

Introduction to Scientific Software Deployment and Development

damien.francois@uclouvain.be
November 2022

<http://www.ceci-hpc.be/training.html>

PERIODIC TABLE OF DEVOPS TOOLS (V1)															Xebialabs Deliver Faster					
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Fr	Free	CI	Repo Mgmt	Testing
Fm	Freemium	Deployment	Config / Provisioning	Containerization
Pd	Paid	Cloud / IaaS / PaaS	Release Mgmt	Collaboration
En	Enterprise	BI / Monitoring	Logging	Security

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106 Os Ki Kibana	107 Fm Nr New Relic	108 Os Ni Nagios	109 Os Gg Ganglia	110 Os Ct Cacti	111 Os Gr Graphite	112 Os Ic Icinga	113 En Sp Splunk	114 Fm Sl Sumo Logic	115 Os Ls Logstash	116 Fm Lg Loggly	117 Os Gr Graylog	118 Os Sn Snort	119 Os Tr Tripwire	120 En Cy CyberArk

Goal of this session:

“Promote the tools
the professionals are using for
developing and **deploying** programs,
to make them **correct**, **maintainable**, **shareable**, and **fast**,
efficiently.”

“...to make them **correct and maintainable**, ..., *efficiently*”

Paul F. Dubois. 1999. **Ten Good Practices in Scientific Programming**. *Computing in Science and Eng.* 1, 1 (January 1999), 7-11. DOI=10.1109/MCISE.1999.743610 <http://dx.doi.org/10.1109/MCISE.1999.743610>

Wilson G, Aruliah DA, Brown CT, Chue Hong NP, Davis M, Guy RT, et al. (2014) **Best Practices for Scientific Computing**. *PLoS Biol* 12(1): e1001745. doi:10.1371/journal.pbio.1001745

Dubois PF, Epperly T, Kumfert G (2003) **Why Johnny can't build (portable scientific software)**. *Comput Sci Eng* 5: 83–88. doi: 10.1109/mcise.2003.1225867

Prlić A, Procter JB (2012) **Ten Simple Rules for the Open Development of Scientific Software**. *PLoS Comput Biol* 8(12): e1002802. doi:10.1371/journal.pcbi.1002802

Victor R. Basili, Jeffrey C. Carver, Daniela Cruzes, Lorin M. Hochstein, Jeffrey K. Hollingsworth, Forrest Shull, Marvin V. Zelkowitz, "**Understanding the High-Performance-Computing Community: A Software Engineer's Perspective**," *IEEE Software*, vol. 25, no. 4, pp. 29-36, July/August, 2008

Wilson G, Bryan J, Cranston K, Kitzes J, Nederbragt L, Teal TK (2017) **Good enough practices in scientific computing**. *PLoS Comput Biol* 13(6): e1005510. <https://doi.org/10.1371/journal.pcbi.1005510>

Koehler Leman J *et al* "**Better together: Elements of successful scientific software development in a distributed collaborative community**. *PLoS Comput Biol*. 2020 doi: 10.1371/journal.pcbi.1007507.

“...to make them **correct** and **maintainable**, ..., *efficiently*”

Follow programming good practices:

1. Write for humans, not for computers
2. Use the appropriate language
3. Organize for change and make incremental changes
4. Follow good coding principles
5. Plan for mistakes, automate testing
6. Use modern source-code management system
7. Document the design and purpose, not the implementation
8. Optimize only when it works already
9. Debug cleverly

1. Write for humans, not for computers

“Indeed, the ratio of time spent reading versus writing is well over 10 to 1. We are constantly reading old code as part of the effort to write new code. ...[Therefore,] making it easy to read makes it easier to write.”



1. Write for humans, not for computers

Structure clear but goal not obvious

```
1 for i in range(n):
2     for j in range(m):
3         for k in range(l):
4             temp_value = X[i][j][k] * 12.5
5             new_array[i][j][k] = temp_value + 150
```

VS

Sweet spot in-between...

Goal clear but structure less obvious

```
1 PIXEL_NORMALIZATION_FACTOR = 12.5
2 PIXEL_OFFSET_FACTOR = 150
3
4 for row_index in range(row_count):
5     for column_index in range(column_count):
6         for color_channel_index in range(color_channel_count):
7             normalized_pixel_value = (
8                 original_pixel_array[row_index][column_index][color_channel_index]
9                 * PIXEL_NORMALIZATION_FACTOR
10            )
11            transformed_pixel_array[row_index][column_index][color_channel_index] = (
12                normalized_pixel_value + PIXEL_OFFSET_FACTOR
13            )
```

1. Write for humans, not for computers

Avoid naming anti-patterns:

A.1	<i>“Get” - more than an accessor</i>	A getter that performs actions other than returning the corresponding attribute without documenting it. Example: method <code>getImageData</code> which, no matter the attribute value, every time returns a new object (see Fig. 1).	B.6	<i>Expecting but not getting a collection</i>	The name of a method suggests that a collection should be returned but a single object or nothing is returned. Example: method <code>getStats</code> with return type <code>Boolean</code> (see Fig. 15).
A.2	<i>“Is” returns more than a Boolean</i>	The name of a method is a predicate suggesting a true/false value in return. However the return type is not <code>Boolean</code> but rather a more complex type thus allowing a wider range of values without documenting them. Example: <code>isValid</code> with return type <code>int</code> (see Fig. 6).	C.1	<i>Method name and return type are opposite</i>	The intent of the method suggested by its name is in contradiction with what it returns. Example: method <code>disable</code> with return type <code>ControlEnableState</code> . The inconsistency comes from “disable” and “enable” having opposite meanings (see Fig. 16).
A.3	<i>“Set” method returns</i>	A set method having a return type different than <code>void</code> and not documenting the return type/values with an appropriate comment (see Fig. 7).	C.2	<i>Method signature and comment are opposite</i>	The documentation of a method is in contradiction with its declaration. Example: method <code>isNavigateForwardEnabled</code> is in contradiction with its comment documenting “a back navigation”, as “forward” and “back” are antonyms (see Fig. 17).
A.4	<i>Expecting but not getting a single instance</i>	The name of a method indicates that a single object is returned but the return type is a collection. Example: method <code>getExpansion</code> returning <code>List</code> (see Fig. 9).	D.1	<i>Says one but contains many</i>	The name of an attribute suggests a single instance, while its type suggests that the attribute stores a collection of objects. Example: attribute <code>target</code> of type <code>Vector</code> . It is unclear whether a change affects one or multiple instances in the collection (see Fig. 18).
B.1	<i>Not implemented condition</i>	The comments of a method suggest a conditional behavior that is not implemented in the code. When the implementation is default this should be documented (see Fig. 10).	D.2	<i>Name suggests Boolean but type does not</i>	The name of an attribute suggests that its value is true or false, but its declaring type is not <code>Boolean</code> . Example: attribute <code>isReached</code> of type <code>int[]</code> where the declared type and values are not documented (see Fig. 19).
B.2	<i>Validation method does not confirm</i>	A validation method (e.g., name starting with “validate”, “check”, “ensure”) does not confirm the validation, i.e., the method neither provides a return value informing whether the validation was successful, nor documents how to proceed to understand (see Fig. 11).	E.1	<i>Says many but contains one</i>	The name of an attribute suggests multiple instances, but its type suggests a single one. Example: attribute <code>stats</code> of type <code>Boolean</code> . Documenting such inconsistencies avoids additional comprehension effort to understand the purpose of the attribute (see Fig. 20).
B.3	<i>“Get” method does not return</i>	The name suggests that the method returns something (e.g., name starts with “get” or “return”) but the return type is <code>void</code> . The documentation should explain where the resulting data is stored and how to obtain it (see Fig. 12).	F.1	<i>Attribute name and type are opposite</i>	The name of an attribute is in contradiction with its type as they contain antonyms. Example: attribute <code>start</code> of type <code>MAssociationEnd</code> . The use of antonyms can induce wrong assumptions (see Fig. 21).
B.4	<i>Not answered question</i>	The name of a method is in the form of predicate whereas the return type is not <code>Boolean</code> . Example: method <code>isValid</code> with return type <code>void</code> (see Fig. 13).	F.2	<i>Attribute signature and comment are opposite</i>	The declaration of an attribute is in contradiction with its documentation. Example: attribute <code>INCLUDE_NAME_DEFAULT</code> whose comment documents an “exclude pattern”. Whether the pattern is included or excluded is thus unclear (see Fig. 22).
B.5	<i>Transform method does not return</i>	The name of a method suggests the transformation of an object but there is no return value and it is not clear from the documentation where the result is stored. Example: method <code>javaToNative</code> with return type <code>void</code> (see Fig. 14).			

1. Write for humans, not for computers

The screenshot shows a Stack Overflow question page. The page title is "What does the ????! operator do in C?". The question was asked 11 years ago, modified 1 year, 2 months ago, and viewed 379k times. The question has 2471 votes. A blue banner indicates it is a "Highly active question" and that the user has enough reputation to answer or unprotect it. The question text is: "I saw a line of C that looked like this: !ErrorHasOccured() ????! HandleError();". The user asks: "It compiled correctly and seems to run ok. It seems like it's checking if an error has occurred, and if it has, it handles it. But I'm not really sure what it's actually doing or how it's doing it. It does look like the programmer is trying express their feelings about errors. I have never seen the ????! before in any programming language, and I can't find documentation for it anywhere. (Google doesn't help with search terms like ????!). What does it do and how does the code sample work?"

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What does the ????! operator do in C?

Asked 11 years ago Modified 1 year, 2 months ago Viewed 379k times

2471

Highly active question. You have enough reputation to answer or unprotect this question.

I saw a line of C that looked like this:

```
!ErrorHasOccured() ????! HandleError();
```

It compiled correctly and seems to run ok. It seems like it's checking if an error has occurred, and if it has, it handles it. But I'm not really sure what it's actually doing or how it's doing it. It does look like the programmer is trying express their feelings about errors.

I have never seen the ????! before in any programming language, and I can't find documentation for it anywhere. (Google doesn't help with search terms like ????!). What does it do and how does the code sample work?

1. Write for humans, not for computers

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What does the ?!?! operator do in C?

