuing (and that your program hasn't crashed). At the start of the operation, call the progressbar's `start` method. At the end of the operation, call its `stop` method. The progressbar will take care of the rest.

Unfortunately, "the progressbar will take care of the rest" isn't quite so simple. In fact, if you `start` the progressbar, call a function that takes several minutes to complete, and then `stop` the progressbar, your program will appear frozen the whole time, with the progressbar not updating. In fact, it will not likely appear onscreen at all. Yikes!

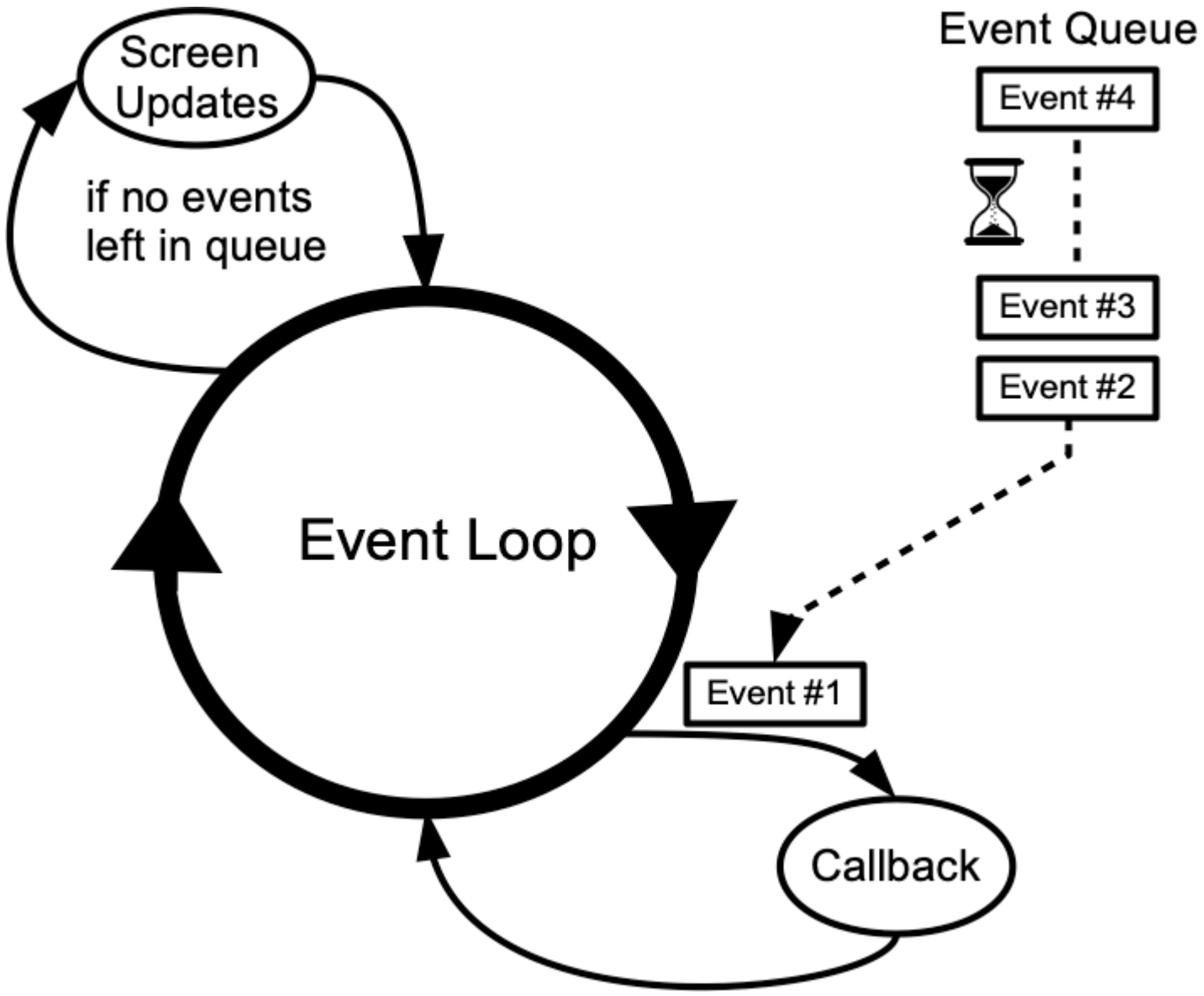
To learn why that is and how to address it, the next chapter takes a deeper dive into Tk's event loop.

Event Loop

At the end of the last chapter, we explained how to use a progressbar to provide feedback to users about long-running operations. The progressbar itself was simple: call its `start` method, perform your operation, and then call its `stop` method. Unfortunately, you learned that if you tried this, your application would most likely appear completely frozen.

To understand why, we need to revisit our discussion of event handling way back in the Tk Concepts chapter. As we've seen, after we construct an application's initial user interface, it enters the Tk event loop. The event loop continually processes events, pulled from the system event queue, usually dozens of times a second. It watches for mouse or keyboard events, invoking command callbacks and event bindings as needed.

Less obviously, all screen updates are processed only in the event loop. For example, you may change the text of a label widget. However, that change doesn't appear onscreen immediately. Instead, the widget notifies Tk that it needs to be redrawn. Later on, in between processing other events, Tk's event loop will ask the widget to redraw itself. *All drawing occurs only in the event loop*. The change *appears* to happen immediately because the time between changing the widget and the actual redraw in the event loop is so short.

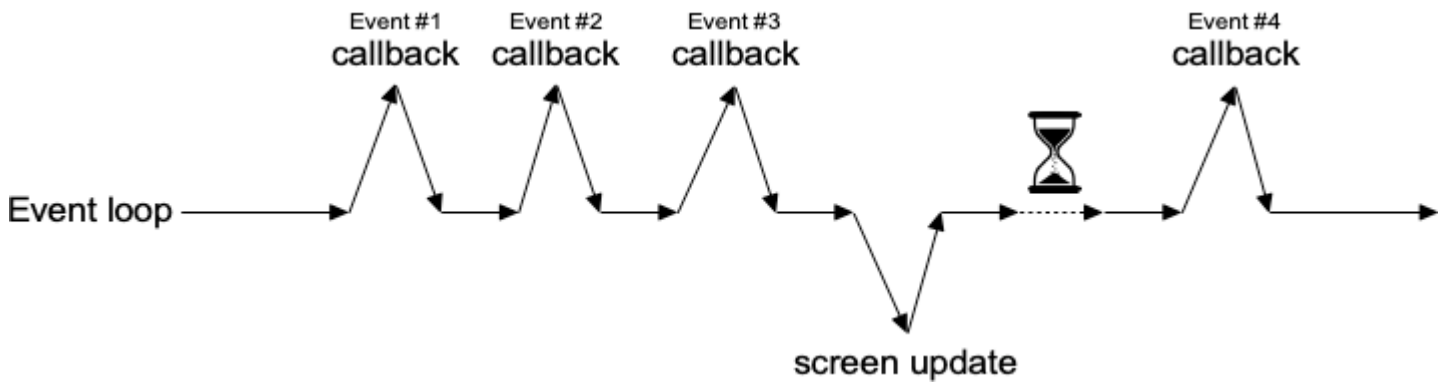


Event loop showing application callbacks and screen updates.

Blocking the Event Loop

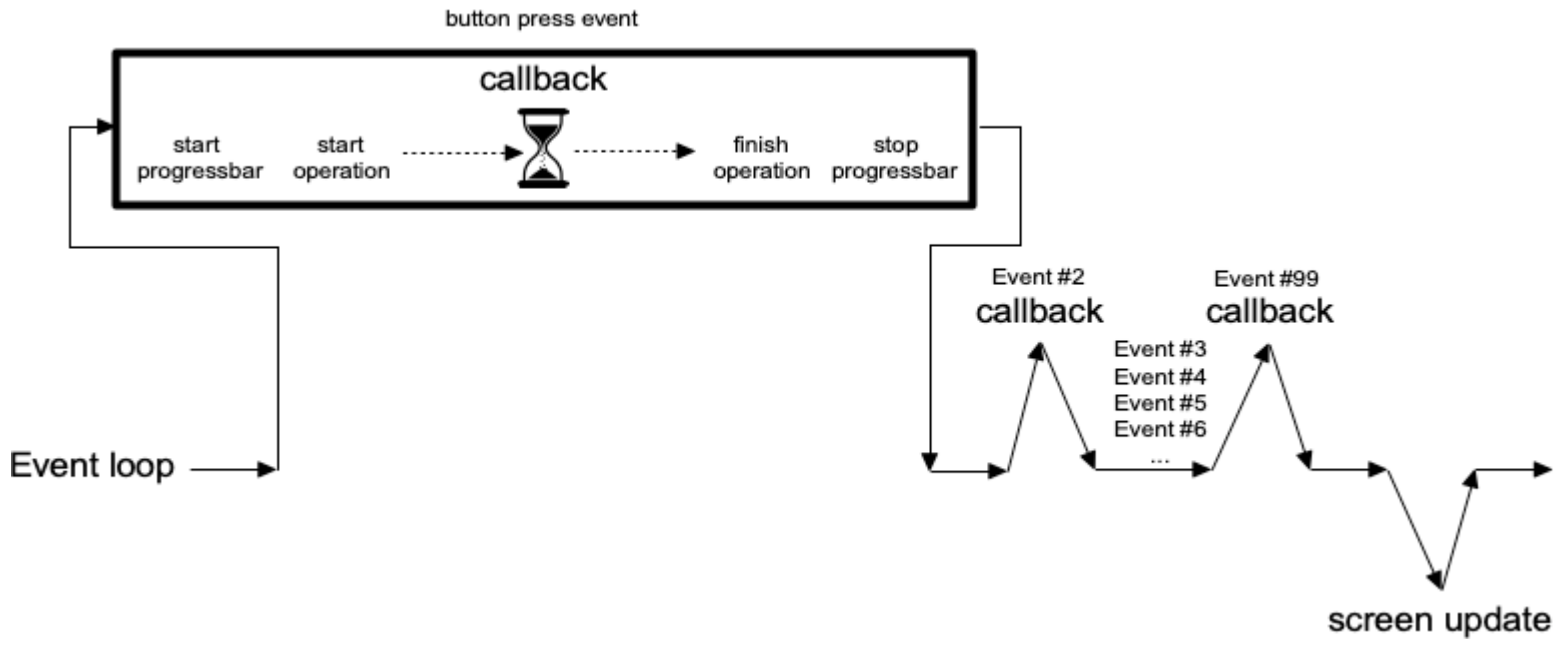
You run into problems when the event loop is prevented from processing events for a lengthy period. Your application won't redraw or respond to events and will appear to be frozen. The event loop is said to be *blocked*. How can this happen?

Let's start by visualizing the event loop as an execution timeline. In a normal situation, each deviation from the event loop (callback, screen update) takes only a fraction of a second before returning control to the event loop.



Execution timeline for a well-behaved event loop.

In our scenario, the whole thing probably started from an event like a user pressing a button. So the event loop calls our application code to handle the event. Our code creates the progressbar, performs the (lengthy) operations, and stops the progressbar. Only then does our code return control back to the event loop. No events have been processed in the meantime, and no screen redrawing has occurred. Events have been piling up in the event queue.



Lengthy callback blocking the event loop.

To prevent blocking the event loop, event handlers must execute quickly and return control to the event loop.

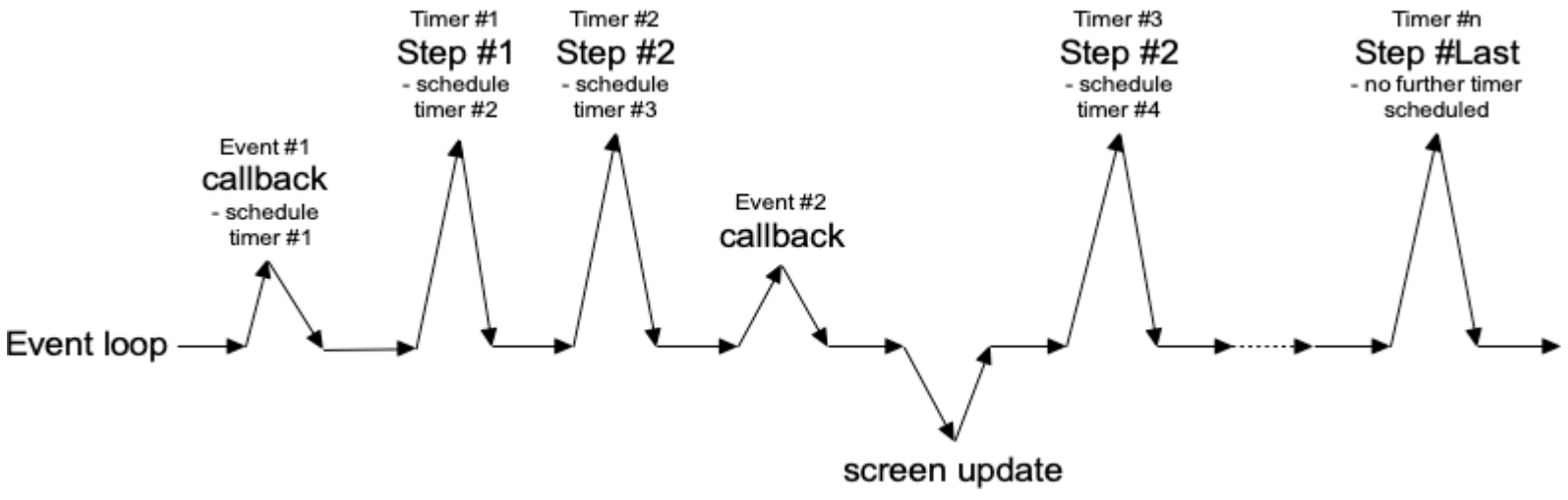
If you have a long-running operation to perform or anything like network I/O that could potentially take a long time, there are a few different approaches you can take.

For the more technically inclined, Tk uses a single-threaded, event-driven programming model. All the GUI code, the event loop, and your application run within the same thread. Because of this, any calls or computations that block event handlers are highly discouraged. Some GUI toolkits use different models that allow for blocking code, running the GUI and event handlers in separate threads from application code, etc. Attempting to shoehorn these models into Tk can be a recipe for frustration and lead to fragile and hacky code. If you respect Tk's model rather than fight it, you won't run into problems.

One Step at a Time

If possible, the very best thing you can do is break your operation into tiny steps, each of which can execute very quickly. You let the event loop be responsible for when the next step occurs. That way, the event loop continues to run, processing regular events, updating the screen, and, in between all that, calling your code to perform the next step of the operation.

To do this, we make use of *timer events*. Our program can ask the event loop to generate one of these events at a later time. As part of its regular work, when the event loop reaches that time, it will call back into our code to handle the event. Our code would perform the next step of the operation. It then schedules another timer event for the *next* step of the operation and immediately returns control back to the event loop.



Breaking up a large operation into small steps tied together with timer events.

Tk's `after` command can be used to generate timer events. You provide the number of milliseconds to wait until the event should be fired. It may happen later than that if Tk is busy processing other events, but it won't happen before that. You can also ask that an `idle` event be generated; it will fire when no other events in the queue need to be processed. (Tk's screen updates and redraws occur in the context of idle events.) You can find more details on `after` in the reference manual.

In the following example, we'll perform a lengthy operation that is broken up into 20 small steps. While this operation is being performed, we'll update a progressbar and allow users to interrupt the operation.

```
def start():
    b.configure(text='Stop', command=stop)
    l['text'] = 'Working...'
    global interrupt; interrupt = False
    root.after(1, step)

def stop():
    global interrupt; interrupt = True

def step(count=0):
    p['value'] = count
    if interrupt:
        result(None)
        return
    root.after(100)  # next step in our operation; don't take too long!
    if count == 20:  # done!
        result(42)
        return
    root.after(1, lambda: step(count+1))

def result(answer):
    p['value'] = 0
    b.configure(text='Start!', command=start)
    l['text'] = "Answer: " + str(answer) if answer else "No Answer"

f = ttk.Frame(root); f.grid()
b = ttk.Button(f, text="Start!", command=start); b.grid(column=1, row=0, padx=5, pady=5)
l = ttk.Label(f, text="No Answer"); l.grid(column=0, row=0, padx=5, pady=5)
p = ttk.Progressbar(f, orient="horizontal", mode="determinate", maximum=20);
p.grid(column=0, row=1, padx=5, pady=5)
```

To interrupt the process, we set a global variable, checking it each time the timer event fires. Another option would be to cancel the pending timer event. When we create the timer event, it returns an id number to uniquely identify the pending timer. To cancel it, we can call the `after_cancel` *method, passing it that unique id.*

You'll also note that we used a blocking form of `after` *to simulate performing our operation. Rather than scheduling an event, in this form, the call blocks, waiting a given time before returning. It works the same as a* `sleep` *system call.*

Asynchronous I/O

Timer events take care of breaking up a long-running computation, where you know that each step can be guaranteed to complete quickly so that your handler will return to the event loop. What if you have an operation that may not complete quickly? This can happen when you make a variety of calls to the operating system. The most common is when we're doing some kind of I/O, whether writing a file, communicating with a database, or retrieving data from a remote web server.

Most I/O calls are *blocking*, so they don't return until the operation completes (or fails). What we want to use instead are *non-blocking* or *asynchronous* I/O calls. When you make an asynchronous I/O call, it returns immediately, before the operation is completed. Your code can continue running, or in this case, return back to the event loop. Later on, when the I/O operation completes, your program is notified and can process the result of the I/O operation.

If this sounds like treating I/O as another type of event, you're exactly right. In fact, it's also called *event-driven I/O*.

In Python, asynchronous I/O is provided by the `asyncio` module and other modules layered on top of it.

All asyncio applications rely heavily on an event loop. How convenient; Tkinter has a great event loop! Unfortunately, the asyncio event loop and the Tkinter event loop are not the same. You can't run both at the same time, at least not within the same thread (well, you can have one repeatedly call the other, but it's pretty hacky and fragile).

My recommendation: keep Tkinter in the main thread and spin-off your asyncio event loops in another thread.

Your application code, running in the main thread, may need to coordinate with the asyncio event loop running in the other thread. You can call a function running in the asyncio event loop thread (even from the Tkinter event loop, e.g., in a widget callback) using the asyncio `call_soon_threadsafe` method. To call Tkinter from the asyncio event loop, keep reading.

Threads or Processes

Sometimes it's either impossible or impractical to break up a long-running computation into discrete pieces that each run quickly. Or you may be using a library that doesn't support asynchronous operations. Or, like Python's `asyncio`, it doesn't play nice with Tk's event loop. In cases like these, to keep your Tk GUI responsive, you'll need to move those time-consuming operations or library calls out of your event handlers and run them somewhere else. Threads, or even other processes, can help with that.

Running tasks in threads, communicating with them, etc., is beyond the scope of this tutorial. However, there are some restrictions on using Tk with threads that you should be aware of. The main rule is that you must only make Tk calls from the thread where you loaded Tk.

Tkinter goes to great lengths internally so that you can make Tkinter calls from multiple threads by routing them to the main thread (the one that created the Tk instance). It mostly works, but not always. Despite all it tries to do, I highly recommend you make all Tkinter calls from a single thread.

If you need to communicate from another thread to the thread running Tkinter, keep it as simple as possible. Use `event_generate` to post a virtual event to the Tkinter event queue, and then `bind` to that event in your code.

```
root.event_generate("<<MyOwnEvent>>")
```

It can be even more complicated. The Tcl/Tk libraries can be built either with or without thread support. If you have more than one thread in your application, make sure you're running in a threaded build. If you're unsure, check the Tcl variable `tcl_platform(threaded)`; it should be `1`, not `0`.

```
>>> tkinter.Tcl().eval('set tcl_platform(threaded)')
```

Most everyone should be running threaded builds. The ability to create non-threaded builds in Tcl/Tk is likely to go away in the future. If you're using a non-threaded build with threaded code, consider this a bug in your application, not a challenge to make it work.

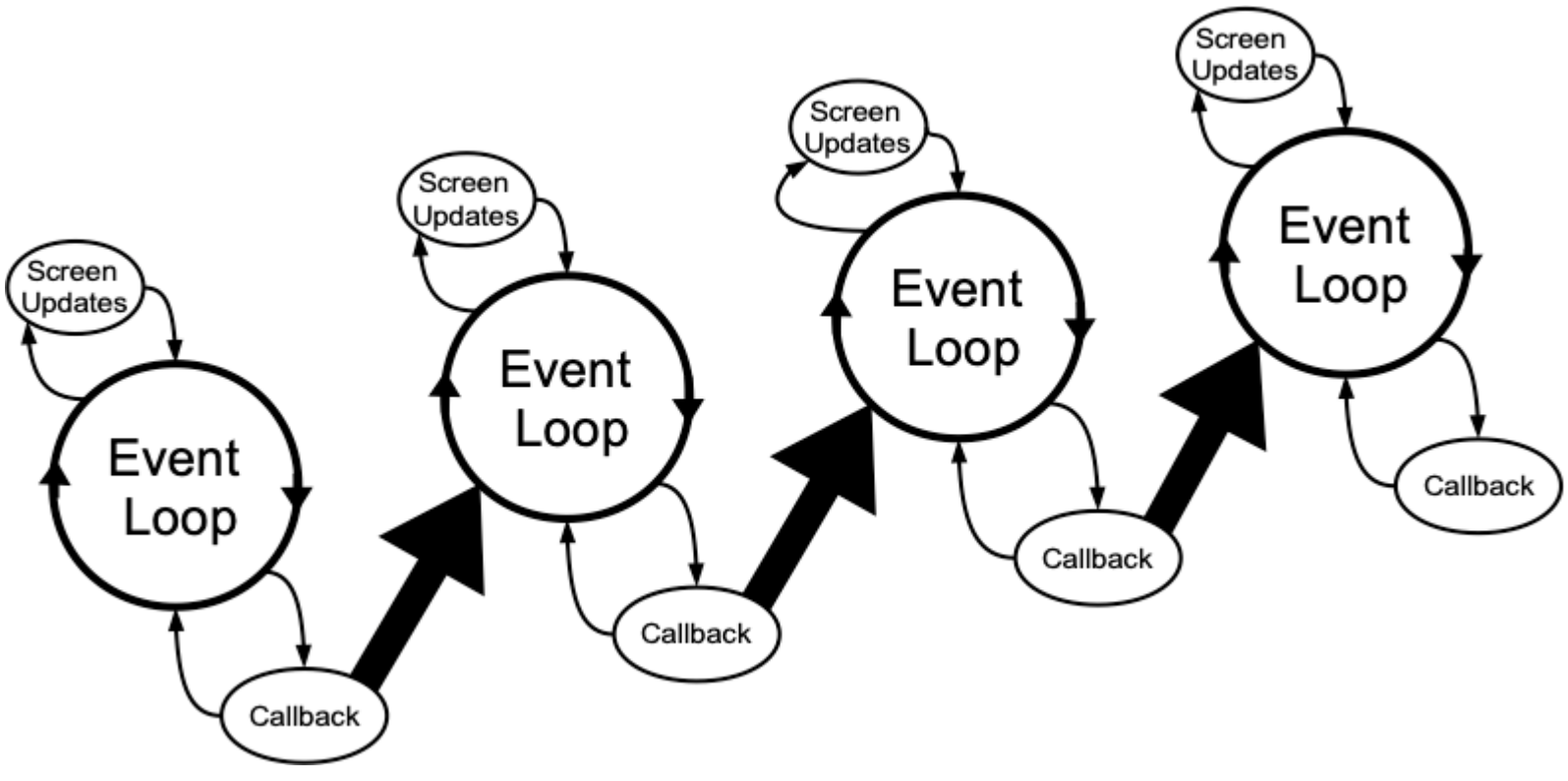
Nested Event Processing

The previous three approaches are the correct ways to handle long-running operations while keeping your Tk GUI responsive. What they have in common is a single event loop that continuously processes events of all kinds. That event loop will call event handlers in your application code, which do their thing and quickly return.

There is one other way. Within your long-running operation, you can invoke the event loop to process a bunch of events. You can do this with a single command, `update`. There's no messing around with timer events or asynchronous I/O. Instead, you just sprinkle some `update` calls throughout your operation. If you want to only keep the screen redrawing but not process other events, there's even an option for that (`update_idletasks`).

This approach is seductively easy. And if you're lucky, it might work. At least for a little while. But sooner or later, you're going to run into serious difficulties trying to do things that way. Something won't be updating, event handlers aren't getting called that should be, events are going missing or being fired out of order, or worse. You'll turn your program's logic inside out and tear your hair out trying to make it work again.

When you use `update`, you're not returning control back to the running event loop. You're effectively starting a new event loop nested within the existing one. Remember, the event loop follows a single thread of execution: no threads, no coroutines. If you're not careful, you're going to end up with event loops called from within event loops called from... well, you get the idea. If you even realize you're doing this, unwinding the event loops (each of which may have different conditions to terminate it) will be an interesting exercise. The reality won't match your mental model of a simple event loop dispatching events one at a time, independent of every other event. It's a classic example of fighting against Tk's model. In very specific circumstances, it's possible to make it work. In practice, you're asking for trouble. Don't say you haven't been warned...



Nested event loops... this way madness lies.

Menus

This chapter describes how to handle menubars and popup menus in Tk. For a polished application, these are areas you particularly want to pay attention to. Menus need special care if you want your application to fit in with other applications on your users' platform.

Speaking of which, the recommended way to figure out which platform you're running on is:

```
root.tk.call('tk', 'windowingsystem')     # returns x11, win32 or aqua
```

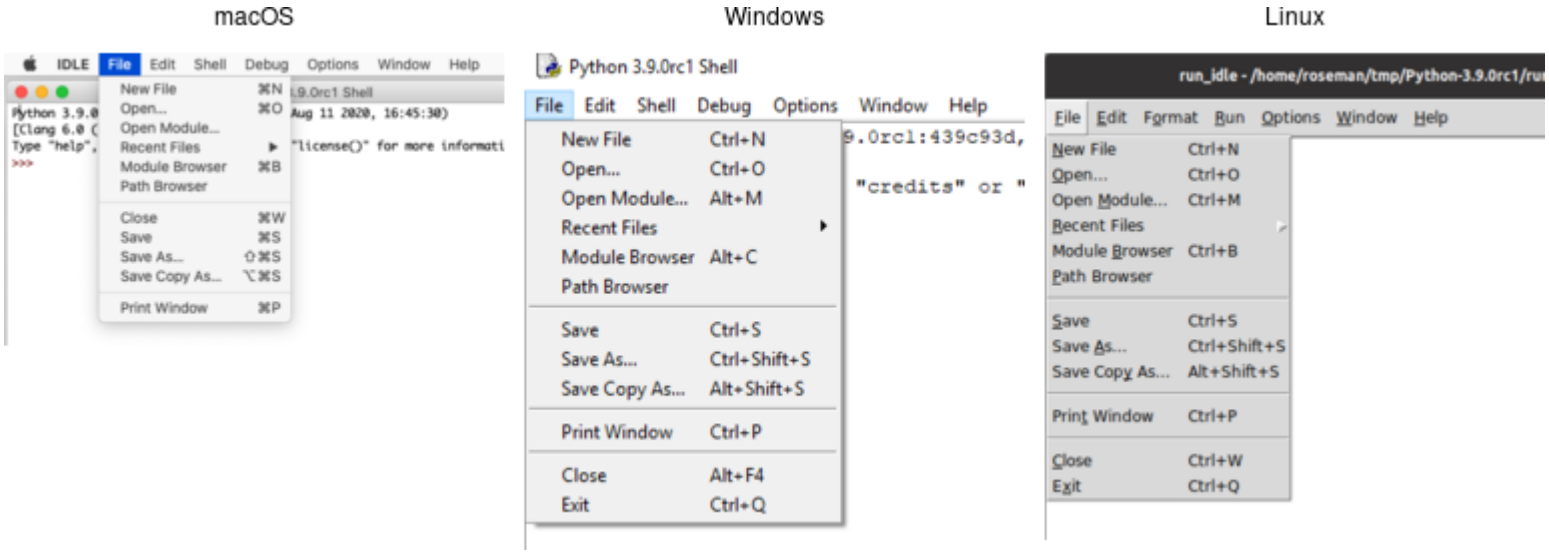
Tkinter does not provide a direct equivalent to this call. However, it is possible to directly execute an arbitrary Tcl-based Tk command using the `call()` method (available on any Tkinter widget). Here, we're invoking the Tcl/Tk command `tk windowingsystem`.

This is more useful than examining global variables like `tcl_platform` or `sys.platform`; older checks that used these methods should be reviewed. While there used to be a strong correlation between platform and windowing system, that's less true today. For example, if your platform is identified as Unix, that might mean Linux under X11, macOS under Aqua, or even macOS under X11.

Menubars

In this section, we'll look at menubars: how to create them, what goes in them, how they're used, etc.

Properly designing a menubar and its set of menus is beyond the scope of this tutorial. However, if you're creating an application for someone other than yourself, here is a bit of advice. First, if you find yourself with many menus, very long menus, or deeply nested menus, you may need to rethink how your user interface is organized. Second, many people use the menus to explore what the program can do, particularly when they're first learning it, so try to ensure major features are accessible by the menus. Finally, for each platform you're targeting, become familiar with how applications use menus. Consult the platform's human interface guidelines for full details about the design, terminology, shortcuts, and much more. This is an area you will likely have to customize for each platform.



Menubars.

You'll notice applications on some recent Linux distributions that show their menus at the top of the screen when active rather than in the window itself. Tk does not yet support this style of menus.

Menu Widgets and Hierarchy

- Widget Roundup
- Reference Manual

Menus are implemented as widgets in Tk, just like buttons and entries. Each menu widget consists of a number of different *items* in the menu. Items have various attributes, such as the text to display for the item, a keyboard accelerator, and a command to invoke.

Menus are arranged in a hierarchy. The menubar is itself a menu widget. It has several items ("File," "Edit," etc.), each of which is a submenu containing more items. These items can include things like the "Open..." command in a "File" menu but also separators between other items. It can even have items that open up their own submenu (so-called *cascading* menus). As you'd expect from other things you've seen already in Tk, anytime you have a submenu, it must be created as a child of its parent menu.

Menus are part of the classic Tk widgets; there is no menu widget in the themed Tk widget set.

Before you Start

It's essential to put the following line in your application somewhere before you start creating menus.

```
root.option_add('*tearOff', FALSE)
```

Without it, each of your menus (on Windows and X11) will start with what looks like a dashed line and allows you to "tear-off" the menu, so it appears in its own window. You should eliminate tear-off menus from your application as they're not a part of any modern user interface style.

This is a throw-back to the Motif-style X11 that Tk's original look and feel were based on. Get rid of them unless your application is designed to run only on that old box collecting dust in the basement. We'll all look forward to a future version of Tk where this misguided paean to backward compatibility is removed.

While on the topic of ancient history, the `option_add` bit uses the option database. This provided a standardized way to customize some aspects of X11 user interfaces through text-based configuration files, but it's no longer used today. Older Tk programs may use the `option` command internally to separate style configuration options from widget creation code. That approach pre-dated themed Tk styles, which should be used for that purpose today. However, it's somehow fitting to use the obsolete option database to automatically remove the obsolete tear-off menus.

Creating a Menubar

In Tk, menubars are associated with individual windows; each toplevel window can have at most one menubar. This is visually obvious on Windows and many X11 systems, where menus are part of each window, sitting just below the title bar.

On macOS, though, there is a single menubar along the top of the screen, shared by each window. As far as your Tk program is concerned, each window still has its own menubar. As you switch between windows, Tk ensures that the correct menubar is displayed. If you don't specify a menubar for a particular window, Tk uses the menubar associated with the root window; you'll have noticed by now that this is automatically created for you when your Tk application starts.

Because all windows have a menubar on macOS, it's important to define one, either for each window or a fallback menubar for the root window. Otherwise, you'll end up with the "built-in" menubar, which contains menus that are only intended for typing commands directly into the interpreter.

To create a menubar for a window, first, create a menu widget. Then, use the window's `menu` configuration option to attach the menu widget to the window.

```
win = Toplevel(root)
menubar = Menu(win)
win['menu'] = menubar
```

You can use the same menubar for more than one window. In other words, you can specify the same menubar as the `menu` configuration option for several toplevel windows. This is particularly useful on Windows and X11, where you may want a window to include a menu but don't necessarily need to juggle different menus in your application. However, if the contents or state of menu items depends on what's going on in the active window, you'll have to manage this yourself.

This is truly ancient history, but menubars used to be implemented by creating a frame widget containing the menu items and packing it into the top of the window like any other widget. Hopefully, you don't have any code or documentation that still does this.

Adding Menus

We now have a menubar, but that's pretty useless without some menus to go in it. So again, we'll create a menu widget for each menu, each one a child of the menubar. We'll then add them all to the menubar.

```
menubar = Menu(parent)
menu_file = Menu(menubar)
menu_edit = Menu(menubar)
menubar.add_cascade(menu=menu_file, label='File')
menubar.add_cascade(menu=menu_edit, label='Edit')
```

The `add_cascade` method adds a menu item, which itself is a menu (a submenu).

Adding Menu Items

Now that we have a couple of menus in our menubar, we can add a few items to each menu.

Command Items

Regular menu items are called `command` items in Tk. We'll see some other types of menu items shortly. Notice that menu items are part of the menu itself; we don't have to create a separate menu widget for each one (submenus being the exception).

```
menu_file.add_command(label='New', command=newFile)
menu_file.add_command(label='Open...', command=openFile)
menu_file.add_command(label='Close', command=closeFile)
```

The ellipsis ("...") is a special character on macOS, more tightly spaced than three periods in a row. Tk takes care of substituting this character for you automatically.

Each menu item has associated with it several configuration options, analogous to widget configuration options. Each type of menu item has a different set of available options. Cascade menu items have a `menu` option used to specify the submenu, command menu items have a `command` option to specify the command to invoke when the item is chosen. Both have a `label` option to specify the text to display for the item.

Submenus

We've already seen `cascade` menu items used to add a menu to a menubar. Not surprisingly, if you want to add a submenu to an existing menu, you also use a `cascade` menu item exactly the same way. You might use this to build build a "recent files" submenu, for example.

```
menu_recent = Menu(menu_file)
menu_file.add_cascade(menu=menu_recent, label='Open Recent')
for f in recent_files:
    menu_recent.add_command(label=os.path.basename(f), command=lambda f=f: openFile(f))
```

Separators

A third type of menu item is the `separator`, which produces the dividing line you often see between different menu items.

```
menu_file.add_separator()
```

Checkbutton and Radiobutton Items

Finally, there are also `checkbutton` and `radiobutton` menu items that behave analogously to checkbutton and radiobutton widgets. These menu items have a variable associated with them. Depending on its value, an indicator (i.e., checkmark or selected radiobutton) may be shown next to its label.

```
check = StringVar()
menu_file.add_checkbutton(label='Check', variable=check, onvalue=1, offvalue=0)
radio = StringVar()
menu_file.add_radiobutton(label='One', variable=radio, value=1)
menu_file.add_radiobutton(label='Two', variable=radio, value=2)
```

When a user selects a checkbutton item that is not already checked, it sets the associated variable to the value in `onvalue`. Selecting an item that is already checked sets it to the value in `offvalue`. Selecting a radiobutton item sets the associated variable to the value in `value`. Both types of items also react to any changes you make to the associated variable.

Like command items, checkbutton and radiobutton menu items support a `command` configuration option that is invoked when the menu item is chosen. The associated variable and the menu item's state are updated before the callback is invoked.

