Building useful project utils in Python

From spaghetti shell scripts to presentable Python

Johan Herland
@jherland
<jherland@cisco.com>
<johan@herland.net>

Prerequisites

- Basic familiarity with Unix shell scripting (`bash`)
- Some familiarity with `python3` (`python2` also works, but YMMV)

Outline

- Motivation
  - What scripts are we talking about?
  - Shell scripts! What are they good for?
  - Why is Python better?
- Shell → Python — Tips + Techniques
  - Code organization
  - Command-line interfaces in Python
  - Running other programs from Python
  - Manipulating the filesystem from Python
  - Writing unit tests in Python
  - A controversial take on error handling
- Case study — `binst`
  - A real-world rewrite from Shell to Python
  - Adding features that would have been impossible in Shell
- Summary
- Q & A

Motivation

What scripts are we talking about?

"The glue that holds your project together"

Developer tools

- Wrappers for more complex commands
- Workflow helpers

Build-time

- Small + simple build systems
- Build system helpers, plug-ins
- Code generators

Packaging, deployment, release, ...

- Signing images
- Publishing assets

In production

- Embedded targets
- Inside deployed containers

Shell scripts! What are they good for?

Pros

- Short and simple stuff
- Straightforward logic
- No data structures

Shell scripts! What are they good for?

Pros

- Short and simple stuff
- Straightforward logic
- No data structures

Cons

- Scripts grow, in length and complexity
- Complex logic
- Data structures
- Configurability
- Reusability
- Safety!

Why is Python better?

Showdown! Shell vs. Python

Why is Python better? — Syntax

Shell

- Reasonably easy to become productive
- Similar to command-line; skills are transferable
- Complexity → write-only
- Trivial (and necessary) to run other programs
- Many pitfalls, hard to become **safe**
- Many online resources/examples
- **Common practice** != **Best practice**!

```
filename="My favourite quotations.txt"
touch $filename
```

Why is Python better? — Syntax

Shell

- Reasonably easy to become productive
- Similar to command-line; skills are transferable
- Complexity → write-only
- Trivial (and necessary) to run other programs
- Many pitfalls, hard to become **safe**
- Many online resources/examples
- **Common practice** != **Best practice**!

```
filename="My favourite quotations.txt"
touch $filename
```

Python

- Simple and beginner-friendly syntax
- Considered one of the more readable languages
- Not as trivial to run other programs
- Fewer pitfalls than shell.
- Lots of literature and resources.
- Harder to come across "dangerous" examples

Why is Python better? — Data structures and types

Shell

- Everything is a string
- Whitespace in values often cause problems, and must be handled carefully
- Some support for integer arithmetic
- Some support for arrays

> «Unlike many other programming languages, Bash does not segregate its variables by "type." Essentially, Bash variables are character strings, but, depending on context, Bash permits arithmetic operations and comparisons on variables. The determining factor is whether the value of a variable contains only digits.»
>
> — Advanced Bash-Scripting Guide

Why is Python better? — Data structures and types

Shell

- Everything is a string
- Whitespace in values often cause problems, and must be handled carefully
- Some support for integer arithmetic
- Some support for arrays

> «Unlike many other programming languages, Bash does not segregate its variables by "type." Essentially, Bash variables are character strings, but, depending on context, Bash permits arithmetic operations and comparisons on variables. The determining factor is whether the value of a variable contains only digits.»
>
> — Advanced Bash-Scripting Guide

Python

- Dynamically (but strongly) typed
- Built-in types:
  - Numerics — `int`, `float`, `complex`
  - Sequences — `list`, `tuple`, `range`
    - Text and binary data — `str`, `bytes`, ...
    - Sets — `set`, ...
  - Mappings — `dict`
  - Others:
    - Modules
    - Classes and Class instances
    - Functions and Methods
    - Iterators and Generators
    - Exceptions
    - ...

Why is Python better? — Modularity

Shell

Within files: functions

- (sometimes non-obvious behavior, though, e.g. variables have global scope by default)

Between files: access in two ways:

1. Direct call (*think:* run as subprocess)
2. Use `source`
   (*think:* `#include` — no namespaces!)

However, a script cannot easily figure out if it has been *called* or *sourced*, so scripts are typically **either** written for immediate usage **or** a as *bag of functions* reusable by sourcing (but does nothing when called).

Why is Python better? — Modularity

Shell

Within files: functions

- (sometimes non-obvious behavior, though, e.g. variables have global scope by default)

Between files: access in two ways:

1. Direct call (*think:* run as subprocess)
2. Use `source`
   (*think:* `#include` — no namespaces!)

However, a script cannot easily figure out if it has been *called* or *sourced*, so scripts are typically **either** written for immediate usage **or** a as *bag of functions* reusable by sourcing (but does nothing when called).

Python

Within files: functions, classes, data, …

Between files: access in two ways:

1. `import`
2. Call via `subprocess`

Modules with `__main__` guards allows **both** for importability, and for immediate usage!