Asked 11 years ago Modified 1 year, 2 months ago Viewed 379k times

Highly active question. You have enough reputation to answer or unprotect this question.

```
2471  
if (ErrorHasOccured() )  
    HandleError();
```

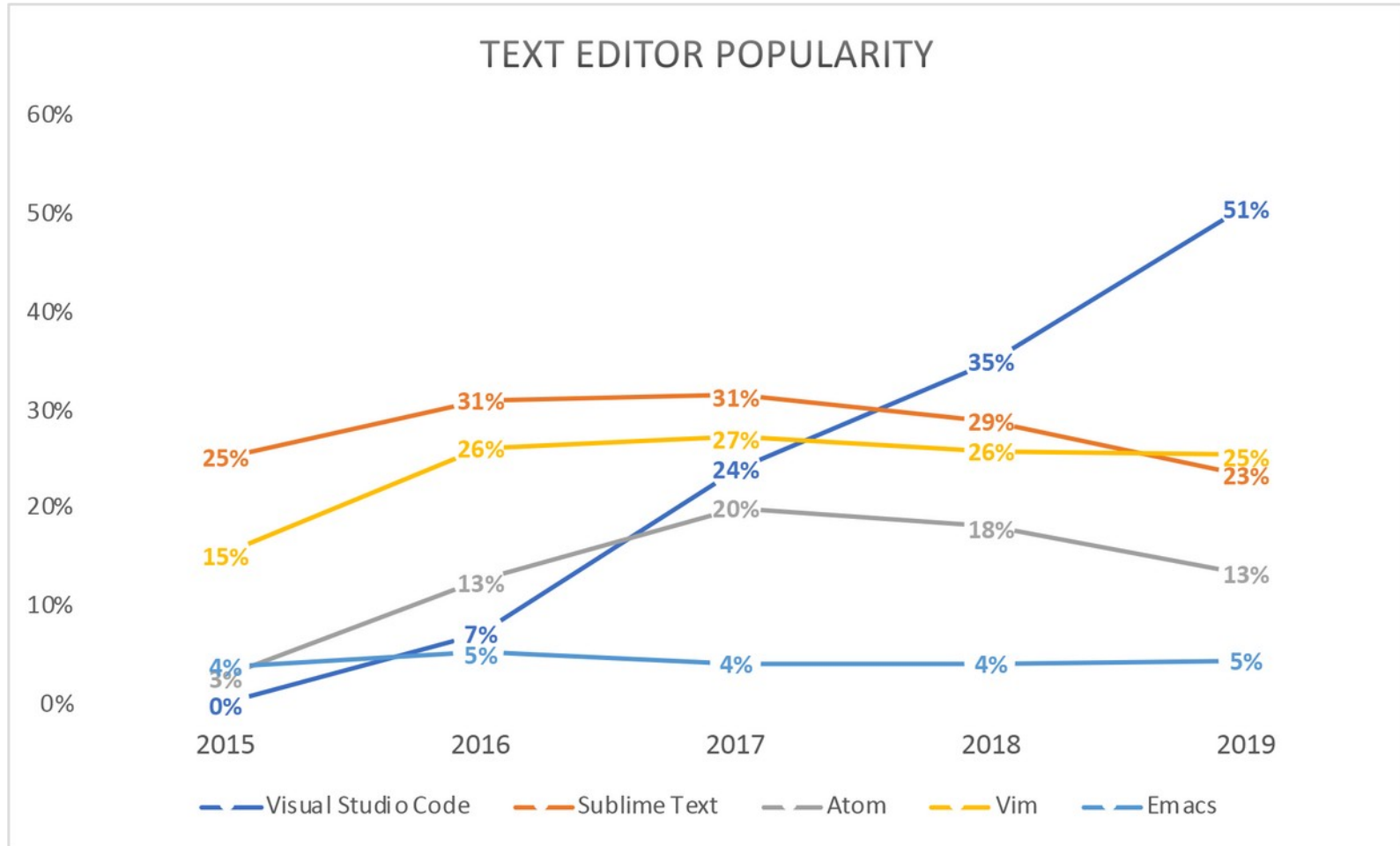
I saw a line of C that looked like this:
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I have never seen the ?!?! before in any programming language, and I can't find documentation for it anywhere. (Google doesn't help with search terms like ?!?!). What does it do and how does the code sample work?

<https://stackoverflow.com/questions/7825055/what-does-the-operator-do-in-c>

1. Write for humans, not for computers (and learn your editor)



2. Use the appropriate language



are all valid choices in a scientific context.

2. Use the appropriate language

What they have in common:

- Computation-efficiency concern
- Optimized libraries available for linear algebra, signal processing, learning, etc.
- Support for parallel computing
- Extensions/libraries for using accelerators (GPUs)

2. Use the appropriate language



“Functional programming”

Very close to mathematical formulation

Imposes constraints that make code less prone to bugs and easier to make parallel

Not very popular in HPC (yet)

3. Organize for change and make incremental changes

Scientific software specifications are always changing:

- ◆ Work from working state to another working state
- ◆ Document the changes and why they were made
- ◆ Refactor upon “code smell”

Keyword: **modularity**: small independent interchangeable building blocks (e.g. functions)

3 1/2 . Avoid “code smells”

```
41 @ static MappedField validateQuery(final Class clazz, final Mapper mapper, final StringBuilder origProp, final FilterOperator op, final
42 MappedField mf = null;
43 final String prop = origProp.toString();
44 boolean hasTranslations = false;
45 if (!origProp.substring(0, 1).equals("$")) {
46     final String[] parts = prop.split(regex "\\.");
47     if (clazz == null) { return null; }
48     MappedClass mc = mapper.getMappedClass(clazz);
49     //CHECKSTYLE:OFF
50     for (int i = 0; ; ) {
51         //CHECKSTYLE:ON
52         final String part = parts[i];
53         boolean fieldIsArrayOperator = part.equals("$");
54         mf = mc.getMappedField(part);
55         //translate from java field name to stored field name
56         if (mf == null && !fieldIsArrayOperator) {
57             mf = mc.getMappedFieldByJavaField(part);
58             if (validateNames && mf == null) {
59                 throw new ValidationException(format("The field '%s' could not be found in '%s' while validating - %s; if you wi
60             });
61             hasTranslations = true;
62             if (mf != null) {
63                 parts[i] = mf.getNameToStore();
64             }
65         }
66         i++;
67         if (mf != null && mf.isMap()) {
68             //skip the map key validation, and move to the next part
69             i++;
70         }
71         if (i >= parts.length) {
72             break;
73         }
74         if (!fieldIsArrayOperator) {
75             //catch people trying to search/update into @Reference/@Serialized fields
76             if (validateNames && !canQueryPast(mf)) {
77                 throw new ValidationException(format("Cannot use dot-notation past '%s' in '%s'; found while validating - %s", p
78             });
79             if (mf == null && mc.isInterface()) {
80                 break;
81             } else if (mf == null) {
82                 throw new ValidationException(format("The field '%s' could not be found in '%s'", prop, mc.getClazz().getName()));
83             }
84             //get the next MappedClass for the next field validation
85             mc = mapper.getMappedClass(mf.isSingleValue()) ? mf.getType() : mf.getSubClass();
86         }
87     }
88     //record new property string if there has been a translation to any part
89     if (hasTranslations) {
90         origProp.setLength(0); // clear existing content
91         origProp.append(parts[0]);
92         for (int i = 1; i < parts.length; i++) {
```

What's a prop?

What's a part?

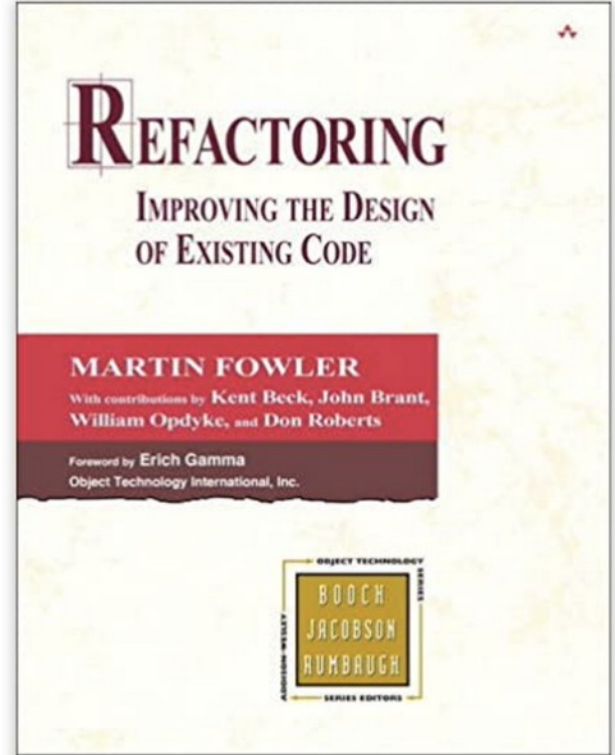
Eek!

Why all the null checks?

Control the loop

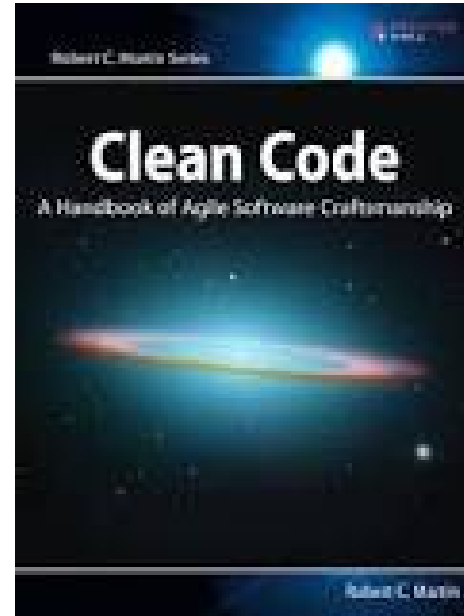
Comments, because code is unclear

Parameter mutation!



4. Follow good coding principles

- Don't repeat yourself (DRY)
- Keep it simple (KISS)
- One level of abstraction
- Single responsibility principle
- Separation of concern
- Avoid premature optimization
- Follow style guidelines
- Many others...



Bill Mitchell [View profile](#) [More options](#) Sep 26 1991, 1:57 am In article <5...@ksr.com>
j...@ksr.com (John F. Woods) writes:

[...] Always code as if the guy who ends up maintaining your code will be a violent psychopath who knows where you live. Code for readability.

Damn right!

4. Follow good coding principles and style



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What is the "-->" operator in C++?

After reading [Hidden Features and Dark Corners of C++/STL](#) on `comp.lang.c++.moderated`, I was completely surprised that the following snippet compiled and worked in both Visual Studio 2008 and G++ 4.4.

7883

Here's the code:

1831

```
#include <stdio.h>
int main()
{
    int x = 10;
    while (x --> 0) // x goes to 0
    {
        printf("%d ", x);
    }
}
```

I'd assume this is C, since it works in GCC as well. Where is this defined in the standard, and where has it come from?

<https://stackoverflow.com/questions/1642028/what-is-the-operator-in-c>

4. Follow good coding principles and style



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7883

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Here's the code:

```
while (x-- > 0)
```

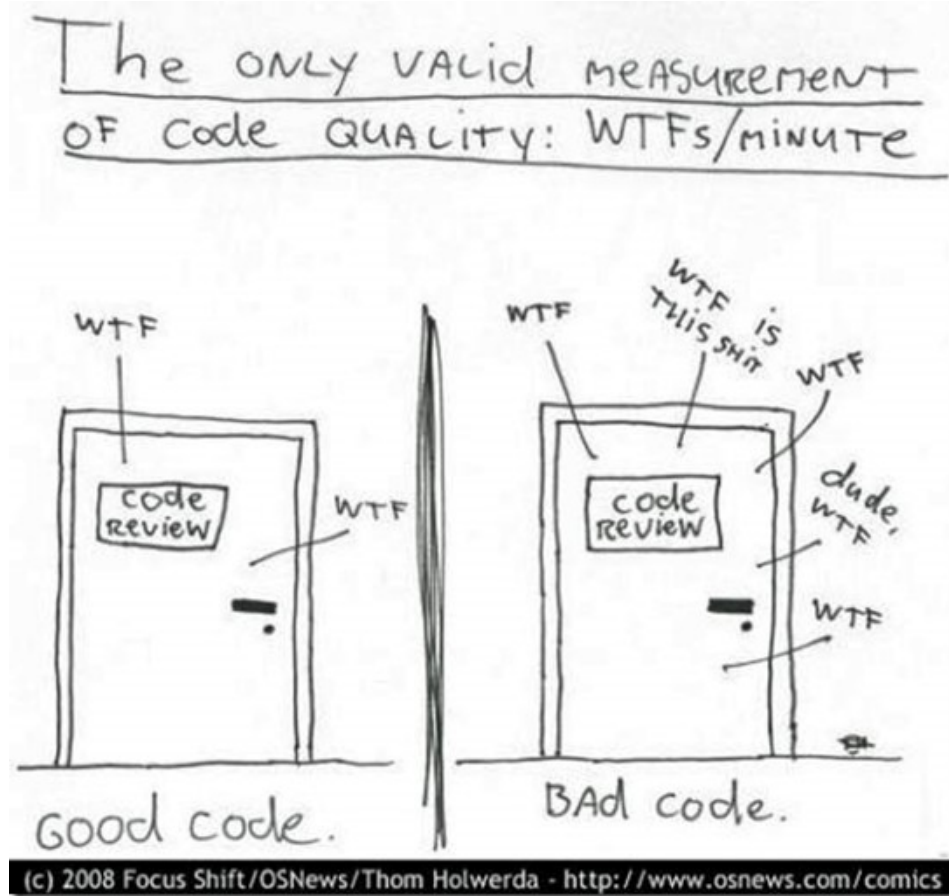
1831

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#include <stdio.h>
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4. Follow good coding principles and style



4. Follow good coding principles and style

The image displays three overlapping browser windows, each showing a different coding style guide or document.