> *Radiobutton menu items are not part of the Windows or macOS human interface guidelines. On those platforms, the item's indicator is a checkmark, as it would be for a checkbutton item. The semantics still work. It's a good way to select between multiple items since it will show one of them selected (checked).*

Manipulating Menu Items

As well as adding items to the end of menus, you can also insert them in the middle of menus via the `insert` *`index type ?option value...?`* method; here *`index`* is the position (0..n-1) of the item you want to insert before. You can also delete one or more menu items using the `delete` *`index ?endidx?`* method.

```
menu_recent.delete(0, 'end')
```

Like most everything in Tk, you can look at or change the value of an item's options at any time. Items are referred to via an *index*. Usually, this is a number (`0..n-1`) indicating the item's position in the menu. You can also specify the label of the menu item (or, in fact, a "glob-style" pattern to match against the item's label).

```
print( menu_file.entrycget(0, 'label')) # get label of top entry in menu
print( menu_file.entryconfigure(0))     # show all options for an item
```

State

You can disable a menu item so that users cannot select it. This can be done via the `state` option, setting it to the value `disabled`. Use a value of `normal` to re-enable the item.

Menus should always reflect the current state of your application. If a menu item is not presently relevant (e.g., the "Copy" item is only applicable if something in your application is selected), you should disable it. When your application state changes so that the item is applicable, make sure to enable it.

```
menu_file.entryconfigure('Close', state=DISABLED)
```

Sometimes you may have menu items whose name changes in response to application state changes, rather than the menu item being disabled. For example, A web browser might have a menu item that changes between "Show Bookmarks" and "Hide Bookmarks" as a bookmarks pane is hidden or displayed.

```
menu_bookmarks.entryconfigure(3, label="Hide Bookmarks")
```

> *As your program grows complex, it's easy to miss enabling or disabling some items. One strategy is to centralize all the menu state changes in one routine. Whenever there is a state change in your application, it should call this routine. It should examine the current state and update menus accordingly. The same code can also handle toolbars, status bars, or other user interface components.*

Accelerator Keys

The `accelerator` option is used to indicate a keyboard equivalent that corresponds to a menu item. This does not actually *create* the accelerator but only displays it next to the menu item. You still need to create an event binding for the accelerator yourself.

Remember that event bindings can be set on individual widgets, all widgets of a certain type, the toplevel window containing the widget you're interested in, or the application as a whole. As menu bars are associated with individual windows, event bindings for menu items will usually be on the toplevel window the menu is associated with.

Accelerators are very platform-specific, not only in terms of which keys are used for what operation, but what modifier keys are used for menu accelerators (e.g., on macOS, it is the "Command" key, on Windows and X11, it is usually the "Control" key). Examples of valid accelerator options are `Command-N`, `Shift+Ctrl+X`, and `Command-Option-B`. Commonly used modifiers include `Control`, `Ctrl`, `Option`, `Opt`, `Alt`, `Shift`, "`Command`, `Cmd`, and `Meta`.

On macOS, modifier names are automatically mapped to the different modifier icons that appear in menus, i.e., `Shift` ⇒ ⇧, `Command` ⇒ ⌘, `Control` ⇒ ^, and `Option` ⇒ ⌥.

```
m_edit.entryconfigure('Paste', accelerator='Command+V')
```

Underline

All platforms support keyboard traversal of the menubar via the arrow keys. On Windows and X11, you can also use other keys to jump to particular menus or menu items. The keys that trigger these jumps are indicated by an underlined letter in the menu item's label. To add one of these to a menu item, use the `underline` configuration option for the item. Its value should be the index of the character you'd like underlined (from 0 to the length of the string - 1). Unlike accelerator keys, the menu will watch for the keystroke, so no separate event binding is needed.

```
m.add_command(label='Path Browser', underline=5)  # underline "B"
```

Images

It is also possible to use images in menu items, either beside the menu item's label or replacing it altogether. To do this, use the `image` and `compound` options, which work just like in label widgets. The value for `image` must be a Tk image object, while `compound` can have the values `bottom`, `center`, `left`, `right`, `top`, or `none`.

Menu Virtual Events

Platform conventions for menus suggest standard menus and items that should be available in most applications. For example, most applications have an "Edit" menu, with menu items for "Copy," "Paste," etc. Tk widgets like entry or text will react appropriately when those menu items are chosen. But if you're building your own menus, how do you make that work? What `command` would you assign to a "Copy" menu item?

Tk handles this with virtual events. As you'll recall from the Tk Concepts chapter, these are high-level application events, not low-level operating system events. Tk's widgets will watch for specific events. When you build your menus, you can generate those events rather than directly invoking a callback function. Your application can create event bindings to watch for those events too.

Some developers create virtual events for every item in their menus, generating those events instead of directly calling routines in their code. It's one way of splitting off your user interface code from the rest of your application. Remember that even if you do this, you'll still need code that enables and disables menu items, adjusts their labels, etc., in response to application state changes.

Here's a minimal example showing how we'd add two items to an "Edit" menu, the standard "Paste" item, and an application-specific "Find..." item that will open a dialog to find or search for something. We'll include an entry widget so that we can check that "Paste" works.

```
from tkinter import *
from tkinter import ttk, messagebox

root = Tk()
ttk.Entry(root).grid()
m = Menu(root)
m_edit = Menu(m)
m.add_cascade(menu=m_edit, label="Edit")
m_edit.add_command(label="Paste", command=lambda: root.focus_get().event_generate("<<Paste>>"))
m_edit.add_command(label="Find...", command=lambda: root.event_generate("<<OpenFindDialog>>"))
root['menu'] = m

def launchFindDialog(*args):
    messagebox.showinfo(message="I hope you find what you're looking for!")

root.bind("<<OpenFindDialog>>", launchFindDialog)
root.mainloop()
```

When you generate a virtual event, you need to specify the widget that the event should be sent to. We want the "Paste" event to be sent to the widget with the keyboard focus (usually indicated by a focus ring). You can determine which widget has the keyboard focus using the `focus` command. Try it out, choosing the Paste item when the window is first opened (when there's no focus) and after clicking on the entry (making it the focus). Notice the entry handles the `<<Paste>>` event itself. There's no need for us to create an event binding.

The `<<OpenFindDialog>>` event is sent to the root window, which is where we create an event binding. If we had multiple toplevel windows, we'd send it to a specific window.

Tk predefines the following virtual events: `<<Clear>>`, `<<Copy>>`, `<<Cut>>`, `<<Paste>>`, `<<PasteSelection>>`, `<<PrevWindow>>`, `<<Redo>>`, and `<<Undo>>`. For additional information, see the `event` command reference.

Platform Menus

Each platform has a few menus in every menubar that are handled specially by Tk.

macOS

You've probably noticed that Tk on macOS supplies its own default menubar. It includes a menu named after the program being run (in this case, your programming language's shell, e.g., "Wish", "Python", etc.), a File menu, and standard Edit, Windows, and Help menus, all stocked with various menu items.

You can override this menubar in your own program, but to get the results you want, you'll need to follow some particular steps (in some cases, in a particular order).

Starting at Tk 8.5.13, the handling of special menus on macOS changed due to the underlying Tk code migrating from the obsolete Carbon API to Cocoa. If you're seeing duplicate menu names, missing items, things you didn't put there, etc., review this section carefully.

The first thing to know is that if you don't specify a menubar for a window (or its parent window, e.g., the root window), you'll end up with the default menubar Tk supplies, which unless you're just mucking around on your own, is almost certainly not what you want.

The Application Menu

Every menubar starts with the system-wide apple icon menu. To the right of that is a menu for the frontmost application. It is always named after the binary being run. When you attach a menubar to the window, if it does *not already contain* a specially named `.apple` menu (see below), Tk will provide its default application menu. It includes an "About Tcl & Tk" item, followed by the standard menu items: preferences, the services submenu, hide/show items, and quit. Again, you don't want this.

If you supply your own `.apple` menu, when the menubar is attached to the window, Tk will add the standard items (preferences and onward) onto the end of any items you have added. Perfect! Items you add *after* the menubar is attached to the window will appear after the quit item, which, again, you don't want.

The application menu, which we're dealing with here, is distinct from the apple menu (the one with the apple icon, just to the left of the application menu). Despite that, we really mean the application menu, even though Tk still refers to it as the "apple" menu. This is a holdover from pre-OS X days when these sorts of items did go in the actual apple menu, and there was no separate application menu.

So, in other words, in your program, make sure you:

1. Create a menubar for each window or the root window. *Do not attach the menubar to the window yet!*
2. Add a menu to the menubar named `.apple`. It will be used as the application menu.
3. The menu will automatically be named the same as the application binary; if you want to change this, rename (or make a copy of) the binary used to run your script.
4. Add the items you want to appear at the top of the application menu, i.e., an "About yourapp" item, followed by a separator.
5. *After* doing all this, you can *then* attach the menubar to your window via the window's `menu` configuration option.

```
win = Toplevel(root)
menubar = Menu(win)
appmenu = Menu(menubar, name='apple')
menubar.add_cascade(menu=appmenu)
appmenu.add_command(label='About My Application')
appmenu.add_separator()
win['menu'] = menubar
```

While usually, Tkinter chooses a widget pathname for us, we've had to explicitly provide one (`apple`) using the `name` option when creating the application menu.

Handling the Preferences Menu Item

As you've noticed, the application menu always includes a "Preferences..." menu item. This menu item should open a preferences dialog if your application has one. If not, this menu item should be disabled, which it is by default.

To hook up your preferences dialog, you'll need to define a Tcl procedure named `::tk::mac::ShowPreferences`. It will be called when the Preferences menu item is chosen; if the procedure is not defined, the menu item will be disabled.

```
def showMyPreferencesDialog():
    ....

root.createcommand('tk::mac::ShowPreferences', showMyPreferencesDialog)
```

Providing a Help Menu

Like the application menu, any help menu you add to your own menubar is treated specially on macOS. As with the application menu that needed a special name (`.apple`), the help menu must be given the name `.help`. The help menu should also be added *before the menubar is attached to the window*.

The help menu will include the standard macOS search box to search help, as well as an item named "*yourapp* Help." As with the name of the application menu, this comes from your program's executable and cannot be changed. Similar to how preferences dialogs are handled, to respond to this help item, you need to define a Tcl procedure named `::tk::mac::ShowHelp`. If this procedure is not defined, it will *not* disable the menu item. Instead, it will generate an error when the help item is chosen.

If you don't want to include help, don't add a help menu to the menubar, and none will be shown.

Unlike on X11 and earlier versions of Tk on macOS, the Help menu will not automatically be put at the end of the menubar, so ensure it is the last menu added.

You can also add other items to the help menu. These will appear after the application help item.

```
helpmenu = Menu(menubar, name='help')
menubar.add_cascade(menu=helpmenu, label='Help')
root.createcommand('tk::mac::ShowHelp', ...)
```

Providing a Window Menu

On macOS, a "Window" menu contains items like minimize, zoom, bring all to front, etc. It also includes a list of currently open windows. Before that list, other application-specific items are sometimes provided.

By providing a menu named `.window`, this standard window menu will be added. Tk automatically keeps it in sync with all your toplevel windows, without any extra code on your part. You can also add any application-specific commands to this menu. These appear before the list of your windows.

```
windowmenu = Menu(menubar, name='window')
menubar.add_cascade(menu=windowmenu, label='Window')
```

Other Menu Handlers

You've seen how handling certain standard menu items required you to define Tcl callback procedures, e.g., `tk::mac::ShowPreferences` and `tk::mac::ShowHelp`.

There are several other callbacks that you can define. For example, you might intercept the Quit menu item, prompting users to save their changes before quitting. Here is the complete list:

`tk::mac::ShowPreferences`
Called when the "Preferences..." menu item is selected.

`tk::mac::ShowHelp`
Called to display main online help for the application.

`tk::mac::Quit`
Called when the Quit menu item is selected, when a user is trying to shut down the system etc.

`tk::mac::OnHide`
Called when your application has been hidden.

`tk::mac::OnShow`
Called when your application is shown after being hidden.

`tk::mac::OpenApplication`
Called when your application is first opened.

`tk::mac::ReopenApplication`
Called when a user "reopens" your already-running application (e.g., clicks on it in the Dock)

`tk::mac::OpenDocument`
Called when the Finder wants the application to open one or more documents (e.g., that were dropped on it). The procedure is passed a list of pathnames of files to be opened.

`tk::mac::PrintDocument`
As with OpenDocument, but the documents should be printed rather than opened.

For additional information, see the `tk_mac` command reference.

Windows

On Windows, each window has a "System" menu at the top left of the window frame, with a small icon for your application. It contains items like "Close", "Minimize", etc. In Tk, if you create a system menu, you can add new items below the standard items.

```
sysmenu = Menu(menubar, name='system')
menubar.add_cascade(menu=sysmenu)
```

While Tkinter usually chooses a widget pathname for us, we've had to explicitly provide one with the name `system`; this is the cue that Tk needs to recognize it as the system menu.

X11

On X11, if you create a help menu, Tk ensures that it is always the last menu in the menubar.

```
menu_help = Menu(menubar, name='help')
menubar.add_cascade(menu=menu_help, label='Help')
```

While Tkinter usually chooses a widget pathname for us, we've had to explicitly provide one with the name `help`; this is the cue that Tk needs to recognize it as the help menu.

Contextual Menus

Contextual menus ("popup" menus) are typically invoked by a right mouse button click on an object in the application. A menu pops up at the location of the mouse cursor. Users can then select an item from the menu (or click outside it to dismiss it without choosing any item).

To create a contextual menu, we'll use exactly the same commands we used to create menus in the menubar. Typically, we'd create one menu with several command items and potentially some cascade menu items and their associated menus.

To activate the menu, users will perform a contextual menu click. We'll have to create an event binding to capture that click. That, however, can mean different things on different platforms. On Windows and X11, this can be clicking the right mouse button (the third mouse button). On macOS, it can be either clicking the left (or only) button with the control key held down or right-clicking on a multi-button mouse. Unlike Windows and X11, macOS refers to this as the second mouse button, not the third, so that's the event we'll see in our program.

Most earlier programs that have used popup menus assumed it was only "button 3" they needed to worry about.

Besides capturing the correct contextual menu event, we also need to capture the mouse's location. It turns out we need to do this relative to the entire screen (global coordinates) and not local to the window or widget you clicked on (local coordinates). The `%X` and `%Y` substitutions in Tk's event binding system will capture those for us.

The last step is telling the menu to pop up at the particular location via the `post` method. Here's an example of the whole process, using a popup menu on the application's main window.

```
from tkinter import *
root = Tk()
menu = Menu(root)
for i in ('One', 'Two', 'Three'):
    menu.add_command(label=i)
if (root.tk.call('tk', 'windowingsystem')=='aqua'):
    root.bind('<2>', lambda e: menu.post(e.x_root, e.y_root))
    root.bind('<Control-1>', lambda e: menu.post(e.x_root, e.y_root))
else:
    root.bind('<3>', lambda e: menu.post(e.x_root, e.y_root))
root.mainloop()
```

Windows and Dialogs

Everything we've done up until now has been in a single window. In this chapter, we'll cover how to use multiple windows, change various attributes of windows, and use some of the standard dialog boxes available in Tk.

Creating and Destroying Windows

We've seen that all Tk programs start out with a root toplevel window, and then widgets are created as children of that root window. Creating new toplevel windows works almost exactly the same as creating new widgets.

Toplevel windows are created using the **`Toplevel`** class:

```
t = Toplevel(parent)
```

Note: Toplevels are part of the classic Tk widgets, not the themed widgets.

Unlike regular widgets, we don't have to `grid` a toplevel for it to appear onscreen. Once we've created a new toplevel, we can create other widgets as children of that toplevel and `grid` them inside the toplevel. The new toplevel behaves exactly like the automatically created root window.

To destroy a window, use its **`destroy`** method:

```
window.destroy()
```

Note that you can use `destroy` on any widget, not just a toplevel window. When you destroy a window, all windows (widgets) that are children of that window are also destroyed. Be careful! If you destroy the root window (that all other widgets are descended from), that will terminate your application.

In a typical document-oriented application, we want to allow closing a window while leaving others open. In that case, we may want to create a new toplevel for every window and not put anything directly inside the root window at all. While we can't just destroy the root window, we can remove it entirely from the screen using its `withdraw` method, which we'll see shortly.

Window Behavior and Styles

There are lots of things about how windows behave and how they look that can be changed.

Window Title

To examine or change the title of the window:

```
oldtitle = window.title()
window.title('New title')
```

Size and Location

In Tk, a window's position and size on the screen are known as its *geometry*. A full geometry specification looks like this: `width`**x**`height`**±**`x`**±**`y`.

Width and height (usually in pixels) are pretty self-explanatory. The `x` (horizontal position) is specified with a leading plus or minus, so `+25` means the left edge of the window should be 25 pixels from the left edge of the screen, while `-50` means the right edge of the window should be 50 pixels from the right edge of the screen. Similarly, a `y` (vertical) position of `+10` means the top edge of the window should be ten pixels below the top of the screen, while `-100` means the bottom edge of the window should be 100 pixels above the bottom of the screen.

Geometry specifies the actual coordinates on the screen. It doesn't make allowances for systems like macOS with a menubar along the top or a dock along the bottom. So specifying a position of `+0+0` would actually place the top part of the window under the system menu bar. It's a good idea to leave a healthy margin (at least 30 pixels) from the screen's edge.

Screen positions can be different than you might expect when you have multiple monitors on your system. We'll cover that shortly.

Here is an example of changing the size and position. It places the window towards the top righthand corner of the screen:

```
window.geometry('300x200-5+40')
```

You can retrieve the current geometry the same way; just don't provide a new geometry value. However, if you try it immediately after changing the geometry, you'll find it doesn't match. Remember that all drawing effectively occurs in the background in response to idle times via the event loop. Until that drawing occurs, the internal geometry of the window won't be updated. If you do want to force things to update immediately, you can.

```
window.update_idletasks()
print(window.geometry())
```

We've seen that the window defaults to the size requested by the widgets that are gridded into it. If we create and add new widgets interactively in the interpreter or add new widgets in response to other events, the window size adjusts. This behavior continues until either we explicitly provide the window's geometry as above or a user resizes the window. At that point, even if we add more widgets, the window won't change size. You'll want to be sure you're using all of `grid`'s features (e.g., `sticky`, `weight`) to make everything fit nicely.

Resizing Behavior

By default, toplevel windows, including the root window, can be resized by users. However, sometimes you may want to prevent users from resizing the window. You can do this via the `resizable` method. Its first parameter controls whether users can change the width, and the second if they can change the height. So to disable all resizing:

```
window.resizable(FALSE,FALSE)
```

If a window is resizable, you can specify a minimum and/or maximum size that you'd like the window's size constrained to (again, parameters are width and height):

```
window.minsize(200,100)
window.maxsize(500,500)
```

You saw earlier how to obtain the current size of the window via its geometry. Wondering how large it would be if you didn't specify its geometry, or a user didn't resize it? You can retrieve the window's *requested size*, i.e., how much space it requests from the geometry manager. Like with drawing, geometry calculations are only done at idle time in the event loop, so you won't get a useful response until the widget has appeared onscreen.

```
window.winfo_reqwidth()   # or winfo_reqheight
```

You can use the `reqwidth` and `reqheight` methods on any widget, not just toplevel windows. There are other `winfo` methods you can call on any widget, such as `width` and `height`, to get the actual (not requested) width and height. For more, see the `winfo` command reference.

Intercepting the Close Button

Most windows have a close button in their title bar. By default, Tk will destroy the window if users click on that button. You can, however, provide a callback that will be run instead. A common use is to prompt the user to save an open file if modifications have been made.

```
window.protocol("WM_DELETE_WINDOW", callback)
```

The somewhat obscurely-named `WM_DELETE_WINDOW` originated with X11 window manager protocols.

Transparency

Windows can be made partially transparent by specifying an alpha channel, ranging from `0.0` (fully transparent) to `1.0` (fully opaque).

```
window.attributes("-alpha", 0.5)
```

Tkinter's wrapper to the underlying `wm attributes` command doesn't interpret options, handle keyword arguments, etc.

On macOS, you can additionally specify a `-transparent` attribute (using the same mechanism as with `-alpha`), which makes the window background transparent and removes its shadow. You should also set the `background` configuration option for the window and any frames to the color `systemTransparent`.

Full Screen

You can make a window expand to take up the full screen:

```
window.attributes("-fullscreen", 1)
```

Other macOS-Specific Attributes

In addition to the `-transparent` attribute described above, macOS windows boast some additional attributes.

The (red) close widget in the title bar can indicate that the content inside the window has been modified (e.g., the file needs to be saved). Set the `-modified` attribute to `1` to indicate this or `0` to remove the modified indicator.

You can draw users' attention to the window by bouncing its icon in the macOS dock. To do so, set the window's `-notify` attribute.

If a window contains the contents of a document, you can place an icon in the title bar specifying the file the document refers to. Users can drag this icon as a proxy for dragging the file in the Finder. Set the window's `-titlepath` attribute to the full path of the file. Note that this does not change the title of the window (you'll need to change that separately) but just provides the icon.

On macOS, windows can also take a variety of appearances for different purposes, e.g., utility windows, modal dialogs, floating windows, and so on. An unsupported command in Tk called `MacWindowStyle` lets you assign one of these appearances to a window. Unlike many options in Tk that can be changed later, these appearances must be assigned after creating the window but before it appears onscreen.

```
t = Toplevel(root)
t.tk.call("::tk::unsupported::MacWindowStyle", "style", t._w, "utility")
```

Besides `utility`, other useful appearance styles include `floating`, `plain`, and `modal`.

While officially unsupported, this feature has been available for a long time in Tk. In the future, it will likely migrate to the `wm attributes` command. For further information, including more details on the different appearances and optional attributes, see the MacWindowStyle wiki page.

Iconifying and Withdrawing

On most systems, you can temporarily remove the window from the screen by iconifying it. In Tk, whether or not a window is iconified is referred to as the window's *state*. The possible states for a window include `normal` and `iconic` (for an iconified window), and several others: `withdrawn`, `icon`, or `zoomed`.

You can query or set the current window state directly. There are also methods `iconify`, `deiconify`, and `withdraw`; these are shortcuts for setting the `iconic`, `normal`, and `withdrawn` states, respectively.

```
thestate = window.state()
window.state('normal')
window.iconify()
window.deiconify()
window.withdraw()
```

For document-centric applications, where you want to allow closing any window without the application exiting (as would happen if you destroy the root window), use `withdraw` on the root window to remove it from the screen, use new toplevel windows for your user interface.

Stacking Order

Stacking order refers to the order that windows are "placed" on the screen, from bottom to top. When the positions of two windows overlap each other, the one closer to the top of the stacking order will obscure or overlap the one lower in the stacking order.

You can ensure that a window is always at the top of the stacking order (or at least above all others where this attribute isn't set):

```
window.attributes("-topmost", 1)
```

You can find the current stacking order, listed from lowest to highest:

```
root.tk.eval('wm stackorder '+str(window))
```

This method isn't exposed cleanly in Tkinter. It returns the internal names of each window, not the window object.

You can also just check if one window is above or below another:

```
if (root.tk.eval('wm stackorder '+str(window)+' isabove '+str(otherwindow))=='1') ...
if (root.tk.eval('wm stackorder '+str(window)+' isbelow '+str(otherwindow))=='1') ...
```

You can also raise or lower windows, either to the very top (bottom) of the stacking order, or just above (below) a designated window:

```
window.lift()
window.lift(otherwin)
window.lower()
window.lower(otherwin)
```

Tkinter uses the name `lift` since `raise` is a reserved keyword in Python.

Why do you need to pass a window to get the stacking order? Stacking order applies not only for toplevel windows, but for any *sibling* widgets (those with the same parent). If you have several widgets gridded together but overlapping, you can raise and lower them relative to each other:

```
from tkinter import *
from tkinter import ttk
root = Tk()
little = ttk.Label(root, text="Little")
bigger = ttk.Label(root, text='Much bigger label')
little.grid(column=0,row=0)
bigger.grid(column=0,row=0)
root.after(2000, lambda: little.lift())
root.mainloop()
```

This uses timer events, which we covered in the event loop chapter. The `after` command schedules a script to run in a certain number of milliseconds in the future but leaves the event loop to continue.

Screen Information

We've previously used the `winfo` command to find out information about specific widgets. It can also provide information about the entire display or *screen*. As usual, see the `winfo` command reference for full details.

For example, you can determine the screen's color depth (how many bits per pixel) and color model (usually `truecolor` on modern displays), its pixel density, and resolution.

```
print("color depth=" + str(root.winfo_screendepth())+ " (" + root.winfo_screenvisual() + ")")
print("pixels per inch=" + str(root.winfo_pixels('1i')))
print("width=", str(root.winfo_screenwidth()) + " height=", str(root.winfo_screenheight()))
```

Multiple Monitors

While normally you shouldn't have to pay attention to it, if you have multiple monitors on your system and want to customize things a bit, there are some tools in Tk to help.

First, there are two ways that multiple monitors can be represented. The first is with logically separate displays. This is often the case on X11 systems, though it can be changed, e.g., using the `xrandr` system utility. A downside of this model is that once a window is created on a screen, it can't be moved to a different one. You can determine the screen that a Tk window is running on, which looks something like `:0.0` (an X11-formatted display name).

```
root.winfo_screen()
```

When first creating a `toplevel`, you can specify the screen it should be created on using the `screen` configuration option.

Different monitors may have different resolutions, color depths, etc. You'll notice that all the screen information calls we just covered are methods invoked on a specific widget. They will return information about whatever screen that window is located on.

Alternatively, multiple monitors can also be represented as one big virtual display, which is the case on macOS and Windows. When you ask for information about the screen, Tk will return information on the *primary monitor*. For example, if you have two Full HD monitors side-by-side, the screen resolution will be reported as 1920 x 1080, not 3840 x 1080. This is probably a good thing; it means that if we're positioning or sizing windows, we don't need to worry about multiple monitors, and everything will just show up correctly on the primary monitor.

What if a user moves a window from the primary monitor to a different one? If you ask for its position, it will be relative to the primary monitor. So in our side-by-side FHD monitor setup, if you call the `winfo_x` method on a window positioned near the left edge of a monitor, it might return `100` (if it's on the primary monitor), `-1820` (if it's on a monitor to the left of the primary monitor), or `2020` (if it's on a monitor to the right of the primary monitor). You can still use the `geometry` method we saw a bit earlier to position the window on a different monitor, even though the geometry specification may look a bit odd, e.g., `+-1820+100`.

You can find out approximately how large the entire display is, spanning multiple monitors. To do so, check a toplevel widget's maximum size, i.e., how large the user can resize it (you can't do this after you've already changed it, of course). This may be a bit smaller than the full size of the display. For example, on macOS, it will be reduced by the size of the menubar at the top of the screen.

```
root.wm_maxsize()
```

Dialog Windows

Dialog boxes are a type of window used in applications to get information from users, inform them that some event has occurred, confirm an action, and more. The appearance and usage of dialog boxes are usually quite specifically detailed in a platform's style guide. Tk comes with several dialog boxes built-in for common tasks. These help you conform to platform-specific style guidelines.

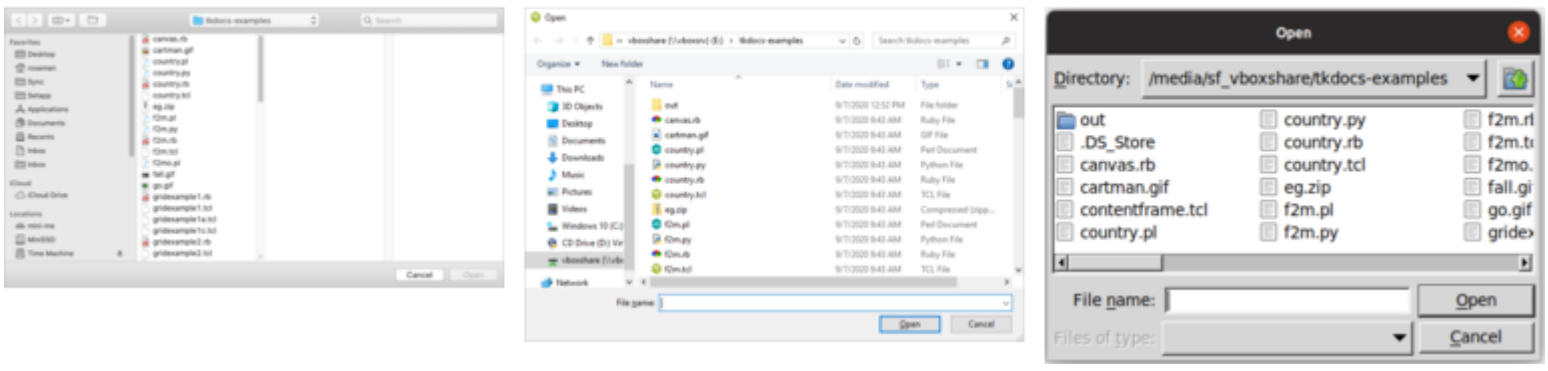
Selecting Files and Directories

Tk provides several dialogs to let users select files or directories. On Windows and macOS, these invoke the underlying operating system dialogs directly. The "open" variant on the dialog is used when you want users to select an existing file (like in a `"File | Open..."` menu command), while the "save" variant is used to choose a file to save into (usually used by the `"File | Save As..."` menu command).

```
from tkinter import filedialog
filename = filedialog.askopenfilename()
filename = filedialog.asksaveasfilename()
dirname = filedialog.askdirectory()
```

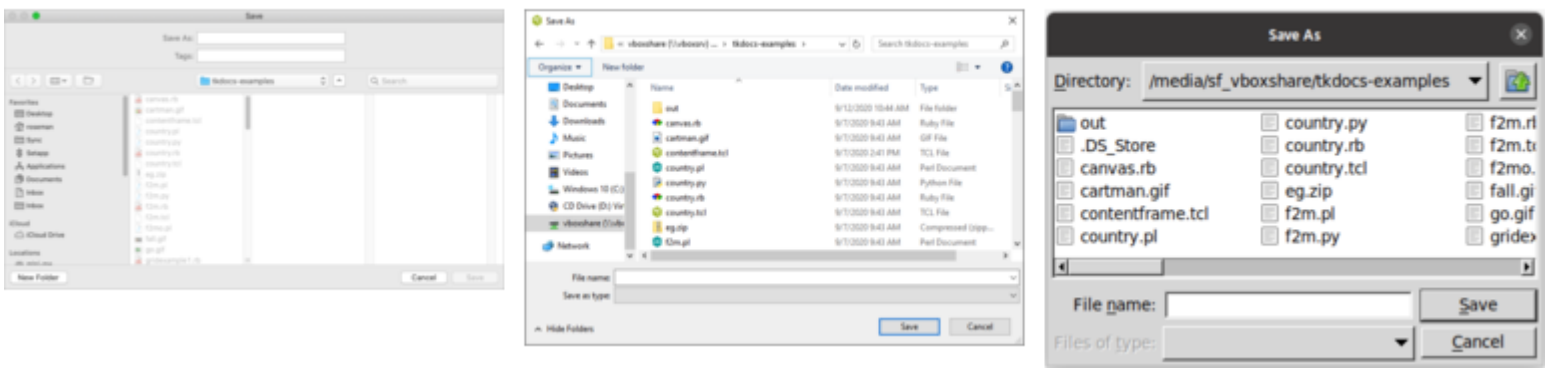
All of these commands produce *modal* dialogs. This means that the commands will not complete until a user submits the dialog. These commands return the full pathname of the file or directory a user has chosen or an empty string if a user cancels out of the dialog.

macOS Windows Linux



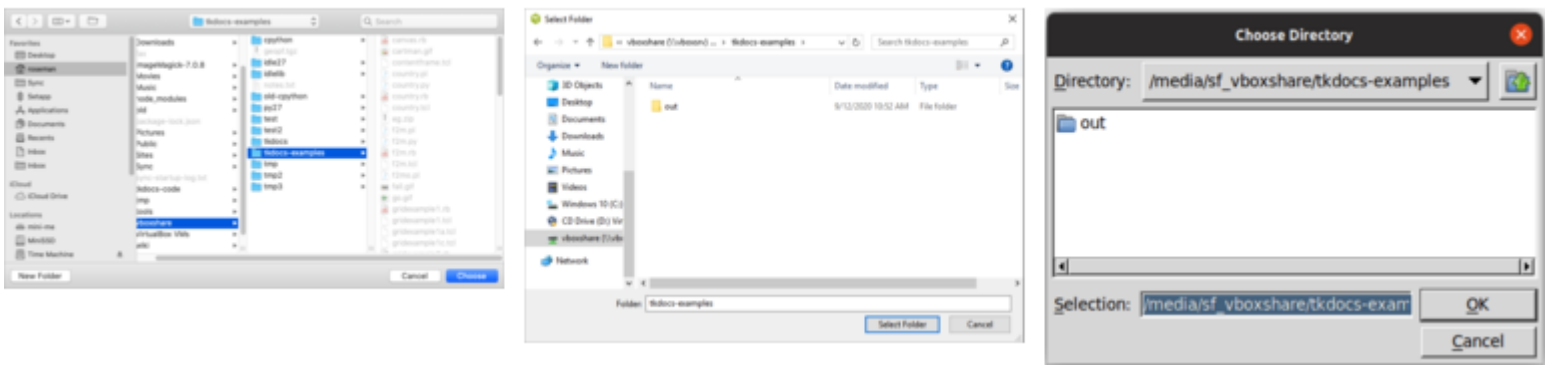
Open file dialogs.

macOS Windows Linux



Save file dialogs.

macOS Windows Linux



Choose directory dialogs.

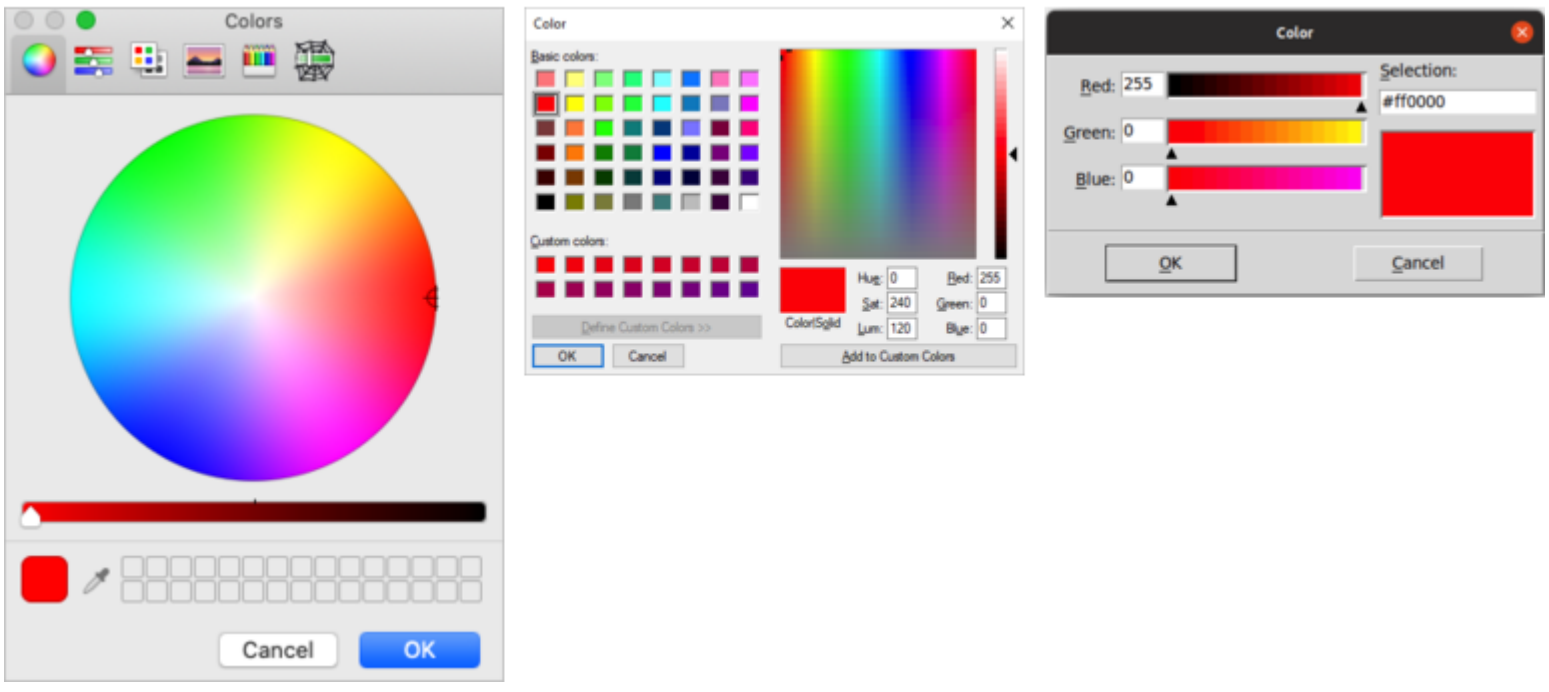
Various options can be passed to these dialogs, allowing you to set the allowable file types, initial directory, default filename, and many more. These are detailed in the getOpenFile (includes `getSaveFile`) and chooseDirectory reference manual pages.