Why is Python better? — Modularity (cont.)

foo.sh:

```
#!/bin/sh

echo "This is always run"

foo() {
    echo "This is foo"
}
```

bar.sh:

```
#!/bin/sh

source foo.sh

foo()
```

Why is Python better? — Modularity (cont.)

foo.sh:

```sh
#!/bin/sh

echo "This is always run"

foo() {
    echo "This is foo"
}
```

bar.sh:

```sh
#!/bin/sh

source foo.sh

foo()
```

foo.py:

```python
#!/usr/bin/env python3

print("This is always run")

def foo():
    print('This is foo')

if __name__ == '__main__':
    print("Skipped when this file is imported")
```

bar.py:

```python
#!/usr/bin/env python3

import foo

foo.foo()
```

Why is Python better? — Tools & Libraries

Shell

- Language itself is very minimal
- Use system binaries from Unix ecosystem to do heavy lifting

Why is Python better? — Tools & Libraries

Shell

- Language itself is very minimal
- Use system binaries from Unix ecosystem to do heavy lifting

Python

- Very rich stdlib — can do most things "within" the language
- Lots more 3rd-party modules available (e.g. Python Package Index)
- Use `subprocess` module to call out to other binaries

Shell → Python

Tips + Techniques

Code organization

- Start by simply transcribing your shell script into Python!
  - One statement after another
  - No change in structure
  - Everything is run from top to bottom

Code organization

- Start by simply transcribing your shell script into Python!
  - One statement after another
  - No change in structure
  - Everything is run from top to bottom

- Refactor code into functions, classes, data structures, …
  - Incrementally improve the structure of your script

Code organization

- Start by simply transcribing your shell script into Python!
  - One statement after another
  - No change in structure
  - Everything is run from top to bottom
- Refactor code into functions, classes, data structures, …
  - Incrementally improve the structure of your script
- Add the `__main__` guard
  - Makes the functions/classes/data reusable from other scripts

Code organization

- Start by simply transcribing your shell script into Python!
  - One statement after another
  - No change in structure
  - Everything is run from top to bottom

- Refactor code into functions, classes, data structures, …
  - Incrementally improve the structure of your script

- Add the `__main__` guard
  - Makes the functions/classes/data reusable from other scripts

- Add a `main()` function
  - Common convention in python
  - Other scripts can now `import` + `main()` instead of `subprocess.run()`

Code organization

- Start by simply transcribing your shell script into Python!
  - One statement after another
  - No change in structure
  - Everything is run from top to bottom
- Refactor code into functions, classes, data structures, …
  - Incrementally improve the structure of your script
- Add the `__main__` guard
  - Makes the functions/classes/data reusable from other scripts
- Add a `main()` function
  - Common convention in python
  - Other scripts can now `import` + `main()` instead of `subprocess.run()`
- Split reusable functionality into separate/stand-alone modules
  - Add unit tests here to verify API + functionality

Command-line interfaces in Python

Follow Unix conventions:

- Exit code 0 → success, non-zero → failure
  - Default exit code from python is 0
  - Uncaught exceptions result in exit code 1
- Use `sys.stdin` / `sys.stdout` for default I/O
  - `print()` defaults to `sys.stdout`
- Log errors to `sys.stderr`
  - The `logging` module defaults to `sys.stderr`
- Mandatory command-line args are *positional*
- Optional command-line args use `--dashes`

Command-line interfaces in Python

Follow Unix conventions:

- Exit code 0 → success, non-zero → failure
  - Default exit code from python is 0
  - Uncaught exceptions result in exit code 1
- Use `sys.stdin` / `sys.stdout` for default I/O
  - `print()` defaults to `sys.stdout`
- Log errors to `sys.stderr`
  - The `logging` module defaults to `sys.stderr`
- Mandatory command-line args are *positional*
- Optional command-line args use `--dashes`

Use `argparse` ↓

Using `argparse`:

```
#!/usr/bin/env python3
'''Calculate the square of a given number.'''

import argparse
import sys


def calc(num, exp):
    return num ** exp


def main():
    parser = argparse.ArgumentParser(description=sys.modules[__name__].__doc__)
    parser.add_argument(
        'num', type=int,
        help='the number to be squared')
    parser.add_argument(
        '--cube', '-3', action='store_true',
        help='calculate the cube (instead of square)')
    parser.add_argument(
        '--file', '-f', type=argparse.FileType('w'), default=sys.stdout,
        help='write result here (stdout by default)')

    args = parser.parse_args()
    result = calc(args.num, 3 if args.cube else 2)
    print(result, file=args.file)


if __name__ == '__main__':
    main()
```