Top Window: Google C++ Style Guide
URL: <https://google-styleguide.googlecode.com/svn/trunk/cppguide.html>
Title: Google C++ Style Guide
Table of Contents:

Header Files	Self-contained Headers The #define Guard Forward Declarations Inline Functions Function Parameter Ordering Names and Order of Includes
Scoping	Namespaces Nested Classes Nonmember, Static Member, and Global Functions Local Variables Static and Global Variables
Classes	Doing Work in Constructors Initialization Explicit Constructors Copyable and Movable Type Delegating and Inheriting Constructors Structs vs. Classes Inheritance Multiple Inheritance Operator Overloading Access Control Declaration Order Write Short Functions

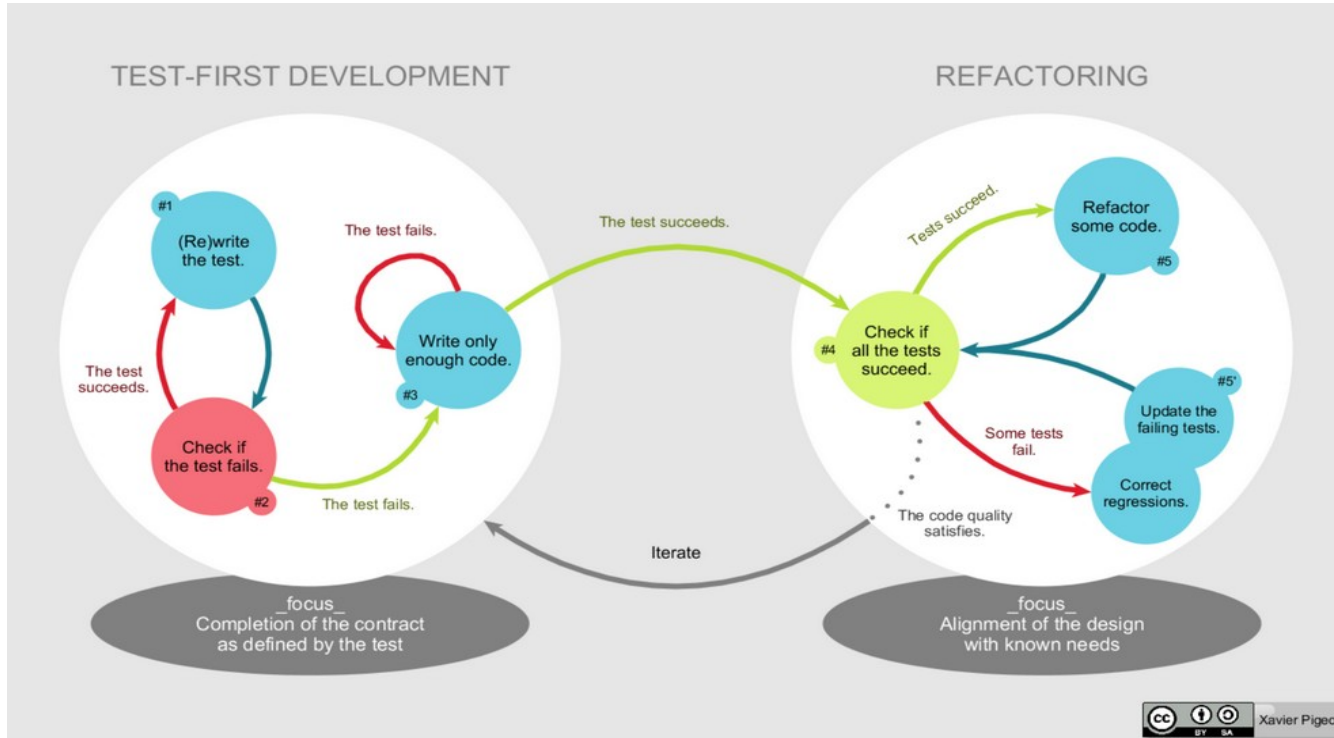
Middle Window: Linux kernel coding style
URL: <https://www.kernel.org/doc/Documentation/>
Title: Linux kernel coding style
Text:
`This is a short document describing the preferred coding style for the linux kernel. Coding style is very personal, and I won't force my views on anybody, but this is what goes for anything that I have been able to maintain, and I'd prefer it for most other things too. At least consider the points made here.`
`First off, I'd suggest printing out a copy of the GNU coding style. Burn them, it's a great symbolic gesture.`

Bottom Window: PEP 0008 -- Style Guide for Python Code | Python.org
URL: <https://www.python.org/dev/peps/pep-0008/>
Title: PEP 0008 -- Style Guide for Python Code | Python.org
Navigation: About Downloads Documentation Community Success Stories News Events
Search: Search GO Socialize Sign In
Tweets: Python Software Foundation @ThePSF 3 Sep

Python >>> Python Developer's Guide >>> PEP Index >>> PEP 0008 -- Style Guide for Python Code

5. Plan for mistakes, automate testing; Test-driven development

Write the tests before you even write the code



6. Use modern source-code management system



git

for your code, papers, thesis, etc.

2021

Introduction to code versioning

by Dr Olivier Mattelaer (UCLouvain/CISM)

📅 Wednesday 27 Oct 2021, 09:00 → 12:00 Europe/Brussels

📍 comodal (louvain-la-neuve or remote)

Description

Code versioning is very important to master, even for non programmers. It allows tracking the changes made to a submission script, a piece of code, a configuration file, or even a dataset and propagate the changes in a consistent and systematic way to all clusters.

Contents:

- Notions of code versioning
- Working as a team with code versioning
- Using git to access code from others
- Publishing code

Prerequisite:

- Being able to use SSH with private keys
- Being familiar with a text editor
- Mastering the Linux command line and the GNU utilities (mkdir, cp, scp, etc.)

Type: Hands-on

Target audience: Rookie programmer

Must: This session is a must-have for anyone not familiar with code versioning or git.

Organized by UCLouvain/CISM

Registration

👤 Participants

👤 11 / 60

📝 Register

Contact ✉ egs-cism@listes.uclouvain.be
☎ 0494424767

7. Document the purpose and design, not the implementation

```
function res = f(base, num)
% Assign base to res
res = base
% loop from 2 to num
for i=2:num
    % multiply current res by base
    res=base*res;
end
```

VS

```
function res = pow(base, num)
% compute base^num by iterative multiply for baseline check
res = base
for i=2:num
    res=res*base;
end
```


7. Document the purpose and design, not the implementation

Learn Markdown or RestructuredText

Super software

=====

Lorem ipsum dolor sit amet, consectetur adipiscing elit, sed do eiusmod tempor incididunt ut labore et dolore magna aliqua. Ut enim ad minim veniam, ...

Subtitle

Here is a list:

- item 1
- item 2

And a [\[link\]\(http://www.google.com\)](http://www.google.com) as well.

Some code:

```
#!/bin/bash
```

Super software

Lorem ipsum dolor sit amet, consectetur adipiscing elit, sed do eiusmod tempor incididunt ut labore et dolore magna aliqua. Ut enim ad minim veniam, ...

Subtitle

Here is a list:

- item 1
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And a [link](#) as well.

Some code:

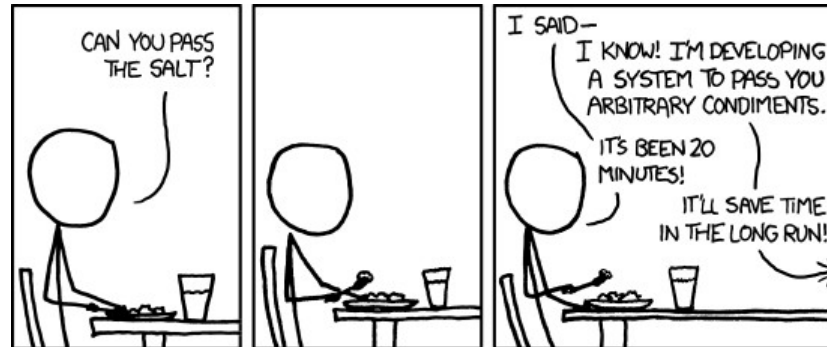
```
#!/bin/bash
echo OK
```

8. Optimize only when it works already

- ◆ Do not try to make it fast when it is not working yet

(focus on data structures, organization, etc. rather than on micro-optimizations)

- ◆ Do not try to make it universal for all possible future needs at the beginning (do not close doors either)



8. Optimize only when it works already

Use a profiler

2021
Debugging/profiling scientific code and scientific libraries

by Bernard Van Renterghem (UCL GISM)

Wednesday 27 Oct 2021, 13:00 → 16:00 Europe/Brussels
comodal (coudain-la-neuve or remote)

Description

When a piece of software does not work the way it is expected to, it needs debugging. Then, when it works, it needs profiling to remove the bottlenecks. This session will also present the standard optimized libraries that will allow you to code faster and more efficiently.

Contents:

- Debugging principles
- The GNU debugger (gdb)
- The Intel debugger
- Advanced features of Intel Cluster studio
 - the support of MIC architecture (Xeon Phi)
 - the Guided Auto Parallelism
 - the Coarray Fortran support
- Intel MKL

Prerequisite:

- Being able to use SSH with private keys
- Being familiar with a text editor
- Mastering the Linux command line and the GNU utilities (mkdir, cp, scp, etc.)
- Previous knowledge of either C, Fortran, Octave, Python or R
- Working knowledge of C or Fortran
- Familiarity with OpenMP and MPI

Type: Hands-on
Target audience: Programmers
Main: This session is important for programmers who want to optimize their code for usage on a cluster.

Organized by UCLouvain/GISM

Registration 4 / 40

Contact egg.com@infos.uclouvain.be
www.uclouvain.be

Incorporate benchmarks in your tests

Hotspots by CPU Utilization

Analysis Configuration Collection Log Summary Bottom-up Caller/Callee Top-down Tree Platform jacobi.c x jacobi.c x

Source Assembly

Source	Effective Time by Utilization			
	Idle	Poor	Ok	High
82 while (k <= maxit && error > tol) {				
83				
84 error = 0.0;				
85 #pragma omp parallel	0.0%	39.9%	0.0%	0.0%
86 {				
87				
88 /* copy new solution into old */				
89 #pragma omp for private(i) // or collapse(2)				
90 for (j=0; j<m; j++){				
91 for (i=0; i<n; i++){	0.0%	2.1%	0.0%	0.0%
92 UOLD(j,i) = U(j,i);	0.0%	7.7%	0.0%	0.0%
93 }				
94				
95 /* compute stencil, residual and update */				
96 #pragma omp for private(i, resid) reduction(+:error) // or co				
97 for (j=1; j<m-1; j++){				
98 for (i=1; i<n-1; i++){	0.0%	0.8%	0.0%	0.0%
99 resid =(0.0%	10.2%	0.0%	0.0%
100 ax * (UOLD(j,i-1) + UOLD(j,i+1))	0.0%	3.1%	0.0%	0.0%
101 + ay * (UOLD(j-1,i) + UOLD(j+1,i))	0.0%	3.8%	0.0%	0.0%
102 + b * UOLD(j,i) - F(j,i)	0.0%	2.3%	0.0%	0.0%
103) / b;	0.0%	0.0%	0.0%	0.0%
104				

9. Debug cleverly

Use a debugger

2021

Debugging/profiling scientific code and scientific libraries

by Bernard Van Renterghem (UCL GISM)

Wednesday 27 Oct 2021, 13:00 → 16:00 Europe/Brussels

comodal (souvain-la-neuve or remote)

Description

When a piece of software does not work the way it is expected to, it needs debugging. Then, when it works, it needs profiling to remove the bottlenecks. This session will also present the standard optimized libraries that will allow you to code faster and more efficiently.