Selecting Colors

Another modal dialog lets users select a color. It will return a color value, e.g. `#ff62b8`. The dialog takes an optional `initialcolor` option to specify an existing color, i.e., that users might want to replace. More information is available in the chooseColor reference manual pages.

```
from tkinter import colorchooser
colorchooser.askcolor(initialcolor='#ff0000')
```

macOS Windows Linux

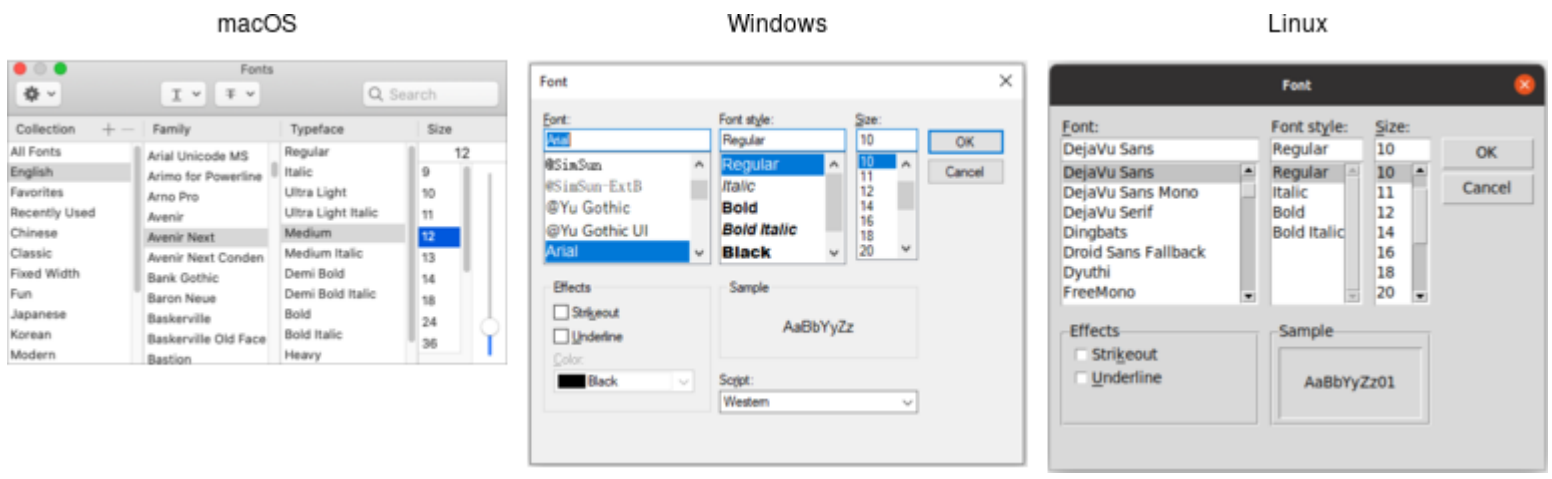


Choose color dialogs.

Selecting Fonts

Tk 8.6 added support for another system dialog: a font chooser. While the file dialogs and color chooser were modal dialogs that block until the dialog is dismissed and then return a result, the font chooser doesn't work like that.

As the font chooser isn't available in Tk 8.5, if your code needs to support older Tk versions, you'll need to take that into account.



Font chooser dialogs.

While the system font dialog is modal on some platforms, e.g., Windows, that's not the case everywhere. On macOS, the system font chooser works more like a floating tool palette in a drawing program, remaining available to change the font for whatever text is selected in your main application window. The Tk font dialog API has to accommodate both models. To do so, it uses callbacks (and virtual events) to notify your application of font changes. Additional details can be found in the fontchooser reference manual pages.

To use the font dialog, first, provide it with an initial font and a callback which will be invoked when a font is chosen. For illustration, we'll have the callback change the font on a label.

```
l = ttk.Label(root, text="Hello World", font="helvetica 24")
l.grid(padx=10, pady=10)

def font_changed(font):
    l['font'] = font

root.tk.call('tk', 'fontchooser', 'configure', '-font', 'helvetica 24', '-command', root.register(font_changed))
root.tk.call('tk', 'fontchooser', 'show')
```

Tkinter has not yet added a convenient way to use this new dialog, so this example code uses the Tcl API directly. You can see the latest work towards a proper Python API and download code at [Issue#28694].

You can query or change the font that is (or will be) displayed in the dialog at any time.

Next, put the dialog onscreen via the `show` method. On platforms where the font dialog is modal, your program will block at this point until the dialog is dismissed. On other platforms, `show` returns immediately; the dialog remains onscreen while your program continues. At this point, a font has not been chosen. There's also a `hide` method to remove it from the screen (not terribly useful when the font dialog is modal).

```
root.tk.call('tk', 'fontchooser', 'show')
root.tk.call('tk', 'fontchooser', 'hide')
```

If the font dialog was modal, and the user chose a font, the dialog would have invoked your callback, passing it a font specification. If they canceled out of the dialog, there'd be no callback. When the dialog isn't modal and the user chooses a font, it will invoke your callback. A <<TkFontchooserFontChanged>> virtual event is also generated; you can retrieve the current font via the dialog's `font` configuration option. If the font dialog is closed, a <<TkFontchooserVisibility>> virtual event is generated. You can also find out if the font dialog is currently visible onscreen via the `visible` configuration option (though changing it is an error; use the `show` and `hide` methods instead).

Because of the significant differences, providing a good user experience on all platforms takes a bit of work. On platforms where the font dialog is modal, it's likely to be invoked from a button or menu item that says, e.g., `Font...`. On other platforms, the button or menu item should toggle between `Show Fonts` and `Hide Fonts`.

If you have several text widgets in your application that can be given different fonts, when one of them gains focus, it should update the font chooser with its current font. This also means that a callback from the font dialog may apply to a different text widget than the one you initially called `show` from! Finally, be aware that the font chooser itself may gain the keyboard focus on some platforms.

As of Tk 8.6.10, there are a few bugs in the font chooser on various platforms. Here's a quick rundown, including workarounds:

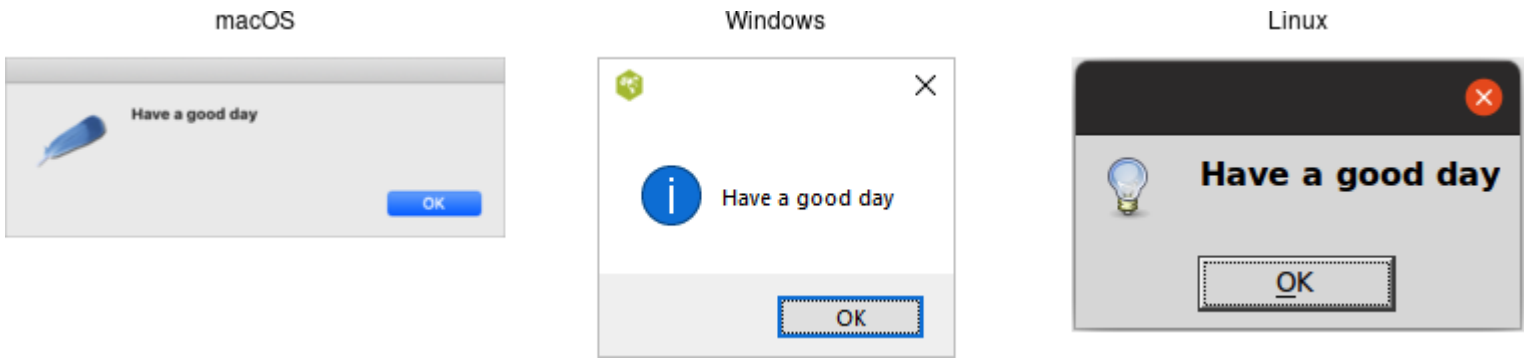
- *on macOS, if you don't provide a font via the `font` configuration option, your callbacks won't be invoked ⇒ always provide an initial font*
- *on X11, if you don't provide values for all configuration options, those you don't include will be reset to their default values ⇒ whenever you change any option, change all of them, even if it's just to their current value*
- *on X11, the font dialog includes an `Apply` button when you provide a callback but omits it when you don't (and just watch for virtual events); however, other bugs mean those virtual events are never generated ⇒ always provide a command callback*
- *on Windows, you can also leave off the `Apply` button by not providing a callback; while virtual events are generated on font changes, the `font` configuration option is never updated ⇒ always provide a command callback, and hold onto the font yourself, rather than trying to ask the font dialog for it later*
- *on Windows, a font change virtual event is not generated if you change the `font` configuration option in your code, though it is on macOS and X11 ⇒ take any necessary actions when you change the font in your code rather than in a virtual event handler*

Because of the differences between platforms and the various bugs, testing is far more important when using the font chooser than the other system dialogs.

Alert and Confirmation Dialogs

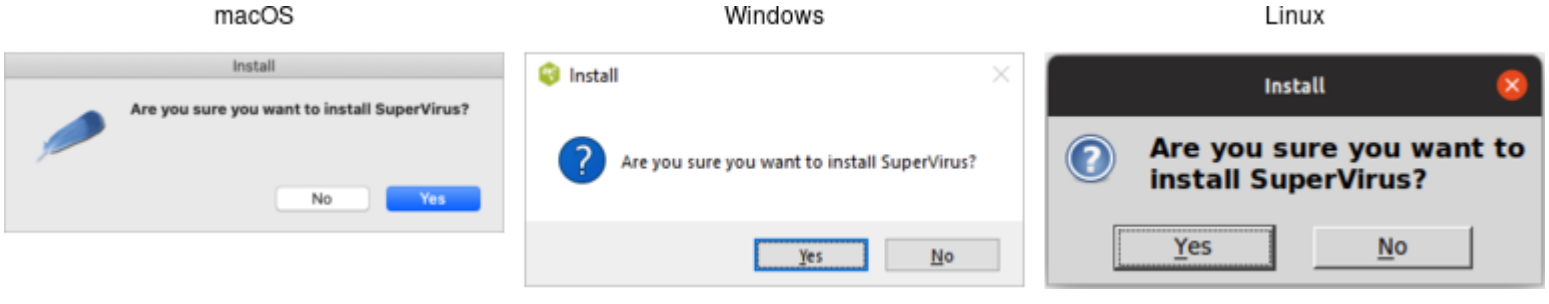
Many applications use various simple modal alerts or dialogs to notify users of an event, ask them to confirm an action, or make another similar choice via clicking on a button. Tk provides a versatile "message box" that encapsulates all these different types of dialogs.

```
from tkinter import messagebox
messagebox.showinfo(message='Have a good day')
```



Simple message boxes.

```
messagebox.askyesno(
          message='Are you sure you want to install SuperVirus?'
          icon='question' title='Install')
```



Example message boxes.

Like the previous dialogs we've seen, these are modal and return the result of a user's action to the caller. The exact return value will depend on the `type` option passed to the command, as shown here:

`ok` *(default)*
⇒ `ok`

`okcancel`
⇒ `ok` or `cancel`

`yesno`
⇒ `yes` or `no`

`yesnocancel`
⇒ `yes`, `no` or `cancel`

`retrycancel`
⇒ `retry` or `cancel`

`abortretryignore`
⇒ `abort`, `retry` or `ignore`

Rather than using a `type` option, Tkinter uses a different method name for each type of dialog. The return values vary with the method:

`showinfo`
⇒ `"ok"`

`showwarning`
⇒ `"ok"`

`showerror`
⇒ `"ok"`

`askokcancel`
⇒ `True` (on ok) or `False` (on cancel)

`askyesno`
⇒ `True` (on yes) or `False` (on no)

`askretrycancel`
⇒ `True` (on retry) or `False` (on cancel)

`askquestion`
⇒ `"yes"` or `"no"`

`askyesnocancel`
⇒ `True` (on yes), `False` (on no), or `None` (on cancel)

Admittedly, the Tkinter `messagebox` API isn't the most consistent. It mixes return types (strings or booleans), there is some duplication (`askyesno` and `askquestion`), and one underlying dialog type (`abortretryignore`) is omitted.

The full list of possible options is shown here:

`type`
As described above.

`message`
The main message displayed inside the alert.

`detail`
A secondary message (if needed).

`title`
Title for the dialog window. Not used on macOS.

`icon`
Icon, one of `info` (default), `error`, `question`, or `warning`.

`default`
Default button, e.g., `ok` or `cancel` for an `okcancel` dialog.

`parent`
Window of your application this dialog is being posted for.

Additional details can be found in the reference manual.

These new messagebox dialogs replace the older `tk_dialog` command, which does not comply with current platform user interface conventions.

Rolling Your Own

If you need to create your own modal dialogs, there are a few things you'll need to take care of. We've covered most of them earlier in the chapter, e.g., setting up window styles, positioning the window, etc.

First, you need to ensure that users can only interact with your dialog. You can use `grab_set` to do this.

If you want your dialog function to block your application (i.e., the call to create the dialog shouldn't return until the dialog is dismissed), this is also possible. There's no reason you'd *need* to do this, as you can respond to callbacks, event bindings, etc., while running the normal event loop, destroy the dialog and move on.

This somewhat cryptic example includes the main steps needed to create a modal dialog.

```
ttk.Entry(root).grid()   # something to interact with
def dismiss ():
    dlg.grab_release()
    dlg.destroy()

dlg = Toplevel(root)
ttk.Button(dlg, text="Done", command=dismiss).grid()
dlg.protocol("WM_DELETE_WINDOW", dismiss) # intercept close button
dlg.transient(root)   # dialog window is related to main
dlg.wait_visibility() # can't grab until window appears, so we wait
dlg.grab_set()        # ensure all input goes to our window
dlg.wait_window()     # block until window is destroyed
```

Application code blocking like this is an example of running a nested event loop that we generally recommend against, though it may be more convenient in certain circumstances.

Tkinter's standard library includes a `simpledialog` module that helps with building your own dialogs. We don't recommend using it directly because it uses the classic Tk widgets rather than the newer themed widgets. However, it does illustrate how to use some of the techniques for making dialogs behave that we just covered.

Organizing Complex Interfaces

If you have a complex user interface, you'll need to find ways to organize it that don't overwhelm your users. There are several different approaches to doing this. Both general-purpose and platform-specific human interface guidelines are good resources when designing your user interface.

When we talk about complexity in this chapter, we don't mean the underlying technical complexity of how the program is implemented. Instead, we mean how it's presented to users. A user interface can be pulled together from many different modules, built from hundreds of widgets combined in a deeply nested hierarchy, but that doesn't mean users need to perceive it as complex.

Multiple windows

One benefit of using multiple windows in an application can be to simplify the user interface. Done well, it can require users to focus only on the contents of one window at a time to complete a task. Forcing them to focus on or switch between several windows can also have the opposite effect. Similarly, showing only the widgets relevant to the current task (i.e., via `grid`) can help simplify the user interface.

White space

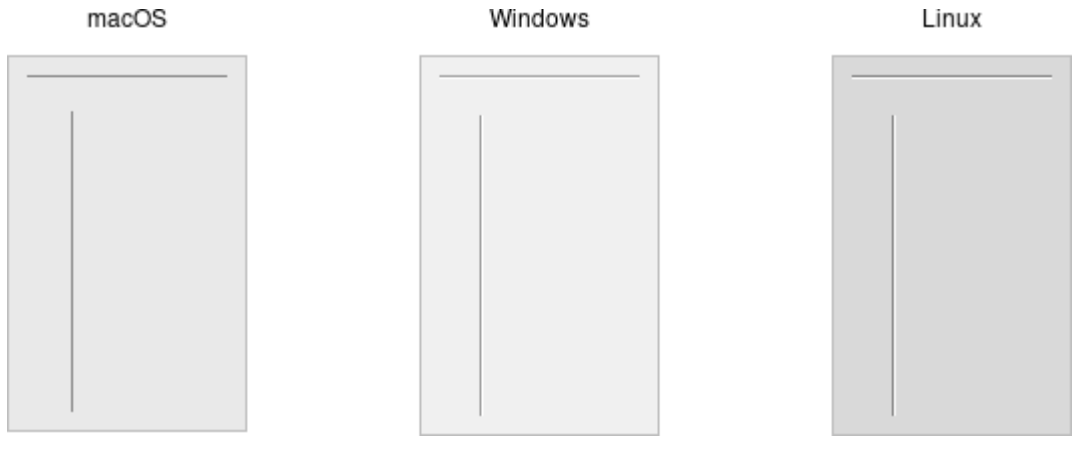
If you do need to display a large number of widgets onscreen at the same time, think about how to organize them visually. We've seen how `grid` makes it easy to align widgets with each other. White space is another useful aid. Place related widgets close to each other (possibly with an explanatory label immediately above) and separate them from other widgets by white space. This helps users organize the user interface in their own minds.

The recommended amount of white space around different widgets, between groups of widgets, around borders, etc., is highly platform-specific. While you can do an adequate job without worrying about exact pixel numbers, you'll need to tune this for each platform if you want a highly polished user interface.

Separator

- Widget Roundup
- Reference Manual

A second approach to grouping widgets in one display is to place a thin horizontal or vertical rule between groups of widgets; often, this can be more space-efficient than using white space, which may be relevant for a tight display. Tk provides a simple **separator** widget for this purpose.



Separator widgets.

Separators are created using the **`ttk.Separator`** class:

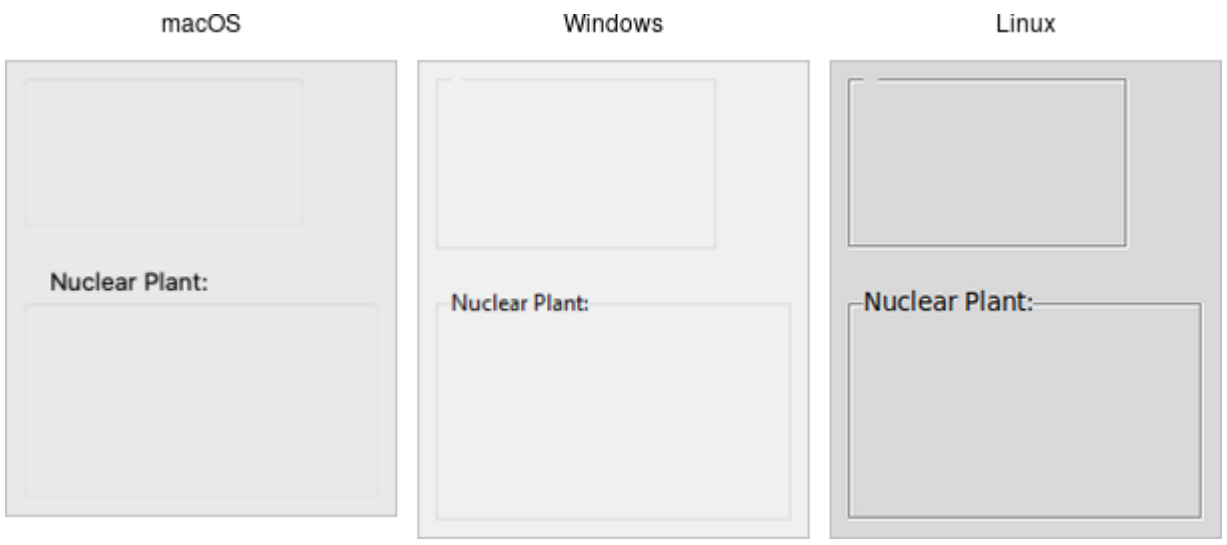
```
s = ttk.Separator(parent, orient=HORIZONTAL)
```

The `orient` option may be specified as either `horizontal` or `vertical`.

Label Frames

- Widget Roundup
- Reference Manual

A **labelframe** widget, also commonly known as a *group box*, provides another way to group related components. It acts like a normal `ttk::frame`, in that it contains other widgets that you `grid` inside it. However, it is visually set off from the rest of the user interface. You can optionally provide a text label to be displayed outside the labelframe.



Labelframe widgets.

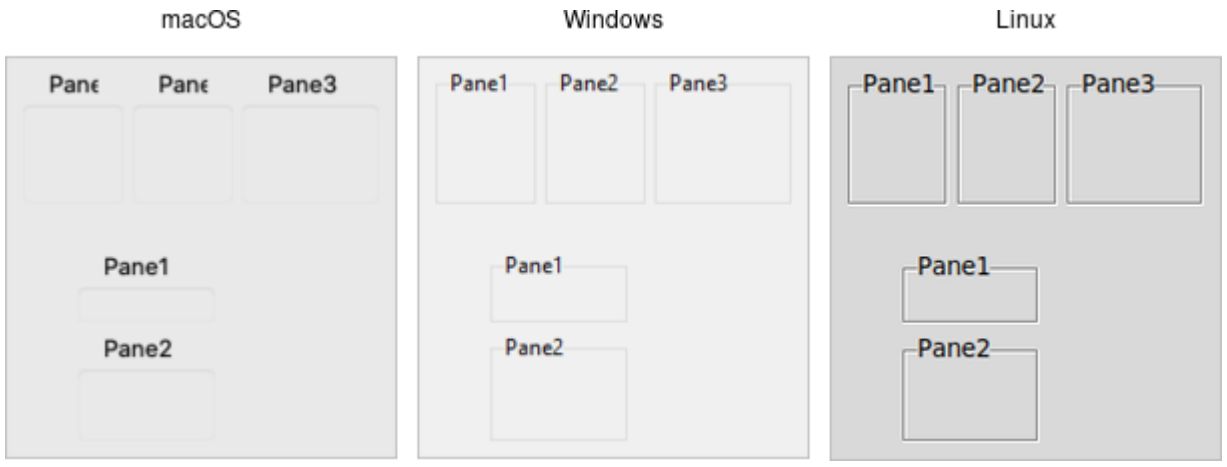
Labelframes are created using the **`ttk.Labelframe`** class:

```
lf = ttk.Labelframe(parent, text='Label')
```

Paned Windows

- Widget Roundup
- Reference Manual

A **panedwindow** widget lets you stack two or more resizable widgets above and below each other (or to the left and right). Users can adjust their relative heights (or widths) by dragging a *sash* located between the panes. Typically the widgets you're adding to a panedwindow will be frames containing many other widgets.



Panedwindow widgets (shown here managing several labelframes).

Panedwindows are created using the **`ttk.Panedwindow`** class:

```
p = ttk.Panedwindow(parent, orient=VERTICAL)
# two panes, each of which would get widgets gridded into it:
f1 = ttk.Labelframe(p, text='Pane1', width=100, height=100)
f2 = ttk.Labelframe(p, text='Pane2', width=100, height=100)
p.add(f1)
p.add(f2)
```

A panedwindow is either `vertical` (its panes are stacked vertically on top of each other) or `horizontal`. Importantly, each pane you add to the panedwindow must be a *direct child* of the panedwindow itself.

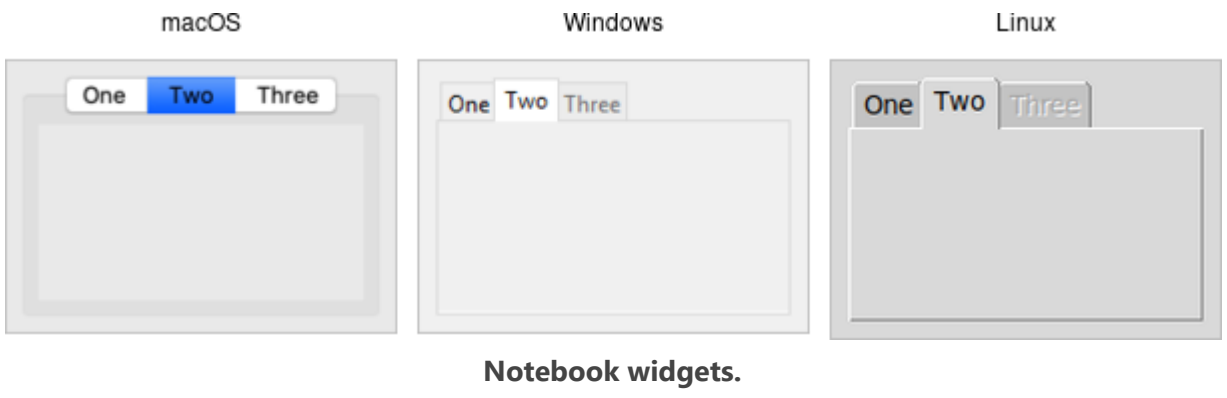
Calling the `add` method adds a new pane at the end of the list of panes. The `insert` *`position subwindow`* method allows you to place the pane at the given position in the list of panes (0..n-1). If the pane is already managed by the panedwindow, it will be moved to the new position. You can use the `forget` *`subwindow`* to remove a pane from the panedwindow (you can also pass a position instead of a subwindow).

You can assign relative weights to each pane so that if the overall panedwindow resizes, certain panes will be allocated more space than others. As well, you can adjust the position of each sash between items in the panedwindow. See the command reference for details.

Notebook

- Widget Roundup
- Reference Manual

A **notebook** widget uses the metaphor of a tabbed notebook to let users switch between one of several *pages* using an index *tab*. Unlike with paned windows, users only see a single page (akin to a pane) at a time.



Notebook widgets.

Notebooks are created using the **`ttk.Notebook`** class:

```
n = ttk.Notebook(parent)
f1 = ttk.Frame(n)   # first page, which would get widgets gridded into it
f2 = ttk.Frame(n)   # second page
n.add(f1, text='One')
n.add(f2, text='Two')
```

The operations on tabbed notebooks are similar to those on panedwindows. Each page is typically a frame and again must be a direct child (subwindow) of the notebook itself. Add a new page and its associated tab after the last tab with the `add` *`subwindow ?option value...?`* method. The `text` tab option sets the label on the tab; also useful is the `state` tab option, which can have the value `normal`, `disabled` (not selectable), or `hidden`.

To insert a tab at somewhere other than the end of the list, use the `insert` *`position subwindow ?option value...?`*, and to remove a given tab, use the `forget` method, passing it either the position (0..n-1) or the tab's subwindow. You can retrieve the list of all subwindows contained in the notebook via the `tabs` method.

To retrieve the currently selected subwindow, call the `select` method, and change the selected tab by passing either the tab's position or the subwindow itself as a parameter.

To change a tab option (like the text label on the tab or its state), you can use the `tab(tabid, option=value)` method (where `tabid` is again the tab's position or subwindow); omit the `=value` to return the current value of the option.

Notebook widgets generate a `<<NotebookTabChanged>>` virtual event whenever a new tab is selected.

Again, there are a variety of less frequently used options and commands detailed in the command reference.

Fonts, Colors, Images

This chapter describes how Tk handles fonts, colors, and images. We've touched on all of these before, but here we'll provide a more in-depth treatment.

Fonts

Tk's label widget allows you to change the font used to display text via the `font` configuration option. The canvas and text widgets, covered in the following chapters, also allow you to specify fonts. Other themed widgets that display text may not have a `font` configuration option, but their fonts can be changed using styles.

We'll cover styles in detail later. In essence, they replace the old way of tweaking multiple configuration options on individual widgets. Instead, fonts, colors, and other settings that control appearance can be bundled together in a style. That style can then be applied to multiple widgets. It's akin to the difference between hardcoding display-oriented markup inside HTML pages vs. using CSS to keep display-specific information separate.

As with many things in Tk, the default fonts are usually a good choice. If you need to make changes, this section shows you the best way to do so, using *named fonts*. Tk includes named fonts suitable for use in all different components of your user interface. They take into account the conventions of the specific platform you're running on. You can also specify your own fonts when you need additional flexibility.

The font command reference provides full details on specifying fonts, as well as other font-related operations.

Many older Tk programs hardcoded fonts, using either the "family size style" format we'll see below, X11 font names, or the older and more arcane X11 font specification strings. These applications looked increasingly dated as platforms evolved. Worse, fonts were often specified on a per-widget basis, leaving font decisions spread throughout the code. Named fonts, particularly the standard fonts that Tk provides, are a far better solution. Reviewing and updating font decisions is an easy and important change to make in any existing application.

Standard Fonts

Each platform defines specific fonts that should be used for standard user interface elements. Tk encapsulates many of these decisions into a standard set of named fonts. They are available on all platforms, though the exact font used will vary. This helps abstract away platform differences. Of course, the standard widgets use these named fonts. The predefined fonts are:

`TkDefaultFont`
Default for items not otherwise specified.

`TkTextFont`
Used for entry widgets, listboxes, etc.

`TkFixedFont`
A standard fixed-width font.

`TkMenuFont`
The font used for menu items.

`TkHeadingFont`
Font for column headings in lists and tables.

`TkCaptionFont`
A font for window and dialog caption bars.

`TkSmallCaptionFont`
A smaller caption font for tool dialogs.

`TkIconFont`
A font for icon captions.

`TkTooltipFont`
A font for tooltips.

Platform-Specific Fonts

Tk provides additional named fonts to help you comply with less common situations on specific platforms. Individual platform guidelines detail how and where these fonts should be used. These fonts are only defined on specific platforms. You'll need to take that into account if your application is portable across platforms.

Tk on X11 recognizes any valid X11 font name (see, e.g., the `xlsfonts` command). However, these can vary with the operating system, installed software, and the configuration of the individual machine. There is no guarantee that a font available on your X11 system has been installed on any other X11 system.

On Windows, Tk provides named fonts for all the fonts that can be set in the "Display" Control Panel. It recognizes the following font names: `system`, `ansi`, `device`, `systemfixed`, `ansifixed`, and `oemfixed`.

On macOS, the Apple Human Interface Guidelines (HIG) specifies a number of additional fonts. Tk recognizes the following names: `systemSystemFont`, `systemSmallSystemFont`, `systemApplicationFont`, `systemViewsFont`, `systemMenuItemFont`, `systemMenuItemCmdKeyFont`, `systemPushButtonFont`, `systemAlertHeaderFont`, `systemMiniSystemFont`, `systemDetailEmphasizedSystemFont`, `systemEmphasizedSystemFont`, `systemSmallEmphasizedSystemFont`, `systemLabelFont`, `systemMenuTitleFont`, `systemMenuItemMarkFont`, `systemWindowTitleFont`, `systemUtilityWindowTitleFont`, `systemToolbarFont`, and `systemDetailSystemFont`.

Working with Named Fonts

Tk provides several operations that help you work with named fonts. You can start by getting a list of all the currently defined named fonts.

```
from tkinter import font
font.names()
```

You can find out the actual system font represented by an abstract named font. This consists of the `family` (e.g., `Times` or `Helvetica`), the `size` (in points if positive, in pixels if negative), the `weight` (`normal` or `bold`), the `slant` (`roman` or `italic`), and boolean attributes for `underline` and `overstrike`. You can find out the font's `metrics` (how tall characters in the font can be and whether it is monospaced), and even `measure` how many pixels wide a piece of text rendered in the font would be.

```
>>> from tkinter import font
>>> f = font.nametofont('TkTextFont')
>>> f.actual()
{'family': '.AppleSystemUIFont', 'size': 13, 'weight': 'normal', 'slant': 'roman', 'underline': 0, 'overstrike': 0}
>>> f.metrics()
{'ascent': 13, 'descent': 3, 'linespace': 16, 'fixed': 0}
>>> f.measure('The quick brown fox')
124
```

Tkinter provides a `Font` class to hold information about a named font. You can create an instance of this class from the name of a font using the `nametofont` function. When you use named fonts in your application (e.g., via a label's `font` configuration option), you can supply either the font name (as a string) or a `Font` instance.

Trying these in an interactive shell and got an error? Even though we're not displaying anything onscreen, you need to initialize Tk before using the various font functions.

You can also create your own fonts, which can then be used exactly like the predefined ones. To do so, choose a name for the font and specify its font attributes as above.

```
from tkinter import font
highlightFont = font.Font(family='Helvetica', name='appHighlightFont', size=12, weight='bold')
ttk.Label(root, text='Attention!', font=highlightFont).grid()
```

If you don't supply a name, Tkinter will generate one, which you can retrieve via *`font`*`.name` or `str(`*`font`*`)`. It's usually best to supply one.

The `family` attribute specifies the font family. Tk ensures the names `Courier`, `Times`, and `Helvetica` are available, though they may be mapped to an appropriate monospaced, serif, or sans-serif font). Other fonts installed on your system can be used, but the usual caveats about portability apply. You can get the names of all available families with:

```
font.families()
```

You can change the attributes of a named font using its `configure` method. You might do this in response to menu options allowing users to zoom in or out, i.e., increasing or decreasing font sizes.

Font Descriptions

Another way to specify fonts is via a list of attributes, starting with the font family, and optionally including a size and one or more style options. Some examples of this are `Helvetica`, `Helvetica 12`, `Helvetica 12 bold`, and `Helvetica 12 bold italic`. These font descriptions can be used anywhere you'd use a named font, e.g., a `font` configuration option.

In general, switching from font descriptions to named fonts is advisable to isolate font differences in one location in the program.

Colors

As with fonts, there are various ways to specify colors. Full details can be found in the colors command reference.

In general, Tk widgets default to the right colors for most situations. If you'd like to change colors, you'll do so via widget-specific commands or options, e.g., the label's `foreground` and `background` configuration options. For most themed widgets, color changes are specified through styles, not by changing the widget directly.

You can specify colors via RGB, as you would in HTML or CSS, e.g. `#3FF` or `#FF016A`. Tk also recognizes names such as `red`, `black`, `grey50`, `light blue`, etc.

Tk recognizes the standard names for colors defined by X11. You can find a complete list in the command reference (noted above).

As with fonts, both macOS and Windows specify many system-specific abstract color names (again, see the reference). The actual color these correspond to may depend on system settings and can change over time, e.g., dark mode, text highlight colors, default backgrounds.

If needed, you can find the RGB values (each between 0 and 65535) for a color using the `winfo_rgb` method on any widget.

```
root.winfo_rgb('red')
```

It should probably go without saying, but restraint in the use of colors is highly advisable!

Images

We've seen the basics of using images already, displaying them in labels or buttons, for example. We create an image object, usually from a file on disk.

```
imgobj = PhotoImage(file='myimage.gif')
label['image'] = imgobj
```

Out of the box, Tk 8.5 includes support for GIF and PPM/PNM images. Tk 8.6 added PNG to this short list. However, a Tk extension library called `Img` adds support for many others: BMP, XBM, XPM, JPEG, PNG (if you're using 8.5), TIFF, etc. Though not included directly in the Tk core, Img is usually included with other packaged distributions (e.g., ActiveTcl).

Instead of using Tk's Img extension, Tkinter uses a made-for-Python image library called `PIL` (Python Imaging Library). More specifically, we'll use a more up-to-date fork of PIL called `pillow`. As it doesn't come bundled with Python, you'll normally need to install it. You should be able to do so via, e.g., `pip install Pillow`.

```
from PIL import ImageTk, Image
myimg = ImageTk.PhotoImage(Image.open('myimage.png'))
```

The `ImageTk.PhotoImage` call provides a drop-in replacement for Tk's `PhotoImage` but supports the broader range of image types.

Tk's images are actually quite powerful and sophisticated and provide various ways to inspect and modify images. You can find out more from the image command reference and the photo command reference.