Using `argparse`:

```
#!/usr/bin/env python3
'''Calculate the square of a given number.'''

import argparse
import sys


def calc(num, exp):
    return num ** exp


def main():
    parser = argparse.ArgumentParser(description=sys.modules[__name__].__doc__)
    parser.add_argument(
        'num', type=int,
        help='the number to be squared')
    parser.add_argument(
        '--cube', '-3', action='store_true',
        help='calculate the cube (instead of square)')
    parser.add_argument(
        '--file', '-f', type=argparse.FileType('w'), default=sys.stdout,
        help='write result here (stdout by default)')

    args = parser.parse_args()
    result = calc(args.num, 3 if args.cube else 2)
    print(result, file=args.file)


if __name__ == '__main__':
    main()
```

```
# <- Module docstring
#    (.__doc__ on the module)



# <- Reusable function:
     import myscript
     myscript.calc(123, 2)


# <- Reuse module docstring
#    in usage help text
# <- Positional integer arg


# <- Optional arg, boolean,
#    default: False

# <- Optional arg, open file



# <- __main__ guard
```

```
$ ./myscript.py
usage: myscript.py [-h] [--cube] [--file FILE] num
myscript.py: error: the following arguments are required: num
```

```
$ ./myscript.py
usage: myscript.py [-h] [--cube] [--file FILE] num
myscript.py: error: the following arguments are required: num
```

```
$ ./myscript.py -h
usage: myscript.py [-h] [--cube] [--file FILE] num

Calculate the square of a given number.

positional arguments:
  num                   the number to be squared

optional arguments:
  -h, --help            show this help message and exit
  --cube, -3            calculate the cube (instead of square)
  --file FILE, -f FILE  write result here (stdout by default)
```

```
$ ./myscript.py
usage: myscript.py [-h] [--cube] [--file FILE] num
myscript.py: error: the following arguments are required: num
```

```
$ ./myscript.py -h
usage: myscript.py [-h] [--cube] [--file FILE] num

Calculate the square of a given number.

positional arguments:
  num                   the number to be squared

optional arguments:
  -h, --help            show this help message and exit
  --cube, -3            calculate the cube (instead of square)
  --file FILE, -f FILE  write result here (stdout by default)
```

```
$ ./myscript.py 5
25
```

```
$ ./myscript.py
usage: myscript.py [-h] [--cube] [--file FILE] num
myscript.py: error: the following arguments are required: num
```

```
$ ./myscript.py -h
usage: myscript.py [-h] [--cube] [--file FILE] num

Calculate the square of a given number.

positional arguments:
  num                   the number to be squared

optional arguments:
  -h, --help            show this help message and exit
  --cube, -3            calculate the cube (instead of square)
  --file FILE, -f FILE  write result here (stdout by default)
```

```
$ ./myscript.py 5
25
```

```
$ ./myscript.py 5 -3
125
```

```
$ ./myscript.py
usage: myscript.py [-h] [--cube] [--file FILE] num
myscript.py: error: the following arguments are required: num
```

```
$ ./myscript.py -h
usage: myscript.py [-h] [--cube] [--file FILE] num

Calculate the square of a given number.

positional arguments:
  num                   the number to be squared

optional arguments:
  -h, --help            show this help message and exit
  --cube, -3            calculate the cube (instead of square)
  --file FILE, -f FILE  write result here (stdout by default)
```

```
$ ./myscript.py 5
25
```

```
$ ./myscript.py 5 -3
125
```

```
$ ./myscript.py 10 -3 -f foo
$ cat foo
1000
```

Running other programs from Python — `subprocess`

Simple cases

```
import subprocess

# Prepare command as a list of strings
argv = ['ping', '-c1', 'google.com']

# Run command, get its exit code
exitcode = subprocess.run(argv).returncode

# Run command, raise exception on non-zero exit code
subprocess.run(argv, check=True)

# Run command, raise exception if it fails, capture its output
result = subprocess.run(argv, check=True, capture_output=True)
output, errors = result.stdout, result.stderr
```

Running other programs from Python — `subprocess`

Simple cases

```
import subprocess

# Prepare command as a list of strings
argv = ['ping', '-c1', 'google.com']

# Run command, get its exit code
exitcode = subprocess.run(argv).returncode

# Run command, raise exception on non-zero exit code
subprocess.run(argv, check=True)

# Run command, raise exception if it fails, capture its output
result = subprocess.run(argv, check=True, capture_output=True)
output, errors = result.stdout, result.stderr
```

More complex cases

See https://docs.python.org/3/library/subprocess.html

Manipulating the filesystem from Python — `pathlib`

- Features:
  - Creating/moving/removing files and dirs
  - Looking for specific (types of) files
  - Handling *relative* vs *absolute* paths
- Replaces/supersedes:
  - Parts of `os.path.*` and elsewhere in `os.*`
  - `fnmatch.fnmatch()` and `glob.glob()`
- https://docs.python.org/3/library/pathlib.html

