CS615 - Aspects of System Administration

Writing System Tools

Department of Computer Science
Stevens Institute of Technology
Jan Schaumann
jschauma@stevens.edu
https://www.cs.stevens.edu/~jschauma/615/
Tools
Benefits of Automation

- *repeatability* – some of the tasks we perform are complex and need to be executed in a fixed order
Benefits of Automation

- **repeatability** – some of the tasks we perform are complex and need to be executed in a fixed order.

- **reliability** – we are forgetful, make mistakes and typos, think we know better, ...
Benefits of Automation

- **repeatability** – some of the tasks we perform are complex and need to be executed in a fixed order

- **reliability** – we are forgetful, make mistakes and typos, think we know better, ...

- **regularity** – some tasks need to be executed at a specific time, some with a specific frequency, ...
Benefits of Automation

- **repeatability** – some of the tasks we perform are complex and need to be executed in a fixed order

- **reliability** – we are forgetful, make mistakes and typos, think we know better, ...

- **regularity** – some tasks need to be executed at a specific time, some with a specific frequency, ...

- **flexibility** – minor variations of a complex task or the environment it executes in
Benefits of Automation

- **repeatability** – some of the tasks we perform are complex and need to be executed in a fixed order
- **reliability** – we are forgetful, make mistakes and typos, think we know better, ...
- **regularity** – some tasks need to be executed at a specific time, some with a specific frequency, ...
- **flexibility** – minor variations of a complex task or the environment it executes in

Remember the Lego blocks: Breaking complex tasks into smaller components allows us to apply these benefits recursively.
Words of Wisdom

Anything you do more than once is worth automating.
Who benefits from automation?

- ourselves
- our peers
- our users
- our organization
- anybody anywhere
Evolution of SysAdmin Tools

- Single user
  - Aliases & functions in e.g. ~/.bashrc; other dot files
- Multi-user (your org)
  - Longer scripts in e.g. ~/bin
- Multi-user (peers)
  - Scripts and tools deployed into e.g. /usr/local or /home/$company
- Multi-user (world)
  - Packaged and documented tools; utilized and distributed organization wide
  - Widely distributed projects; internal or external services accessed via an API

Number of assumptions you can make decreases

Number of users increases
Automation Pitfalls

- implementation and debugging takes time and effort
Automation Pitfalls

- Implementation and debugging takes time and effort
- Automation often increases complexity
Automation Pitfalls

- implementation and debugging takes time and effort
- automation often increases complexity
- automation increases the (potential for (negative)) impact
Automation Pitfalls

- implementation and debugging takes time and effort
- automation often increases complexity
- automation increases the (potential for (negative)) impact
- automation may lead to a loss of audit trail or accountability
Automation Pitfalls

- Implementation and debugging takes time and effort
- Automation often increases complexity
- Automation increases the (potential for (negative)) impact
- Automation may lead to a loss of audit trail or accountability
- Abstracting a problem requires understanding it
Automation Pitfalls

- implementation and debugging takes time and effort
- automation often increases complexity
- automation increases the (potential for (negative)) impact
- automation may lead to a loss of audit trail or accountability
- abstracting a problem requires understanding it
- system tools require documentation
Automation Pitfalls

- implementation and debugging takes time and effort
- automation often increases complexity
- automation increases the (potential for (negative)) impact
- automation may lead to a loss of audit trail or accountability
- abstracting a problem requires understanding it
- system tools require documentation

Note: some of these are hidden benefits!
Approaching Automation

Three basic categories:

- scripting
- programming
- software engineering
Approaching Automation

Three basic categories:

- scripting
  - automating *very* simple tasks
Approaching Automation

Three basic categories:

- scripting
  - automating *very* simple tasks
  - customization of user environment
Approaching Automation

Three basic categories:

- scripting
  - automating *very* simple tasks
  - customization of user environment
  - often only suitable for one individual user
Approaching Automation

Three basic categories:

- scripting
  - automating *very* simple tasks
  - customization of user environment
  - often only suitable for one individual user
  - usually eventually evolves into larger programs
Approaching Automation

Three basic categories:

- scripting
  - automating *very* simple tasks
  - customization of user environment
  - often only suitable for one individual user
  - usually eventually evolves into larger programs

- programming
  - suitable for simple to moderately complex tasks
Approaching Automation

Three basic categories:

- **scripting**
  - automating *very* simple tasks
  - customization of user environment
  - often only suitable for one individual user
  - usually eventually evolves into larger programs

- **programming**
  - suitable for simple to moderately complex tasks
  - results frequently used by a small base of users
Approaching Automation

Three basic categories:

- **scripting**
  - automating *very* simple tasks
  - customization of user environment
  - often only suitable for one individual user
  - usually eventually evolves into larger programs

- **programming**
  - suitable for simple to moderately complex tasks
  - results frequently used by a small base of users
  - uses basic framework or common toolkits
Approaching Automation

Three basic categories:

- **scripting**
  - automating *very* simple tasks
  - customization of user environment
  - often only suitable for one individual user
  - usually eventually evolves into larger programs

- **programming**
  - suitable for simple to moderately complex tasks
  - results frequently used by a small base of users
  - uses basic framework or common toolkits
  - provides consistent interface
Approaching Automation

Three basic categories:

- **scripting**
  - automating *very* simple tasks
  - customization of user environment
  - often only suitable for one individual user
  - usually eventually evolves into larger programs

- **programming**
  - suitable for simple to moderately complex tasks
  - results frequently used by a small base of users
  - uses basic framework or common toolkits
  - provides consistent interface
  - may evolve into full product
Approaching Automation

Three basic categories:

- software development
  - required for any reasonably complex task
Approaching Automation

Three basic categories:

- software development
  - required for any reasonably complex task
  - uses formal software engineering approach (measurable goals, requirements, specifications, ...)

Writing System Tools

April 6, 2018
Approaching Automation

Three basic categories:

- software development
  - required for any reasonably complex task
  - uses formal software engineering approach (measurable goals, requirements, specifications, ...)
  - may evolve from previous prototypes
Approaching Automation

Three basic categories:

- software development
  - required for any reasonably complex task
  - uses formal software engineering approach (measurable goals, requirements, specifications, ...)
  - may evolve from previous prototypes
  - requires ongoing continuous maintenance / development efforts
The right tool?
Picking the right tool

Make sure to understand your requirements:

- motivation / goals
- target audience
- scope
- dependencies
- input / output requirements and constraints
The right tool?

Bourne shell (/bin/sh)

- lowest common denominator
- available and reliable on most platforms (but beware of non-portable bash(1) "enhancements")
- beware of "quick-and-dirty" solutions, they grow to become unmaintainable
- treat shell as any other programming language:
  - use functions
  - use suitably scoped variables
  - follow Unix philosophy
  - properly package your tool

Note: you can “program” in shell, building complex systems.
The right tool?

Perl, Python, Ruby, Node, ...

- suitable for moderately complex tasks
- move to these when sed(1), awk(1), etc. become too cumbersome
- text manipulation frequently easier
- beware of "quick-and-dirty" solutions, they grow to become unmaintainable
- try to build self-contained modules that can be tested independent of the "main" program
- wealth of libraries available – use them! (And remember to explicitly require them.)
- properly package your tool

Note: LOC is not a direct indicator of duct-tapeness.
The right tool?

Perl, PHP, Tcl, JavaScript, CoffeeScript, ...

- http/web server interfaces
- CGI "scripts" / server-side execution
- interface with/utilize APIs in a specific domain/vendor products
- frequent cause of all sorts of security problems due to interface with user data / exposure on the internet
The right tool?

C, C++, Go, ...

- performance benefits
- portability
- sufficient low-levelness
- systems understanding
- fix/patch your other tools / the system
Interpreted Languages

General advantages:

- short development cycle
- normally facilitate things like string manipulation, arithmetic and more complex regular expressions
- easily handle multiple file handles and other I/O
- some security features
- tens of thousands of special- and general-purpose modules available
Interpreted Languages

General Disadvantages:

- no one tool fits all purposes
- tens of thousands of special- and general-purpose modules available
  => lots of duplication, stale code, questionable quality packaging and dependency resolution nightmares
- security features frequently neglected or circumvented ("too hard" or more precisely "inconvenient")
- everybody has their particular favorite (and dislikes one or the other)
- interpreter not (necessarily) universally available / installed
Regular Expressions

Example exercises:

- check if a string is a valid date
  03/07/2016, 7.3.2016, 2016-03-07, 2016/03/07, ...

- check if a string is a valid IPv4 address
  0.0.0.0, 255.255.255.255, ...

- check if a string is a valid IPv6 address
  ::1, fe80::e276:63ff:fe72:3900%xennet0, 2001:470:30:84:e276:63ff:fe72:3900, ...