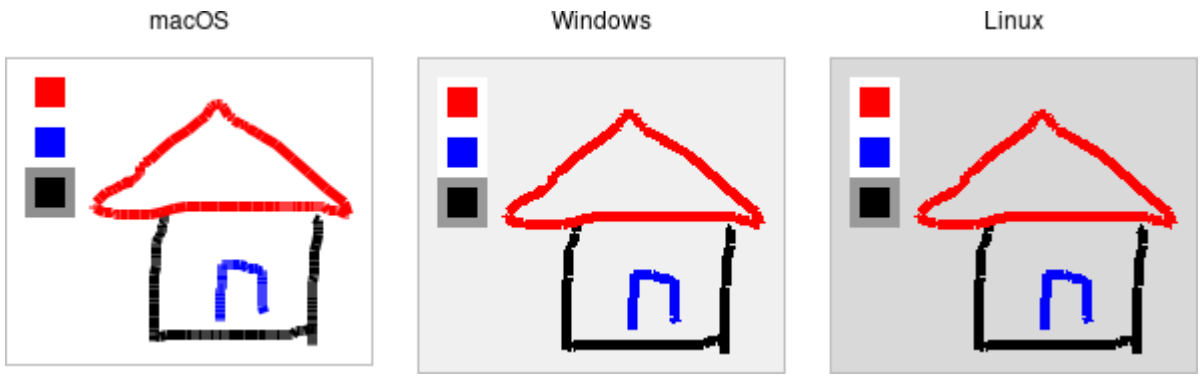
The types of multi-color images we've seen here are referred to in Tk as photo images. Tk also provides a second type, two-bit bitmap images, which were widely used in the '90s when most Unix workstations used quite large (compared with PCs) monitors, but they were only black and white. Needless to say, color is mostly de rigueur these days, so updating to full-color images for icons and so on is highly advisable. Though in what some may consider retro-styling, some flat and material design schemes have returned to black and white. Plus ça change...

Canvas

- Widget Roundup
- Reference Manual

A **canvas** widget manages a 2D collection of graphical objects — lines, circles, text, images, other widgets, and more. Tk's canvas is an incredibly powerful and flexible widget and truly one of Tk's highlights. It is suitable for a wide range of uses, including drawing or diagramming, CAD tools, displaying or monitoring simulations or actual equipment, and building more complex widgets out of simpler ones.

Note: Canvas widgets are part of the classic Tk widgets, not the themed Tk widgets.



Canvas widgets.

Canvas widgets are created using the `Canvas` class:

```
canvas = Canvas(parent, width=500, height=400, background='gray75')
```

You'll often provide a width and height, either in pixels or any of the other standard distance units. As always, you can ask the geometry manager to expand it to fill the available space in the window. You might provide a default background color for the canvas, specifying colors as you learned about in the last chapter. Canvas widgets also support other appearance options like `relief` and `borderwidth` that we've used before.

Canvas widgets have a tremendous number of features, and we won't cover everything here. Instead, we'll start with a simple example, a freehand sketching tool, and incrementally add new pieces, each showing another feature of canvas widgets.

Creating Items

When you create a new canvas widget, it is essentially a large rectangle with nothing on it, truly a blank canvas, in other words. To do anything useful with it, you'll need to add *items* to it. There are a wide variety of different *types* of items you can add. Here, we'll add a simple *line* item to the canvas.

To create a line, you need to specify its starting and ending *coordinates*. Coordinates are expressed as the number of pixels away from the top-left corner, horizontally and vertically, i.e. (*x*,*y*). The pixel at the top-left corner, known as the *origin*, has coordinates (0,0). The "*x*" value increases as you move to the right, and the "*y*" value increases as you move down. A line is described by two points, which we'd refer to as (*x0*,*y0*) and (*x1*,*y1*). This code creates a line from (10,5) to (200,50):

```
canvas.create_line(10, 5, 200, 50)
```

The `create_line` method returns an item *id* (an integer) that uniquely refers to this item. We'll see how it can be used shortly. Often, we don't need to refer to the item later and can ignore the returned id.

A Simple Sketchpad

Let's start our simple sketchpad example. For now, we'll implement freehand drawing on the canvas with the mouse. We create a canvas widget and attach event bindings to it to capture mouse clicks and drags. When the mouse is first pressed, we'll remember that location as the "start" of our next line. As the mouse is moved with the mouse button held down, we create a line item from this "start" position to the current mouse location. This current location becomes the "start" position for the next line item. Every mouse drag creates a new line item.

```
from tkinter import *
from tkinter import ttk

def savePosn(event):
    global lastx, lasty
    lastx, lasty = event.x, event.y

def addLine(event):
    canvas.create_line((lastx, lasty, event.x, event.y))
    savePosn(event)

root = Tk()
root.columnconfigure(0, weight=1)
root.rowconfigure(0, weight=1)

canvas = Canvas(root)
canvas.grid(column=0, row=0, sticky=(N, W, E, S))
canvas.bind("<Button-1>", savePosn)
canvas.bind("<B1-Motion>", addLine)

root.mainloop()
```

Again, in this simple example, we're using global variables to store the start position. In practice, we'd encapsulate all of this in a Python class. Here's one way we could do that. Note that this example creates a subclass of `Canvas`, which is treated like any other widget in the code. We could have equally well used a standalone class, as we did with the "feet to meters" example.

```
from tkinter import *
from tkinter import ttk

class Sketchpad(Canvas):
    def __init__(self, parent, **kwargs):
        super().__init__(parent, **kwargs)
        self.bind("<Button-1>", self.save_posn)
        self.bind("<B1-Motion>", self.add_line)

    def save_posn(self, event):
        self.lastx, self.lasty = event.x, event.y

    def add_line(self, event):
        self.create_line((self.lastx, self.lasty, event.x, event.y))
        self.save_posn(event)

root = Tk()
root.columnconfigure(0, weight=1)
root.rowconfigure(0, weight=1)

sketch = Sketchpad(root)
sketch.grid(column=0, row=0, sticky=(N, W, E, S))

root.mainloop()
```

Try it out - drag the mouse around the canvas to create your masterpiece.

Item Attributes

When creating items, you can also specify one or more item *attributes*, affecting how it appears. For example, we can specify that the line should be red and three pixels wide.

```
canvas.create_line(10, 10, 200, 50, fill='red', width=3)
```

The exact set of attributes will vary according to the type of item. Some commonly used ones are:

`fill`
: color to draw the object

`width`

line width of the item (or its outline)

`outline`
for filled shapes like rectangles, the color to draw the item's outline

`dash`
draw a dashed line instead of a solid one, e.g., `2 4 6 4` alternates short (2 pixels) and long (6 pixels) dashes with 4 pixels between

`stipple`
instead of a solid fill color, use a pattern, typically `gray75`, `gray50`, `gray25`, or `gray12`; stippling is currently not supported on macOS

`state`
assign a state of `normal` (default), `disabled` (item event bindings are ignored), or `hidden` (removed from display)

`disabledfill, disabledwidth, ...`
if the item's `state` is set to `disabled`, the item will display using these variants of the usual attributes

`activefill, activewidth, ...`
when the mouse pointer is over the item, it will display using these variants of the usual attributes

If you have canvas items that change state, creating the item with both the regular and `disabled*` attribute variants can simplify your code. You simply need to change the item's `state` rather than writing code to change multiple display attributes. The same applies to the `active*` attribute variants. Both encourage a more declarative style that can remove a lot of boilerplate code.

Just like with Tk widgets, you can change the attributes of canvas items after they're created.

```
id = canvas.create_line(0, 0, 10, 10, fill='red')
...
canvas.itemconfigure(id, fill='blue', width=2)
```

Item Types

Canvas widgets support a wide variety of item types.

Line

Our sketchpad created simple line items, each a single segment with a start point and an end point. Lines items can also consist of multiple segments.

```
canvas.create_line(10, 10, 200, 50, 90, 150, 50, 80)
```

Lines have several interesting additional attributes, allowing for drawing curves, arrows, and more.

`arrow`
place an arrowhead at the start (`first`), end (`last`), or both ends (`both`); default is `none`

`arrowshape`
allows changing the appearance of any arrowheads

`capstyle`
for wide lines without arrowheads, this controls how the end of lines are drawn; one of `butt` (default), `projecting`, or `round`

`joinstyle`
for wide lines with multiple segments, this controls drawings of each vertex; one of `round` (default), `bevel`, or `miter`

`smooth`
if specified as `true` (or `bezier`), draws a smooth curve (via quadratic splines) between multiple segments rather than using straight lines; `raw` specifies a different type of curve (cubic splines)

`splinesteps`
controls the smoothness of curved lines, i.e., those with the `smooth` option set

Rectangle

Rectangles are specified by the coordinates of opposing corners, e.g., top-left and bottom-right. They can be filled in (via `fill`) with one color, and the `outline` given a different color.

```
canvas.create_rectangle(10, 10, 200, 50, fill='red', outline='blue')
```

Oval

Ovals items work exactly the same as rectangles.

```
canvas.create_oval(10, 10, 200, 150, fill='red', outline='blue')
```

Polygon

Polygon items allow you to create arbitrary shapes as defined by a series of points. The coordinates are given in the same way as multipoint lines. Tk ensures the polygon is "closed," attaching the last point to the first if needed. Like ovals and rectangles, they can have separate `fill` and `outline` colors. They also support the `joinstyle`, `smooth`, and `splinesteps` attributes of line items.

```
canvas.create_polygon(10, 10, 200, 50, 90, 150, 50, 80, 120, 55, fill='red', outline='blue')
```

Arc

Arc items draw a portion of an oval; think of one piece of a pie chart. Its display is controlled by three attributes:

- `start`: how far along the oval the arc should start, in degrees (0 is the 3-o'clock position)
- The `extent`: how many degrees "wide" the arc should be, positive for counter-clockwise from the start, negative for clockwise
- `style`: one of `pieslice` (the default), `arc` (draws just the outer perimeter), or `chord` (draws the area between a line connecting the start and end points of the arc and the outer perimeter).

```
canvas.create_arc(10, 10, 200, 150, fill='yellow', outline='black', start=45, extent=135, width=5)
```

Image

Image items can display arbitrary images. By default, the item is centered at the coordinates you specify, but this can be changed with the `anchor` option, e.g., `nw` means the coordinates are where to put the top-left of the image.

```
myimg = PhotoImage(file='pretty.png')
canvas.create_image(10, 10, image=myimg, anchor='nw')
```

There's also a `bitmap` item type for images having only two colors, which can be changed via `foreground` and `background`. They're not commonly used these days.

Text

Text items can display a block of text. Positioning the text works the same as with image items. Specify the text to display using the `text` attribute. All of the text in the item will have the same color (specified by the `fill` attribute) and the same font (specified by a `font` attribute).

The text item can display multiple lines of text if you embed `\n` in the text. Alternatively, you can have the item automatically wrapped into multiple lines by providing a `width` attribute to represent the maximum width of a line. The alignment of multiple lines of text can be set using the `justify` attribute, which can be one of `left` (the default), `right`, or `center`.

```
canvas.create_text(100, 100, text='A wonderful story', anchor='nw', font='TkMenuFont', fill='red')
```

Widget

One of the coolest things you can do with the canvas widget is embed *other widgets* inside it. This can be a lowly button, an entry (think in-place editing of text items), a listbox, a frame itself containing a complex set of widgets... anything! Remember when we said way back when that a canvas widget could act as a geometry manager? This is what we meant.

Canvas items that display other widgets are known as *window* items (Tk's longstanding terminology for widgets). They are positioned like text and image items. You can give them explicit `width` and `height` attributes; they default to the widget's preferred size. Finally, it's important that the widget you're placing on the canvas (via the `window`) attribute be a child widget of the canvas.

```
b = ttk.Button(canvas, text='Implode!')
canvas.create_window(10, 10, anchor='nw', window=b)
```

Modifying Items

We've seen how you can modify the configuration options on an item — its color, width, etc. There are several other things you can do with items.

To delete items, use the `delete` method.

To change an item's size and position, you can use the `coords` method. You supply new coordinates for the item, specified the same way as when you first created it. Calling this method without a new set of coordinates will return the current coordinates of the item. You can use the `move` method to offset one or more items horizontally or vertically from their current position.

All items are ordered from top to bottom in what's called the stacking order. If an item later in the stacking order overlaps an item below it, the first item will be drawn on top of the second. The `raise` (`lift` in Tkinter) and `lower` methods allow you to adjust an item's position in the stacking order.

There are several more operations detailed in the reference manual to modify items and retrieve information about them.

Event Bindings

We've already seen that the canvas widget as a whole, like any other Tk widget, can capture events using the `bind` command.

You can also attach bindings to individual items in the canvas (or groups of them, as we'll see in the next section using tags). So if you want to know whether or not a particular item has been clicked on, you don't need to watch for mouse click events for the canvas as a whole and then figure out if that click happened on your item. Tk will take care of all this for you.

To capture these events, you use a bind command built into the canvas. It works exactly like the regular bind command, taking an event pattern and a callback. The only difference is you specify the canvas item this binding applies to.

```
canvas.tag_bind(id, '<1>', ...)
```

Note the difference between the item-specific `tag_bind` *method and the widget-level* `bind` *method.*

Let's add some code to our sketchpad example to allow changing the drawing color. We'll first create a few different rectangle items, each filled with a different color. We'll then attach a binding to each of these. When they're clicked on, they'll set a global variable to the new drawing color. Our mouse motion binding will look at that variable when creating the line segments.

```
color = "black"
def setColor(newcolor):
    global color
    color = newcolor

def addLine(event):
    global lastx, lasty
    canvas.create_line((lastx, lasty, event.x, event.y), fill=color)
    lastx, lasty = event.x, event.y

id = canvas.create_rectangle((10, 10, 30, 30), fill="red")
canvas.tag_bind(id, "<Button-1>", lambda x: setColor("red"))
id = canvas.create_rectangle((10, 35, 30, 55), fill="blue")
canvas.tag_bind(id, "<Button-1>", lambda x: setColor("blue"))
id = canvas.create_rectangle((10, 60, 30, 80), fill="black")
canvas.tag_bind(id, "<Button-1>", lambda x: setColor("black"))
```

Tags

We've seen that every canvas item can be referred to by a unique id number. There is another handy and powerful way to refer to items on a canvas, using *tags*.

A tag is just an identifier of your creation, something meaningful to your program. You can attach tags to canvas items; each item can have any number of tags. Unlike item id numbers, which are unique for each item, many items can share the same tag.

What can you do with tags? We saw that you can use the item id to modify a canvas item (and we'll see soon there are other things you can do to items, like move them around, delete them, etc.). Any time you can use an item id, you can use a tag. For example, you can change the color of all items having a specific tag.

Tags are a good way to identify collections of items in your canvas (items in a drawn line, items in a palette, etc.). You can use tags to correlate canvas items to particular objects in your application (for example, tag all canvas items that are part of the robot with id #X37 with the tag "robotX37"). With tags, you don't have to keep track of the ids of canvas items to refer to groups of items later; tags let Tk do that for you.

You can assign tags when creating an item using the `tags` item configuration option. You can add tags later with the `addtag` method or remove them with the `dtags` method. You can get the list of tags for an item with the `gettags` method or return a list of item id numbers having the given tag with the `find` command.

For example:

```
>>> c = Canvas(root)
>>> c.create_line(10, 10, 20, 20, tags=('firstline', 'drawing'))
1
>>> c.create_rectangle(30, 30, 40, 40, tags=('drawing'))
2
>>> c.addtag('rectangle', 'withtag', 2)
>>> c.addtag('polygon', 'withtag', 'rectangle')
>>> c.gettags(2)
('drawing', 'rectangle', 'polygon')
>>> c.dtag(2, 'polygon')
>>> c.gettags(2)
('drawing', 'rectangle')
>>> c.find_withtag('drawing')
(1, 2)
```

As you can see, methods like `withtag` accept either an individual item or a tag; in the latter case, they will apply to all items having that tag (which could be none). The `addtag` and `find` methods have many other options, allowing you to specify items near a point, overlapping a particular area, etc.

Let's use tags first to put a border around whichever item in our color palette is currently selected.

```
def setColor(newcolor):
    global color
    color = newcolor
    canvas.dtag('all', 'paletteSelected')
    canvas.itemconfigure('palette', outline='white')
    canvas.addtag('paletteSelected', 'withtag', 'palette%s' % color)
    canvas.itemconfigure('paletteSelected', outline='#999999')

id = canvas.create_rectangle((10, 10, 30, 30), fill="red", tags=('palette', 'palettered'))
id = canvas.create_rectangle((10, 35, 30, 55), fill="blue", tags=('palette', 'paletteblue'))
id = canvas.create_rectangle((10, 60, 30, 80), fill="black", tags=('palette', 'paletteblack', 'paletteSelected'))

setColor('black')
canvas.itemconfigure('palette', width=5)
```

Let's also use tags to make the current stroke being drawn appear more prominent. When the mouse button is released, we'll return the line to normal.

```
def addLine(event):
    global lastx, lasty
    canvas.create_line((lastx, lasty, event.x, event.y), fill=color, width=5, tags='currentline')
    lastx, lasty = event.x, event.y

def doneStroke(event):
    canvas.itemconfigure('currentline', width=1)

canvas.bind("<B1-ButtonRelease>", doneStroke)
```

Scrolling

In many applications, you'll want the canvas to be larger than what appears on the screen. You can attach horizontal and vertical scrollbars to the canvas in the usual way via the `xview` and `yview` methods.

You can specify both how large you'd like it to be on screen and its full size (which would require scrolling to see). The `width` and `height` configuration options control how much space the canvas widget requests from the geometry manager. The `scrollregion` configuration option tells Tk how large the canvas surface is by specifying its left, top, right, and bottom coordinates, e.g., `0 0 1000 1000`.

You should be able to modify the sketchpad program to add scrolling, given what you already know. Give it a try.

Once you've done that, scroll the canvas down just a little bit, and then try drawing. You'll see that the line you're drawing appears *above* where the mouse is pointing! Surprised?

What's going on is that the global `bind` command doesn't know that the canvas is scrolled (it doesn't know the details of any particular widget). So if you've scrolled the canvas down by 50 pixels, and you click on the top left corner, bind will report that you've clicked at (0,0). But we know that because of the scrolling, that position should really be (0,50).

The `canvasx` and `canvasy` methods translate the position onscreen (which bind reports) into the actual point on the canvas (taking into account scrolling).

Be careful if you're adding `canvasx` and `canvasy` methods directly to the event binding scripts. You need to watch the quoting and substitutions to ensure the conversions are done when the event fires. As always, it's better to place that code in a procedure separate from the event binding itself.

Here then, is our complete example. We probably don't want the palette to be scrolled away when the canvas is scrolled, but we'll leave that for another day.

```
from tkinter import *
from tkinter import ttk
root = Tk()

h = ttk.Scrollbar(root, orient=HORIZONTAL)
v = ttk.Scrollbar(root, orient=VERTICAL)
canvas = Canvas(root, scrollregion=(0, 0, 1000, 1000), yscrollcommand=v.set, xscrollcommand=h.set)
h['command'] = canvas.xview
v['command'] = canvas.yview

canvas.grid(column=0, row=0, sticky=(N,W,E,S))
h.grid(column=0, row=1, sticky=(W,E))
v.grid(column=1, row=0, sticky=(N,S))
root.grid_columnconfigure(0, weight=1)
root.grid_rowconfigure(0, weight=1)

lastx, lasty = 0, 0

def xy(event):
    global lastx, lasty
    lastx, lasty = canvas.canvasx(event.x), canvas.canvasy(event.y)

def setColor(newcolor):
    global color
    color = newcolor
    canvas.dtag('all', 'paletteSelected')
    canvas.itemconfigure('palette', outline='white')
    canvas.addtag('paletteSelected', 'withtag', 'palette%s' % color)
    canvas.itemconfigure('paletteSelected', outline='#999999')

def addLine(event):
    global lastx, lasty
    x, y = canvas.canvasx(event.x), canvas.canvasy(event.y)
    canvas.create_line((lastx, lasty, x, y), fill=color, width=5, tags='currentline')
    lastx, lasty = x, y

def doneStroke(event):
    canvas.itemconfigure('currentline', width=1)

canvas.bind("<Button-1>", xy)
canvas.bind("<B1-Motion>", addLine)
canvas.bind("<B1-ButtonRelease>", doneStroke)

id = canvas.create_rectangle((10, 10, 30, 30), fill="red", tags=('palette', 'palettered'))
canvas.tag_bind(id, "<Button-1>", lambda x: setColor("red"))
id = canvas.create_rectangle((10, 35, 30, 55), fill="blue", tags=('palette', 'paletteblue'))
canvas.tag_bind(id, "<Button-1>", lambda x: setColor("blue"))
id = canvas.create_rectangle((10, 60, 30, 80), fill="black", tags=('palette', 'paletteblack', 'paletteSelected'))
canvas.tag_bind(id, "<Button-1>", lambda x: setColor("black"))

setColor('black')
canvas.itemconfigure('palette', width=5)
root.mainloop()
```

Text

- Widget Roundup
- Reference Manual

A **text** widget manages a multi-line text area. Like the canvas widget, Tk's text widget is an immensely flexible and powerful tool that can be used for a wide variety of tasks. It can provide a simple multi-line text area as part of a form. But text widgets can also form the basis for a stylized code editor, an outliner, a web browser, and much more.

Note: Text widgets are part of the classic Tk widgets, not the themed Tk widgets.

Text widgets.

While we briefly introduced text widgets in an earlier chapter, we'll go into more detail here. You'll get a better sense of the level of sophistication they allow. Still, if you plan to do any significant work with the text widget, the reference manual is a well-organized, helpful, and highly-recommended read.

Text widgets are created using the `Text` class:

```
text = Text(parent, width=40, height=10)
```

You'll often provide a width (in characters) and height (in lines). As always, you can ask the geometry manager to expand it to fill the available space in the window.

The Basics

If you simply need a multi-line text field for a form, there are only a few things to worry about: create and size the widget (check), provide an initial value, and retrieve the text after a user has submitted the form.

Providing Initial Content

Text widgets start with nothing in them, so we'll need to add any initial content ourselves. Because text widgets can hold a lot more than plain text, a simple mechanism (like the entry widget's `textvariable` configuration option) isn't sufficient.

Instead, we'll use the widget's `insert` method:

```
text.insert('1.0', 'here is my\ntext to insert')
```

The "1.0" here is the position where to insert the text, and can be read as "line 1, character 0". This refers to the first character of the first line. Historically, especially on Unix, programmers tend to think about line numbers as 1-based and character positions as 0-based.

The text to insert is just a string. Because the widget can hold multi-line text, the string we supply can be multi-line as well. To do this, simply embed `\n` (newline) characters in the string at the appropriate locations.

Retrieving the Text

After users have made any changes and submitted the form (for example), your program can retrieve the contents of the widget via the `get` method:

```
thetext = text.get('1.0', 'end')
```

The two parameters are the start and end position; `end` has the obvious meaning. You can provide different start and end positions if you want to obtain only part of the text. You'll see more on positions shortly.

Customizing Appearance

We previously saw the `width` and `height` configuration options for text widgets. Several other options control its appearance. The most useful are:

`foreground`
color to draw the text in

`background`
background color of the widget

`padx, pady`
extra padding along the inside border of the widget

`borderwidth`
width of the border around widget

`relief`
border style: `flat`, `raised`, `sunken`, `solid`, `ridge`, `groove`

Wrapping and Scrolling

What if some lines of text in the widget are very long, longer than the width of the widget? By default, the text wraps around to the next line. This behavior can be changed with the `wrap` configuration option. It defaults to `char`, meaning wrap lines at any character. Other options are `word` to wrap lines only at word breaks (e.g., spaces), and `none` meaning to not wrap lines at all. In the latter case, some text of longer lines won't be visible unless we attach a horizontal scrollbar to the widget. (Users can also scroll through the text using arrow keys, even if scrollbars aren't present).

Both horizontal and vertical scrollbars can be attached to the text widget in the same way as with other widgets, e.g., canvas, listbox.

```
t = Text(root, width = 40, height = 5, wrap = "none")
ys = ttk.Scrollbar(root, orient = 'vertical', command = t.yview)
xs = ttk.Scrollbar(root, orient = 'horizontal', command = t.xview)
t['yscrollcommand'] = ys.set
t['xscrollcommand'] = xs.set
t.insert('end', "Lorem ipsum...\n...\n...")
t.grid(column = 0, row = 0, sticky = 'nwes')
xs.grid(column = 0, row = 1, sticky = 'we')
ys.grid(column = 1, row = 0, sticky = 'ns')
root.grid_columnconfigure(0, weight = 1)
root.grid_rowconfigure(0, weight = 1)
```

We can also ask the widget to ensure that a certain part of the text is visible. For example, let's say we've added more text to the widget than will fit onscreen (so it will scroll). However, we want to ensure that the top of the text rather than the bottom is visible. We can use the `see` method.

```
text.see('1.0')
```

Disabling the Widget

Some forms will temporarily disable editing in particular widgets unless certain conditions are met (e.g., some other options are set to a certain value). To prevent users from changing a text widget, set the `state` configuration option to `disabled`. Re-enable editing by setting this option back to `normal`.

```
text['state'] = 'disabled'
```

As text widgets are part of the classic widgets, the usual `state` and `instate` methods are not available.

Modifying the Text in Code

While users can modify the text in the text widget interactively, your program can also make changes. Adding text is done with the `insert` method, which we used above to provide an initial value for the text widget.

Text Positions and Indices

When we specified a position of `1.0` (first line, first character), this was an example of an *index*. It tells the `insert` method where to put the new text (just before the first line, first character, i.e., at the very start of the widget). Indices can be specified in a variety of ways. We used another one with the `get` method: `end` means *just past* the end of the text. (Why "just past?" Text is inserted right *before* the given index, so inserting at `end` will add text to the end of the widget). Note that Tk will *always* add a newline at the very end of the text widget.

Here are a few additional examples of indices and how to interpret them:

`3.end`
The newline at the end of line 3.

`1.0 + 3 chars`
Three characters past the start of line 1.

`2.end -1 chars`
The last character before the new line in line 2.

`end -1 chars`
The newline that Tk always adds at the end of the text.

`end -2 chars`
The actual last character of the text.

`end -1 lines`
The start of the last actual line of text.

`2.2 + 2 lines`
The third character (index 2) of the fourth line of text.

`2.5 linestart`
The first character of line 2.

`2.5 lineend`
The position of the newline at the end of line 2.

`2.5 wordstart`
First char. of the word with the char. at index 2.5.

`2.5 wordend`
First char. after the word with the char. at index 2.5.

Some additional things to keep in mind:

- The term `chars` can be abbreviated as `c`, and `lines` as `l`.
- Spaces between terms can be omitted, e.g., `1.0+3c`.
- An index past the end of the text (e.g., `end + 100c`) is interpreted as `end`.
- Indices wrap to subsequent lines as needed; e.g., `1.0 + 10 chars` on a line with only five characters will refer to a position on the second line.
- Line numbers in indices are interpreted as *logical lines,* i.e., each line ends only at the "\n." With long lines and wrapping enabled, one logical line may represent multiple *display lines*. If you'd like to move up or down a single line on the display, you can specify this as, e.g., "1.0 + 2 display lines".
- When indices contain multiple words, make sure they are quoted appropriately so that Tk sees the entire index as one argument.

To determine the *canonical position* of an index, use the `index idx` method. Pass it any index expression, and it returns the corresponding index in the form `line.char`. For example, to find the position of the last character (ignoring the automatic newline at the end), use:

```
text.index('end')
```

You can compare two indices using the `compare` method, which lets you check for equality, whether one index is later in the text than the other, etc.

```
if text.compare(idx1, "==", idx2"): # same position
```

Valid operators are `==`, `!=`, `<`, `<=`, `>`, and `>=`.

Deleting Text

While the `insert` method adds new text anywhere in the widget, the `delete start ?end?` method removes it. We can delete either a single character (specified by index) or a *range* of characters (specified by start and end indices). In the latter case, characters from (and including) the start index until *just before* the end index are deleted (the character at the end index is not deleted). So if we assume for each of these we start off with `"abcd\nefgh"` in the text widget:

```
text.delete('1.2') ⇒ "abd\nefgh"
text.delete('1.1', '1.2') ⇒ "acd\nefgh"
text.delete('1.0', '2.0') ⇒ "efgh"
text.delete('1.2', '2.1') ⇒ "abfgh"
```

There is also a `replace` method that performs a `delete` followed by an `insert` at the same location.

Example: Logging Window

Here's a short example using a text widget as an 80x24 logging window for an application. Users don't edit the text widget at all. Instead, the program writes log messages to it. We'd like to display more than 24 lines (so no scrolling). If the log is full, old messages are removed from the top before new ones are added at the end.

```
from tkinter import *
from tkinter import ttk

root = Tk()
log = Text(root, state='disabled', width=80, height=24, wrap='none')
log.grid()

def writeToLog(msg):
    numlines = int(log.index('end - 1 line').split('.')[0])
    log['state'] = 'normal'
    if numlines==24:
        log.delete(1.0, 2.0)
    if log.index('end-1c')!='1.0':
        log.insert('end', '\n')
    log.insert('end', msg)
    log['state'] = 'disabled'
```

Note that because the program placed the widget in a disabled state, we had to re-enable it to make any changes, even from our program.

Formatting with Tags

So far, we've used text widgets when all the text is in a single font. Now it's time to add formatting like bold, italic, strikethrough, background colors, font sizes, and much more. Tk's text widget implements these using a feature called *tags*.

Tags are objects associated with the text widget. Each tag is referred to via a name chosen by the programmer. Each tag has several configuration options. These are things like fonts and colors that control formatting. Though tags are objects having state, they don't need to be explicitly created but are automatically created the first time the tag name is used.

Adding Tags to Text

Tags can be associated with one or more ranges of text in the widget. As before, ranges are specified via indices. A single index represents a single character, and a pair of indices represent a range from the start character to just before the end character. Tags are added to a range of text using the `tag_add` method.

```
text.tag_add('highlightline', '5.0', '6.0')
```

Tags can also be provided when first inserting text. The `insert` method supports an optional parameter containing a list of one or more tags to add to the text being inserted.

```
text.insert('end', 'new material to insert', ('highlightline', 'recent', 'warning'))
```

As the widget's contents are modified (whether by a user or your program), the tags will adjust automatically. For example, if we tagged the text "the quick brown fox" with the tag "nounphrase", and then replaced the word "quick" with "speedy," the tag still applies to the entire phrase.

Applying Formatting to Tags

Formatting is applied to tags via configuration options; these work similarly to configuration options for the entire widget. As an example:

```
text.tag_configure('highlightline', background='yellow', font='TkFixedFont', relief='raised')
```

Tags support the following configuration options: `background`, `bgstipple`, `borderwidth`, `elide`, `fgstipple`, `font`, `foreground`, `justify`, `lmargin1`, `lmargin2`, `offset`, `overstrike`, `relief`, `rmargin`, `spacing1`, `spacing2`, `spacing3`, `tabs`, `tabstyle`, `underline`, and `wrap`. Check the reference manual for detailed descriptions of these. The `tag_cget` *`tag option`* method allows us to query the configuration options of a tag.

Because multiple tags can apply to the same range of text, there is the possibility of conflict (e.g., two tags specifying different fonts). A priority order is used to resolve these; the most recently created tags have the highest priority, but priorities can be rearranged using the `tag_raise` *`tag`* and `tag_lower` *`tag`* methods.

More Tag Manipulations

To delete one or more tags altogether, we can use the `tag_delete` *`tags`* method. This also, of course, removes any references to the tag in the text. We can also remove a tag from a range of text using the `tag_remove` *`tag start ?end?`* method. Even if that leaves no ranges of text with that tag, the tag object itself still exists.

The `tag_ranges` *`tag`* method will return a list of ranges in the text that the tag has been applied to. There are also `tag_nextrange` *`tag start ?end?`* and `tag_prevrange` *`tag start ?end?`* methods to search forward or backward for the first such range from a given position.

The `tag_names` *`?idx?`* method, called with no additional parameters, will return a list of all tags currently defined in the text widget (including those that may not be presently used). If we pass the method an index, it will return the list of tags applied to just the character at the index.

Finally, we can use the first and last characters in the text having a given tag as indices, the same way we can use "end" or "2.5". To do so, just specify *`tagname`*`.first` or *`tagname`*`.last`.

Differences between Tags in Canvas and Text Widgets

Both canvas and text widgets support "tags" that can be applied to several objects, style them, etc. However, canvas and text tags are not the same and there are substantial differences to take note of.

In canvas widgets, only individual canvas items have configuration options that control their appearance. When we refer to a tag in a canvas, the meaning of that is identical to "all canvas items presently having that tag." The tag itself doesn't exist as a separate object. So in the following snippet, the last rectangle added will *not* be colored red.

```
canvas.itemconfigure('important', fill='red')
canvas.create_rectangle(10, 10, 40, 40, tags=('important'))
```

In contrast, with text widgets, it's not the individual characters that retain the state information about appearance, but tags, which are objects in their own right. So in this snippet, the newly added text *will* be colored red.

```
text.insert('end', 'first text', ('important'))
text.tag_configure('important', foreground='red')
text.insert('end', 'second text', ('important'))
```

Events and Bindings

One very cool thing we can do is define event bindings on tags. That allows us to easily do things like recognize mouse clicks on particular ranges of text and popup a menu or dialog in response. Different tags can have different bindings. This saves the hassle of sorting out questions like "what does a click at this location mean?". Bindings on tags are implemented using the `tag_bind` method:

```
text.tag_bind('important', '<1>', popupImportantMenu)
```

Widget-wide event bindings continue to work as they do for every other widget, e.g., to capture a mouse click anywhere in the text. Besides the normal low-level events, the text widget generates a `<<Modified>>` virtual event whenever a change is made to the content of the widget, and a `<<Selection>>` virtual event whenever there is a change made to which text is selected.

Selecting Text

We can identify the range of text selected by a user, if any. For example, an editor may have a toolbar button to bold the selected text. While you can tell when the selection has changed (e.g., to update whether or not the bold button is active) via the `<<Selection>>` virtual event, that doesn't tell you what has been selected.

The text widget automatically maintains a tag named `sel`, which refers to the selected text. Whenever the selection changes, the `sel` tag will be updated. So we can find the range of text selected using the `tag_ranges` *`?tag?`* method, passing it `sel` as the tag to report on.

Similarly, we can change the selection by using `tag_add` to set a new selection, or `tag_remove` to remove the selection. The `sel` tag cannot be deleted, however.

> *Though the default widget bindings prevent this from happening, `sel` is like any other tag in that it can support multiple ranges, i.e., disjoint selections. To prevent this from happening, when changing the selection from your code, make sure to remove any old selection before adding a new one.*

The text widget manages the concept of the insertion cursor (where newly typed text will appear) separate from the selection. It does so using a new concept called a *mark*.

Marks

Marks indicate a particular place in the text. In that respect, they are like indices. However, as the text is modified, the mark will adjust to be in the same relative location. In that way, they resemble tags but refer to a single position rather than a range of text. Marks actually don't refer to a position occupied by a character in the text but specify a position *between* two characters.

Tk automatically maintains two different marks. The first, named `insert`, is the present location of the insertion cursor. As the cursor is moved (via mouse or keyboard), the mark moves with it. The second mark, named `current`, tracks the position of the character underneath the current mouse position.

To create your own marks, use the widget's `mark_set` *`name idx`* method, passing it the name of the mark and an index (the mark is positioned just before the character at the given index). This is also used to move an existing mark to a different position. Marks can be removed using the `mark_unset` *`name`* method, passing it the name of the mark. If you delete a range of text containing a mark, that also removes the mark.

The name of a mark can also be used as an index (in the same way `1.0` or `end-1c` are indices). You can find the next mark (or previous one) from a given index in the text using the `mark_next` *`idx`* or `mark_previous` *`idx`* methods. The `mark_names` method will return a list of the names of all marks.