Other modules

- `os` and `os.path`
- `shutil`

Manipulating the filesystem from Python — `pathlib`

- Features:
  - Creating/moving/removing files and dirs
  - Looking for specific (types of) files
  - Handling *relative* vs *absolute* paths
- Replaces/supersedes:
  - Parts of `os.path.*` and elsewhere in `os.*`
  - `fnmatch.fnmatch()` and `glob.glob()`
- https://docs.python.org/3/library/pathlib.html

```python
from pathlib import Path

mydir = Path.cwd() / 'mydir'
mydir.mkdir(exist_ok=True)

foo = mydir / 'foo.txt'
if foo.exists():
    foo.rename(foo.with_suffix('.backup'))

with foo.open('w') as f:
    for path in mydir.iterdir():
        print(path.relative_to(mydir), file=f)

for path in mydir.glob('*.backup'):
    path.unlink()
```

Other modules

- `os` and `os.path`
- `shutil`

Writing unit tests in Python

What to test

- As much as possible
- Certainly reusable functionality

Available frameworks

- `doctest`
- `unittest`
- `pytest` (not in the standard library)
- Many others…

Writing unit tests in Python

What to test

- As much as possible
- Certainly reusable functionality

Available frameworks

- `doctest`
- `unittest`
- `pytest` (not in the standard library)
- Many others…

Note

This is not a talk on test frameworks or unit testing in general.

For everything but the smallest scripts, put your tests in separate files, or even separate directories, but here we'll look at how you can put small tests in the same file as the rest of the script.

Remember?

```
#!/usr/bin/env python3
'''Calculate the square of a given number.'''

import argparse
import sys


def calc(num, exp):
    return num ** exp


def main():
    parser = argparse.ArgumentParser(description=sys.modules[__name__].__doc__)
    parser.add_argument(
        'num', type=int,
        help='the number to be squared')
    parser.add_argument(
        '--cube', '-3', action='store_true',
        help='calculate the cube (instead of square)')
    parser.add_argument(
        '--file', '-f', type=argparse.FileType('w'), default=sys.stdout,
        help='write result here (stdout by default)')

    args = parser.parse_args()
    result = calc(args.num, 3 if args.cube else 2)
    print(result, file=args.file)


if __name__ == '__main__':
    main()
```

Writing unit tests in Python — `doctest`

Ad-hoc testing:

```
$ python
Python 3.7.0 (default, Jul 15 2018, 10:44:58)
[...]
>>> import myscript
>>> myscript.calc(3, 2)
9
```

Let's formalize that a bit:

```
def calc(num, exp):
    '''Return 'num' raised to the power of 'exp'.

    >>> [calc(0, 2), calc(1, 2), calc(2, 2)]
    [0, 1, 4]
    >>> [calc(0, 3), calc(1, 3), calc(2, 3)]
    [0, 1, 8]
    '''
    return num ** exp
```

Writing unit tests in Python — `doctest`

Ad-hoc testing:

```
$ python
Python 3.7.0 (default, Jul 15 2018, 10:44:58)
[...]
>>> import myscript
>>> myscript.calc(3, 2)
9
```

Let's formalize that a bit:

```
def calc(num, exp):
    '''Return 'num' raised to the power of 'exp'.

    >>> [calc(0, 2), calc(1, 2), calc(2, 2)]
    [0, 1, 4]
    >>> [calc(0, 3), calc(1, 3), calc(2, 3)]
    [0, 1, 8]
    '''
    return num ** exp
```

Run tests from command-line:

```
$ python -m doctest myscript.py -v
Trying:
    [calc(0, 2), calc(1, 2), calc(2, 2)]
Expecting:
    [0, 1, 4]
ok
Trying:
    [calc(0, 3), calc(1, 3), calc(2, 3)]
Expecting:
    [0, 1, 8]
ok
2 items had no tests:
    myscript
    myscript.main
1 items passed all tests:
   2 tests in myscript.calc
2 tests in 3 items.
2 passed and 0 failed.
Test passed.
```

Run tests from within the script:

```
if __name__ == '__main__':
    import doctest
    doctest.testmod()
```

Writing unit tests in Python — `unittest`

```
import unittest

...

class TestSquare(unittest.TestCase):

    def test_zero_squared_is_zero(self):
        self.assertEqual(0, calc(0, 2))

    def test_one_squared_is_one(self):
        self.assertEqual(1, calc(1, 2))

    def test_two_squared_is_four(self):
        self.assertEqual(4, calc(2, 2))


class TestCube(unittest.TestCase):

    def test_zero_cubed_is_zero(self):
        self.assertEqual(0, calc(0, 3))

    def test_one_cubed_is_one(self):
        self.assertEqual(1, calc(1, 3))

    def test_two_cubed_is_eight(self):
        self.assertEqual(8, calc(2, 3))
```

Writing unit tests in Python — `unittest`

```
import unittest

...

class TestSquare(unittest.TestCase):

    def test_zero_squared_is_zero(self):
        self.assertEqual(0, calc(0, 2))

    def test_one_squared_is_one(self):
        self.assertEqual(1, calc(1, 2))

    def test_two_squared_is_four(self):
        self.assertEqual(4, calc(2, 2))


class TestCube(unittest.TestCase):

    def test_zero_cubed_is_zero(self):
        self.assertEqual(0, calc(0, 3))

    def test_one_cubed_is_one(self):
        self.assertEqual(1, calc(1, 3))

    def test_two_cubed_is_eight(self):
        self.assertEqual(8, calc(2, 3))
```

