Bug Hunting with Structural Code Search

Rijnard van Tonder

sourcegraph

@rvtond

grep

- Regular expression search for plain text
- Good for bug hunting

grep example on libssh2

```
ALLOC\([^,]*,[^;]*[*][^;]*\);
```

[1] https://papers.put.as/papers/macosx/2013/SyScan2013_Stefan_Esser_Mountain_Lion_iOS_Vulnerabilities_Garage_Sale.pdf

grep example on libssh2

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ALLOC\([^,]*,[^;]*[*][^;]*\);
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grep example on libssh2

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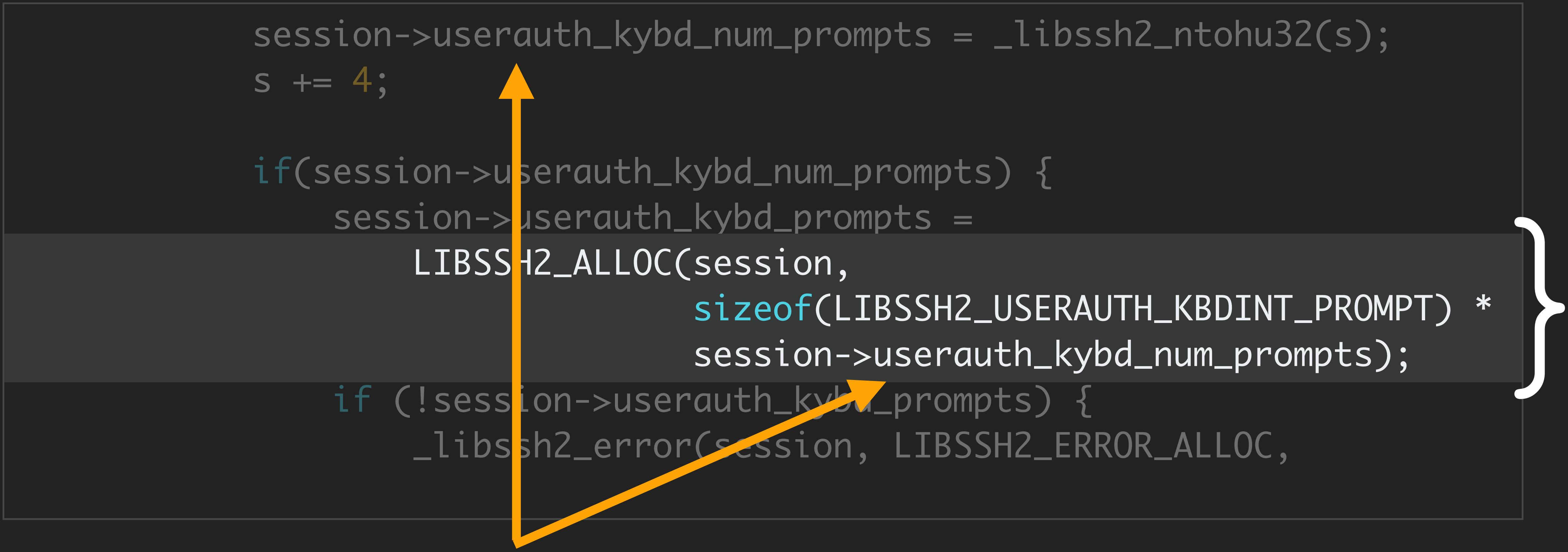

```
session->userauth_kybd_num_prompts = _libssh2_ntohu32(s);
s += 4;

if(session->userauth_kybd_num_prompts) {
    session->userauth_kybd_prompts =
        LIBSSH2_ALLOC(session,
                      sizeof(LIBSSH2_USERAUTH_KBDINT_PROMPT) *
                      session->userauth_kybd_num_prompts);
    if (!session->userauth_kybd_prompts) {
        _libssh2_error(session, LIBSSH2_ERROR_ALLOC,
```

The bug: attacker controlled alloc size => integer overflow

grep example on libssh2

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grep example on libssh2

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grep example on libssh2

```
ALLOC\([^,]*,[^;]*[*][^;]*\);
```