Marks also have a *gravity*, which can be modified with the `mark_gravity` *`name ?direction?`* method, which affects what happens when text is inserted at the mark. Suppose we have the text "ac" with a mark in between that we'll symbolize with a pipe, i.e., "a|c." If the gravity of that mark is `right` (the default), the mark attaches itself to the "c." If the new text "b" is inserted at the mark, the mark will remain stuck to the "c," and so the new text will be inserted before the mark, i.e., "ab|c." If the gravity is instead `left`, the mark attaches itself to the "a," and so new text will be inserted after the mark, i.e., "a|bc."

Images and Widgets

Like canvas widgets, text widgets can contain images and any other Tk widgets (including frames containing many other widgets). In a sense, this allows the text widget to work as a geometry manager in its own right. The ability to add images and widgets within the text opens up a world of possibilities for your program.

Images are added to a text widget at a particular index, with the image specified as an existing Tk image. Other options that allow you to fine-tune padding, etc.

```
flowers = PhotoImage(file='flowers.gif')
text.image_create('sel.first', image=flowers)
```

Other widgets are added to a text widget in much the same way as images. The widget being added must be a descendant of the text widget in the widget hierarchy.

```
b = ttk.Button(text, text='Push Me')
text.window_create('1.0', window=b)
```

Even More

Text widgets can do many more things. Here, we'll briefly mention just a few more of them. For details on any of these, see the reference manual.

Search

The text widget includes a powerful `search` method to locate a piece of text within the widget. This is useful for a "Find" dialog, as one obvious example. You can search backward or forward from a particular position or within a given range, specify the search term using exact text, case insensitive, or via regular expressions, find one or all occurrences of the search term, etc.

Modifications, Undo and Redo

The text widget keeps track of whether changes have been made (useful to know whether it needs to be saved to a file, for example). We can query (or change) using the `edit_modified` *`?bool?`* method. There is also a complete multi-level undo/redo mechanism, managed automatically by the widget when we set its `undo` configuration option to `true`. Calling `edit_undo` or `edit_redo` modifies the current text using information stored on the undo/redo stack.

Eliding Text

Text widgets can include text that is not displayed. This is known as "elided" text, and is made available using the `elide` configuration option for tags. It can be used to implement an outliner, a "folding" code editor, or even to bury extra meta-data intermixed with displayed text. When specifying positions within elided text, you have to be a bit more careful. Methods that work with positions have extra options to either include or ignore the elided text.

Introspection

Like most Tk widgets, the text widget goes out of its way to expose information about its internal state. We've seen this in terms of the `get` method, widget configuration options, `names` and `cget` for both tags and marks, etc. There is even more information available that can be useful for a wide variety of tasks. Check out the `debug`, `dlineinfo`, `bbox`, `count`, and `dump` methods in the reference manual.

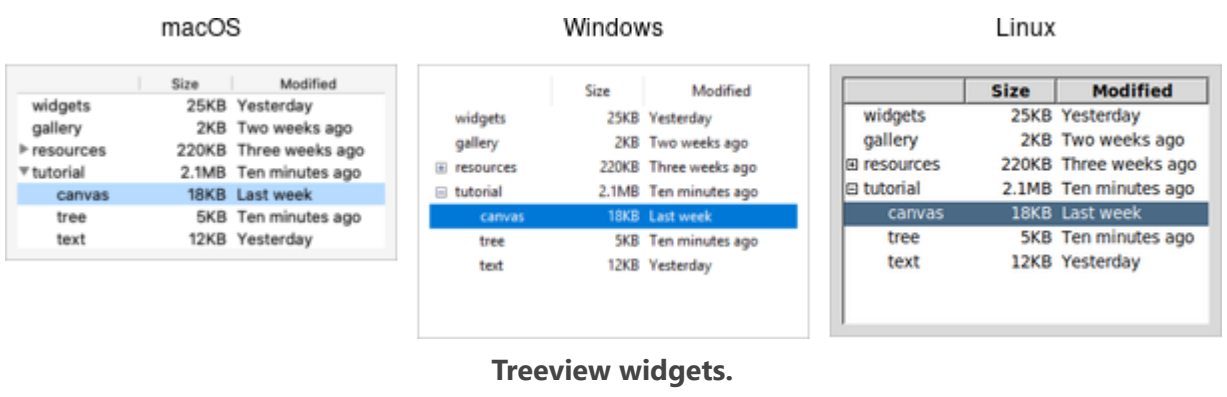
Peering

The Tk text widget allows the same underlying text data structure (containing all the text, marks, tags, images, etc.) to be shared between two or more different text widgets. This is known as *peering* and is controlled via the `peer` method.

Treeview

- Widget Roundup
- Reference Manual

A **treeview** widget displays a hierarchy of items and allows users to browse through it. One or more attributes of each item can be displayed as columns to the right of the tree. It can be used to build user interfaces similar to the tree display you'd find in file managers like the macOS Finder or Windows Explorer. As with most Tk widgets, it offers incredible flexibility so it can be customized to suit a wide range of situations.



Treeview widgets.

Treeview widgets are created using the **`ttk.Treeview`** class:

```
tree = ttk.Treeview(parent)
```

Horizontal and vertical scrollbars can be added in the usual manner if desired.

Adding Items to the Tree

To do anything useful with the treeview, we'll need to add one or more *items* to it. Each item represents a single node in the tree, whether a leaf node or an internal node containing other nodes. Items are referred to by a unique id. You can assign this id when the item is first created, or the widget can automatically generate one.

Items are created by inserting them into the tree, using the treeview's `insert` method. To insert an item, we need to know where to insert it. That means specifying the parent item and where within the list of the parent's existing children the new item should be inserted.

The treeview widget automatically creates a root node (which is not displayed). Its id is the empty string. It serves as the parent of the first level of items that are added. Positions within the list of a node's children are specified by index (0 being the first, and `end` meaning insert after all existing children).

Normally, you'll also specify the *name* of each item, which is the text displayed in the tree. Other options allow you to add an image beside the name, specify whether the node is open or closed, etc.

```
# Inserted at the root, program chooses id:
tree.insert('', 'end', 'widgets', text='Widget Tour')

# Same thing, but inserted as first child:
tree.insert('', 0, 'gallery', text='Applications')

# Treeview chooses the id:
id = tree.insert('', 'end', text='Tutorial')

# Inserted underneath an existing node:
tree.insert('widgets', 'end', text='Canvas')
tree.insert(id, 'end', text='Tree')
```

Inserting the item returns the id of the newly created item.

Rearranging Items

A node (and its descendants, if any) can be moved to a different location in the tree. The only restriction is that a node cannot be moved underneath one of its descendants for obvious reasons. As before, the target location is specified via a parent node and a position within its list of children.

```
tree.move('widgets', 'gallery', 'end')  # move widgets under gallery
```

Items can be *detached* from the tree. This removes the item and its descendants from the hierarchy but does not destroy the items. This allows us to later reinsert them with `move`.

```
tree.detach('widgets')
```

Items can also be *deleted*, which does completely destroy the item and its descendants.

```
tree.delete('widgets')
```

To traverse the hierarchy, there are methods to find the parent of an item (`parent item`), its next or previous sibling (`next item` and `prev item`), and return the list of children of an item (`children item`).

We can control whether or not the item is open and shows its children by modifying the `open` item configuration option.

```
tree.item('widgets', open=TRUE)
isopen = tree.item('widgets', 'open')
```

Displaying Information for each Item

The treeview can display one or more additional pieces of information about each item. These are shown as columns to the right of the main tree display.

Each column is referenced by a symbolic name that we assign. We can specify the list of columns using the `columns` configuration option of the treeview widget, either when first creating the widget or later on.

```
tree = ttk.Treeview(root, columns=('size', 'modified'))
tree['columns'] = ('size', 'modified', 'owner')
```

We can specify the width of the column, how the display of item information in the column is aligned, and more. We can also provide information about the column's heading, such as the text to display, an optional image, alignment, and a script to invoke when the item is clicked (e.g., to sort the tree).

```
tree.column('size', width=100, anchor='center')
tree.heading('size', text='Size')
```

What to display in each column for each item can be specified individually by using the `set` method. You can also provide a list describing what to display in all the columns for the item. This is done using the `values` item configuration option. It takes a list of values and can be provided when first inserting the item or changed later. The order of the list must be the same as the order in the `columns` widget configuration option.

```
tree.set('widgets', 'size', '12KB')
size = tree.set('widgets', 'size')
tree.insert('', 'end', text='Listbox', values=('15KB', 'Yesterday', 'mark'))
```

Item Appearance and Events

Like the text and canvas widgets, the treeview widget uses *tags* to modify the appearance of items in the tree. We can assign a list of tags to each item using the `tags` item configuration option (again, when creating the item or later on).

Configuration options can then be specified on the tag, applied to all items having that tag. Valid tag options include `foreground` (text color), `background`, `font`, and `image` (not used if the item specifies its own image).

We can also create event bindings on tags to capture mouse clicks, keyboard events, etc.

```
tree.insert('', 'end', text='button', tags=('ttk', 'simple'))
tree.tag_configure('ttk', background='yellow')
tree.tag_bind('ttk', '<1>', itemClicked)
# the item clicked can be found via tree.focus()
```

The treeview will generate virtual events `<<TreeviewSelect>>`, `<<TreeviewOpen>>`, and `<<TreeviewClose>>`, which allow us to monitor changes to the widget made by users. We can use the `selection` method to determine the current selection (the selection can also be changed from your program).

Customizing the Display

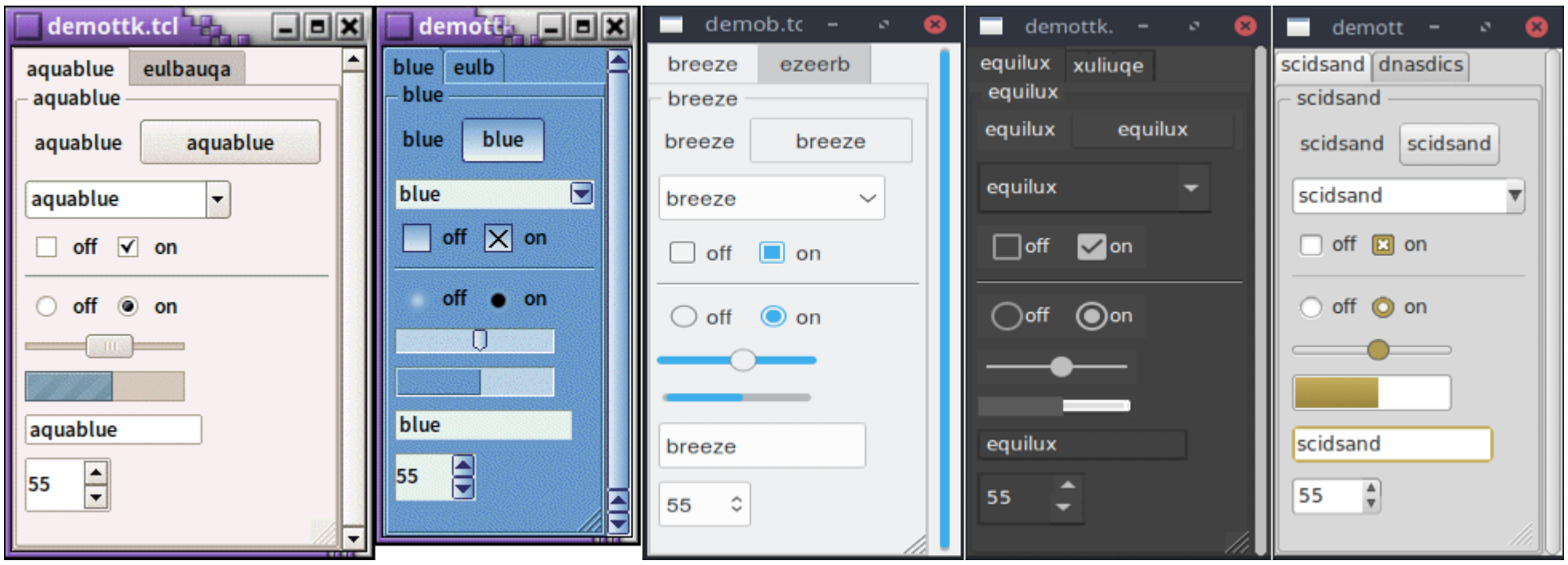
There are many aspects of how the treeview widget is displayed that we can customize. We've already seen some of them, such as the text of items, fonts and colors, names of column headings, and more. Here are a few additional ones.

- Specify the desired number of rows to show using the `height` widget configuration option.
- Control the width of each column using the column's `width` or `minwidth` options. The column holding the tree can be accessed with the symbolic name `#0`. The overall requested width for the widget is based on the sum of the column widths.
- Choose which columns to display and the order to display them in using the `displaycolumns` widget configuration option.
- You can optionally hide one or both of the column headings or the tree itself (leaving just the columns) using the `show` widget configuration option (default is "tree headings" to show both).
- You can specify whether a single item or multiple items can be selected by users via the `selectmode` widget configuration option, passing `browse` (single item), `extended` (multiple items, the default), or `none`.

Styles and Themes

The *themed* aspect of the modern Tk widgets is one of the most powerful and exciting aspects of the newer widget set. Yet, it's also one of the most confusing.

This chapter explains styles (which control how widgets like buttons look) and themes (which are a collection of styles that define how all the widgets in your application look). Changing themes can give your application an entirely different look.



Applying different themes.

Note that it's not just colors that have changed, but the actual shape of individual widgets. Styles and themes are *extremely* flexible.

Why?

However, before you get carried away, very few applications will benefit from switching themes like this. Some games or educational programs might be exceptions. Using the standard Tk theme for a given platform will display widgets the way people expect to see them, particularly if they're running macOS and Windows.

> *On Linux systems, there's far less standardization of look and feel. Users expect (and are more comfortable with) some variability and "coolness." Because different widget sets (typically GTK and QT) are used by window managers, control panels, and other system utilities, Tk can't seamlessly blend in with the current settings on any particular system. Most of the Linux screenshots in this tutorial use Tk's `alt` theme. Despite users being accustomed to variability, there are limits to what most users will accept. A prime example is the styling of core widgets in Tk's classic widget set, matching circa-1992 OSF/Motif.*

Styles and themes, used in a more targeted manner and with significant restraint, can have a role to play in modern applications. This chapter explains why and when you might want to use them and how to go about doing so. We'll begin by drawing a parallel between Tk's styles and themes and another realm of software development.

Understanding Styles and Themes

If you're familiar with web development, you know about cascading stylesheets (CSS). There are two ways it can be used to customize the appearance of an element in your HTML page. One way is to add a bunch of style attributes (fonts, colors, borders, etc.) directly to an element in your HTML code via the `style` attribute. For example:

```
<label style="color:red; font-size:14pt; font-weight:bold; background-color:yellow;">Meltdown imminent!</label>
```

The other way to use CSS is to attach a *class* to each widget via the `class` attribute. The details of how elements of that class appear are provided elsewhere, often in a separate CSS file. You can attach the same class to many elements, and they will all have the same appearance. You don't need to repeat the full details for every element. More importantly, you separate the logical content of your site (HTML) from its appearance (CSS).

```
<label class="danger">Meltdown imminent!</label>
...
<style type="text/css">
label.danger {color:red; font-size:14pt; font-weight:bold; background-color:yellow;}
</style>
```

Back to Tk.

- In the classic Tk widgets, all appearance customizations require specifying each detail on individual widgets, akin to *always* using the `style` HTML attribute.
- In the themed Tk widgets, *all* appearance customizations are made via attaching a style to a widget, akin to using the `class` HTML attribute. Separately, you define how widgets with that style will appear, akin to writing CSS.
- Unlike with HTML, *you can't freely mix and match*. You can't customize some themed entries or buttons with styles and others by directly changing appearance options.

Yes, there are a few exceptions, like labels where you can customize the font and colors through both styles and configuration options.

Benefits

So why use styles and themes in Tk? They take the fine-grained details of appearance decisions away from individual instances of widgets.

That makes for cleaner code and less repetition. If you have 20 entry widgets in your application, you don't need to repeat the exact appearance details every time you create one (or write a wrapper function). Instead, you assign them a style.

Styles also put all appearance decisions in one place. And because styles for a button and styles for other widgets can share common elements, it promotes consistency and improves reuse.

Styles also have many benefits for widget authors. Widgets can delegate most appearance decisions to styles. A widget author no longer has to hardcode logic to the effect of "when the state is disabled, consult the 'disabledforeground' configuration option and use that for the foreground color." Not only did that make coding widgets longer (and more repetitive), but it also restricted how a widget could be changed based on its state. If the widget author omitted logic to change the font when the state changed, you were out of luck as an application developer using the widget.

*Using styles, widget authors don't need to provide code for every possible appearance option. That not only simplifies the widget but paradoxically ensures that a wider range of appearances **can** be set, including those the widget author may not have anticipated.*

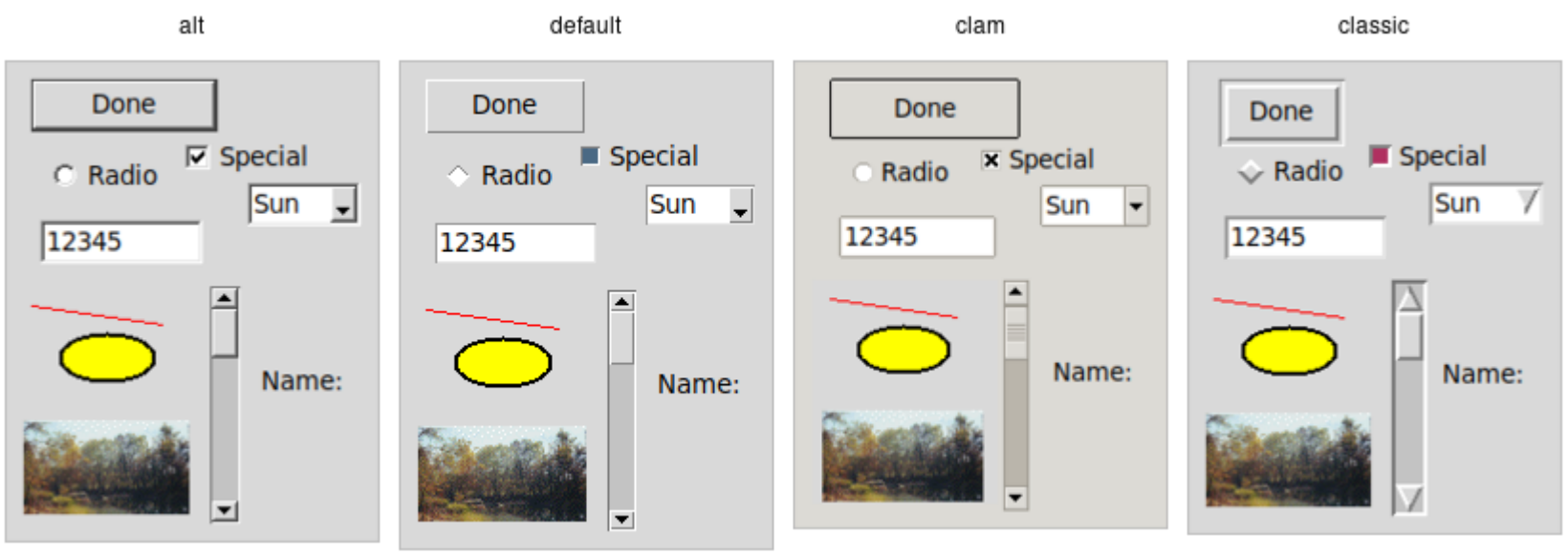
Using Existing Themes

Before delving into the weightier matters of tastefully and selectively modifying and applying styles to improve the usability of your application and cleanliness of your code, let's deal with the fun bits: using existing themes to completely reskin your application.

Themes are identified by a name. You can obtain the names of all available themes:

```
>>> s = ttk.Style()
>>> s.theme_names()
('aqua', 'step', 'clam', 'alt', 'default', 'classic')
```

Tkinter encapsulates all style manipulations in the `ttk.Style` class. We'll therefore need an instance of that class for this and other operations.



Built-in themes.

Besides the built-in themes (`alt`, `default`, `clam`, and `classic`), macOS includes a theme named `aqua` to match the system-wide style, while Windows includes themes named `vista`, `winxpnative`, and `winnative`.

Only one theme can be active at a time. To obtain the name of the theme currently in use, use the following:

```
>>> s.theme_use()
'aqua'
```

This API, which was originally targeted for Tk 8.6, was back-ported to Tk 8.5.9. If you're using an earlier version of Tk getting this info is a bit trickier.

Switching to a new theme can be done with:

```
s.theme_use('themename')
```

What does this actually do? Obviously, it sets the current theme to the indicated theme. Doing this, therefore, replaces all the currently available styles with the set of styles defined by the theme. Finally, it refreshes all widgets, so they take on the appearance described by the new theme.

Third-Party Themes

With a bit of looking around, you can find some existing add-on themes available for download. A good starting point is https://wiki.tcl-lang.org/page/List+of+ttk+Themes.

Though themes can be defined in any language that Tk supports, most that you will find are written in Tcl. How can you install them so that they are available to use in your application?

As an example, let's use the "awdark" theme, available from https://sourceforge.net/projects/tcl-awthemes/. Download and unzip the `awthemes-*.zip` file somewhere. You'll notice it contains a bunch of `.tcl` files, a subdirectory `i` containing more directory with images used by the theme, etc.

One of the files is named `pkgIndex.tcl`. This identifies it as a Tcl package, which is similar to a module in other languages. If we look inside, you'll see a bunch of lines like `package ifneeded awdark 7.7`. Here, `awdark` is the name of the package, and `7.7` is its version number. It's not unusual, as in this case, for a single `pkgIndex.tcl` file to provide several packages.

To use it, we need to tell Tcl where to find the package (via adding its directory to Tcl's `auto_path`) and the name of the package to use.

```
root.tk.call('lappend', 'auto_path', '/full/path/to/awthemes-9.3.1')
root.tk.call('package', 'require', 'awdark')
```

If the theme is instead implemented as a single Tcl source file, without a `pkgIndex.tcl`, you can make it available like this:

```
root.tk.call('source', '/full/path/to/themefile.tcl')
```

You should now be able to use the theme in your own application, just as you would a built-in theme.

Using Styles

We'll now tackle the more complex issue of taking full advantage of styles and themes within your application, not just reskinning it with an existing theme.

Definitions

We first need to introduce a few essential concepts.

Widget Class

A *widget class* identifies the type of a particular widget, whether it is a button, a label, a canvas, etc. All themed widgets have a default class. Buttons have the class `TButton`, labels `TLabel`, etc.

Widget State

A *widget state* allows a single widget to have more than one appearance or behavior, depending on things like mouse position, different state options set by the application, and so on.

As you'll recall, all themed widgets maintain a set of binary state flags, accessed by the `state` and `instate` methods. The flags are: `active`, `disabled`, `focus`, `pressed`, `selected`, `background`, `readonly`, `alternate`, and `invalid`. All widgets have the same set of state flags, though they may ignore some of them (e.g., a label widget would likely ignore an `invalid` state flag). See the themed widget page in the reference manual for the exact meaning of each state flag.

Style

A *style* describes the appearance (or appearance*s*) of a widget class. All themed widgets having the same widget class will have the same appearance(s).

Styles are referred to by the name of the widget class they describe. For example, the style `TButton` defines the appearance of all widgets with the class `TButton`.

Styles know about different states, and one style can define different appearances based on a widget's state. For example, a style can specify how a widget's appearance should change if the `pressed` state flag is set.

Theme

A *theme* is a collection of styles. While each style is widget-specific (one for buttons, one for entries, etc.), a theme collects many styles together. All styles in the same theme will be designed to visually "fit" together with each other. (Tk doesn't technically restrict bad design or judgment, unfortunately!)

Using a particular theme in an application really means that, by default, the appearance of each widget will be controlled by the style within that theme responsible for that widget class.

Style Names

Every style has a name. If you're going to modify a style, create a new one, or use a style for a widget, you need to know its name.

How do you know what the names of the styles are? If you have a particular widget, and you want to know what style it is currently using, you can first check the value of its `style` configuration option. If that is empty, it means the widget is using the *default* style for the widget. You can retrieve that via the widget's class. For example:

```
>>> b = ttk.Button()
>>> b['style']
''
>>> b.winfo_class()
'TButton'
```

In this case, the style that is being used is `TButton`. The default styles for other themed widgets are named similarly, e.g., `TEntry`, `TLabel`, etc.

*It's always wise to check the specifics. For example, the treeview widget's class is `Treeview`, **not** `TTreeview`.*

Beyond the default styles, though, styles can be named pretty much anything. You might create your own style (or use a theme that has a style) named `FunButton`, `NuclearReactorButton`, or even `GuessWhatIAm` (not a wise choice).

More often, you'll find names like `Fun.TButton` or `NuclearReactor.TButton`. These suggest variations of a base style; as you'll see, this is something Tk supports for creating and modifying styles.

The ability to retrieve a list of all currently available styles is currently not supported. This will likely appear in Tk 8.7 in the form of a new command, `ttk::style theme styles`, returning the list of styles implemented by a theme. It also proposes adding a `style` method for all widgets, so you don't have to examine both the widget's `style` configuration option and its class. See TIP #584.

Applying a Style

To use a style means to apply that style to an individual widget. All you need is the style's name and the widget to apply it to. Setting the style can be done at creation time:

```
b = ttk.Button(parent, text='Hello', style='Fun.TButton')
```

A widget's style can also be changed later with the `style` configuration option:

```
b['style'] = 'Emergency.TButton'
```

Creating a Simple Style

So how do we create a new style like `Emergency.TButton`?

In situations like this, you're creating a new style only slightly different from an existing one. This is the most common reason for creating new styles.

For example, you want most of the buttons in your application to keep their usual appearance but have certain "emergency" buttons highlighted differently. Creating a new style (e.g., `Emergency.TButton`), derived from the base style (`TButton`), is appropriate.

Prepending another name (`Emergency`) followed by a dot onto an existing style creates a new style derived from the existing one. The new style will have exactly the same options as the existing one except for the indicated differences:

```
s.configure('Emergency.TButton', font='helvetica 24', foreground='red', padding=10)
```

As shown earlier, you can then apply that style to an individual button widget via its `style` configuration option. Every other button widget would retain its normal appearance.

How do you know what options are available to change for a given style? That requires diving a little deeper inside styles.

You may have existing code using the classic widgets that you'd like to move to the themed widgets. Most appearance changes made to classic widgets through configuration options can probably be dropped. For those that can't, you may need to create a new style, as shown above.

State-specific appearance changes can be treated similarly. In classic Tk, several widgets supported a few state changes via configuration options. For example, setting a button's `state` option to `disabled` would draw it with a greyed-out label. Some allowed an additional state, `active`, which represented a different appearance. You could change the widget's appearance in multiple states via a set of configuration options, e.g., `foreground`, `disabledforeground`, and `activeforeground`.

State changes via configuration options should be changed to use the `state` method on themed widgets. Configuration options to modify the widget's appearance in a particular state should be dealt with in the style.

*Classic Tk widgets also supported a very primitive form of styles that you may encounter. This used the **option database,** a now-obscure front end to X11-style configuration files.*

In classic Tk, all buttons had the same class (`Button`), all labels had the same class (`Label`), etc. You could use this widget class both for introspection and for changing options globally through the option database. It let you say, for example, that all buttons should have a red background.

*A **few** classic Tk widgets, including frame and toplevel widgets, let you **change** the widget class of a particular widget when it was first created by providing a `class` configuration option. For example, you could specify that one specific frame widget had a class of `SpecialFrame`, while others would have the default class `Frame`. You could use the option database to change the appearance of just the `SpecialFrame` frames.*

Styles and themes take that simple idea and give it rocket boosters.

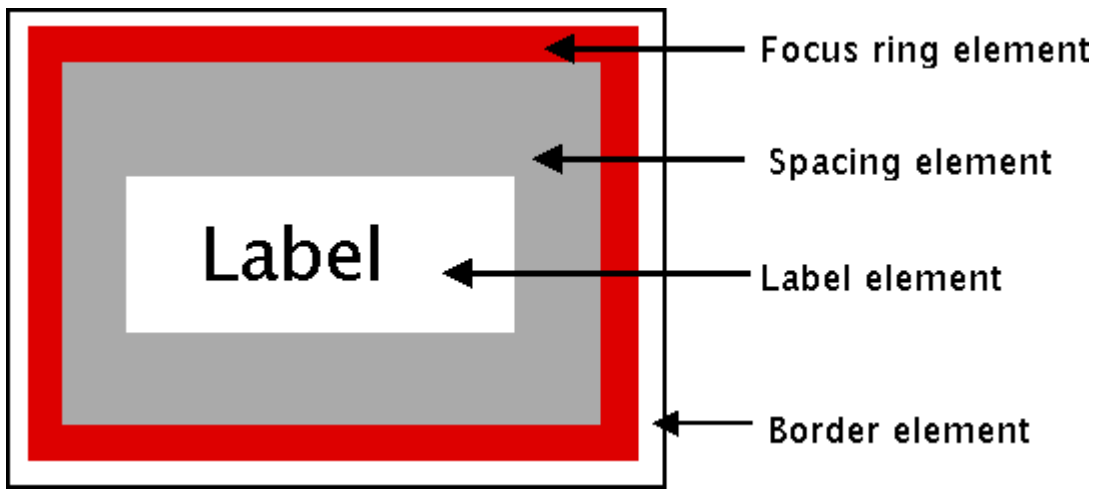
What's Inside a Style?

If all you want to do is *use* a style or create a new one with a few tweaks, you now know everything you need. If, however, you want to make more substantial changes, things start to get "interesting."

Elements

While each style controls a single type of widget, each widget is usually composed of smaller pieces, called *elements*. It's the job of the style author to construct the entire widget out of these smaller elements. What these elements are depends on the widget.

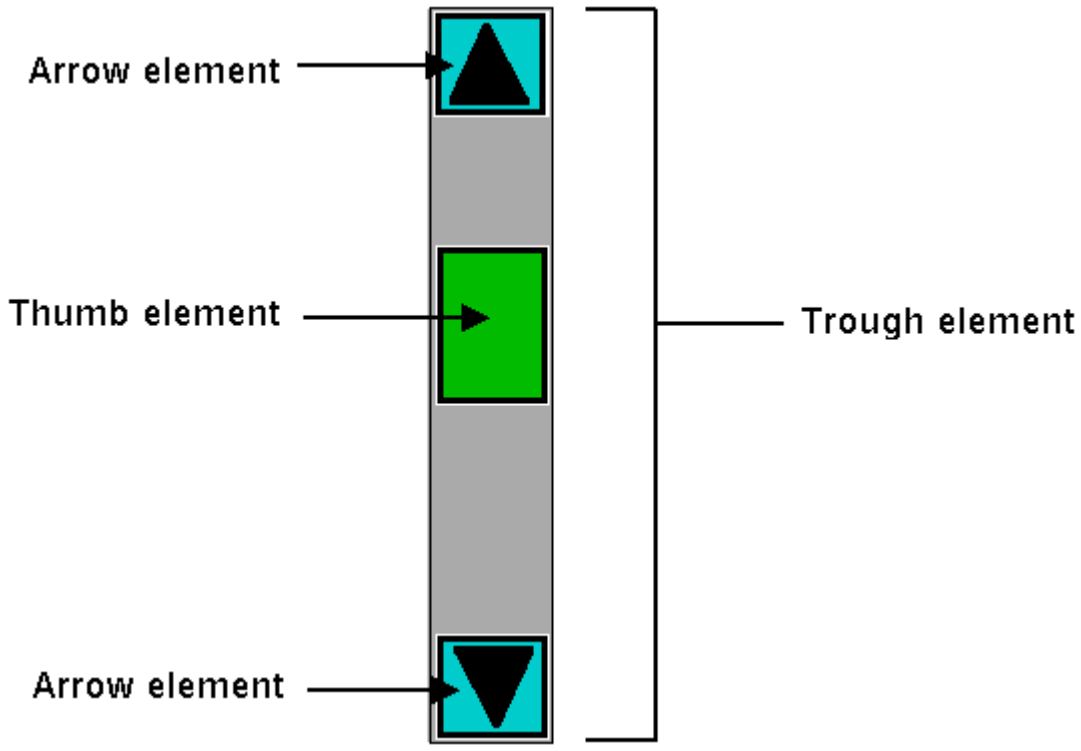
Here's an example of a button. It might have a border on the very outside. That's one element. Just inside that, there may be a focus ring. Normally, it's just the background color, but could be highlighted when a user tabs into the button. So that's a second element. Then there might be some spacing between that focus ring and the button's label. That spacing is a third element. Finally, the text label of the button itself is a fourth element.



Possible elements of a button.

Why might the style author have divided it up that way? If you have one part of the widget that may be in a different location or a different color than another, it may be a good candidate for an element. Note that this is just one example of how a button could be constructed from elements. Different styles and themes could (and do) accomplish this in different ways.

Here is an example of a vertical scrollbar. It consists of a "trough" element, which contains other elements. These include the up and down arrow elements at either end and a "thumb" element in the middle (it might have additional elements, like borders).



Possible elements of a scrollbar.

Layout

Besides specifying which elements make up a widget, a style also defines how those elements are arranged within the widget. This is called their *layout*. Our button had a label element inside a spacing element, inside a focus ring element, inside a border element. Its logical layout is this:

```
border {
    focus {
        spacing {
            label
        }
    }
}
```

We can ask Tk for the layout of the `TButton` style:

```
>>> s.layout('TButton')
[("Button.border", {"children": [("Button.focus", {"children": [("Button.spacing",
{"children": [("Button.label", {"sticky": "nswe"})], "sticky": "nswe"})],
"sticky": "nswe"})], "sticky": "nswe", "border": "1"})]
```

If we clean this up and format it a bit, we get something with this structure:

```
Button.border -sticky nswe -border 1 -children {
    Button.focus -sticky nswe -children {
        Button.spacing -sticky nswe -children {
            Button.label -sticky nswe
        }
    }
}
```

This starts to make sense; we have four elements, named `Button.border`, `Button.focus`, `Button.spacing`, and `Button.label`. Each has different element options, such as `children`, `sticky`, and `border` that specify layout or sizes. Without getting into too much detail at this point, we can clearly see the nested layout based on the `children` and `sticky` attributes.

> *Styles uses a simplified version of Tk's `pack` geometry manager to specify element layout. This is detailed in the style reference manual page.*

Element Options

Each of these elements has several different options. For example, a label element has a font and a foreground color. An element representing the thumb of a scrollbar may have one option to set its background color and another to provide the width of a border. These can be customized to adjust how the elements within the overall widget look.

You can determine what options are available for each element? Here's an example of checking what options are available for the label inside the button (which we know from the `layout` method is identified as `Button.label`):

```
>>> s.element_options('Button.label')
('compound', 'space', 'text', 'font', 'foreground', 'underline', 'width', 'anchor', 'justify',
'wraplength', 'embossed', 'image', 'stipple', 'background')
```

In the following sections, we'll look at the not-entirely-straightforward way to work with element options.

Manipulating Styles

In this section, we'll see how to change the style's appearance by modifying style options. You can do this either by modifying an existing style, or more typically, by creating a new style. We saw how to create a simple style that was derived from another one earlier:

```
s.configure('Emergency.TButton', font='helvetica 24', foreground='red', padding=10)
```

Modifying a Style Option

Modifying an option for an existing style is done similarly to modifying any other configuration option, by specifying the style, name of the option, and new value:

```
s.configure('TButton', font='helvetica 24')
```

You'll learn more about what the valid options are shortly.

> *If you modify an existing style, like we've done here with `TButton`, that modification will apply to all widgets using that style (by default, all buttons). That may well be what you want to do.*

To retrieve the current value of an option, use the `lookup` method:

```
>>> s.lookup('TButton', 'font')
'helvetica 24'
```

State Specific Style Options

Besides the normal configuration options for the style, the widget author may have specified different options to use when the widget is in a particular widget state. For example, when a button is disabled, it may change the button's label to grey.