Run tests from command-line:

```
$ python -m unittest myscript.py
......
----------------------------------------------------------
Ran 6 tests in 0.000s

OK
```

Run tests from within the script:

```
if __name__ == '__main__':
    unittest.main()
```

Writing unit tests in Python — `pytest`

```python
def test_calc():
    vectors = [
        (0, 2, 0), (1, 2, 1), (2, 2, 4),
        (0, 3, 0), (1, 3, 1), (2, 3, 8),
    ]
    for num, exp, expect in vectors:
        assert calc(num, exp) == expect
```

Writing unit tests in Python — `pytest`

```python
def test_calc():
    vectors = [
        (0, 2, 0), (1, 2, 1), (2, 2, 4),
        (0, 3, 0), (1, 3, 1), (2, 3, 8),
    ]
    for num, exp, expect in vectors:
        assert calc(num, exp) == expect
```

Run tests from command-line:

```
$ pytest myscript.py
================ test session starts ================
[...]
collected 1 item

myscript.py .                                  [100%]

============== 1 passed in 0.01 seconds =============
```

Run tests from within the script:

```python
if __name__ == '__main__':
    import pytest
    pytest.main([__file__])
```

A controversial take on error handling

A controversial take on error handling

Don't!

A controversial take on error handling

Don't!

- Sloppy error handling is worse than *no* error handling
- Python tracebacks are actually useful for debugging
- Simplify and remove error handling that might otherwise obscure the source of the error
- Allow Python exceptions to *escape* and terminate the program
- Guarantees non-zero exit code

Catching exceptions, and replacing them with a (generic) error message often hides useful details about the error, whereas the traceback points directly at a relevant line of code, and often includes the value that triggered the error.

A controversial take on error handling

Don't!

- Sloppy error handling is worse than *no* error handling
- Python tracebacks are actually useful for debugging
- Simplify and remove error handling that might otherwise obscure the source of the error
- Allow Python exceptions to *escape* and terminate the program
- Guarantees non-zero exit code

Catching exceptions, and replacing them with a (generic) error message often hides useful details about the error, whereas the traceback points directly at a relevant line of code, and often includes the value that triggered the error.

That said, ...

Simple usage/user errors are best handled with a simple error message (but `argparse` gives you this for free).

Tracebacks may not work as well if the distance between script users and script maintainers is large.