Contents:

- Debugging principles
- The GNU debugger (gdb)
- The Intel debugger
- Advanced features of Intel Cluster studio
 - the support of MIC architecture (Docker Phi)
 - the Guided Auto Parallelism
 - the Coarray Fortran support
- Intel MPI

Prerequisite:

- Being able to use SSH with private keys
- Being familiar with a text editor
- Mastering the Linux command line and the GNU utilities (mkdir, cp, scp, etc.)
- Previous knowledge of either C, Fortran, Octave, Python or R
- Working knowledge of C or Fortran
- Familiarity with OpenMP and MPI

Type: Hands-on

Target audience: Programmers

Remark: This session is important for programmers who want to optimize their code for usage on a cluster.

Organized by UCLouvain/GISM

Registration [Participants](#) 4 / 40 [Register](#)

Contact egg.chem@uclouvain.be
uclouvain@uclouvain.be

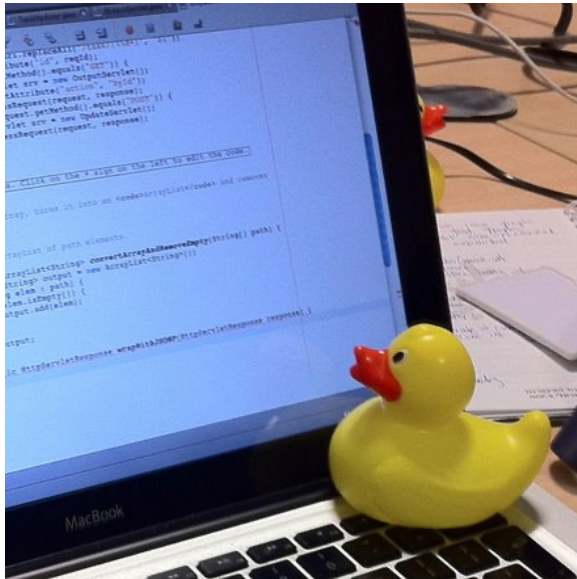
The screenshot shows the Winpdb debugger interface. The top menu includes File, Breakpoints, Control, Window, and Help. The toolbar contains various debugging symbols. The main window is divided into several panes:

- Namespace:** A tree view showing the current namespace. The 'main' function is expanded, showing attributes like __class__, __doc__, __name__, func_closur, func_code, func_default, func_dict, func_doc, func_global, func_name, open_new, os, pickle, re, and rpdb2.
- Source /data/sys/bin/winpdb-1.3.6/winpdb.py:** The source code of the winpdb.py file. The current line is 4637, which is a conditional breakpoint: `if __name__ == '__main__':`. The code includes a `main()` function and a `get_version()` function.
- Threads:** A table showing the current threads. The main thread is in a 'waiting at break point' state.
- Stack:** A table showing the current stack frames. The top frame is `winpdb.py` at line 4637, and the bottom frame is `rpdb2.py` at line 14044.
- Console:** The console output shows the debugger's startup sequence, including the version (RPDB_2_3_6), copyright information, and the message: `Successfully attached to '/data/sys/bin/winpdb-1.3.6/winpdb.py'.`

The status bar at the bottom indicates the state: **State: WAITING AT BREAK POINT**.

9. Debug cleverly

Use a method



Describe out loud to an imaginary rubber duck (or a willing colleague) each line in your code in simple terms and why it is obviously correct.

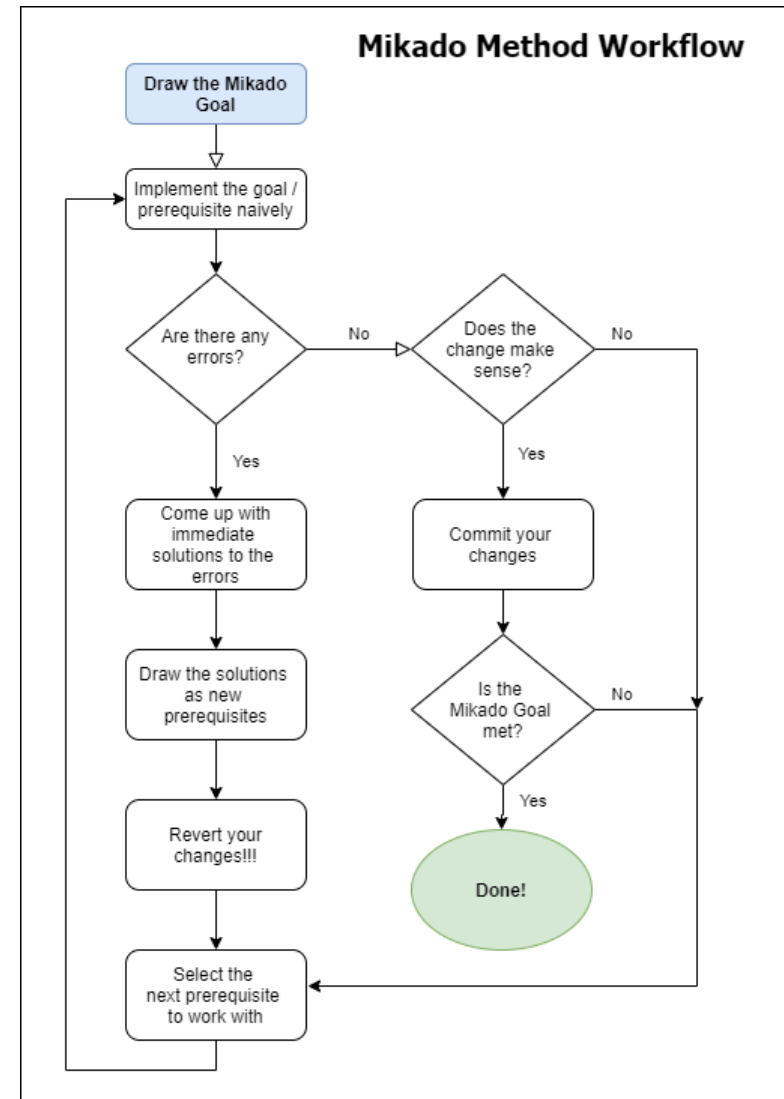
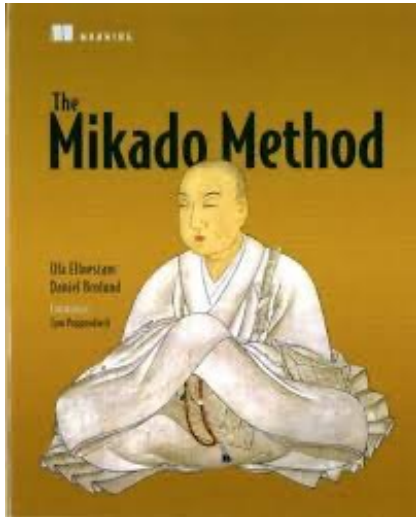
At some point, if you get hesitant, that is probably where the bug is!

Dig that part of the code until you are confident again that it works.

Or discover that it does actually not work as expected ...

9. Debug cleverly

Use a method



“... to make them ... **shareable** ..., *efficiently*”

1. Automate the compiling process
2. Learn about containers
3. License your code

1. Automate the compiling process



About Resources Developer Resources Download



CMake News & Blogs

10.06.2015 CMake 3.4.0-rc1 is now ready!

10.02.2015 Automated Tests on GitHub for your ITK-dependent project with Cir...

09.24.2015 Kitware at SciPy 2015

Article Talk

Read Edit View history

Search

GNU build system

From Wikipedia, the free encyclopedia



This article **needs additional citations for verification**. Please help [improve this article](#) by [adding citations to reliable sources](#). Unsourced material may be challenged and removed.

(September 2009)

The **GNU build system**, also known as the **Autotools**, is a suite of [programming tools](#) designed to assist in making [source code packages portable](#) to many [Unix-like](#) systems.

It can be difficult to make a software program portable: the [C compiler](#) differs from system to system; certain library functions are missing on some systems; header files may have different names. One way to handle this is to write conditional code, with code blocks selected by means of preprocessor directives (`#ifdef`); but because of the wide variety of build environments this approach quickly becomes unmanageable. Autotools is designed to address this problem more manageably.

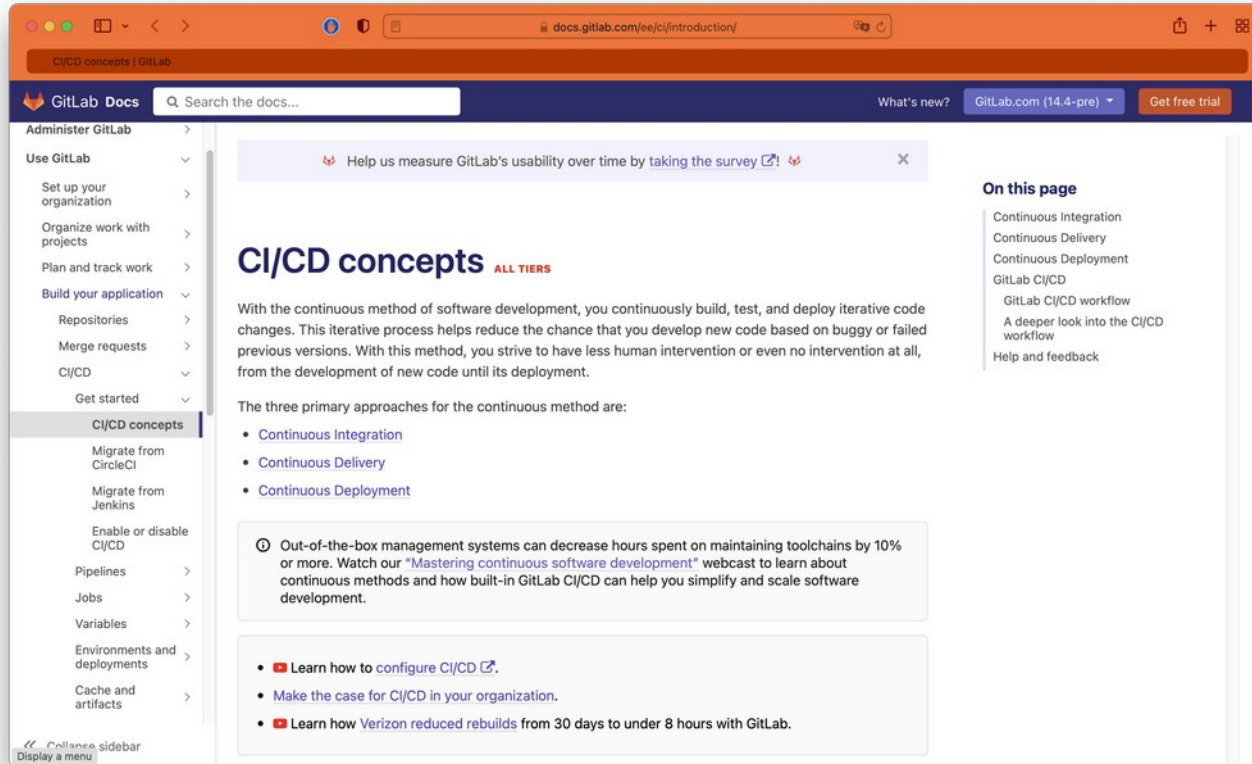
Autotools is part of the [GNU toolchain](#) and is widely used in many [free software](#) and [open source](#) packages. Its component tools are [free software](#), licensed under the [GNU General](#)



Making sure it compiles on your laptop is not enough

It has to compile on all the clusters...