> *Remember that the state is composed of one or more state flags (or their negation), as set by the widget's `state` method or queried via the `instate` method.*

You can specify state-specific variations for one or more of a style's configuration options with a *map*. For each configuration option, you can specify a list of widget states, along with the value that option should be assigned when the widget is in that state.

The following example provides for the following variations from a button's normal appearance:

- when the widget is in the disabled state, the background color should be set to `#d9d9d9`
- when the widget is in the active state (mouse over it), the background color should be set to `#ececec`
- when the widget is in the disabled state, the foreground color should be set to `#a3a3a3` (this is in addition to the background color change we already noted)
- when the widget is in the state where the button is pressed, and the widget is not disabled, the relief should be set to `sunken`

```
s.map('TButton',
    background=[('disabled','#d9d9d9'), ('active','#ececec')],
    foreground=[('disabled','#a3a3a3')],
    relief=[('pressed', '!disabled', 'sunken')])
```

> *Because widget states can contain multiple flags, more than one state may match an option (e.g., `pressed` and `pressed !disabled` will both match if the widget's `pressed` state flag is set). The list of states is evaluated in the order you provide in the map command. The first state in the list that matches is used.*

Sound Difficult to you?

You now know that styles consist of elements, each with various options, composed together in a layout. You can change options on styles to make all widgets using the style appear differently. Any widgets using that style take on the appearance that the style defines. Themes collect an entire set of related styles, making it easy to change the appearance of your entire user interface.

So what makes styles and themes so difficult in practice? Three things. First:

> *You can only modify options for a style, not element options (except sometimes).*

We talked earlier about identifying the elements used in the style by examining its layout and identifying what options were available for each element. But when we went to make changes to a style, we seemed to be configuring an option for the *style* without specifying an individual element. What's going on?

Again, using our button example, we had an element `Button.label`, which, among other things, had a `font` configuration option. What happens is that when that `Button.label` element is drawn, it looks at the `font` configuration option set on the *style* to determine what font to draw itself in.

To understand why, you need to know that when a style includes an element as a piece of it, that element does not maintain any (element-specific) storage. In particular, it does not store any configuration options itself. When it needs to retrieve options, it does so via the containing style, which is passed to the element. Individual elements, therefore, are "flyweight" objects in GoF pattern parlance.

Similarly, any other elements will look up their configuration options from options set on the style. What if two elements use the same configuration option (like a background color)? Because there is only one background configuration option (stored in the style), both elements will use the same background color. You can't have one element use one background color and the other use a different background color.

*Except when you can. There are a few nasty, widget-specific things called **sublayouts** in the current implementation, which let you sometimes modify just a single element, via configuring an option like `TButton.Label` (rather than just `TButton`, the name of the style).*

Some styles also provide additional configuration options that let you specify what element the option affects. For example, the `TCheckbutton` style provides a `background` option for the main part of the widget and an `indicatorbackground` option for the box that shows whether it is checked.

*Are the cases where you can do this documented? Is there some way to introspect to determine when you can do this? The answer to both questions is "sometimes" (believe it or not, this is an improvement; the answer to both used to be a clear "no"). You can sometimes find **some** of the style's options by calling the style's `configure` method without providing any new configuration options. The reference manual pages for each themed widget now generally include a **styling options** section that lists options that **may** be available to change.*

This is one area of the themed widget API that continues to evolve over time.

The second difficulty is also related to modifying style options:

> *Available options don't necessarily have an effect, and it's not an error to modify a bogus option.*

You'll sometimes try to change an option that is supposed to exist according to element options, but it will have no effect. For example, you can't modify the background color of a button in the `aqua` theme used by macOS. While there are valid reasons for these cases, it's not easy to discover them, which can make experimenting frustrating at times.

Perhaps more frustrating when you're experimenting is that specifying an `incorrect` style name or option name does not generate an error. When doing a `configure` or `lookup` you can provide an entirely arbitrary name for a style or an option. So if you're bored with the `background` and `font` options, feel free to configure a `dowhatimean` option. It may not do anything, but it's not an error. Again, it may make it hard to know what you should be modifying and what you shouldn't.

This is one of the downsides of having a very lightweight and dynamic system. You can create new styles by providing their name when configuring style options without explicitly creating a style object. At the same time, this does open itself to errors. It's also not possible to find out what styles currently exist or are used. And remember that style options are really just a front end for element options, and the elements in a style can change at any time. It's not obvious that options should be restricted to those referred to by current elements alone, which may themselves not all be introspectable.

Finally, here is the last thing that makes styles and themes so difficult:

> *The elements available, the names of those elements, which options are available or affect each of those elements, and which are used for a particular widget can be different in every theme.*

So? Remember, the default theme for each platform (Windows, macOS, and Linux) is different (which is a good thing). Some implications of this:

1. If you want to define a new type of widget (or a variation of an existing widget) for your application, you'll need to do it separately and differently for each theme your application uses (i.e., at least three for a cross-platform application).
2. As the elements and options available may differ for each theme/platform, you may need a quite different customization approach for each theme/platform.
3. The elements, names, and element options available with each theme are not typically documented (outside of reading the theme definition files themselves) but are generally identified via theme introspection (which we'll see soon). Because all themes aren't available on all platforms (e.g., `aqua` is only available on macOS), you'll need ready access to every platform and theme you need to run on.

Consider trying to customize a button. You know it uses the `TButton` style. But that style is implemented using a different theme on each platform. If you examine the layout of that style in each theme, you'll discover each uses different elements arranged differently. If you try to find the advertised options available for each element, you see those are different too. And of course, even if an option is nominally available, it may not have an effect).

The bottom line is that in classic Tk, where you could modify any of a large set of attributes for an individual widget, you'd be able to do something on one platform, and it would sorta-kinda work (but probably need tweaking) on others. In themed Tk, the easy option just isn't there, and you're pretty much forced to do it the right way if you want your application to work with multiple themes/platforms. It's more work upfront.

Advanced: More on Elements

While that's about as far as we're going to go on styles and themes in this tutorial, for curious users and those who want to delve further into creating new themes, we can provide a few more interesting tidbits about elements.

Because elements are the building blocks of styles and themes, it begs the question of "where do elements come from?" Practically speaking, we can say that elements are normally created in C code and conform to a particular API that the theming engine understands.

At the very lowest level, elements come from something called an *element factory*. At present, there is a default one, which most themes use, and uses Tk drawing routines to create elements. A second allows you to create elements from images and is accessible at the script level using the `ttk::style element create` method (from Tcl). Any image format supported by Tk is available, including scalable image formats like SVG, if you have the right extension. Finally, there is a third, Windows-specific engine using the underlying "Visual Styles" platform API.

If a theme uses elements created via a platform's native widgets, the calls to use those native widgets will normally appear within that theme's element specification code. Of course, themes whose elements depend on native widgets or API calls can only run on the platforms that support them.

Themes will then take a set of elements and use those to assemble the styles that are actually used by the widgets. And given the whole idea of themes is that several styles can share the same appearance, it's not surprising that different styles share the same elements.

So while the `TButton` style includes a `Button.padding` element, and the `TEntry` style includes an `Entry.padding` element, underneath, these padding elements are more than likely one and the same. They may appear differently, but that's because of different configuration options, which, as we recall, are stored in the style that uses the element.

It's also probably not surprising to find out that a theme can provide a set of common options that are used as defaults for each style if the style doesn't specify them otherwise. This means that if pretty much everything in an entire theme has a green background, the theme doesn't need to explicitly say this for each style. This uses a root style named `"."`. If `Fun.TButton` can inherit from `TButton`, why can't `TButton` inherit from `"."`?

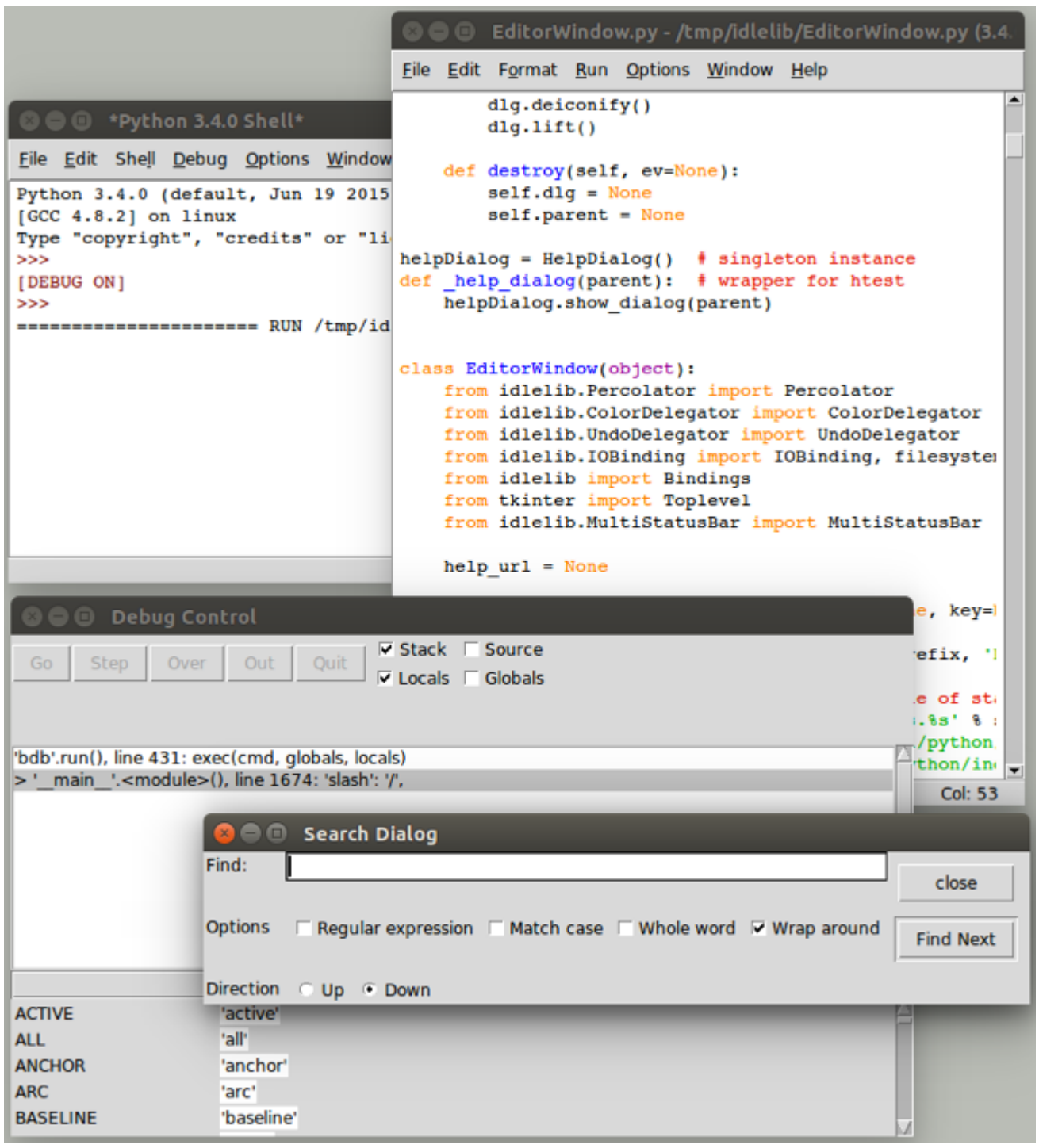
Finally, it's worth having a look at how existing themes are defined, both at the C code level in Tk's C library and via the Tk scripts found in Tk's "library/ttk" directory or in third-party themes. Search for `Ttk_RegisterElementSpec` in Tk's C library to see how elements are specified.

Case Study: IDLE Modernization

This chapter presents a case study of modernizing the appearance of a substantial Tk-based application.

Some of the changes here are slowly finding their way into the Python source tree, but most are not there yet. You can find temporary snapshots on GitHub.

IDLE (Integrated DeveLopment Environment) is the standard Python development environment that is bundled with every Python release. It consists of an interactive Python shell, editors with syntax highlighting, a debugger, etc. Its user interface is written in Tkinter.



Overview of IDLE user interface (on Linux).

IDLE was never intended to be a replacement for more full-featured development environments. Because it is relatively simple and bundled with Python, it is popular for those learning (and teaching) the language.

Originally created by Python BDFL Guido van Rossum in 1998, IDLE has been incrementally added to over the years by multiple other developers. But with limited development effort spent on it, it was showing its age, especially on platforms (e.g., macOS) infrequently used by those improving IDLE.

A Python Central comparison of IDE's described IDLE this way:

> *All those features are, in fact, present, but they do not really make an IDE. In fact, while IDLE offers some of the features you expect from an IDE, it does so without even being a satisfactory text editor. The interface is buggy and fails to take into account how Python works, especially in the interactive shell, the auto-completion is useless outside the standard library, and the editing functionality is so limited that no serious Python programmer — heck, no serious typist — could use it full-time.*
>
> *If you use an IDE, it should not be IDLE.*

With its buggy and dated user interface, IDLE was at risk of being removed from the Python distribution altogether. Yet, because it is simple and bundled, many people, particularly those teaching Python, were eager to see IDLE leap forward.

IDLE was obviously a great candidate to be modernized, using newer Tk features like the themed widgets to help spur some redesign. But it was about more than just swapping widgets. Many improvements could be made just by changing how the "classic" widgets were being used to better reflect a more modern design aesthetic.

IDLE, which is an application, is part of Python's standard library (i.e., 99% designed to be used by other code). That meant following many policies and procedures (not really appropriate for an application) that made changes difficult. Removing some of those roadblocks (see PEP 434) was a significant step required for the types of changes being discussed here.

Project Goals

As you can imagine, modernizing a large application like this, based on "classic" Tkinter, was not entirely straightforward. In this chapter, I'll walk through some of the user interface changes made and why.

Everyone involved wanted to see IDLE look a lot better than it did, though nobody was under the illusion that it would turn into a stunning example of cutting-edge design. But something that fit in more so that people could learn about Python without getting distracted by the clumsiness of their tools seemed doable.

The goal also wasn't to compete with Python IDE's more commonly used by professional programmers, such as PyCharm, WingIDE, PyDev, Komodo, etc. Though some more experienced Python developers use IDLE, sporadically or otherwise, it primarily needed to appeal to newcomers to the language and often those new to programming altogether.

There was no shortage of previous attempts to radically advance IDLE, resulting in several *forks* boasting all kinds of improvements. Many of them used other GUI toolkits or modules that weren't part of the standard library. Staying with Tkinter and the standard library was important to ensure every improvement could, over time, make it into the *official* version that ships with Python, rather than becoming just another fork.

As well, the hope was to make IDLE easier to contribute to. This suggested pruning down a substantial volume of code, removing some redundancies and inconsistencies, cleaning up some of the more complex pieces, simplifying interactions between system components, etc. There was also a substantial list of reported bugs that we hoped to make a dent in.

While no less critical, I'll largely defer discussion of the substantial issues surrounding software architecture, backward compatibility (including systems running Tk 8.4, pre-ttk, which received only a few selective improvements), etc.

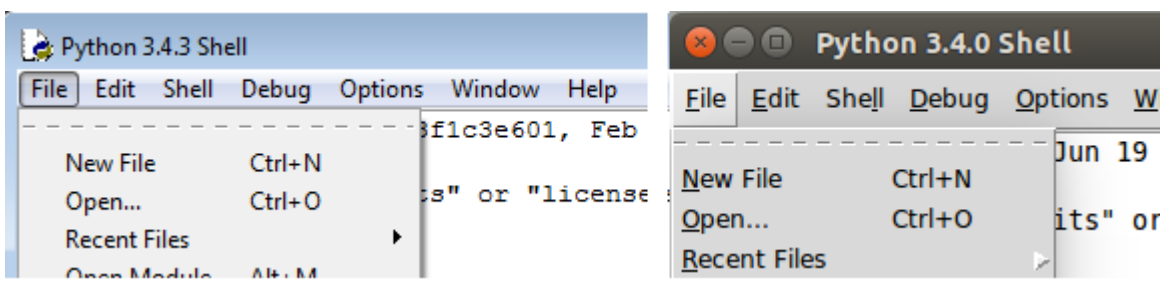
Throughout this chapter, you'll find links to individual issues in Python's issue tracking system, which often provide additional insight into various peoples' thought processes around changes.

> *As you'll see, this chapter highlights many of the shortcomings of IDLE's user interface. This is done mainly for emphasis because many of the problems shown here are common to many applications and user interfaces. I have only the highest respect for the people who donated their limited time and resources to this open source project and had to consciously make tradeoffs between time, features, and user interface, all within the context of a decidedly non-trivial codebase.*

As the material in this chapter relates to a specific Python application, all the examples will be given solely in Python and using Tkinter. So if you're wondering why you're seeing Python code here where you didn't everywhere else, that's why.

Menus

The very first change that was made was to remove the archaic tearoff menus. The macOS version of Tk doesn't even support them, but they were still there on Windows and X11. See [Issue#13884].



Tearoff menus on Windows and Linux.

The change here was to add a "tearoff=0" option to the few places in the code where these menus were created.

At least that was easy.

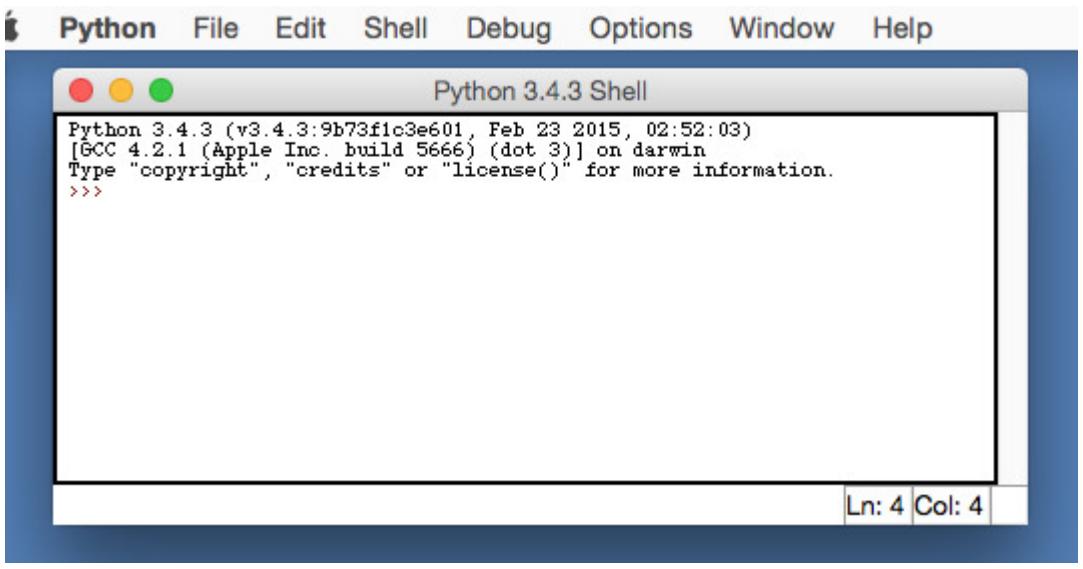
There were also several bugs where items in the menu were not properly disabled when the feature was unavailable. This led to either menu items that did nothing (confusing for learners) or error dialogs that said little more than "you can't do that."

Main Window

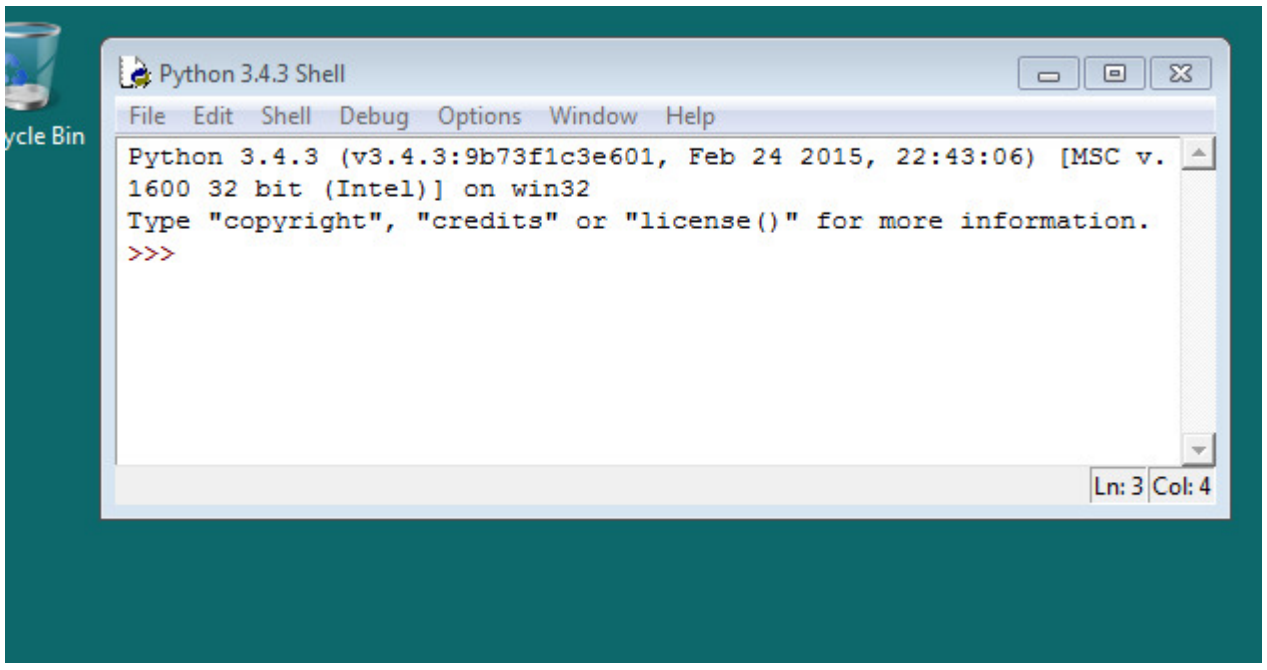
One good thing about IDLE is that because it revolves around an editor and a shell, most of it really is a Tk text widget, and there was very little about *its* user interface that had to change. But even in the main window, which is mostly just a text widget, there were improvements to be had.

The following images show the original version of IDLE's shell window, pre-modernization, just as someone would see when they first launched the program.

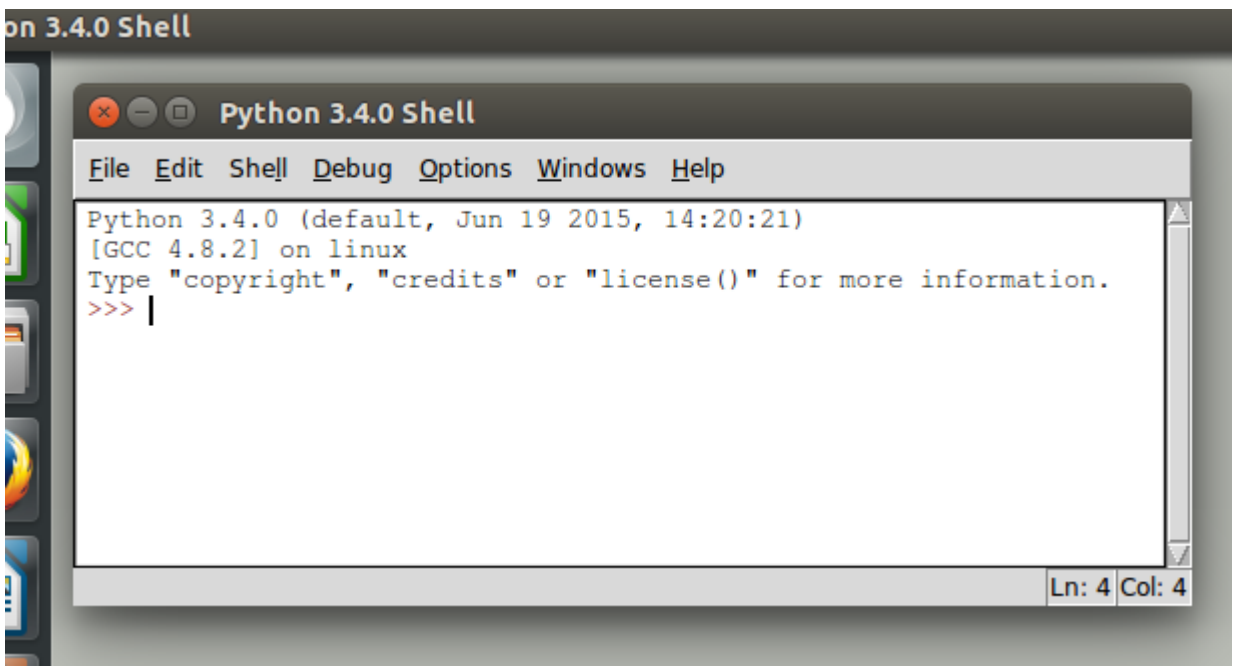
Looking at them, what improvements would you make?



Main IDLE window on macOS.



Main IDLE window on Windows.



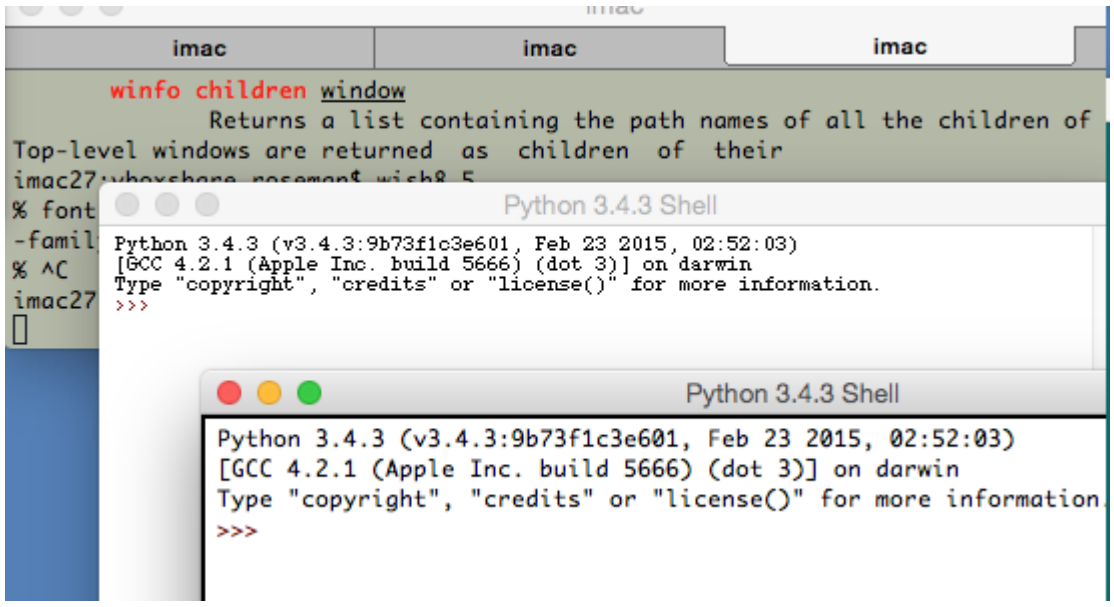
Main IDLE window on Linux.

Default Font

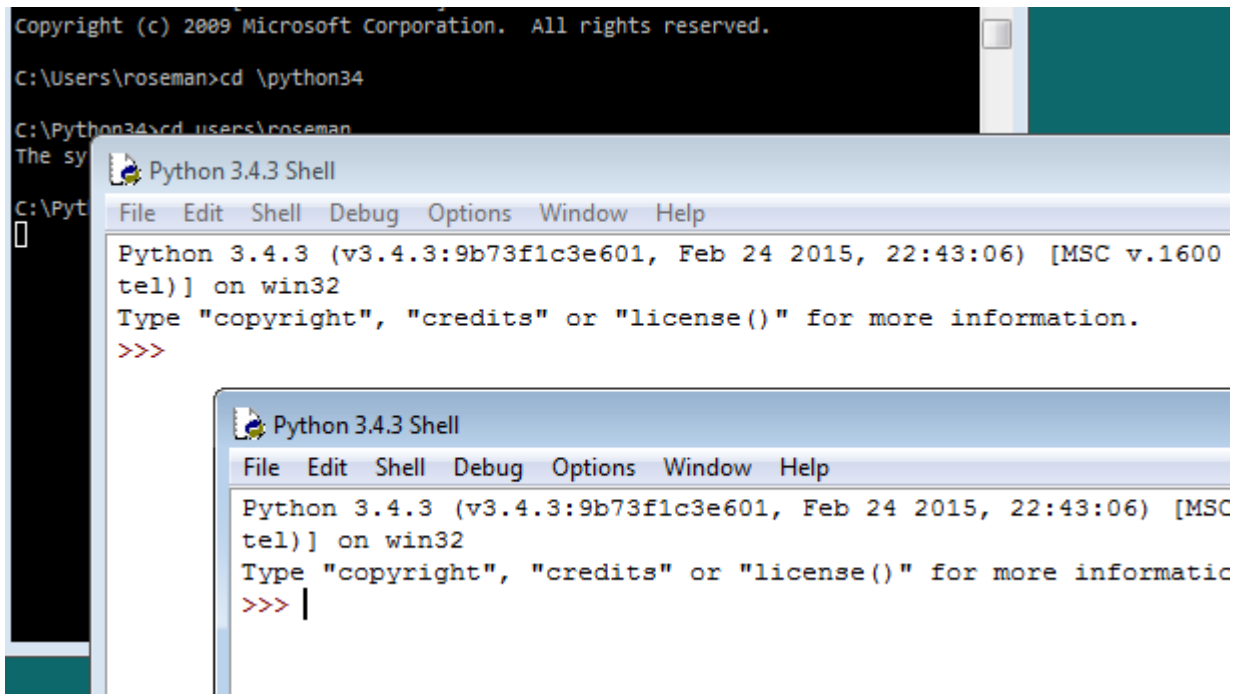
The first change that was made had to do with the default font. IDLE hardcoded 10 point Courier and used that on all platforms. This didn't actually look too bad in Windows, was ok on Linux, but looked terrible on macOS; see [Issue#24745]. Sure this could be changed through a preferences dialog, but the defaults certainly didn't leave a good impression.

While one option would simply be to write the code to pick a good font depending on which platform we're running on, the default was instead changed to use Tk's built-in `TkFixedFont`, which provides a better default on each platform.

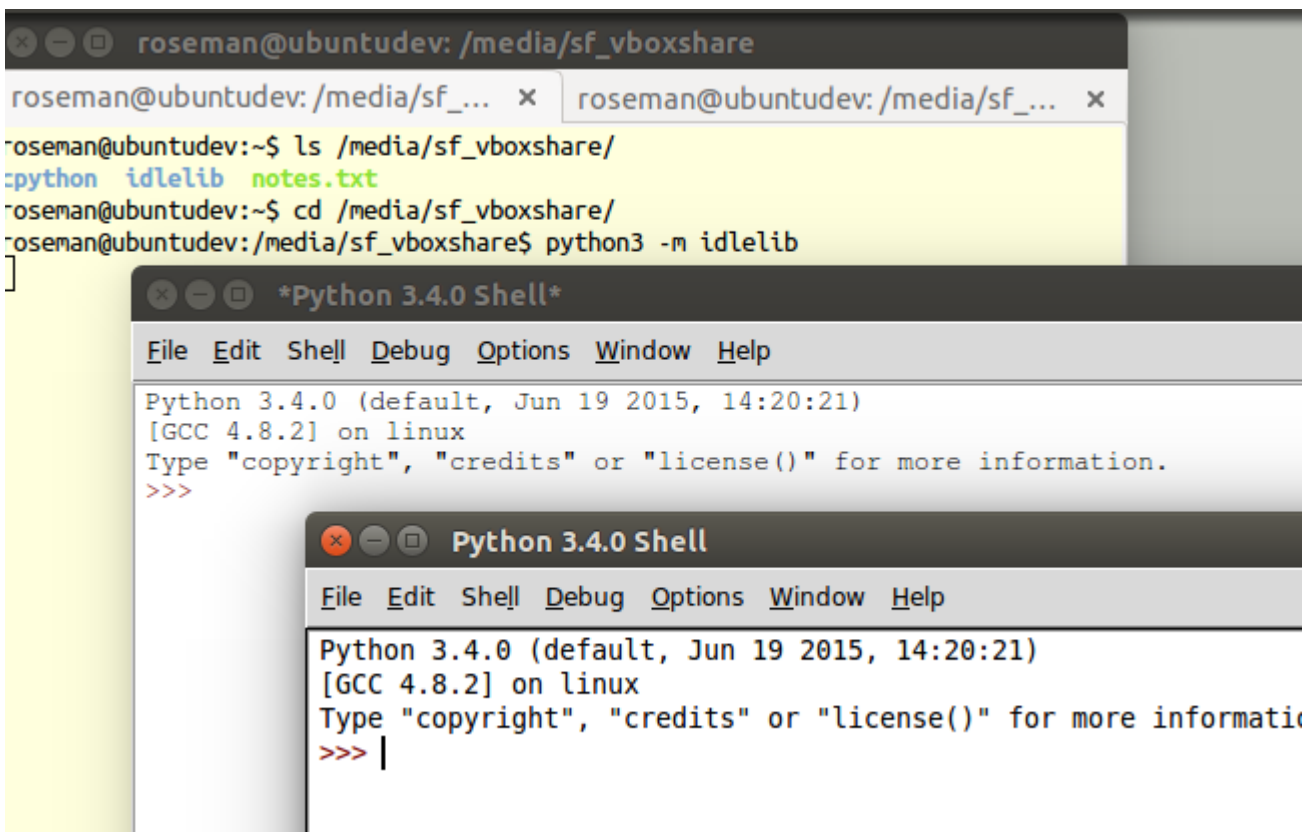
You can see the differences in the screenshots below. Notice how the new fonts seem to match better with system terminal windows that are shown.



IDLE main window using TkFixedFont (macOS).



IDLE main window using TkFixedFont (Windows).



IDLE main window using TkFixedFont (Linux).

Speaking of preferences dialogs, if you want to change the font it often helps to know what the font actually is (using `Font.actual`). Here's the new code from IDLE's preferences dialog that figures that out:

```
if (family == 'TkFixedFont'):
            f = Font(name = 'TkFixedFont', exists = True, root = root)
            actualFont = Font.actual(f)
            family = actualFont['family']
            size = actualFont['size']
            if size < 0:
                size = 10  # if font in pixels, ignore actual size
            bold = 1 if actualFont['weight']=='bold' else 0
```

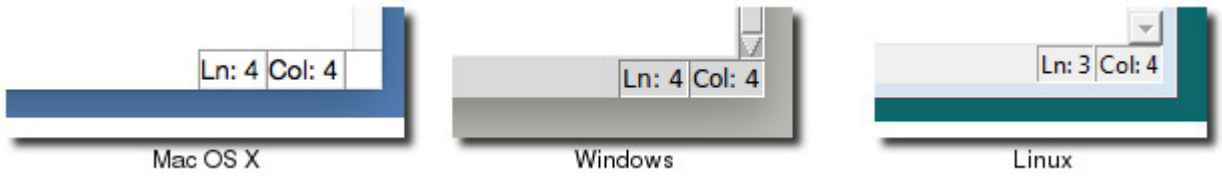
For the record, the fonts that Tk chose for TkFixedFont are Monaco 11 on macOS, Courier New 10 on Windows, and DejaVu Sans Mono 10 on Linux (Ubuntu 14 to be specific).

Around the Text Widget

There were a few other cosmetic things that just weren't right around the edge of the main window; see [Issue#24750]. Look back at the earlier screenshots of the IDLE main window.

Notice there's a border around the text widget. It's most noticeable on macOS, where it's a dark black, somewhat less so on Linux, and barely perceptible on Windows. This is the result of Tk's "highlightthickness" attribute, which is present when the text widget has the focus.

If the text widget doesn't have the focus, such as when the window becomes inactive, the highlight goes away:



Status bar on inactive window.

Notice how on the macOS screenshot, without the highlight, the status bar at the bottom of the window blends into the text widget. Not good.