- extract all URLs from a document
  http://example.com, ftp://example.com/dir/file.html,
  https://example.com/?foo=bar&blob=';alert(1);,
  http://example.com/?redir=http://example.com,

- extract all proper words from a document
  word, it’s, Name, Henry the 3rd, cross-site scripting, ...
Regular Expressions

IPv4:
Regular Expressions

IPv4:

\((25[0-5] | 2[0-4][0-9] | [01]?[0-9][0-9]) \.(25[0-5] | 2[0-4][0-9] | [01]?[0-9][0-9]) \.(25[0-5] | 2[0-4][0-9] | [01]?[0-9][0-9]) \.(25[0-5] | 2[0-4][0-9] | [01]?[0-9][0-9])\)
Regular Expressions

IPv4:


IPv6:

((\[0-9a-fA-F\]{1,4}:){7,7}\[0-9a-fA-F\]{1,4}|(\[0-9a-fA-F\]{1,4}:){1,7}|(\[0-9a-fA-F\]{1,6}:\[0-9a-fA-F\]{1,4}|(\[0-9a-fA-F\]{1,5}::\[0-9a-fA-F\]{1,4}|(\[0-9a-fA-F\]{1,4}::\[0-9a-fA-F\]{1,3}|(\[0-9a-fA-F\]{1,3}::\[0-9a-fA-F\]{1,2}|(\[0-9a-fA-F\]{1,2}::\[0-9a-fA-F\]{1,1}|\[0-9a-fA-F\]{1,1}::))%)%\[0-9a-zA-Z\]{1,}::(ffff(:0{1,4}){0,1}:){0,1}(25[0-5]|2[0-4]|1{0,1}[0-9])\.(3,3)(25[0-5]|2[0-4]|1{0,1}[0-9])\.(0,1)[0-9].(25[0-5]|2[0-4]|1{0,1}[0-9])\.(0,1)[0-9])

{3,3}{25[0-5]|2[0-4]|1{0,1}[0-9])\.(0,1)[0-9])}
Regular Expressions

Some people, when confronted with a problem, think "I know, I'll use regular expressions." Now they have two problems.

Better:

```c
if (inet_pton(AF_INET, $ip)) {
    # AF_INET
} elsif (inet_pton(AF_INET6, $ip)) {
    # AF_INET6
} else {
    # not an IP address
}
```

Know when you need to be precise, and when 'good enough' is good enough.
Hooray!

5 Minute Break
User Interface
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.
Be Boring

Use boring technology.

Write boring code.
Know your languages / eco-system

Some advice transcends language:

```
$ echo import this | python
```
The Zen of Python

Beautiful is better than ugly.
The Zen of Python

Explicit is better than implicit.
Simple is better than complex.

http://xkcd.com/399/
The Zen of Python

Complex is better than complicated.
The Zen of Python

Flat is better than nested.
Sparse is better than dense.

Readability counts.
A comment on comments

Write descriptive code, use descriptive variables and function names.

Comments should explain *why*, not *what*.
The Zen of Python

Special cases aren’t special enough to break the rules.
The Zen of Python

Special cases aren’t special enough to break the rules.

Although practicality beats purity.
Errors should never pass silently.
Errors should never pass silently.

(That would be implicitly accepted failure.)
Errors should never pass silently.

(That would be implicitly accepted failure.)

(You know what would be better than something *implicit*?)
The Zen of Python

Errors should never pass silently.

(That would be implicitly accepted failure.)

(You know what would be better than something *implicit*?)

(Why, of course, something *explicit!*
Errors should never pass silently.

Unless explicitly silenced.
In the face of ambiguity, refuse the temptation to guess.
The Zen of Python

There should be one – and preferably only one – obvious way to do it.
The Zen of Python

There should be one – and preferably only one – obvious way to do it.

Although that way may not be obvious at first unless you’re Dutch.
The Zen of Python

Now is better than never.
The Zen of Python

Now is better than never.

Although never is often better than *right* now.
The Zen of Python

If the implementation is hard to explain, it's a bad idea.
The Zen of Python

If the implementation is easy to explain, it *may* be a good idea.
A simple interface, easy to explain. Yet...
The Zen of Python

Namespaces are one honking great idea – let’s do more of those!
Documentation

WTFM
Robustness Principle or Postel’s Law

Be conservative in what you do; be liberal in what you accept from others.
POLA

Principle of Least Astonishment
Know your Users

Who will use your tools?

- you yourself only
- your peers
- your "users"
- anybody else

What assumptions can you make?
How will your users script around your tool?
Avoid the Quick Fix

There’s nothing as permanent as a temporary solution.
Avoid the Project That Was Never Finished

Don’t let the Perfect be the enemy of the Good.
Avoid Feature Creep

http://www.feepingcreatures.com
Release Early, Release Often

“More users find more bugs.”

F. Brooks, “The Mythical Man Month”
Take a good look in the mirror!

Looks like you are the ass.
Learn to write a detailed bug report

Pre-requisite:

- RTFM
- Internet Search
- Know Your Community
Learn to write a detailed bug report

Pre-requisite: Do your homework.