METASYNTAX
(REPEAT)

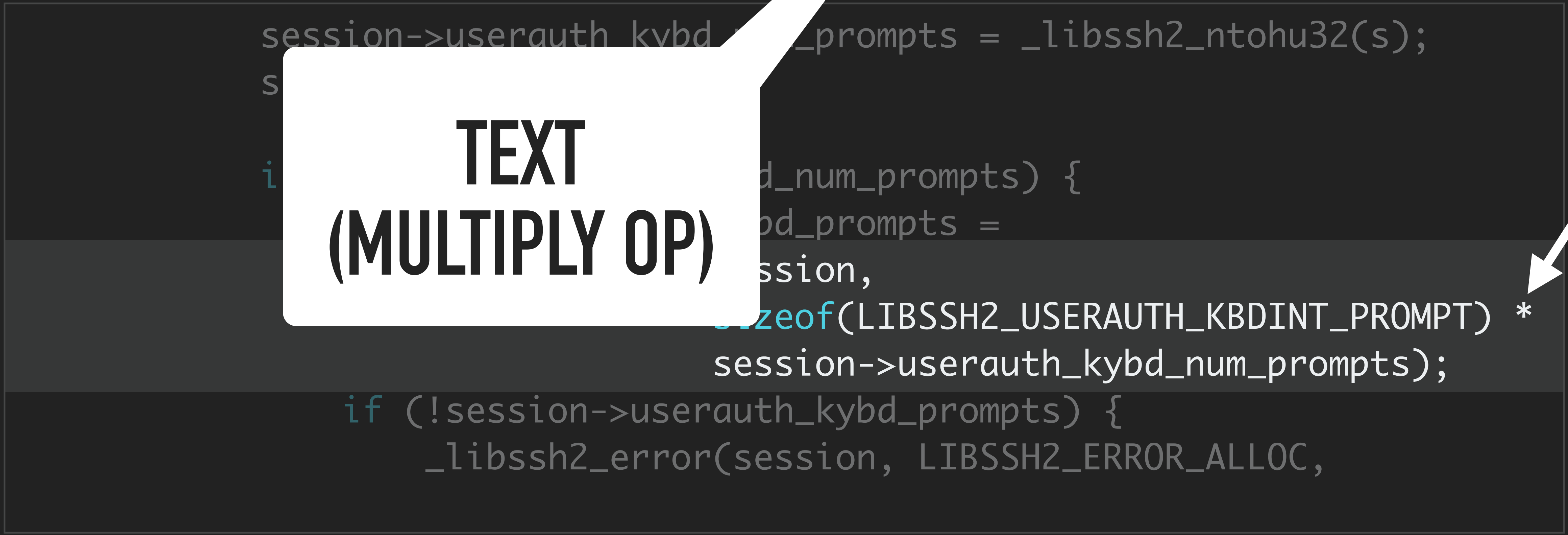
grep example on libssh2

```
ALLOC\([^,]*,[^;]*[*][^;]*\);
```

TEXT
(MULTIPLY OP)

grep example on libssh2

```
ALLOC\([^,]*,[^;]*[*][^;]*\);
```



```
        session->userauth_kybd_    _prompts = _libssh2_ntohu32(s);
        s

        i                     d_num_prompts) {
                              bd_prompts =
                              ssion,
                              izeof(LIBSSH2_USERAUTH_KBDINT_PROMPT) *
                              session->userauth_kybd_num_prompts);
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grep example on libssh2

```
ALLOC\([^,]*,[^;]*[*][^;]*\);
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- Code structure matters

grep example on libssh2

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ALLOC\([^,]*,[^;]*[*][^;]*\);
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- Code structure matters

grep example on libssh2

```
ALLOC\([^,]*,[^;]*[*][^;]*\);
```

- Code structure matters
- Can we do better?