As you'll see from looking at other applications, the border around the text widget is no longer a common convention. So let's start by removing that, which is as easy as adding "highlightthickness=0" when creating the text widget.

That still leaves us with the problem of the status bar blending into the editor. We changed the status bar to be a `ttk.Frame` widget, which has a background shading on all platforms. We also placed a `ttk.Separator` widget just above the status bar to give us that clean separation.

Each of the line and column indicators were labels, previously created with:

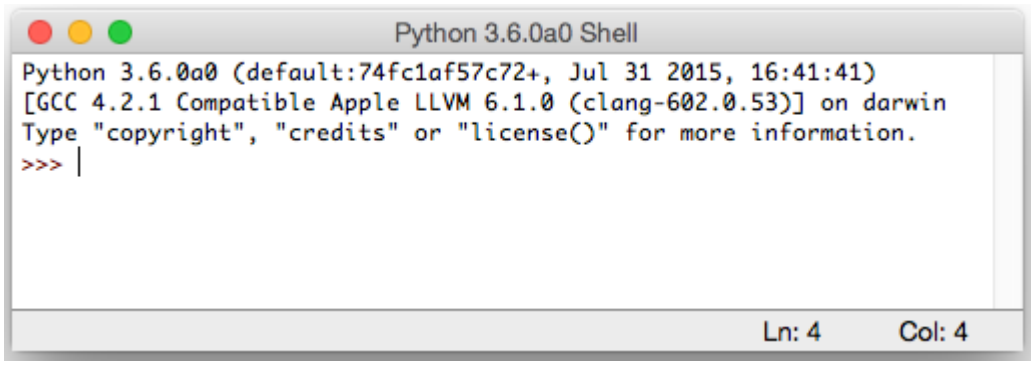
```
label = Label(self, bd=1, relief=SUNKEN, anchor=W)
```

This was replaced with a `ttk.Label` to ensure it matched the frame. We also did away with the 1990's sunken "3d" look.

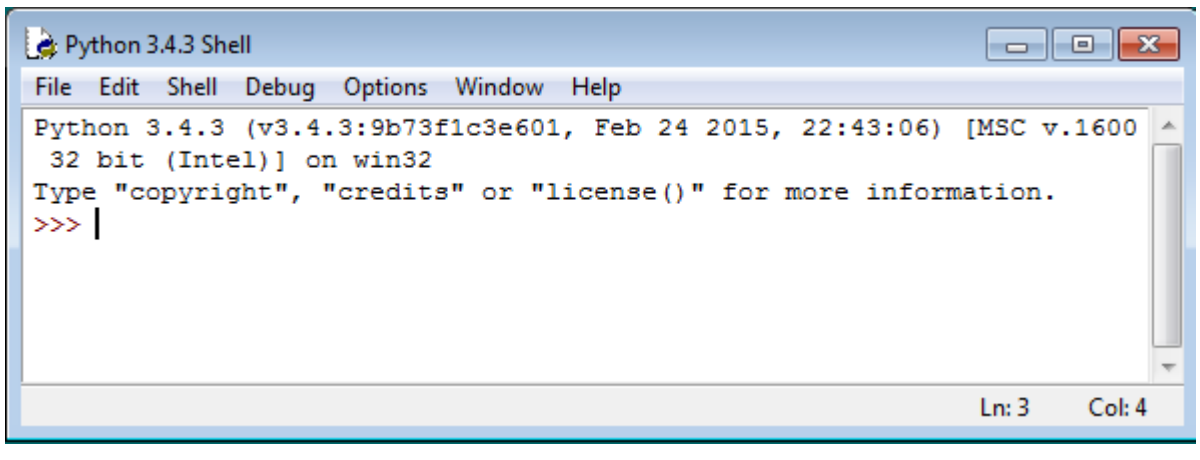
```
label = ttk.Label(self)
```

Last but not least, we can replace the original Tk scrollbar with the newer `ttk.Scrollbar` widget.

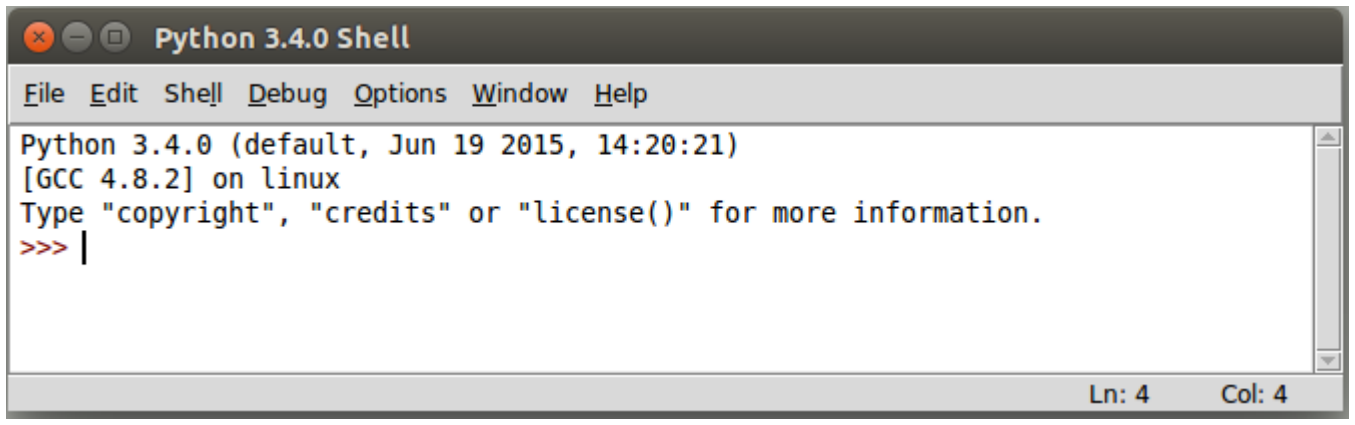
The resulting changes to the main window are shown below. Despite these being fairly minor, often subtle changes, they go a long way towards IDLE's main window looking a lot cleaner, more modern, and "just fitting in" on all platforms.



IDLE's main window, with improvements (macOS).



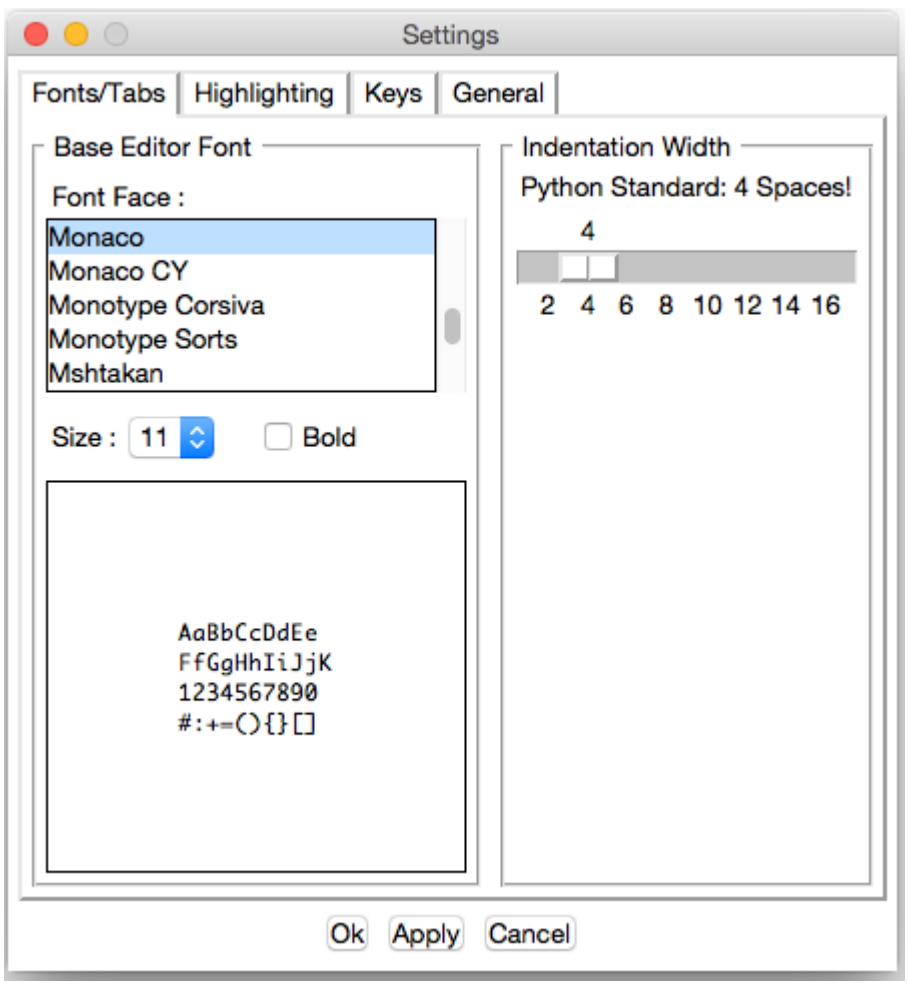
IDLE's main window, with improvements (Windows).



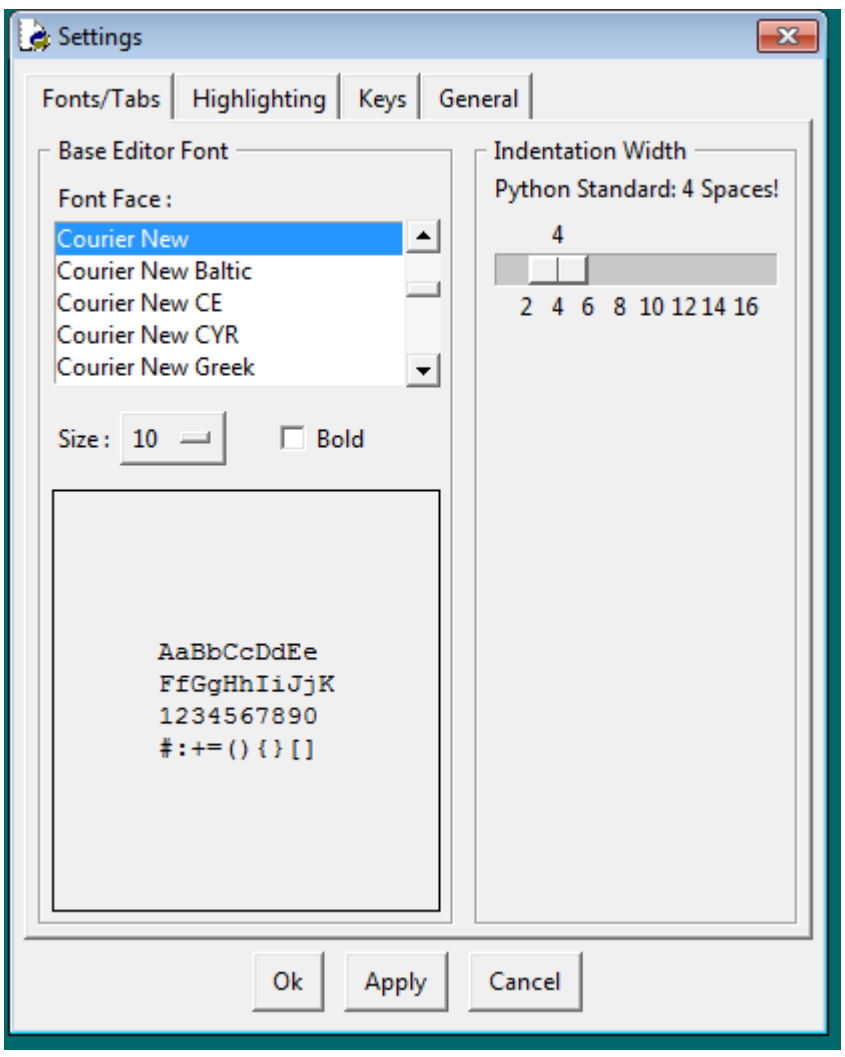
IDLE's main window, with improvements (Linux).

Preferences Dialog

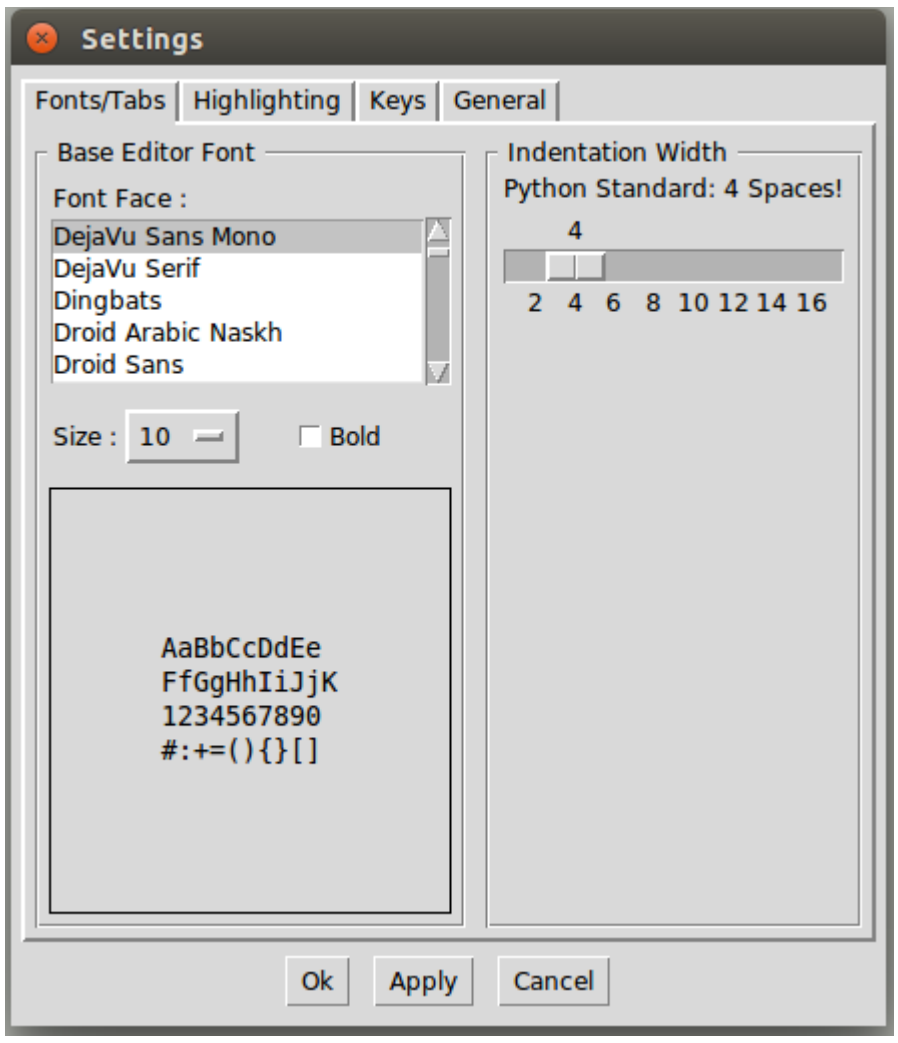
One visible piece that greatly needed improvement was the Preferences dialog. Again, here are screenshots on the three platforms:



IDLE's Preferences window (macOS).



IDLE's Preferences window (Windows).



IDLE's Preferences window (Linux).

The other tabs allow you to modify individual colors for syntax highlighting, keystrokes assigned to particular operations, and a few other miscellaneous things.

While there was some debate as to the need for this level of configuration on what was primarily a learning environment, it seemed reasonable to at least make what was there look and work better before considering any more radical surgery; see [Issue#24810].

Among other things, the Preferences dialog was changed from modal (which, amusingly enough, didn't quite work on macOS, allowing multiple copies to be created) to modeless, though I won't go further into that at this point; see [Issue#24760].

Tabs

The first issue to address was the tabs used to switch between the four different preference panes. The original used a custom "megawidget", as classic Tk doesn't have its own widget. While the Windows and Linux ones don't look too bad, on recent versions of macOS, there is a built-in tab widget that looks quite different.

> *It's actually more common in macOS applications now to use something similar to a toolbar (row of icons with labels along the top or side) to switch between preference panes, though some programs do still use tabs. Tabs are very common on Windows and Linux.*

The code was modified to use the `ttk.Notebook` widget, which not only looks better on each platform but allows us to scrap a lot of code for managing tabs ourselves.

Updating Widgets

The next obvious step was upgrading the "classic" widgets to their themed counterparts. On this screen, that included the buttons, labels, frames, checkbox, scrollbar, etc. There were a few others on some of the other panes. Generally, this was a straightforward process, often involving removing widget options that were no longer needed or supported by the themed widgets.

Sometimes choosing a different widget made more sense. In this screen, the option menu used for font size was better replaced by a combobox. Similarly, the scale widget is not commonly seen in today's user interfaces and was replaced with the more familiar (and compact) spinbox widget.

There were also various non-standard ways of using certain widgets or specifying certain types of data. These were generally modified to use more familiar paradigms. There were several general issues discussed relating to the design of these dialogs, see, e.g., [Issue#24776], and [Issue#24782].

Layout

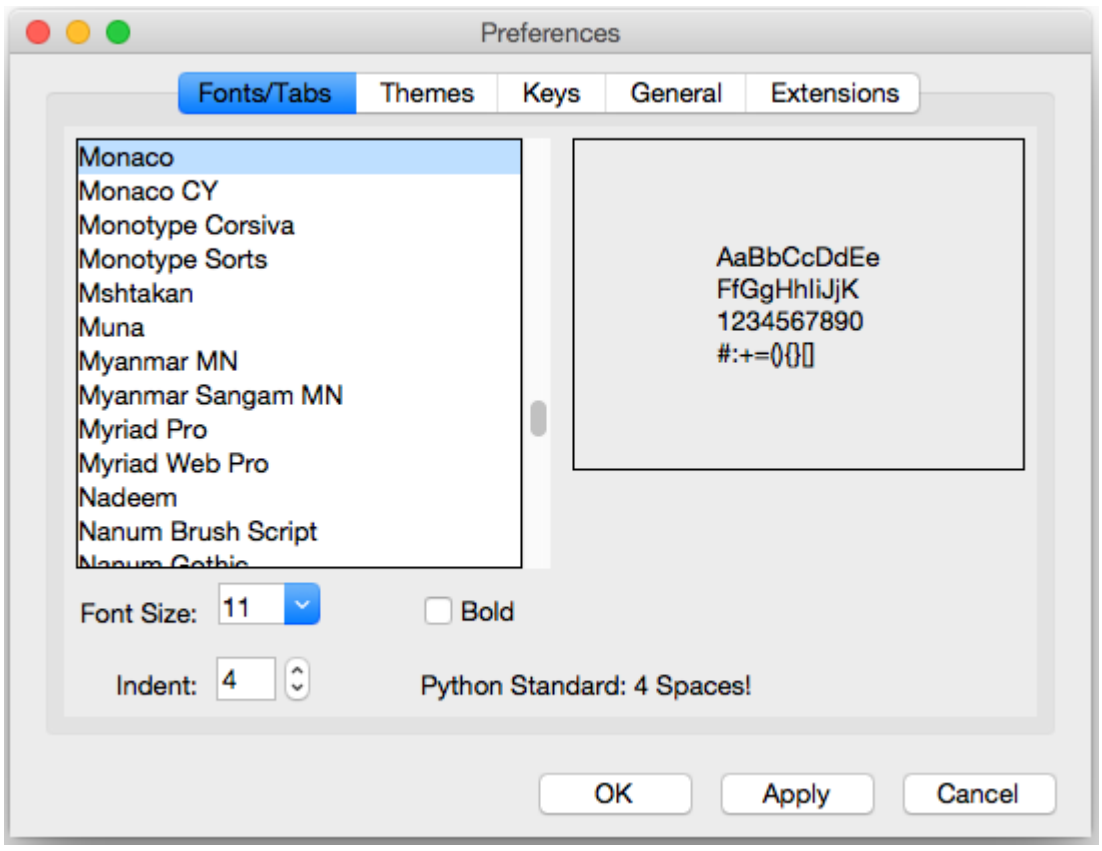
While this dialog is a bad example (just given the space imbalance between the left and right halves), a lot of time was spent looking at widget spacing and alignment in dialog boxes.

The general approach was to find similar examples in other applications and use those as a guide. Where are the buttons located? How are multiple fields of a dialog organized? Where are labels relative to the widget they're labeling? Are they left- or right-aligned, capitalized, or do they have a trailing colon? These are the sorts of questions to think about.

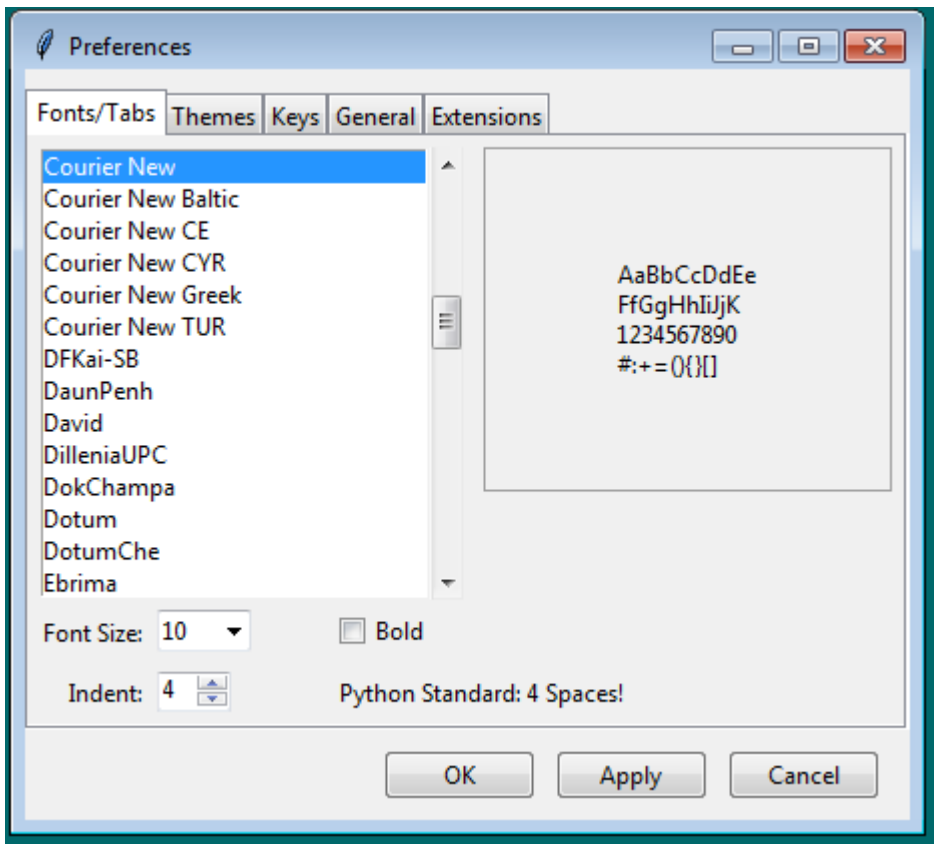
> *A great starting point is converting from using the old `pack` geometry manager to `grid`. Because of the way it works, `pack`-based layouts tend to have weird and inconsistent alignment and spacing, especially if they've been modified over time. Using `grid` will increase maintainability because it uses a more familiar mental model and isn't dependent on the order in which widgets are inserted.*

It's likely impossible to come up with one layout that looks fantastic on all platforms, but often you can come up with one (possibly with a couple platform-specific tweaks in the code) that looks decent.

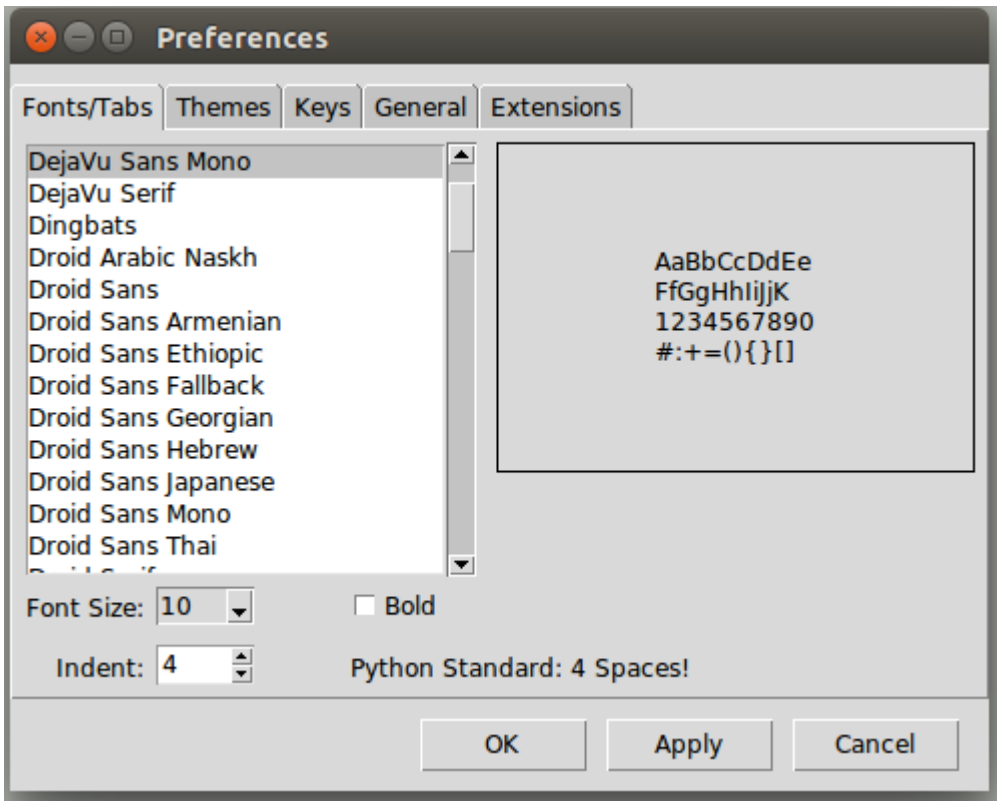
A revised version of the dialog, incorporating many of the techniques here, is shown below.



IDLE Preferences, revised version (macOS).



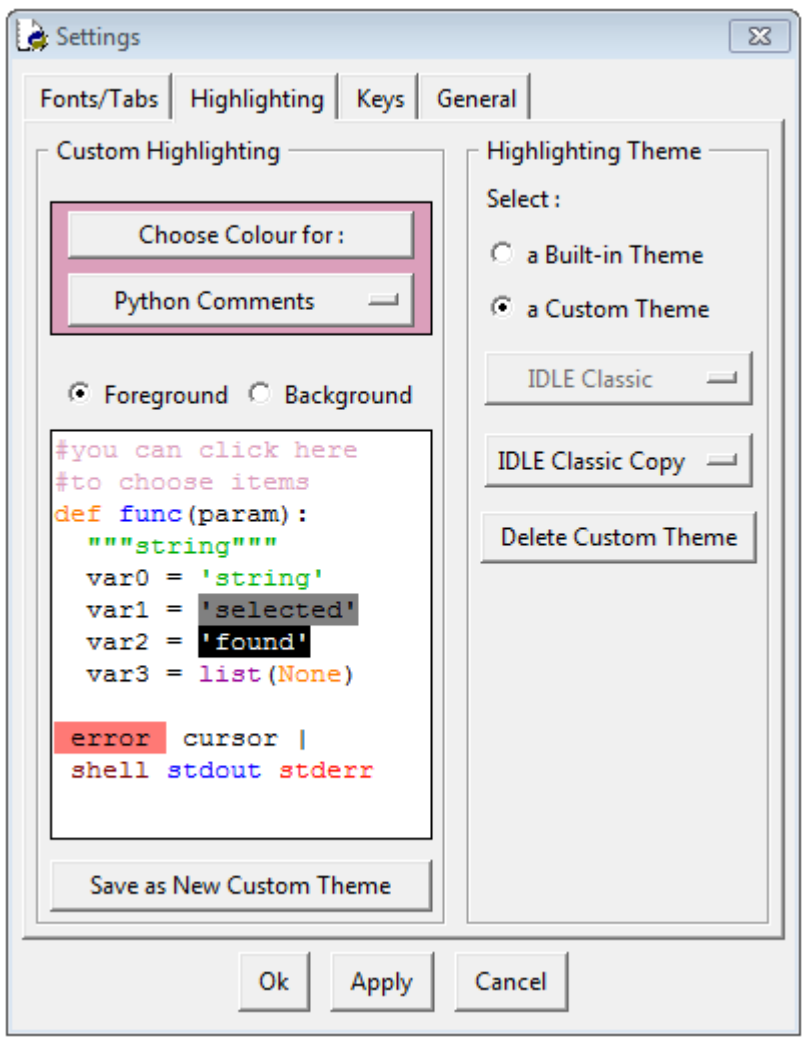
IDLE Preferences, revised version (Windows).



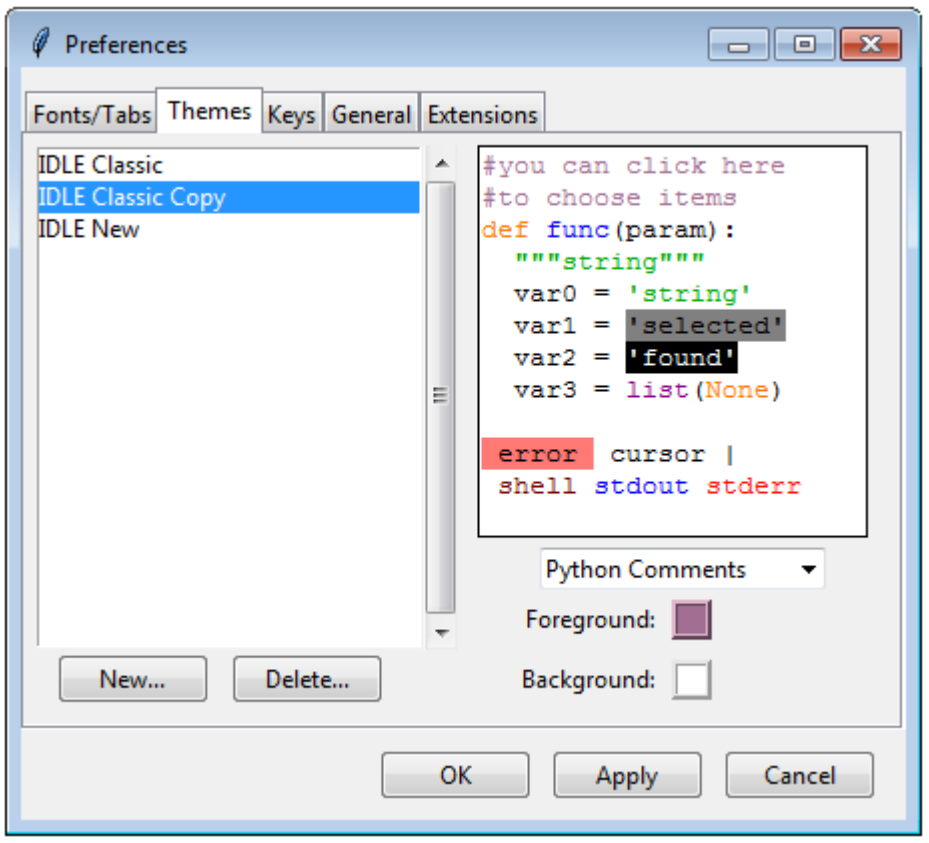
IDLE Preferences, revised version (Linux).

Another Example

The screenshot below shows a before and after of the IDLE Preferences pane, which controls syntax coloring; see [Issue#24781].



IDLE Themes pane, before (Windows).



IDLE Themes pane, after (Windows).

Again, substituting widgets and using more familiar conventions is one piece of this. I think the bigger changes have to do with thinking about things from the users' perspective. Particularly as a beginner tool, if you're in here at all, it's probably to switch themes, not tweak colors, which is more prominent in the new version. It also does away with an arbitrary distinction between "built-in" and "custom" themes.

I think the new version is a big improvement, though I have yet to convince some people of this to date. This being open source, we'll see what happens!

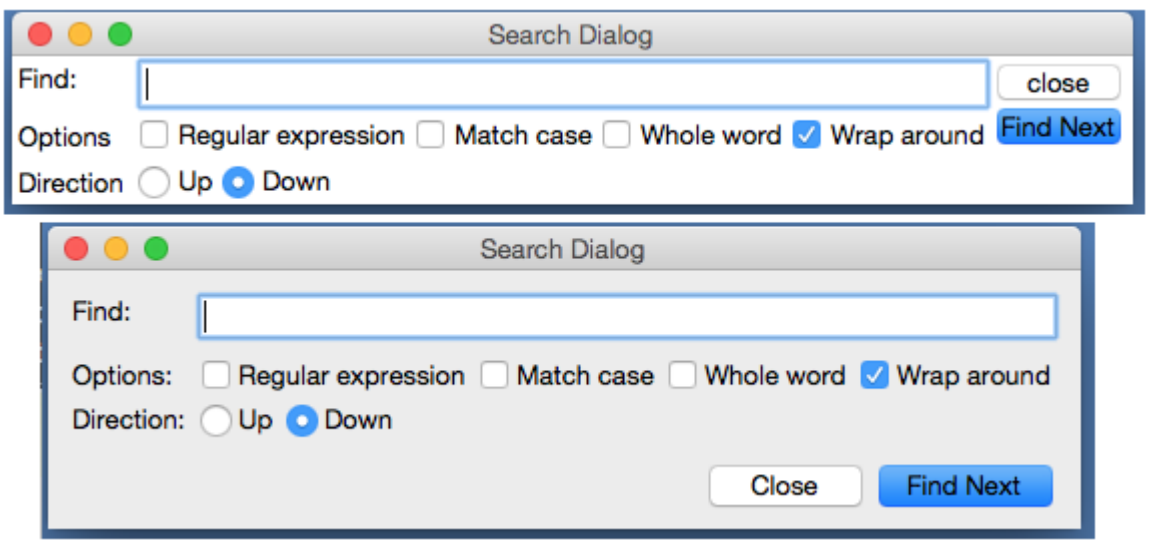
Other Dialogs

There are multiple other dialog boxes in IDLE; we'll consider a couple more examples here.