1. Automate the compiling process



The screenshot displays the GitLab Docs website in a browser window. The address bar shows the URL `docs.gitlab.com/ee/ci/introduction/`. The page title is "CI/CD concepts | GitLab". The navigation sidebar on the left includes sections like "Administer GitLab", "Use GitLab", and "CI/CD concepts", with the latter being the active section. The main content area features a search bar, a survey notification, and the heading "CI/CD concepts ALL TIERS". Below the heading, there is a paragraph explaining the continuous method of software development. A section titled "The three primary approaches for the continuous method are:" lists "Continuous Integration", "Continuous Delivery", and "Continuous Deployment". A callout box highlights that "Out-of-the-box management systems can decrease hours spent on maintaining toolchains by 10% or more." and provides a link to a webcast. At the bottom, there are three bullet points with links to learn more about configuring CI/CD, making the case for CI/CD, and how Verizon reduced rebuilds.

CI/CD concepts | GitLab

GitLab Docs Search the docs... What's new? GitLab.com (14.4-pre) Get free trial

Help us measure GitLab's usability over time by [taking the survey](#)

CI/CD concepts ALL TIERS

With the continuous method of software development, you continuously build, test, and deploy iterative code changes. This iterative process helps reduce the chance that you develop new code based on buggy or failed previous versions. With this method, you strive to have less human intervention or even no intervention at all, from the development of new code until its deployment.

The three primary approaches for the continuous method are:

- [Continuous Integration](#)
- [Continuous Delivery](#)
- [Continuous Deployment](#)

📌 Out-of-the-box management systems can decrease hours spent on maintaining toolchains by 10% or more. Watch our "Mastering continuous software development" webcast to learn about continuous methods and how built-in GitLab CI/CD can help you simplify and scale software development.

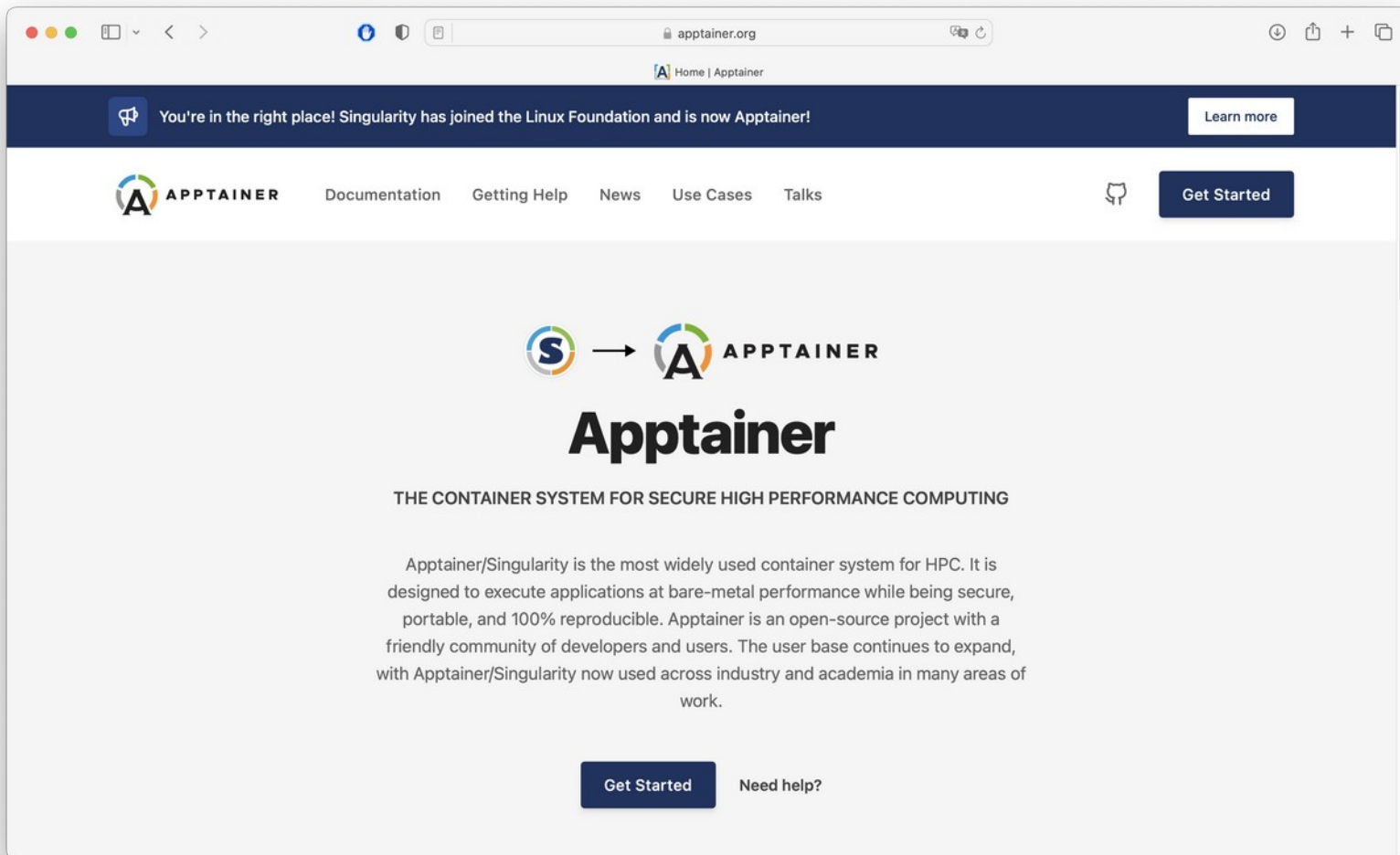
- [Learn how to configure CI/CD](#)
- [Make the case for CI/CD in your organization.](#)
- [Learn how Verizon reduced rebuilds from 30 days to under 8 hours with GitLab.](#)

On this page

- Continuous Integration
- Continuous Delivery
- Continuous Deployment
- GitLab CI/CD
 - GitLab CI/CD workflow
 - A deeper look into the CI/CD workflow
- Help and feedback

Collapsible sidebar Display a menu

2. Learn about containers






The screenshot shows the Apptainer website homepage in a browser window. The address bar displays 'apptainer.org'. A dark blue banner at the top contains the text 'You're in the right place! Singularity has joined the Linux Foundation and is now Apptainer!' and a 'Learn more' button. Below the banner is a navigation bar with the Apptainer logo, 'Documentation', 'Getting Help', 'News', 'Use Cases', 'Talks', a GitHub icon, and a 'Get Started' button. The main content area features a large graphic showing the Singularity logo (a blue 'S' in a circle) with an arrow pointing to the Apptainer logo (a blue 'A' in a circle) followed by the word 'APPTAINER'. Below this is the word 'Apptainer' in a large, bold, black font. Underneath is the tagline 'THE CONTAINER SYSTEM FOR SECURE HIGH PERFORMANCE COMPUTING'. A paragraph of text describes Apptainer/Singularity as the most widely used container system for HPC, designed for bare-metal performance, security, portability, and 100% reproducibility. At the bottom, there are two buttons: 'Get Started' and 'Need help?'.

apptainer.org

Home | Apptainer

You're in the right place! Singularity has joined the Linux Foundation and is now Apptainer! [Learn more](#)

APPTAINER Documentation Getting Help News Use Cases Talks  [Get Started](#)

 →  **APPTAINER**

Apptainer

THE CONTAINER SYSTEM FOR SECURE HIGH PERFORMANCE COMPUTING

Apptainer/Singularity is the most widely used container system for HPC. It is designed to execute applications at bare-metal performance while being secure, portable, and 100% reproducible. Apptainer is an open-source project with a friendly community of developers and users. The user base continues to expand, with Apptainer/Singularity now used across industry and academia in many areas of work.

[Get Started](#) [Need help?](#)

3. License your code: Why?

- ♦ **Commercial reason :**
 - you want to make money out of it – control distribution
 - forbid reverse engineering
- ♦ **Scientific reason :**
 - you want to it to be used and get citations
 - you need to allow usage, and/or modification, etc.
 - you require others to cite your work
 - you want to protect yourself from liability claims





3. License your code: e.g. MIT


Copyright (c) <year> <copyright holders>

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Can	
▶ Commercial Use	
▶ Modify	
▶ Distribute	
▶ Sublicense	
▶ Private Use	



Cannot	
▶ Hold Liable	





Must	
▶ Include Copyright	
▶ Include License	

3. License your code: e.g. BSD, GPL

BSD Can	
▶ Commercial Use	
▶ Modify	
▶ Distribute	
▶ Place Warranty	

Cannot	
▶ Use Trademark	
▶ Hold Liable	

Must	
▶ Include Copyright	
▶ Include License	

GPL Can	
▶ Commercial Use	
▶ Modify	
▶ Distribute	
▶ Place Warranty	
▶ Use Patent Claims	

Cannot	
▶ Sublicense	
▶ Hold Liable	

Must	
▶ Include Original	
▶ State Changes	
▶ Disclose Source	
▶ Include License	
▶ Include Copyright	
▶ Include Install Instructions	

3. License your code: finding help



LIEU – Network of Knowledge Transfer offices

Coordinator

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3 1/2. GitHub CITATION files

The screenshot shows a web browser window displaying the GitHub Docs page for 'About CITATION files'. The page is titled 'About CITATION files - GitHub Docs' and is part of the 'Manage repository settings' section. The main content area features a heading 'About CITATION files' followed by a paragraph: 'You can add a CITATION file to your repository to help users correctly cite your software.' Below this is another heading 'About CITATION files' and a paragraph: 'You can add a CITATION.cff file to the root of a repository to let others know how you would like them to cite your work. The citation file format is plain text with human- and machine-readable citation information.' An example CITATION.cff file is provided in a code block:

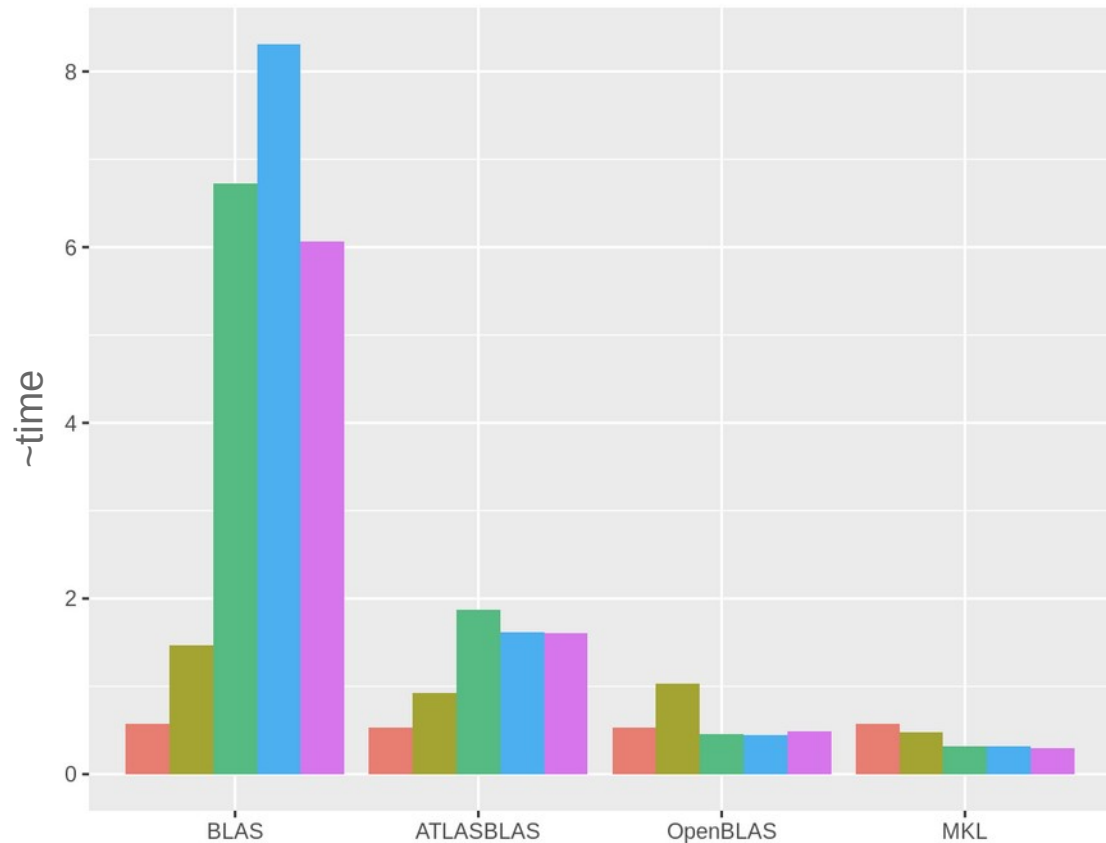
```
cff-version: 1.2.0
message: "If you use this software, please cite it as below."
authors:
  - family-names: "Lisa"
    given-names: "Mona"
    orcid: "https://orcid.org/0000-0000-0000-0000"
  - family-names: "Bot"
    given-names: "Hew"
    orcid: "https://orcid.org/0000-0000-0000-0000"
title: "My Research Software"
version: 2.0.4
doi: 10.5281/zenodo.1234
date-released: 2017-12-18
url: "https://github.com/github/linguist"
```

The right sidebar contains a section 'In this article' with links to 'About CITATION files', 'Citing something other than software', 'Citing a dataset', 'Other citation files', and 'Citation formats'. The left sidebar shows a navigation menu with 'About CITATION files' highlighted under 'Manage repository settings'.

“... to make them ... **fast** ..., *efficiently*”

1. Use optimized libraries
2. Choose the right storage system
3. Think parallel from the start
4. Integrate checkpoint/restart from the start

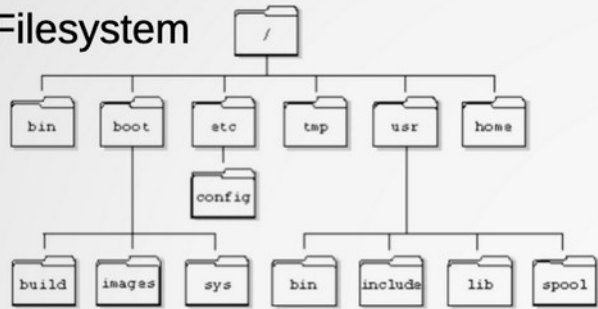
1. Use optimized libraries



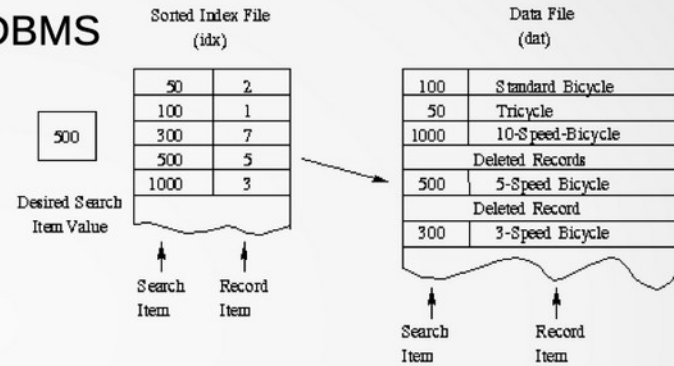
- Creation, transp., deformation of 2.5kx2.5k matrix
- 2.4Kx2.4K normal distributed random matrix $\wedge 1k$
- Sorting of 7M random values
- 2.8Kx2.8K cross-product matrix ($b = a' * a$)
- Linear regr. over a 3Kx3K matrix ($c = a b'$)

2. Choose the right storage system

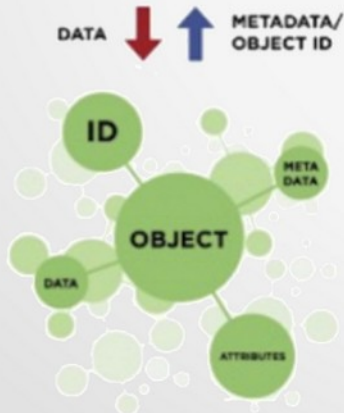
Filesystem



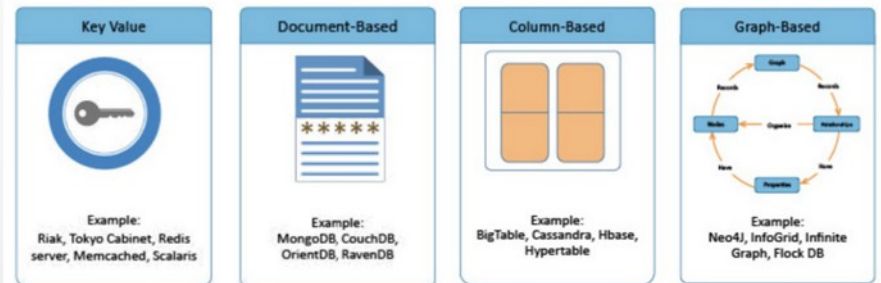
RDBMS



Objects store



NoSQL



3. Think parallel from the start

1. Identify data flows and independent tasks
2. Make data decomposition easy
3. Make work decomposition easy

```
data = [(x1,y1), (x2,y2), .., (x10,y10)]
for i = 1 .. 10
  s[i] = ( data[xi] + data[yi] )
  ss[i] = ( data[xi]^2 + data[yi]^2 )
end
```



```
begin=0, end=10
data = [(x1,y1), (x2,y2), .., (x10,y10)]
for i = begin .. end
  s[i] = ( data[xi] + data[yi] )
end
for i = begin .. end
  ss[i] = ( data[xi]^2 + data[yi]^2 )
end
```

4. Integrate checkpoint/restart from the start

1. Allow starting from a non-initial state
2. Save variables to disk frequently

```
data = [(x1,y1), (x2,y2), .., (x10,y10)]
for i = 1 .. 10
    res[i] = ( data[xi]^2 + data[yi]^2 )
end
```



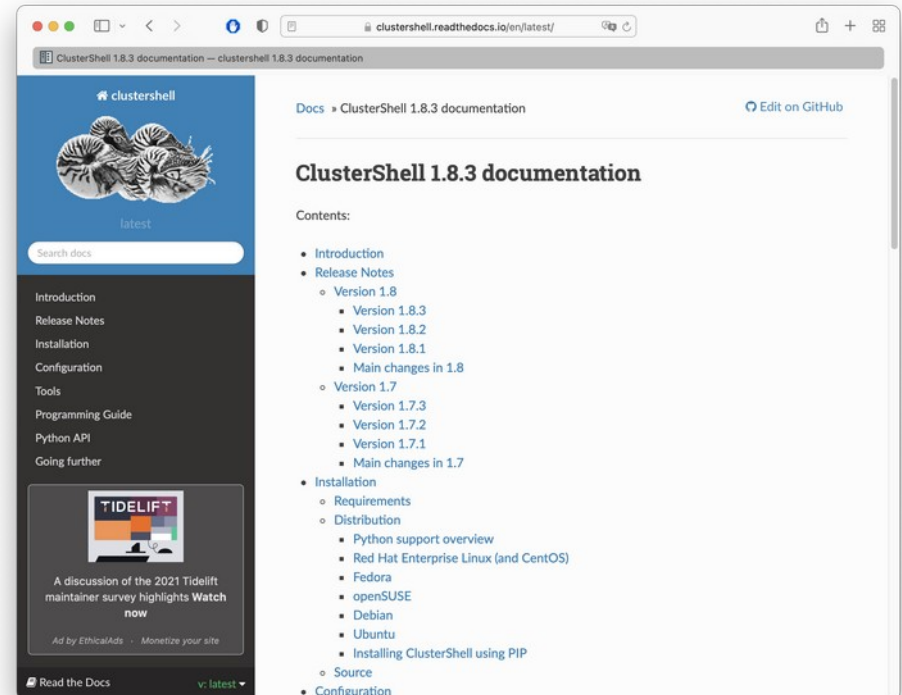
```
if exists(i) and exists(res)
    begin=load(i)
    res=load(res)
else
    begin = 1
end=10
data = [(x1,y1), (x2,y2), .., (x10,y10)]
for i = begin .. end
    res[i] = ( data[xi]^2 + data[yi]^2 )
    save(res, i)
end
```

“ ..., *efficiently*”

1. Perform “multi-host” SSH
2. Master configuration management
3. Use terminal multiplexing
4. Install software like a boss
5. Avoid the boilerplate
6. BACKUPS!

1. Perform “multi-host” SSH

```
> clush -Bw lemaitre3,hercules,nic5,dragon2 "emacs --version"
-----
dragon2,hercules,lemaitre3 (3)
-----
GNU Emacs 24.3.1
Copyright (C) 2013 Free Software Foundation, Inc.
GNU Emacs comes with ABSOLUTELY NO WARRANTY.
You may redistribute copies of Emacs
under the terms of the GNU General Public License.
For more information about these matters, see the file named COPYING.
-----
nic5
-----
GNU Emacs 26.1
Copyright (C) 2018 Free Software Foundation, Inc.
GNU Emacs comes with ABSOLUTELY NO WARRANTY.
You may redistribute copies of GNU Emacs
under the terms of the GNU General Public License.
For more information about these matters, see the file named COPYING.
-----
> clush -Bw lemaitre3,hercules,nic5,dragon2 "scontrol version"
-----
dragon2,lemaitre3 (2)
-----
slurm 20.02.7
-----
hercules
-----
slurm 20.02.6
-----
nic5
-----
slurm 20.02.3
> clush -w lemaitre3,hercules,nic5,dragon2 "squeue -tPD | wc -l"
nic5: 1420
lemaitre3: 288
dragon2: 145
hercules: 102
>
```



The screenshot shows a web browser displaying the ClusterShell 1.8.3 documentation page. The page title is "ClusterShell 1.8.3 documentation" and it includes a search bar and a table of contents. The table of contents lists various sections such as Introduction, Release Notes, Installation, and Configuration. The page also features a sidebar with navigation links and a footer with "Read the Docs" and "v: latest" information.

clustershell

ClusterShell 1.8.3 documentation

ClusterShell 1.8.3 documentation

Docs » ClusterShell 1.8.3 documentation

Edit on GitHub

ClusterShell 1.8.3 documentation

Contents:

- Introduction
- Release Notes
 - Version 1.8
 - Version 1.8.3
 - Version 1.8.2
 - Version 1.8.1
 - Main changes in 1.8
 - Version 1.7
 - Version 1.7.3
 - Version 1.7.2
 - Version 1.7.1
 - Main changes in 1.7
- Installation
 - Requirements
 - Distribution
 - Python support overview
 - Red Hat Enterprise Linux (and CentOS)
 - Fedora
 - openSUSE
 - Debian
 - Ubuntu
 - Installing ClusterShell using PIP
 - Source
- Configuration

Read the Docs v: latest

2. Master configuration management



ANSIBLE

```
> ansible -i lemaitre3,nic5 'all' -m lineinfile -a "dest=myfile line='Contents' create=true"
nic5 | CHANGED => {
  "ansible_facts": {
    "discovered_interpreter_python": "/usr/libexec/platform-python"
  },
  "backup": "",
  "changed": true,
  "msg": "line added"
}
lemaitre3 | SUCCESS => {
  "ansible_facts": {
    "discovered_interpreter_python": "/usr/bin/python"
  },
  "backup": "",
  "changed": false,
  "msg": ""
}
```

2. Master configuration management



```
>> cat inventory playbook.yml myfile
```

	File: inventory
1	[all]
2	
3	lemaitre3 short_name="lm3"
4	nic5 short_name="nic5"
	File: playbook.yml
1	---
2	- hosts:
3	- lemaitre3
4	- nic5
5	tasks:
6	- name: Upload templated file
7	template: src=myfile dest=. mode=700
	File: myfile
1	This cluster's short name is {{ short_name }}

2. Master configuration management



ANSIBLE

```
> ansible-playbook -i inventory playbook.yml --diff

PLAY [lemaitre3,nic5] *****

TASK [Gathering Facts] *****
ok: [nic5]
ok: [lemaitre3]

TASK [Upload templated file] *****
--- before: ./myfile
+++ after: /Users/dfrancois/.ansible/tmp/ansible-local-40594k4ng0q9q/tmpd689k7ap/myfile
@@ -1 +1 @@
-Contents
+This cluster's short name is nic5

changed: [nic5]
--- before: ./myfile
+++ after: /Users/dfrancois/.ansible/tmp/ansible-local-40594k4ng0q9q/tmpa5narr9m/myfile
@@ -1 +1 @@
-Contents
+This cluster's short name is lm3

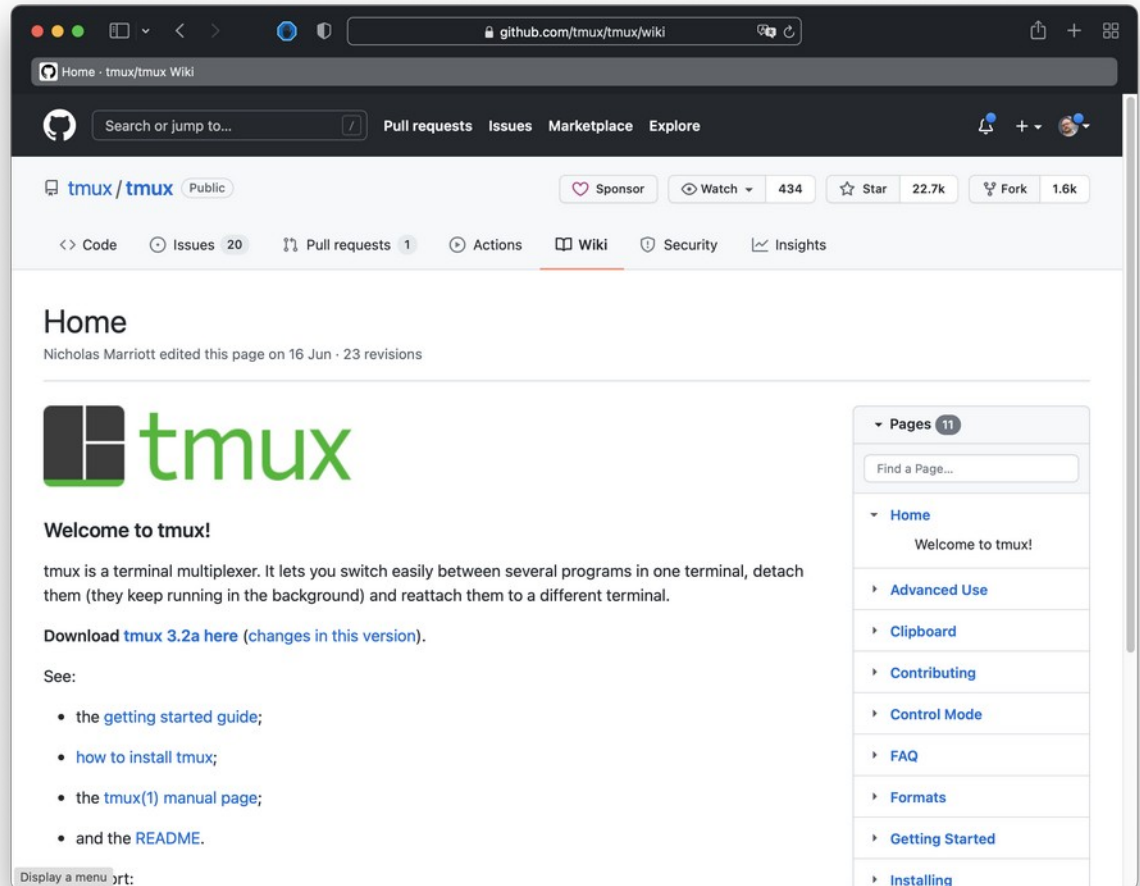
changed: [lemaitre3]

PLAY RECAP *****
lemaitre3      : ok=2    changed=1    unreachable=0    failed=0    skipped=0    rescued=0    ignored=0
nic5           : ok=2    changed=1    unreachable=0    failed=0    skipped=0    rescued=0    ignored=0

> clush -w lemaitre3,nic5 "cat myfile"
nic5: This cluster's short name is nic5
lemaitre3: This cluster's short name is lm3
```

3. Use terminal multiplexing

Do not let SSH disconnections harm your workflow (and much more)



4. Install software like a boss

```
[dfr@lemaitre3 ~]$ eb --search emacs
== found valid index for /usr/easybuild/easyconfigs, so using it...
== found valid index for /usr/easybuild/easyconfigs, so using it...
* /usr/easybuild/easyconfigs/e/Emacs/Emacs-24.3-GCC-4.8.3-bare.eb
* /usr/easybuild/easyconfigs/e/Emacs/Emacs-24.3-GCC-4.8.3.eb
* /usr/easybuild/easyconfigs/e/Emacs/Emacs-24.4-GCC-4.9.2.eb
* /usr/easybuild/easyconfigs/e/Emacs/Emacs-24.5-GCC-4.9.3-2.25.eb
* /usr/easybuild/easyconfigs/e/Emacs/Emacs-25.1-foss-2016a.eb
* /usr/easybuild/easyconfigs/e/Emacs/Emacs-25.3-GCCcore-6.3.0.eb
* /usr/easybuild/easyconfigs/e/Emacs/Emacs-25.3-GCCcore-6.4.0.eb
* /usr/easybuild/easyconfigs/e/Emacs/Emacs-25.3-GCCcore-7.3.0.eb
* /usr/easybuild/easyconfigs/e/Emacs/Emacs-26.3-GCCcore-8.3.0.eb
* /usr/easybuild/easyconfigs/e/Emacs/Emacs-27.1-GCCcore-9.3.0.eb
* /usr/easybuild/easyconfigs/e/Emacs/Emacs-27.1-GCCcore-10.2.0.eb
* /usr/easybuild/easyconfigs/e/Emacs/Emacs-24.3-GCC-4.8.3-bare.eb
* /usr/easybuild/easyconfigs/e/Emacs/Emacs-24.3-GCC-4.8.3.eb
* /usr/easybuild/easyconfigs/e/Emacs/Emacs-24.4-GCC-4.9.2.eb
* /usr/easybuild/easyconfigs/e/Emacs/Emacs-24.5-GCC-4.9.3-2.25.eb
* /usr/easybuild/easyconfigs/e/Emacs/Emacs-25.1-foss-2016a.eb
* /usr/easybuild/easyconfigs/e/Emacs/Emacs-25.3-GCCcore-6.3.0.eb
* /usr/easybuild/easyconfigs/e/Emacs/Emacs-25.3-GCCcore-6.4.0.eb
* /usr/easybuild/easyconfigs/e/Emacs/Emacs-25.3-GCCcore-7.3.0.eb
* /usr/easybuild/easyconfigs/e/Emacs/Emacs-26.3-GCCcore-8.3.0.eb
* /usr/easybuild/easyconfigs/e/Emacs/Emacs-27.1-GCCcore-9.3.0.eb
* /usr/easybuild/easyconfigs/e/Emacs/Emacs-27.1-GCCcore-10.2.0.eb
```



EasyBuild @PyPi EasyBuild docs EasyBuild @GitHub

EasyBuild: building software with ease.

EasyBuild is a software build and installation framework that allows you to manage (scientific) software on High Performance Computing (HPC) systems in an efficient way.

Latest news

- 20150902 - **EasyBuild v2.3.0** is available
- 20150622 - **10th EasyBuild/Lmod hackathon** @ Austin (before SC15)
- 20150315 - **ISC'15 BoF "Getting Scientific Software Installed" accepted**
- 20141104 - **Revamped documentation @ easybuild.readthedocs.org**
- 20141020 - **pre-print of HUST-14 workshop paper available**

Documentation

Read the fine manual (RTFM!) at <http://easybuild.readthedocs.org/>.

Getting started

The recommended way of installing EasyBuild is via the [documented bootstrap procedure](#). You should [configure](#) EasyBuild to behave as you prefer, subsequently.

5. Avoid the boilerplate



```
1 {
2   "project_name": "project_name",
3   "repo_name": "{{ cookiecutter.project_name.lower().replace(' ', '_') }}",
4   "author_name": "Your name (or your organization/company/team)",
5   "description": "A short description of the project.",
6   "open_source_license": ["MIT", "BSD-3-Clause", "No license file"],
7   "s3_bucket": "[OPTIONAL] your-bucket-for-syncing-data (do not include 's3://')",
8   "aws_profile": "default",
9   "python_interpreter": ["python3", "python"]
10 }
```



```
— LICENSE
— Makefile
— README.md
— data
  — external
  — interim
  — processed
  — raw
— docs
— models
— notebooks
— references
— reports
  — figures
— requirements.txt
— setup.py
— src
  — __init__.py
  — data
    — make_dataset.py
  — features
    — build_features.py
  — models
    — predict_model.py
    — train_model.py
  — visualization
    — visualize.py
— tox.ini
```

<- Makefile with commands like `make data` or `make train`
<- The top-level README for developers using this project.
<- Data from third party sources.
<- Intermediate data that has been transformed.
<- The final, canonical data sets for modeling.
<- The original, immutable data dump.
<- A default Sphinx project; see sphinx-doc.org for details
<- Trained and serialized models, model predictions, or model summaries
<- Jupyter notebooks. Naming convention is a number (for ordering), the creator's initials, and a short '-' delimited description, e.g. `1.0-jqp-initial-data-exploration`.
<- Data dictionaries, manuals, and all other explanatory materials.
<- Generated analysis as HTML, PDF, LaTeX, etc.
<- Generated graphics and figures to be used in reporting
<- The requirements file for reproducing the analysis environment, e.g. generated with `pip freeze > requirements.txt`
<- makes project pip installable (pip install -e .) so src can be imported
<- Source code for use in this project.
<- Makes src a Python module
<- Scripts to download or generate data
<- Scripts to turn raw data into features for modeling
<- Scripts to train models and then use trained models to make predictions
<- Scripts to create exploratory and results oriented visualizations
<- tox file with settings for running tox; see tox.readthedocs.io