grep example on libssh2

```
ALLOC\([^,]*,[^;]*[*][^;]*\);
```

comby

~~grep~~ example on libssh2

```
ALLOC\([^,]*,[^;]*[*][^;]*\);
```

comby
~~grep~~ example on libssh2

```
ALLOC\([^,]*,[^;]*[*][^;]*\);
```

```
ALLOC(:[1],:[2]*:[3]);
```

comby
~~grep~~ example on libssh2

```
ALLOC\([^,]*,[^;]*[*][^;]*\);
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HOLES BIND IDENTIFIERS TO SYNTAX

comby
~~grep~~ example on libssh2

```
ALLOC\([^,]*,[^;]*[*][^;]*\);
```

```
ALLOC(:[1],:[2]*:[3]);
```

CONCRETE SYNTAX

comby
~~grep~~ example on libssh2

```
ALLOC\([^,]*,[^;]*[*][^;]*\);
```

```
ALLOC(:[1],:[2]*:[3]);
```

BALANCED DELIMITERS

comby
~~grep~~ example on libssh2

```
ALLOC\([^,]*,[^;]*[*][^;]*\);
```

```
ALLOC(:[1],:[2]*:[3]);
```

BALANCED DELIMITERS → NESTED CODE STRUCTURES. LANGUAGE-AWARE.

comby supports ~all the languages

Assembly, Bash, C/C++, C#, Clojure, CSS, Dart, Elm, Elixir, Erlang, Fortran, F#, Go, Haskell, HTML/XML, Java, Javascript, JSX, JSON, Julia, LaTeX, Lisp, Nim, OCaml, Pascal, PHP, Python, Reason, Ruby, Rust, Scala, SQL, Swift, Plain Text, TSX, Typescript

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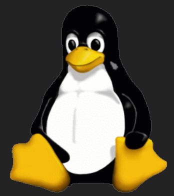
comby on the command line

Find video file at the link

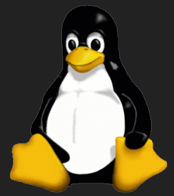
https://drive.google.com/open?id=1Ba-sOhmhRKCrUbdJVvh7mCyoj1aHMMZz

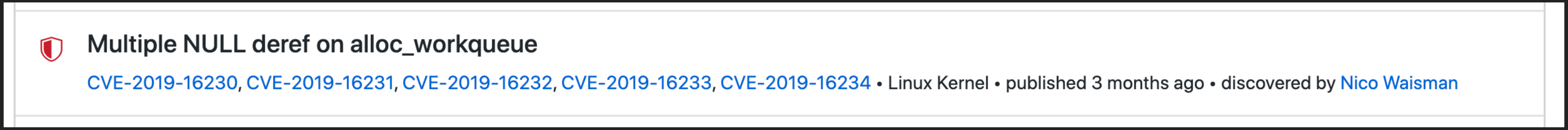
comby on the Linux Kernel



[1] https://en.wikipedia.org/wiki/Tux_(mascot)#/media/File:Tux.png

comby on the Linux Kernel



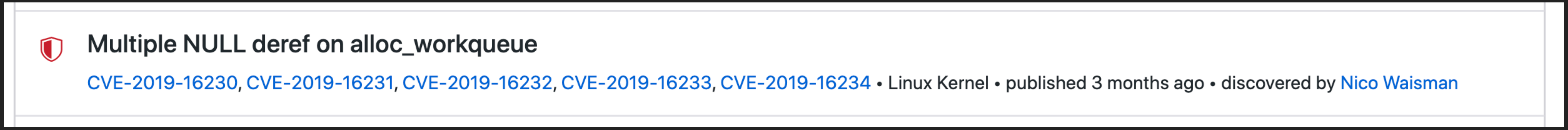


Multiple NULL deref on alloc_workqueue

CVE-2019-16230, CVE-2019-16231, CVE-2019-16232, CVE-2019-16233, CVE-2019-16234 • Linux Kernel • published 3 months ago • discovered by Nico Waisman

[1] https://en.wikipedia.org/wiki/Tux_(mascot)#/media/File:Tux.png [2] https://securitylab.github.com/disclosures

comby on the Linux Kernel



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```
There are multiple points in the Linux Kernel where alloc_workqueue is
not getting checked for errors and as a result, a potential NULL
dereference could occur.
```