Case study

`binst`

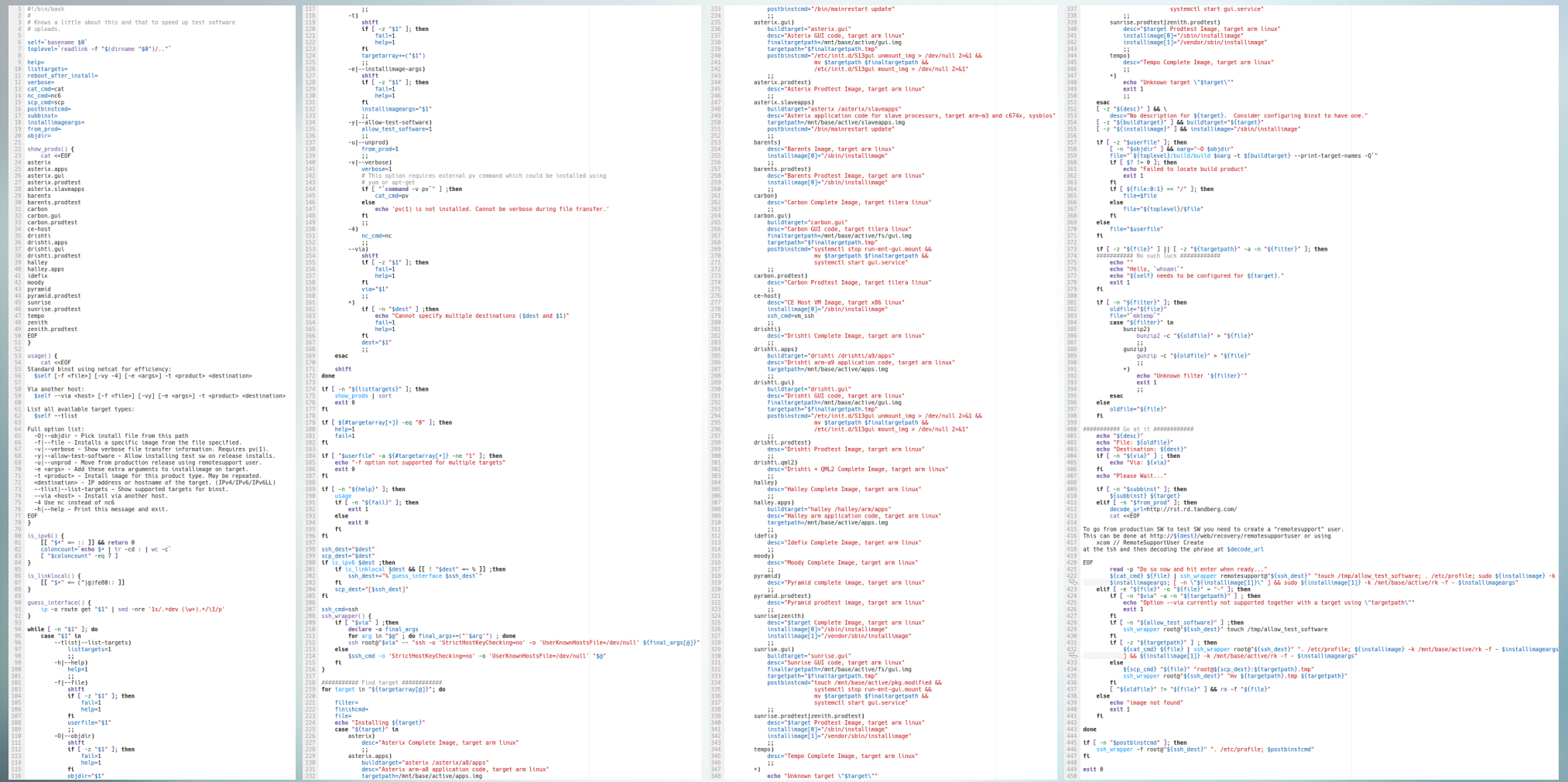
Common developer workflow

build

.pkg

binst

`binst` shell script



`binst` shell script

Stats

- 450 lines of shell (`bash`)
- Helper functions
- Command-line interface (~50%)
- Data structure (almost) (~30%)
- Some logic:
  - `while` loop for command-line argument parsing
  - main `for` loop for binsting multiple targets
  - Lots of `if` / `elif` / `else` for error handling and fallbacks.
- Ends up here in most cases:

```
${cat_cmd} ${file} | ssh_wrapper root@"${ssh_dest}" ". /etc/profile; \
  ${installimage} -k /mnt/base/active/rk -f - $installimageargs; \
  [ -n \"${installimage[1]}\" ] && \
  ${installimage[1]} -k /mnt/base/active/rk -f - $installimageargs"
```

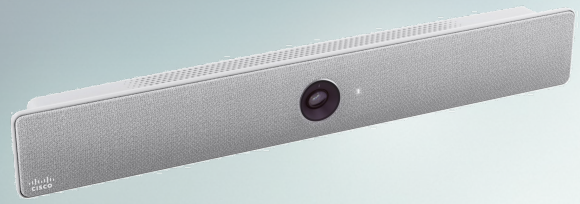
`binst` shell script

Problems

- Complex shell script
- `binst` upgrades are different from in-the-field upgrades:
  - `binst` *pushes* `.pkg` onto the system
  - `binst` bypasses most of the upgrade machinery on the system
  - In the field, the system is told where to find the `.pkg` and *pulls* it from there.
- New requirement: Support systems with multiple devices

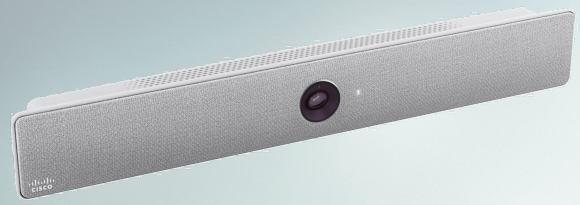
System with multiple devices

Simple systems have the camera built-in to the *codec* (device running the CE S/W)



System with multiple devices

Simple systems have the camera built-in to the *codec* (device running the CE S/W)



Bigger systems have codec running separately from one or more cameras

System with multiple devices

- System comprises codec plus one or more peripherals
  - Upgrading one, but not the other, likely breaks the connection
- Codec plus peripherals must run same/compatible versions
- One `.pkg` is not enough, also need `.pkg` for peripherals
- Introduce .loads files
  - Tells system where to find `.pkg` s
  - System pulls the `.pkg` s needed to upgrade all devices
  - Same mechanism as upgrades in the field
- Changes to dev workflow:
  - one or more build commands
  - single `binst` to update codec + peripherals:

`binsting` with `.loads` files

build
build

.pkg
pkg

.loads

.sgn

binst

Changing `binst`

- Required additions to `binst`:
  - Prepare directory with `.loads` file, `.sgn` file and associated `.pkg`s
  - Serve this directory over HTTP
  - Tell codec to get `.loads` file from server, and wait for the required .pkgs to be pulled.
  - Retain fall-back to old push-method for older and non-functioning systems