Required:

- Description Of Problem
- Steps To Reproduce
- Expected Results
- Actual Results
Learn to write a detailed bug report

Pre-requisite: Do your homework.

Required:
- Description Of Problem
- Steps To Reproduce
- Expected Results
- Actual Results

Optional / recommended:
- Screenshots / exact copy of terminal I/O (script(1))
- Suggested Remediation
- Code Patch
Know how to use your ticket tracking system!

- *value* problem reports
- link related tickets
- have a backlog strategy
- understand the lifetime of a ticket (reported, accepted, assigned, resolved, closed)
- abstain from passive-aggressive ticket closing and re-opening
Increase the Bus Factor

“Just friends.”
Collaboration is non-optional

Efficient use of Version Control Systems is a requirement. They allow you to:

- collaborate with others
- simultaneously work on a code base
- keep old versions of files
- keep a log of the who, when, what, and why of any changes
- perform release engineering by creating *branches*
Commit Messages

Commit messages are like comments: often useless and misleading, but critical in understanding human thinking behind the code.

Commit messages are full sentences in correct and properly formatted English.

Commit messages briefly summarize the what, but provide important historical context as to the how and, more importantly, why.

Commit messages SHOULD reference and integrate with ticket tracking systems.

See also:
- https://is.gd/Wd1LhA
- https://is.gd/CUtwhA
- https://is.gd/rPQj5E
Fix Broken Windows
Scope

“Constraints are friends.”

F. Brooks, “The Mythical Man Month”
Scalability

- Simplify!
Scalability

- Simplify!
- Reduce or eliminate interactions with the user.
Scalability

- Simplify!
- Reduce or eliminate interactions with the user.
- Premature optimization is the root of all evil.
Scalability

- Simplify!
- Reduce or eliminate interactions with the user.
- Premature optimization is the root of all evil.
- So is excusing shoddy programming.
Scalability

- Simplify!
- Reduce or eliminate interactions with the user.
- Premature optimization is the root of all evil.
- So is excusing shoddy programming.
- Fix all warnings and errors.
Scalability

- Simplify!
- Reduce or eliminate interactions with the user.
- Premature optimization is the root of all evil.
- So is excusing shoddy programming.
- Fix all warnings and errors.
- Document all assumptions. Be specific.
Scalability

- Simplify!
- Reduce or eliminate interactions with the user.
- Premature optimization is the root of all evil.
- So is excusing shoddy programming.
- Fix all warnings and errors.
- Document all assumptions. Be specific.
- Always apply the Principle of Least Privilege.
Scalability

- Simplify!
- Reduce or eliminate interactions with the user.
- Premature optimization is the root of all evil.
- So is excusing shoddy programming.
- Fix *all* warnings and errors.
- Document all assumptions. Be specific.
- Always apply the Principle of Least Privilege.
- Assume hostile input and usage.
Scalability

- Simplify!
- Reduce or eliminate interactions with the user.
- Premature optimization is the root of all evil.
- So is excusing shoddy programming.
- Fix all warnings and errors.
- Document all assumptions. Be specific.
- Always apply the Principle of Least Privilege.
- Assume hostile input and usage.
- Understand your code.
Scalability

- Simplify!
- Reduce or eliminate interactions with the user.
- Premature optimization is the root of all evil.
- So is excusing shoddy programming.
- Fix *all* warnings and errors.
- Document all assumptions. Be specific.
- Always apply the Principle of Least Privilege.
- Assume hostile input and usage.
- Understand your code.
- Document your tools.
Program Maintenance

“... is an entropy-increasing process, and even its most skillful execution only delays the subsidence of the system into unfixable obsolescence.”

F. Brooks, “The Mythical Man Month”
Toss it!
HW

https://www.cs.stevens.edu/~jschauma/615/s18-hw5.html
That’s All, Folks!

Go away or I will replace you with a very small shell script.
Reading

Shell:
- http://www.tldp.org/HOWTO/Bash-Prog-Intro-HOWTO.html
- http://sed.sourceforge.net/sed1line.txt
- csh(1), ksh(1), sh(1)

Perl:
- http://www.perl.com
- http://www.cpan.org
- perl(1), perldoc(1), perlfaq(1)

Python:
- http://www.python.org
- pydoc
Reading

Ruby:

- http://is.gd/cE7iFR
- http://is.gd/DR4aNU

Other:

- http://www.regex.alf.nu/
- http://is.gd/jDDGpW
- https://www.netmeister.org/blog/writing-tools.html