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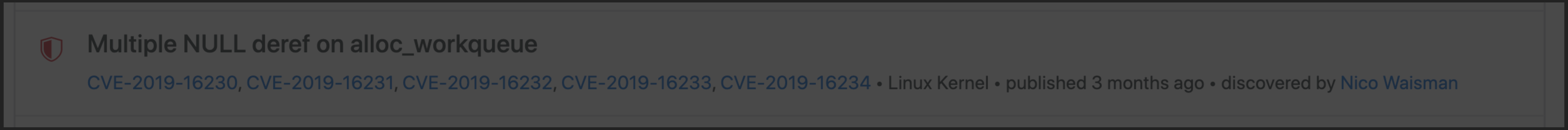
comby on the Linux Kernel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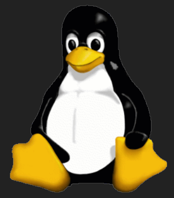
comby on the Linux Kernel



```
alloc_workqueue(:[args]);
```

```
There are multiple points in the Linux Kernel where alloc_workqueue is
not getting checked for errors and as a result, a potential NULL
dereference could occur.
```

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comby on the Linux Kernel

```
alloc_workqueue(:[args]);
```

WON'T MATCH COMMENTS

comby on the Linux Kernel

```
alloc_workqueue(:[args]);
```

274 CALLS

comby on the Linux Kernel

```
alloc_workqueue(:[args]);
```

```
ppd->hfi1_wq =
        alloc_workqueue(
            "hfi%d_%d",
            WQ_SYSFS | WQ_HIGHPRI | WQ_CPU_INTENSIVE |
            WQ_MEM_RECLAIM,
            HFI1_MAX_ACTIVE_WORKQUEUE_ENTRIES,
            dd->unit, pidx);
if (!ppd->hfi1_wq)
        goto wq_error;
```

USUALLY FOLLOWED BY AN 'IF' CHECK ✓

comby on the Linux Kernel

```
alloc_workqueue(:[args]); :[[word]]
```

```
where :[[word]] != “if”
```

RULES PLACE CONSTRAINTS ON MATCHES

comby on the Linux Kernel

```
alloc_workqueue(:[args]); :[[word]]
```

```
where :[[word]] != “if”
```

```
cgroup_destroy_wq = alloc_workqueue("cgroup_destroy", 0, 1);
BUG_ON(!cgroup_destroy_wq);
```

SOMETIMES A DIFFERENT FLAVOR

comby on the Linux Kernel

```
alloc_workqueue(:[args]); :[[word]]
```

```
where :[[word]] != “if”, :[[word]] != “BUG_ON”
```

comby on the Linux Kernel

```
alloc_workqueue(:[args]); :[[word]]
```

```
where :[[word]] != “if”, :[[word]] != “BUG_ON”
```

- 38 calls left

comby on the Linux Kernel

```
alloc_workqueue(:[args]); :[[word]]
```

```
where :[[word]] != “if”, :[[word]] != “BUG_ON”
```

- 38 calls left
- 1.5 minutes

comby on the Linux Kernel

```
alloc_workqueue(:[args]); :[[word]]
```

```
where :[[word]] != “if”, :[[word]] != “BUG_ON”
```

- 38 calls left
- 1.5 minutes

drivers/scsi/lpfc/lpfc_init.c

```
        /* The lpfc_wq workqueue for deferred irq use */
        phba->wq = alloc_workqueue("lpfc_wq", WQ_MEM_RECLAIM, 0);
```

comby on the Linux Kernel

```
alloc_workqueue(:[args]); :[[word]]
```

```
where :[[word]] != “if”, :[[word]] != “BUG_ON”
```

- 38 calls left
- 1.5 minutes

drivers/staging/rtl8723bs/hal/rtl8723b_hal_init.c

```
adapter->priv_checkbt_wq = alloc_workqueue("sdio_wq", 0, 0);
INIT_DELAYED_WORK(&adapter->checkbt_work, (void *)check_bt_status_work);
```

comby on the Linux Kernel

```
   logger->log_workqueue =  create_singlethread_workqueue("cros_usbpd_log");
+  if (!logger->log_workqueue)
+     return -ENOMEM;
```