<https://cookiecutter.readthedocs.io/en/stable/>

<https://github.com/search?q=cookiecutter&type=Repositories>

6. BACKUPS!!!

3-2-1 Backup Rule



X3

Maintain at least 3
copies of your data



X2

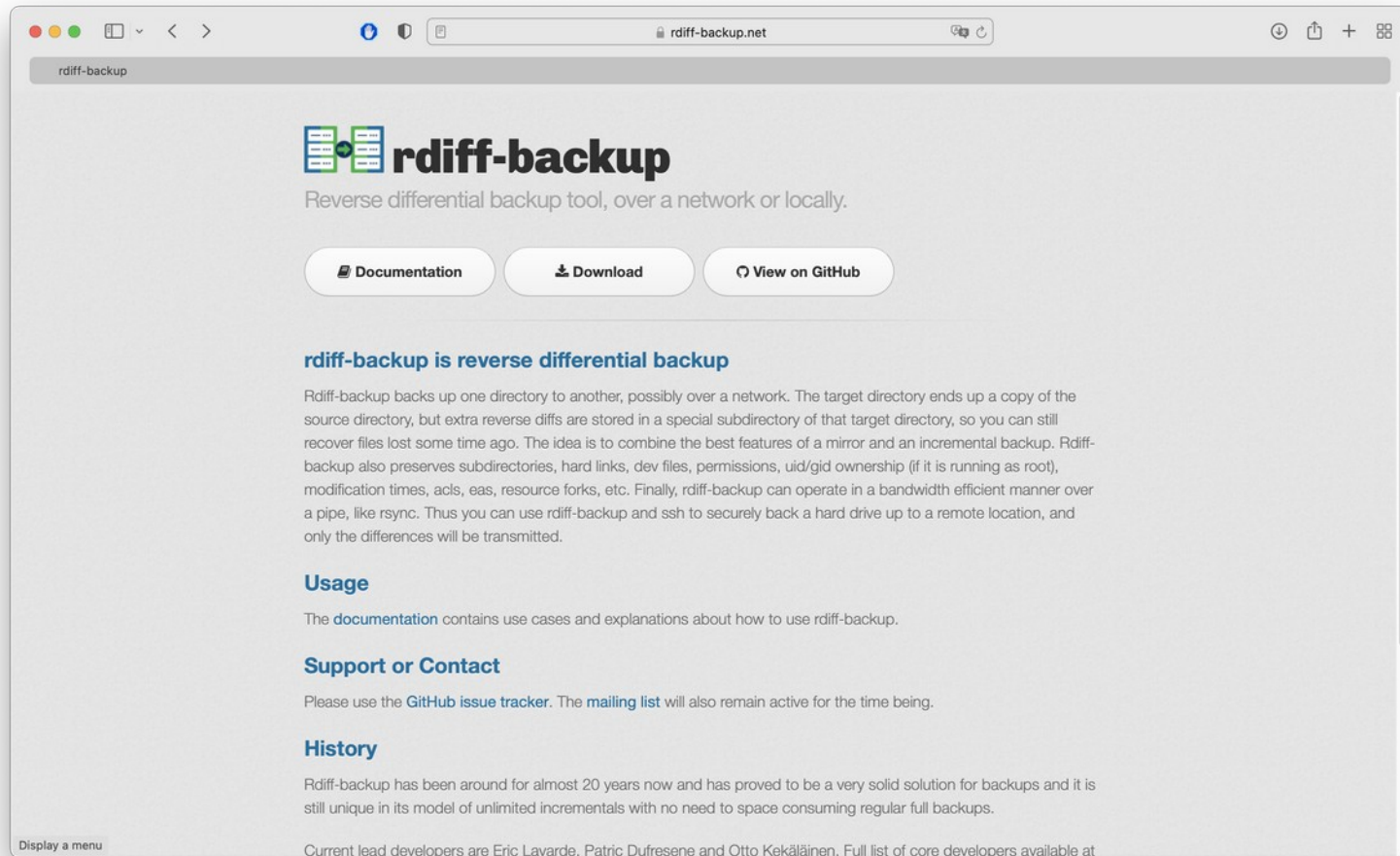
Keep 2 copies stored
at separate locations



X1

Store at least 1 copy
at an off-site location

6. BACKUPS!!!



The screenshot shows the homepage of the rdiff-backup project. At the top, there is a navigation bar with the project name 'rdiff-backup' and a logo consisting of two green document icons with a plus sign. Below the logo, the text 'rdiff-backup' is written in a large, bold, black font, followed by the tagline 'Reverse differential backup tool, over a network or locally.' in a smaller, grey font. Underneath the tagline, there are three rounded rectangular buttons: 'Documentation' with a document icon, 'Download' with a download icon, and 'View on GitHub' with a GitHub icon. The main content area features a section titled 'rdiff-backup is reverse differential backup' in blue. This section contains a paragraph of text explaining the tool's functionality: it backs up one directory to another, possibly over a network, and stores reverse diffs in a special subdirectory to allow recovery of files lost some time ago. It also lists various features like preserving subdirectories, hard links, dev files, permissions, uid/gid ownership, modification times, acls, eas, and resource forks. The text concludes by stating that rdiff-backup can operate in a bandwidth-efficient manner over a pipe, like rsync, and can be used to securely back up a hard drive to a remote location. Below this section, there are three more sections: 'Usage', 'Support or Contact', and 'History', each with a brief introductory paragraph. The 'Usage' section mentions that the documentation contains use cases and explanations. The 'Support or Contact' section advises using the GitHub issue tracker and a mailing list. The 'History' section notes that the tool has been around for almost 20 years and is a solid solution for backups. At the bottom of the page, there is a small 'Display a menu' link on the left and a line of text stating that the current lead developers are Eric Lavarde, Patric Dufresene, and Otto Kekäläinen, with a link to a full list of core developers.

This was:

“A short catalog of *tools*
the professionals are using for
developing and **deploying** programs,
to make them **correct**, **maintainable**, **shareable**, and **fast**,
efficiently.”

We discussed:

- ◆ good practices
- ◆ important choices
- ◆ useful tools
- ◆ practical references

The “Phillip test” (by Philip Guo)

12 simple questions
ordered by 'difficulty'
measures quality of organization
for research programming

If you do not score at least a 7
there is room for improvement
using the tools presented here

1. Do you have reliable ways of taking, organizing, and reflecting on notes as you're working?
2. Do you have reliable to-do lists for your projects?
3. Do you write scripts to automate repetitive tasks?
4. Are your scripts, data sets, and notes backed up on another computer?
5. Can you quickly identify errors and inconsistencies in your raw data sets?
6. Can you write scripts to acquire and merge together data from different sources and in different formats?
7. Do you use version control for your scripts?
8. If you show analysis results to a colleague and they offer a suggestion for improvement, can you adjust your script, re-run it, and produce updated results within an hour?
9. Do you use `assert` statements and test cases to sanity check the outputs of your analyses?
10. Can you re-generate any intermediate data set from the original raw data by running a series of scripts?
11. Can you re-generate all of the figures and tables in your research paper by running a single command?
12. If you got hit by a bus, can one of your lab-mates resume your research where you left off with less than a week of delay?

Work faster & more reliably

PERIODIC TABLE OF DEVOPS TOOLS (V1) Xebialabs
Deliver Faster

Os: Open Source	Database	SCM	Build
Fr: Free	CI	Repo Mgmt	Testing
Fm: Freemium	Deployment	Config / Provisioning	Containerization
Pd: Paid	Cloud / IaaS / PaaS	Release Mgmt	Collaboration
En: Enterprise	BI / Monitoring	Logging	Security

1 En															2 Fm				
O 12c															Aws Amazon Web Services				
3 Os	4 Os													5 En	6 En	7 Os	8 En	9 Os	10 Pd
My MySQL	Gt Git													Ch Chef	Pu Puppet	An Ansible	Sl Salt	Dk Docker	Az Azure
11 En	12 Os													13 Fr	14 En	15 Os	16 Fr	17 Os	18 Fm
Mq MySQL	Sv Subversion													Ssh SSH	Bl BladeLogic	Va Vagrant	Tf Terraform	Rk rkt	Hk Heroku
19 Os	20 Fm	21 Os	22 Os	23 En	24 Os	25 Pd	26 Os	27 Fr	28 Os	29 Fr	30 Os	31 Pd	32 Os	33 Fr	34 Os	35 Os	36 En		
Pq PostgreSQL	Gh Github	Mv Maven	Gr Gradle	Mr Meister	Jn Jenkins	Ba Bamboo	Tr Travis CI	Ar Archiva	Fn FitNesse	Se Selenium	Gn Gatling	Gd Deployment Manager	Sf SmartFrog	Cb Cobbler	Bc Bcf2	Kb Kubernetes	Rs Rackspace		
37 Os	38 Fm	39 Os	40 Os	41 Fm	42 Fm	43 Fm	44 Fm	45 Os	46 Fr	47 Os	48 Fr	49 Fr	50 Fr	51 Os	52 Os	53 Fr	54 Fm		
Mg MongoDB	Bb Bitbucket	Br Buildr	At ANT	Bm BuildMaster	Cs Codeship	Sn Snap CI	Cr CircleCI	Nx Nexus	Cu Cucumber	Cj Cucumber.js	Qu Qunit	Cp Capistrano	Ju Juju	Rd Rundeck	Cf CFEngine	Pk Packer	Bx Bluemix		
55 En	56 Os	57 Fm	58 En	59 Pd	60 Fm	61 Fm	62 Os	63 Os	64 Fr	65 Fr	66 Fr	67 En	68 Fm	69 En	70 Os	71 En	72 En		
Db DB2	Hg Mercurial	Qb QuickBuild	Ub UrbanCode Build	Ta Visual Build	Tc TeamCity	Sh Shippable	Cc CruiseControl	Ay Artifactory	Jt JUnit	Jm JMeter	Tn TestNG	Ry RapidDeploy	Cy CodeDeploy	Oc Octopus Deploy	No CA Nolio	Eb ElasticBox	Ad Apprenda		
73 Fr	74 En	75 Os	76 Os	77 Os	78 Os	79 Fm	80 Os	81 Os	82 Os	83 En	84 En	85 Os	86 En	87 En	88 En	89 Os	90 Os		
Cs Cassandra	Hx Helix	Msb MSBuild	Rk Rake	Lb LunrBuild	Co Continuum	Ca Continus CI	Gu Gump	Ng NuGet	Ap Appium	Xltv XL TestView	Tc TestComplete	Go Go	Ef ElectricFlow	Xld XL Deploy	Ud UrbanCode Deploy	Mo Mesos	Cf Cloud Foundry		

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91 En	92 En	93 En	94 En	95 En	96 Pd	97 En	98 En	99 Fm	100 Pd	101 Fm	102 Fm	103 Fm	104 Pd	105 En
Xlr XL Release	Ur UrbanCode Release	Ls CA Service Virtualization	Bm BMC Release Process	Hp HP Codar	Ex Excel	Pl Plutora Release	Sr Serena Release	Tr Trello	Jr Jira	Rf HipChat	Sl Slack	Fd Flowdock	Pv Pivotal Tracker	Sn ServiceNow
106 Os	107 Fm	108 Os	109 Os	110 Os	111 Os	112 Os	113 En	114 Fm	115 Os	116 Fm	117 Os	118 Os	119 Os	120 En
Ki Kibana	Nr New Relic	Ni Nagios	Gg Ganglia	Ct Cacti	Gr Graphite	lc Icinga	Sp Splunk	Sl Sumo Logic	Ls Logstash	Lg Loggly	Gr Graylog	Sn Snort	Tr Tripwire	Cy CyberArk