- How to get there:
  - *First*: rewrite existing `binst` from Bash into Python
  - Then refactor code to ease readability and maintainability
  - Finally start adding new features
    - Generating `.loads` files
    - Knowledge of which peripheral `.pkg`s may be needed for what targets.
    - Generating signatures for `.loads` files
    - HTTP server to serve directory with `.loads` files and `.pkg` files

Rewriting `binst` from Shell to Python — Proper data structures

```
for target in "${targetarray[@]}"; do
    filter=
    finishcmd=
    file=
    echo "Installing ${target}"
    case "${target}" in
        asterix)
            desc="Asterix Complete Image, target arm li
            ;;
        asterix.apps)
            buildtarget="asterix /asterix/a8/apps"
            desc="Asterix arm-a8 application code, targ
            targetpath=/mnt/base/active/apps.img
            postbinstcmd="/bin/mainrestart update"
            ;;
        asterix.gui)
            buildtarget="asterix.gui"
            desc="Asterix GUI code, target arm linux"
            finaltargetpath=/mnt/base/active/gui.img
            targetpath="$finaltargetpath.tmp"
            postbinstcmd="/etc/init.d/S13gui unmount_im
                          mv $targetpath $finaltargetpa
                          /etc/init.d/S13gui mount_img
            ;;
        ...
```

```
TARGETS = {
    'asterix': {
        'desc': 'Asterix complete image, target arm lin
    },
    'asterix.apps': {
        'desc': 'Asterix arm-a8 application code, targe
        'subtarget': '/asterix/a8/apps',
        'destpath': '/mnt/base/active/apps.img',
        'posthook': '/bin/mainrestart update',
    },
    'asterix.gui': {
        'desc': 'Asterix GUI code, target arm linux',
        'buildtarget': 'asterix.gui',
        'destpath': '/mnt/base/active/gui.img.tmp',
        'posthook': '''\
            /etc/init.d/S13gui unmount_img > /dev/null
            mv "$destpath" "${destpath%.tmp}" &&
            /etc/init.d/S13gui mount_img > /dev/null 2>
    },
    ...
```

Rewriting `binst` from Shell to Python — Command-line interface

```
show_prods() {
    cat <<EOF
...

usage() {
    cat <<EOF
...

...

while [ -n "$1" ]; do
    case "$1" in
        --tlist|--list-targets)
            listtargets=1
            ;;
        -h|--help)
            help=1
            ;;
        -f|--file)
            shift
            if [ -z "$1" ]; then
                fail=1
                help=1
            fi
            userfile="$1"
            ;;
        ...
```

```
def parse_args(*args):
    parser = argparse.ArgumentParser(
        usage=USAGE, description=sys.modules[__name__].__doc__)

    class ListTargets(argparse.Action):
        def __init__(self, default=argparse.SUPPRESS, **kwargs):
            super().__init__(nargs=0, default=default, **kwargs)

        def __call__(self, parser, *args):
            print('\n'.join(sorted(TARGETS.keys())))
            parser.exit()

    parser.add_argument(
        '--list-targets', '--tlist', action=ListTargets,
        help='List available targets.')

    # Allow positional <target> to alternatively be specified with -t/--ta
    target_spec = parser.add_mutually_exclusive_group(required=True)
    target_spec.add_argument(
        'target', nargs='?', choices=sorted(TARGETS.keys()),
        metavar='<target>', help='Install image for this build target.')
    target_spec.add_argument(
        '--target', '-t', dest='target_alt', choices=sorted(TARGETS.keys()
        metavar='<target>', help='Install image for this build target.')
    ...
```

`binst` rewritten to Python

Stats

- 366 lines of Python (~19% reduction)
- Command-line interface (<20%)
- Data structure (~33%)

`binst` rewritten to Python

Stats

- 366 lines of Python (~19% reduction)
- Command-line interface (<20%)
- Data structure (~33%)

Next:

- Add `.loads` file generation
- Add signature generation
- Add HTTP server serving directory with the above + `.pkg` files

loadsfile.py

244 lines of Python, imported by `binst`, but also stand-alone:

```
$ ./loadsfile.py -h
usage: loadsfile.py [-h]
                    [--target {asterix,asterix.nocrypto,carbon,drishti,tempo,sunrise,zenith,halley,moody,...}]
                    [--file FILE] [--output OUTPUT] [--base-url BASE_URL]
                    [--pkgextract PKGEXTRACT] [--verify]

Utility for building .loads files around our build products. .loads file are
JSON documents that declare a collection of related software images (.pkg
files) for one or more of our products. .loads files are an important part of
how we distribute software upgrades for our products. See
https://rdwiki.cisco.com/wiki/Swupgrade for more details.

optional arguments:
  -h, --help            show this help message and exit
  --target {asterix,asterix.nocrypto,carbon,drishti,tempo,sunrise,zenith,halley,moody,pyramid,idefix}
                        Target to include in generated .loads file
  --file FILE, -f FILE  PKG path corresponding to each given --target option
  --output OUTPUT, -o OUTPUT
                        Where to write the resulting .loads file (default:
                        stdout)
  --base-url BASE_URL   Prefix to PKG filenames in resulting .loads file
                        (default: "")
  --pkgextract PKGEXTRACT
                        Path to pkgextract binary (default: find in $PATH)
  --verify              Do not reuse existing .pkg.loads files.
```