[1] https://lore.kernel.org/lkml/20190911201100.11483-1-navid.emamdoost@gmail.com/

comby on the Linux Kernel

```
alloc_workqueue(:[args]); :[[word]]
```

```
create_singlethread_workqueue(:[args]);
```

```
   logger->log_workqueue =  create_singlethread_workqueue("cros_usbpd_log");
+  if (!logger->log_workqueue)
+      return -ENOMEM;
```

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comby on cpython

Modules/_io/winconsoleio.c

```
...
if (!wlen)
    return PyErr_SetFromWindowsErr(0);

wbuf = (wchar_t*)PyMem_Malloc(wlen * sizeof(wchar_t));

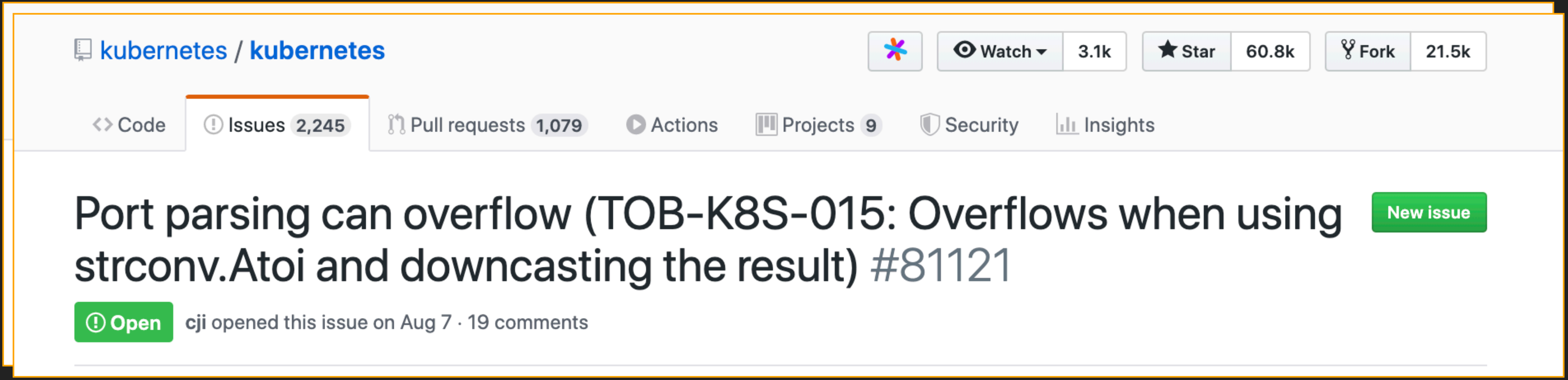
Py_BEGIN_ALLOW_THREADS
wlen = MultiByteToWideChar(CP_UTF8, 0, b->buf, len, wbuf, wlen);
if (wlen) {
    res = WriteConsoleW(self->handle, wbuf, wlen, &n, NULL);
...
```

[1] https://commons.wikimedia.org/wiki/File:Python-logo-notext.svg

comby on kubernetes

[1] https://en.wikipedia.org/wiki/Kubernetes#/media/File:Kubernetes_logo_without_workmark.svg

comby on kubernetes



kubernetes / kubernetes

Port parsing can overflow (TOB-K8S-015: Overflows when using strconv.Atoi and downcasting the result) #81121

Open cji opened this issue on Aug 7 · 19 comments

comby on kubernetes

```
func (sh *suffixHandler) interpret(...) (...) {
        // ...
        parsed, err := strconv.ParseInt(string(suffix[1:]), 10, 64)
        if err != nil {
                return 0, 0, DecimalExponent, false
        }
        return 10, int32(parsed), DecimalExponent, true
}
```

comby on kubernetes

```
func (sh *suffixHandler) interpret(...) (...) {
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}
```

PARSED AS INT64

comby on kubernetes

```
func (sh *suffixHandler) interpret(...) (...) {
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        }
        return 10, int32(parsed), DecimalExponent, true
}
```