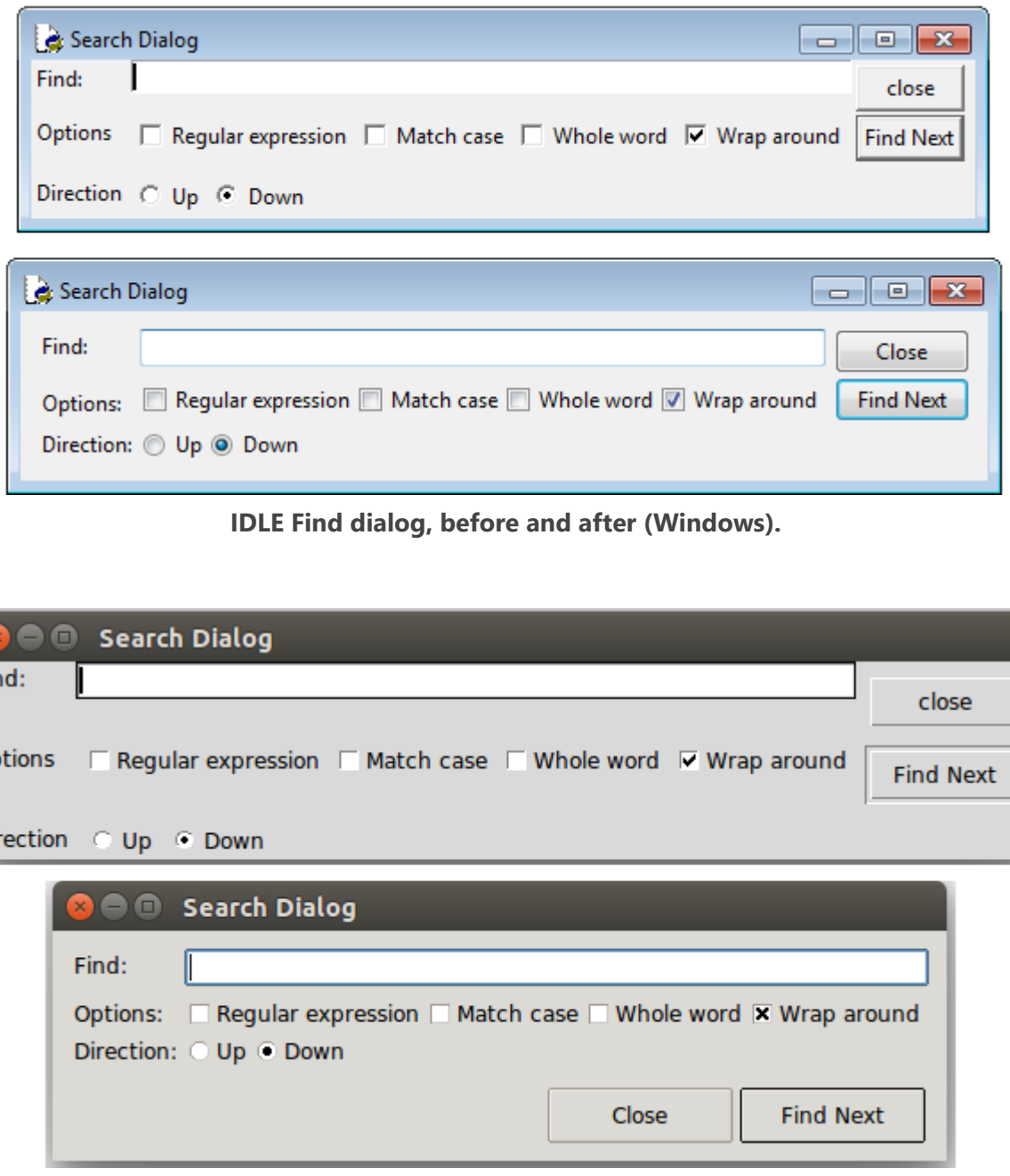
Find Dialog

> *Planning on doing some more changes on these, likely combining Find and Replace into a single dialog.*

One of the find/search dialogs is shown below, again with before and after on the three platforms; see [Issue#23218].



IDLE Find dialog, before and after (macOS).



IDLE Find dialog, before and after (Windows).

IDLE Find dialog, before and after (Linux).

The first step was upgrading the widgets to use the equivalent themed widgets. The effect of this is most obvious with the buttons (being consistent with the capitalization doesn't hurt either).

Speaking of buttons, notice they moved to the bottom on macOS and Linux, though they remained on the right on Windows. On examining multiple different applications, our target users would likely have encountered on each platform, we found these locations were common. With only a few lines of extra code needed to special-case for this layout difference, it made sense to handle things this way.

Other aspects of the layout were also improved. Looking at the original dialogs (especially how the buttons don't align with other widgets), I originally thought it was created with `pack`, and expected to convert it to `grid`. Interestingly, it was already using `grid`. Why then were the widgets unaligned, a hallmark of `pack`-based layouts?

This turned out to be a result of using many *nested frames*. For example, the buttons were placed into their own frame and then placed into the rest of the window. Because of that, the individual buttons couldn't be aligned with widgets in the rest of the user interface.

Nested frames were required when using `pack`, but often with `grid` it is better to avoid them except in exceptional circumstances. That allows you to align different parts of the user interface (at the expense of much columnspan/rowspan tweaking).

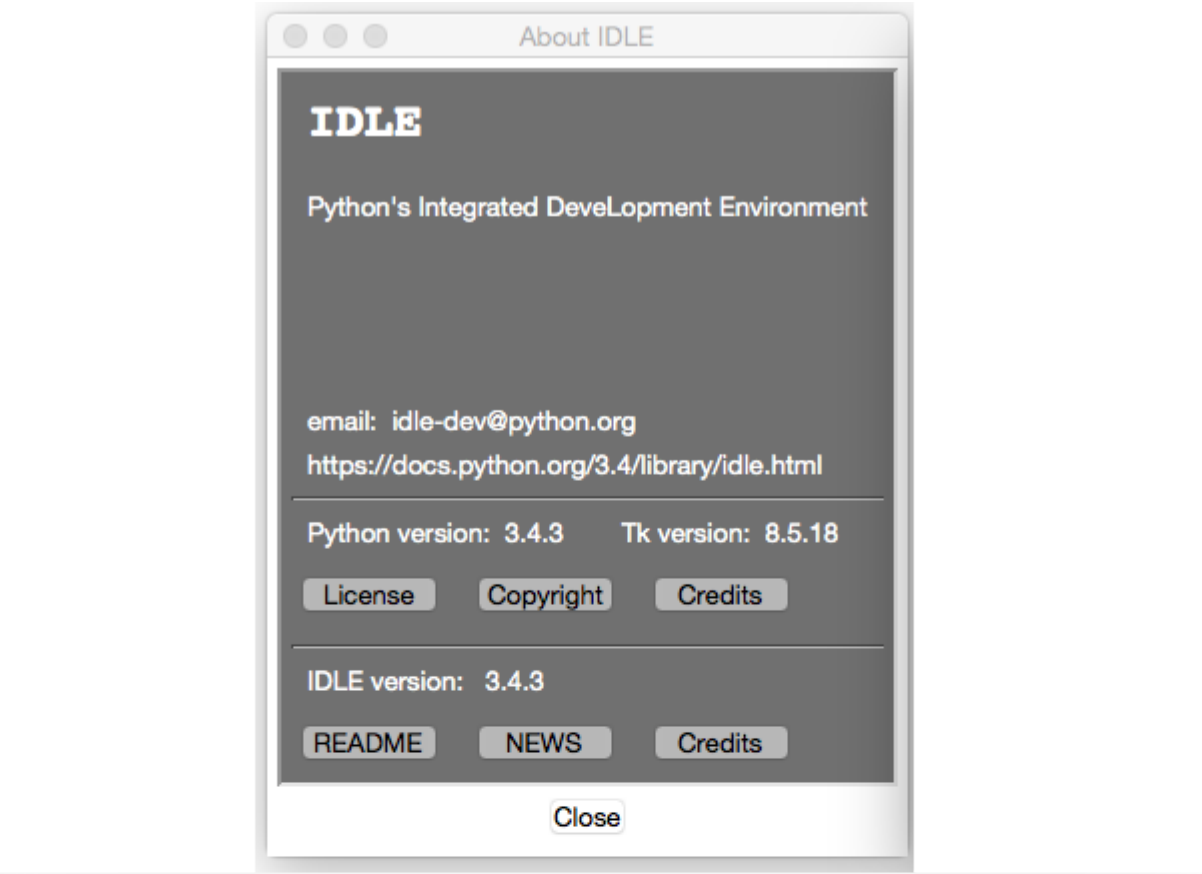
A more substantial reorganization would have likely removed the nested frames, but particularly with adjusting the buttons, this relatively simple layout could be made to work with just a few tweaks.

> 💡 *You'll notice many older Tkinter user interfaces have the problem here of their contents running to the edge of the windows, which often doesn't look right. I've gotten into the habit of placing a `ttk.Frame` directly inside each toplevel, with some additional padding, and then placing the rest of the user interface inside that.*

Like Preferences, the Find dialogs were also modal, which meant you had to dismiss them before doing any editing of your file, though at least they did remember the previous settings when you reopened them. These were eventually changed to be regular modeless windows.

About Dialog

Speaking of modal dialogs, the About box was also originally modal. Not only that, getting more information (e.g., the IDLE README file) resulted in launching *another* modal dialog, which needed to be dismissed to go back to the first modal dialog, which needed... etc.

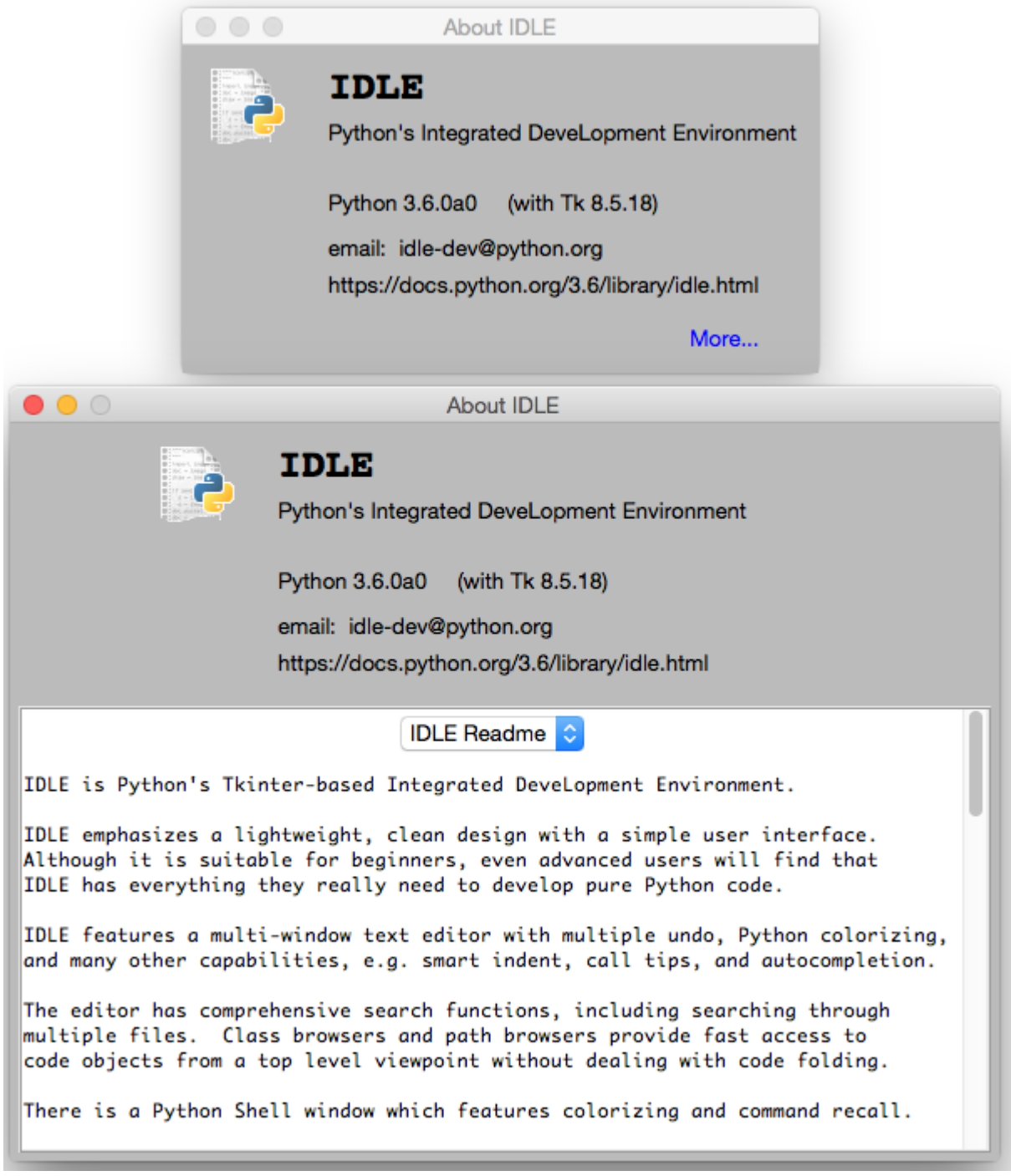


IDLE's doubly-modal About dialog (macOS).

Making the dialog non-modal was the first priority. Second, the nested dialogs were eliminated using a progressive disclosure technique. The initial dialog is fairly sparse but contains a 'More...' "link." When clicked, it expands the window to show one of the documentation files, with an option to switch to any of the others.

The 'More...' "link" effectively plays the role of a button, but takes advantage of everyone's familiarity with web browsers to provide a visually simpler alternative. As far as implementation, we use a (classic, non-themed) label widget, colored blue, and attach a mouse click binding to it.

> 💡 *You can help convey that the link is clickable by changing the cursor when the mouse is over it (via the "cursor" option found on many widgets). On macOS, choose the platform-specific "pointinghand" cursor, on Windows and Linux choose the "hand2" cursor, which actually gets mapped to something more appropriate on those platforms.*



Revised About dialog (macOS).

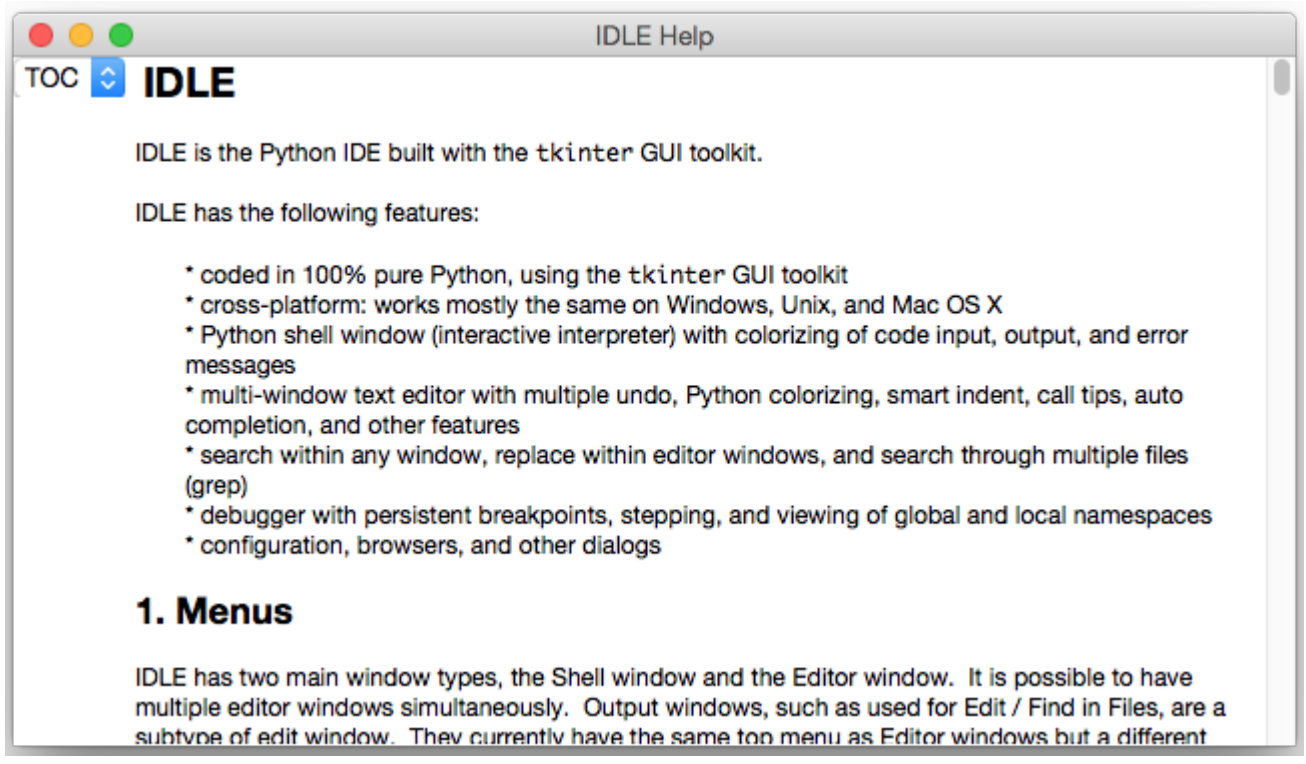
Online Help

IDLE also had a (needless to say, modal) help dialog which displayed information on using the program. This displayed a plain text help file that looked similar to the 'About - Readme' window above.

At the same time, like the rest of Python, there was reference documentation, created as "restructured text" which can then be formatted using a tool called Sphinx into HTML, text, etc.

The documentation in IDLE's help dialog was based on a separate but similar plain text file. Keeping the two in sync was a problem. They were separate because Sphinx's plain text rendering didn't look all that good, and all the extra navigation, etc. in the HTML rendering wouldn't be needed for online help, and then there's the hassle of opening a web browser, etc.; see [Issue#16893].

Tk's text widget is smart enough to handle the very basic formatting used in IDLE's documentation, and Python includes an HTML parser in its standard library. Putting the two together made displaying a simplified version of the HTML reference documentation easy.

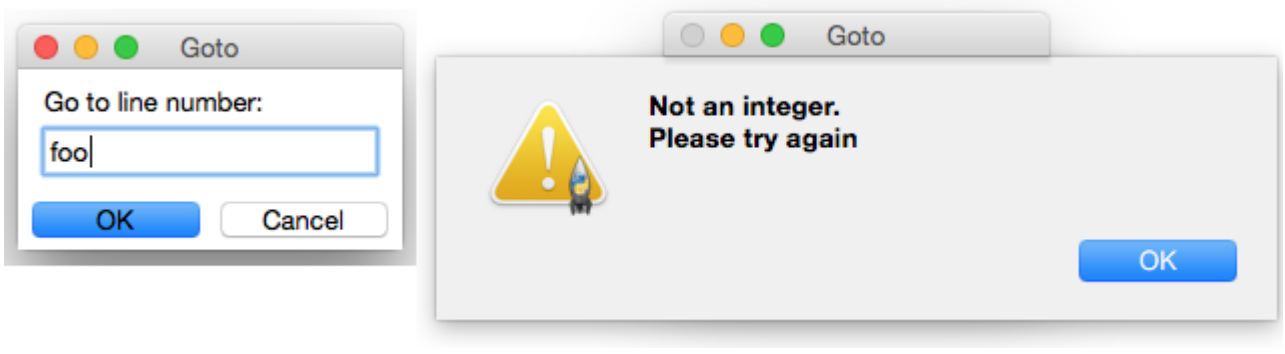


Online help using text widget (macOS).

> *It's easy to get carried away here. Back in the mid-1990s, a tiny HTML parser in Tcl spawned a slew of "web browser in a text widget" adventures, first in Tcl and then in other languages, e.g., Python's Grail. Trying to keep up with everything that large teams of developers are putting into real web browsers is a fool's errand. Yet, for very limited and constrained subsets of HTML (as might be found in online help), it's an entirely reasonable approach.*

Query Dialogs

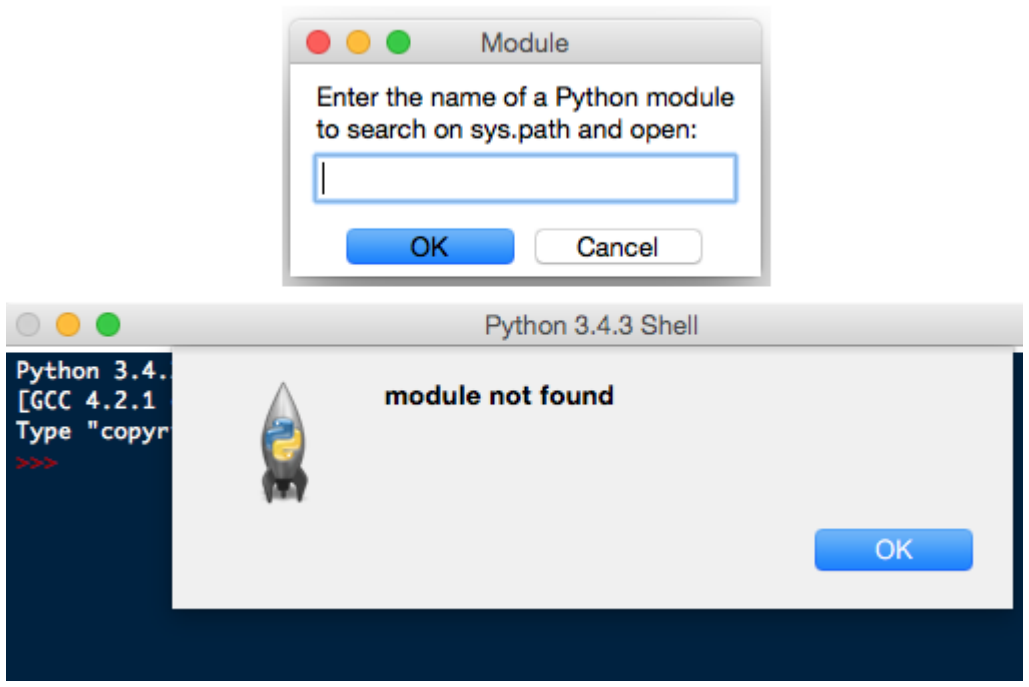
Still with the modal dialog theme, IDLE used the "simpledialog" package, distributed as part of Tkinter, to request certain small pieces of information from users via modal dialogs. An example is the "Goto line..." command. This, along with an example of the alert that is presented if you type in something invalid is shown below.



Goto line dialog and error handling (macOS).

The alert-on-dialog isn't quite as bad as the dialog-on-dialog pattern we saw before. But these dialogs could certainly stand to be cosmetically updated and a few other tweaks made. For example, while they correctly interpreted hitting the Return or Escape keys as synonymous with pressing OK or Cancel, they didn't also allow for the alternate macOS conventions (Enter key on the numeric keypad and Command-period); see [Issue#24812]. Some other customizations would have been nice to have (e.g., changing the name of the OK button) that simpledialog didn't support.

Regarding the error handling, things were, in some cases, handled worse. For example, there is a command to open an editor window containing the source of a module from Python's stdlib. See what happens if you make a typo.

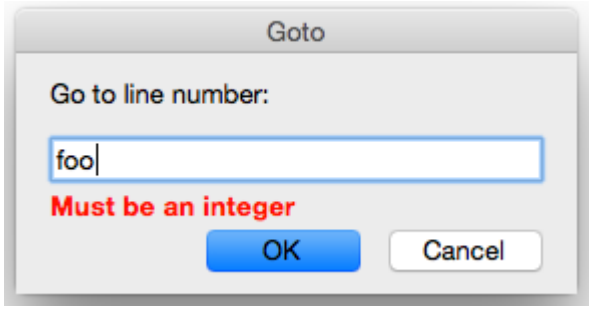


Open module dialog with error (macOS).

Because the dialog doesn't know if the module name is correct, validation isn't done until after the dialog is dismissed. So the error alert gets attached to another window. To try again, you have to dismiss that, use the menu to reopen the dialog, and try again (from scratch).

There were a couple of places in the code where more validation in the dialog was really necessary. Because the "simpledialog" code was part of Tkinter and wasn't readily extensible in the ways needed, developers had to resort to "inheritance by text editor" (i.e., copy the entire simpledialog code and modify the copy). Twice, separately.

Since the appearance needed to be updated anyway, we generalized things and ignored Tkinter's simpledialog module altogether. Instead, a single general-purpose replacement was created that could be used throughout IDLE (and still resulted in less code).



New query dialog (macOS).

Besides the updated widgets and alignment, notice how error messages from invalid input are now shown in the dialog itself (a technique seen frequently in web applications) rather than a separate alert. For macOS, we also made sure to add key bindings for the numeric keypad Enter key and Command-period, and also made sure the window looked like a modal dialog is supposed to via this little gem:

```
self.tk.call('::tk::unsupported::MacWindowStyle', 'style', self._w,
             'moveableModal', '')
```

As far as validation, the query dialog was structured to accept a validation callback, which could then handle arbitrary criteria. For example, here is the validation code used when people enter the name of a new theme. It makes sure it fits certain syntactical requirements and also hasn't been already used.

```
def newtheme(self):
    def validate_theme(s):
        if not s:
            raise ValueError('Cannot be blank')
        if len(s) > 30:
            raise ValueError('Cannot be longer than 30 characters')
        if s in self.all_theme_names():
            raise ValueError('Name already used')
    new_theme = querydialog.askstring(parent=self, prompt='...',
            title='Create New Theme', validatecmd=validate_theme)
    if new_theme is not None:
        ...
```

A generic 'integer' validation callback, with an optional minimum and maximum, was added to the query dialog module for dialogs like the 'Goto line...' dialog.

Dialog Placement

Several dialogs, including alerts, file save, etc., appeared in the middle of the screen, rather than close to the window that they were associated with; see [Issue#25173].

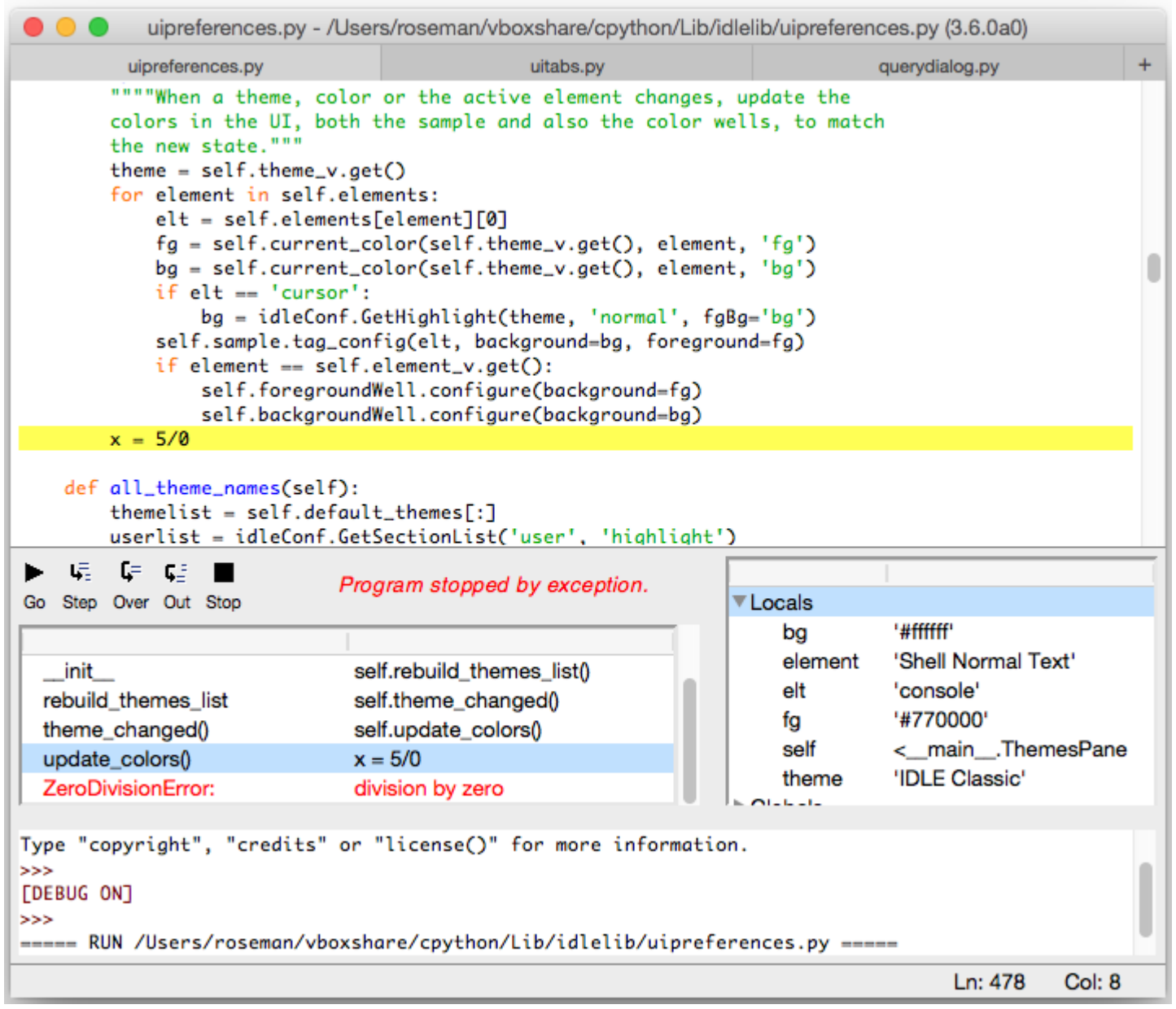
Choosing the right window as the `parent` of the dialog is important to ensure the dialog window appears near that window. On macOS, these dialogs are often attached to the title bar of the parent window (see the error alerts in the previous section).

> *The front ends to these dialogs in Tkinter support both a `master` and a `parent`. While most of the time, "master" and "parent" are used interchangeably in Tkinter, that's not the case here. If you provide only the master, the dialog won't be attached to that window (but the dialog still needs an existing window to create the dialog, which is why the master parameter is there). If the dialog is associated with another window, be sure to use the parent parameter.*

Window Integration

Multiple people had hoped to make it possible to have everything displayed in a single window, to avoid the window management hassles that can sometimes trip up people, see, e.g., [Issue#9262], [Issue#24826], and [Issue#24818].

Below is an early, partially-functional mockup of some of the things we wanted to accomplish.



Early mockup of window integration (macOS).

At this point, almost everything here has been completed, and it ended up looking almost identical to the original mockup. See, once in a while, it happens!

Tabbed Editor

Even beginner programmers have to juggle multiple different source files. If each gets its own window, as was the case originally in IDLE, things can get messy and/or lost pretty quickly. Using tabs to organize multiple files in a single window is a familiar, effective solution.

When architecting your application, don't build large components as subclasses of Toplevel, or assume they'll be the only thing in the window in the future. Getting around that assumption in the code took a large amount of work. If components are instead built as frames, they can be easily inserted into a toplevel, a paned window, a tabbed notebook, another frame, etc.

Luckily, we can rely on the ttk.Notebook widget to provide the tabbed user inteface, just like we did in Preferences.

Or maybe not.

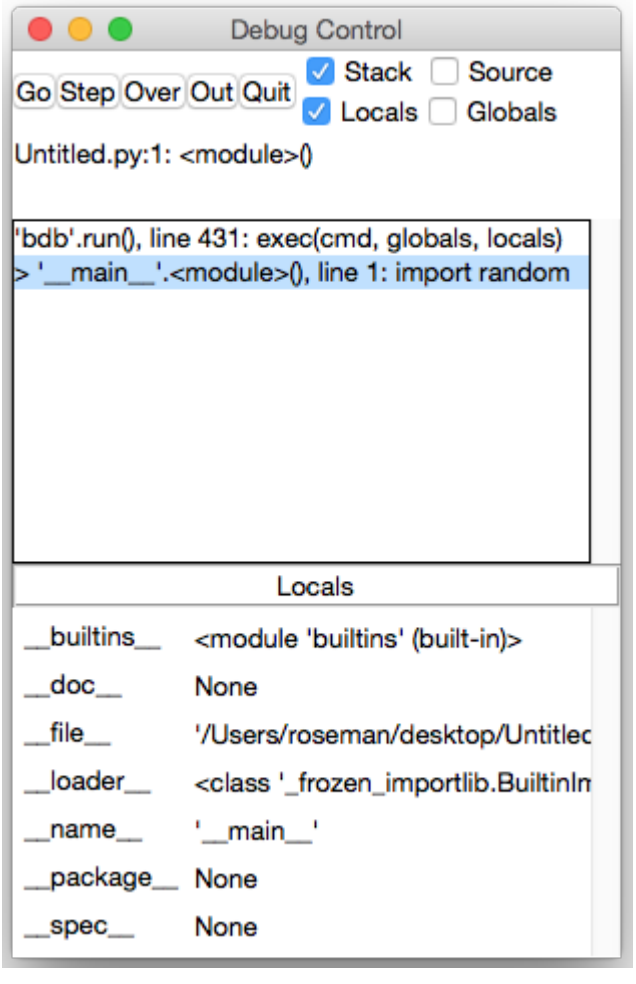
Unfortunately, the ttk.Notebook widget (and the underlying platform widgets it uses) only really support displaying and switching between a small, fixed number of tabs. There's nothing built-in to support adding or closing tabs from the user interface, which we definitely need here. And as every programmer knows, it is more than possible to need a large number of tabs.

As you've seen in different editors and word processors, everyone does things slightly differently. We did our own custom tab widget (sigh...) for IDLE. The design borrowed heavily from the TextMate editor on macOS. It allows creating new tabs, closing old ones, dragging to rearrange the order, tooltips on each tab, indicating if the contained file needed saving, etc. When the number of tabs grows too large to comfortably display, the remainder are accessible via a popup menu on the last visible tab.

The tabbed widget implementation relies on a single Tkinter canvas to display the row of tabs and handle all interaction. Switching the window content is separate from the widget, with a simple callback mechanism used to coordinate everything.

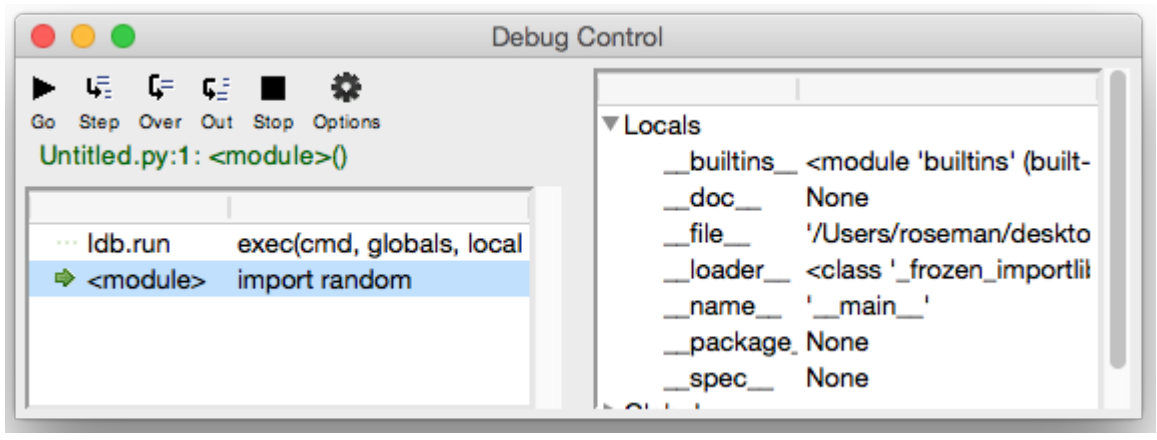
Debugger

The design of the original debugger (which had its own set of flaws, see [Issue#17942]) was too tall to be integrated as we wanted.



Original IDLE debugger (macOS).

The user interface was substantially revised, with a layout that would work both in a standalone window and when integrated. The new version uses a paned window to separate the controls and stack on the left from the variable display on the right. Both the stack and variable display are implemented using tree view widgets. This also provides a great deal of control of how much space each element will use.



New IDLE debugger (macOS).

Integrated Shell and Debugger

Another paned window was used to integrate the shell and the debugger with the tabbed editor. Additional controls will be added to show/hide the panes as the implementation progresses.

The embedded shell is interesting too. Recall that IDLE normally has a single Python shell window running another Python process; when modules in an editor are "run," they do so via that shell. It's nice to have that big shell available, and we don't necessarily want to start up a separate shell in the editor.

New in Tk 8.5, the Text widget actually supports "peers," which are separate widgets that share the same text backend. That means when something changes in one, it changes in the other. It's a seamless way to solve our problem here.

Workarounds, Hacks, and More

This being a chapter on actual experiences modernizing a real application, it would be a lie to say that the underlying user interface toolkit (Tk and the Tkinter wrapper) always worked exactly as it should. Like IDLE, Tkinter and Tcl/Tk are the results of incredible volunteer efforts. That being said...

>  *Tk and Tkinter have some bugs and rough edges. I know you're shocked.*

In this section, I'll try to catalog just a few of the particular "gotchas" that we ran into, as well as provide some little tips that don't necessarily fit elsewhere but help provide a bit more polish to the user interface.

Tool Tips

- tool tips broken on macOS; see [Issue#24570]
- `MacWindowStyle` help for tooltips, vs. `wm overrideredirect` elsewhere

Context Menus

- bogus text widget bindings interfere with popup clicks;see [Issue#24801]
- two different popup click bindings needed on macOS; [Issue#24801]

Peer Text Widgets

- broken peer text widget API in Tkinter;see [Issue#17945]

Modal Windows

- macOS not doing fully modal, plus window style;see [Issue#24760]

Previous | Contents | Single Page | Next

Spotted a mistake? Couldn't find what you were looking for? Suggestions? Let me know!

If you've found this tutorial useful, please check out Modern Tkinter.

Essentials: Tutorial Installing Book Backgrounder Reference

Tutorial Show: Python