loadssign.py

295 lines of Python, imported by `binst`, but also stand-alone:

```
$ ./loadssign.py -h
usage: loadssign.py [-h] [--release] [--test] {ticket,sign,verify} ...

Utility for signing .loads files with local test keys or SWIMS release keys.
.loads files must be signed in order for their contents to be trustworthy.
This is an important part of how we distribute software upgrades for our
products. See https://rdwiki.cisco.com/wiki/Swupgrade for more details.

positional arguments:
  {ticket,sign,verify}
    ticket              Create a SWIMS ticket for signing release S/W
    sign                Generate a .loads signature
    verify              Verify a .loads signature

optional arguments:
  -h, --help            show this help message and exit
  --release             Sign/verify with key/certificate for release S/W
  --test                Sign/verify with key/certificate for test S/W
```

loadsdir.py

519 lines of Python, imported by `binst`, but also stand-alone:

```
$ ./loadsdir.py -h
usage: loadsdir.py [-h]
                   [--target {asterix,asterix.nocrypto,carbon,drishti,tempo,sunrise,zenith,halley,moody,...}]
                   [--file FILE] [--version VERSION] [--loads-name LOADS_NAME]
                   [--symlink] [--copy] [--deps] [--objdir OBJDIR]
                   [--validate] [--ticket TICKET] [--serve]
                   destination

Utility for building loads directories around our build products. loads dirs
are directories containing a .loads file and all the PKG files referenced from
the .loads file. See https://rdwiki.cisco.com/wiki/Swupgrade for more details.

positional arguments:
  destination           Where to write the loads directory contents

optional arguments:
  [...]
  --symlink             Symlink PKG files into loads dir (this is the default behavior)
  --copy                Copy PKG files into loads dir (instead of symlinking)
  --deps, -d            Automatically include dependencies of the given target
  --objdir OBJDIR, -O OBJDIR
                        Look here for dependents' build output (default: _build)
  --validate            Validate any .loads and .pkg files found within the loads dir.
  --ticket TICKET       Use this SWIMS ticket to verify .loads signatures.
  --serve               Serve loads dir over HTTP until you press Ctrl+C.
```

Integrating HTTP server into `binst.py`

```
    if args.loads:
        assert args.target.support_loads()
        server = LoadsServer(args.target, image_path, args.objdir)
        script = '; '.join([
            'origin=$(echo $SSH_CLIENT | cut -d" " -f1)',
            'upgrade_url="http://$origin:{0.port}/{0.loadspath}"'.format(server),
            'echo "xcom SystemUnit SoftwareUpgrade URL: $upgrade_url" | tsh',
        ])
        ssh_cmd = build_ssh_cmd(
            remote_user,
            ssh_address(args.destination),
            script,
            ssh=args.target.ssh)
        print('Triggering {} to upgrade from our port {}...'.format(
            args.destination, server.port))
        if args.verbose:
            print('Running: {}'.format(ssh_cmd))
        if subprocess.call(ssh_cmd, shell=True) != 0:
            print('Failed to trigger upgrade (command: {}).'.format(ssh_cmd))
        else:  # Hand control over to loads server.
            if server.serve():  # Files were served to destination. We're done.
                return 0
            else:  # Destination failed to request anything from us.
                print('No upgrade requests from {}!'.format(args.destination))
        server.cleanup()
        print('Falling back to old/--no-loads behavior...')
```

That's all folks!

Summary

- Use shell scripts for the simplest tasks (3 lines of shell is simpler than 7 lines of python)
- Switch to Python when things start growing
  - Complex logic
  - Data structures
  - Modularity/reuse
  - Configurability
- Write Python scripts that can *both* be imported *and* run from the command-line
- Refactor mercilessly
- Unit tests gives you confidence to refactor!
- Use the Python standard library:
  - `argparse`
  - `subprocess`
  - `pathlib`

Summary

- Use shell scripts for the simplest tasks (3 lines of shell is simpler than 7 lines of python)
- Switch to Python when things start growing
  - Complex logic
  - Data structures
  - Modularity/reuse
  - Configurability
- Write Python scripts that can *both* be imported *and* run from the command-line
- Refactor mercilessly
- Unit tests gives you confidence to refactor!
- Use the Python standard library:
  - `argparse`
  - `subprocess`
  - `pathlib`

> «This is the Unix philosophy: Write programs that do one thing and do it well. Write programs to work together. Write programs to handle text streams, because that is a universal interface.»
>
> — Doug McIlroy

Thanks!

Questions?

Johan Herland
@jherland
<jherland@cisco.com>
<johan@herland.net>

Slides on GitHub.
Slideshow created with remark.