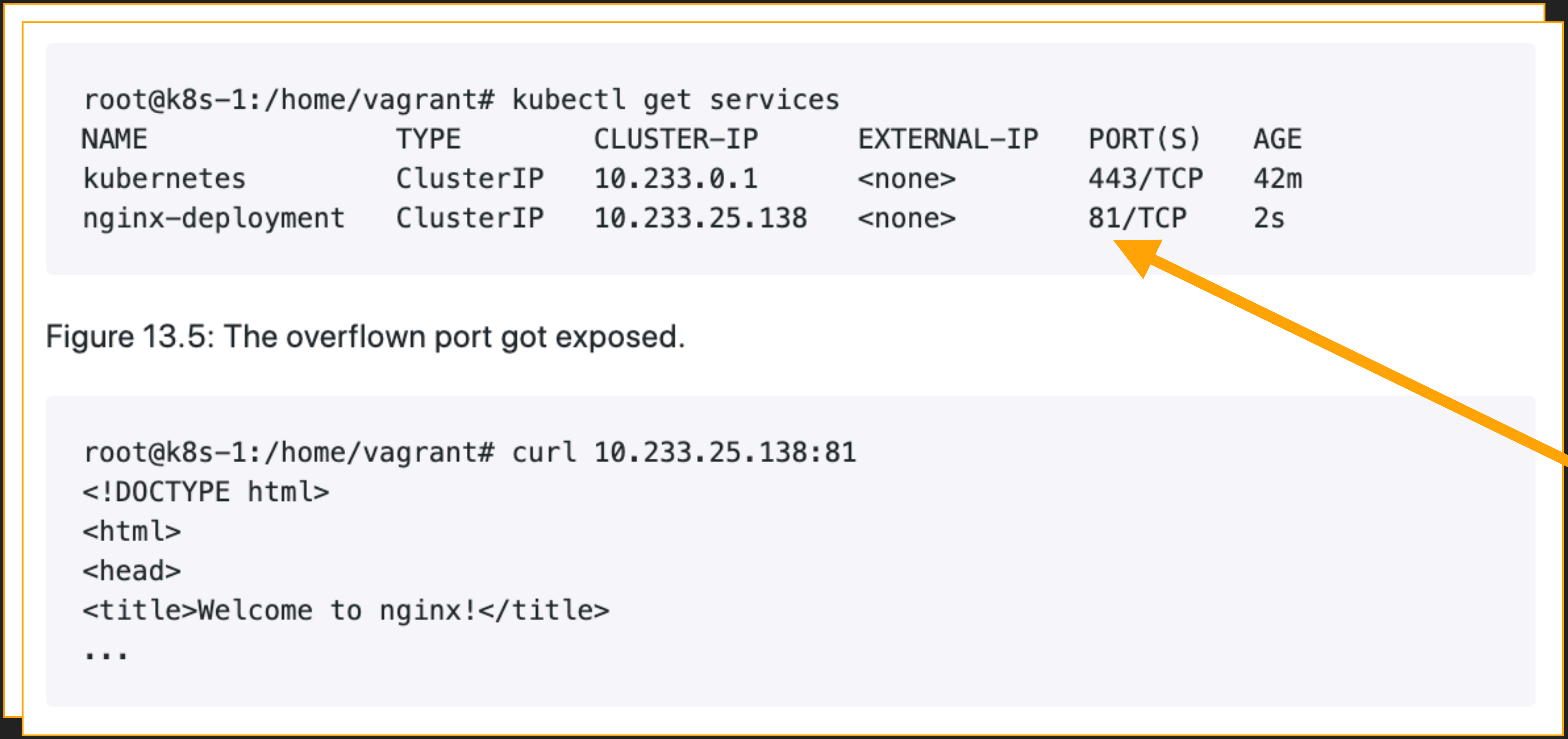
CONVERTED TO INT32
=> COULD OVERFLOW

comby on kubernetes

```
kubectl expose deployment nginx-deployment --port 4294967377 --target-port 80 service/nginx-deployment exposed
```

comby on kubernetes

kubectl expose deployment nginx-deployment --port 4294967377 --target-port 80 service/nginx-deployment exposed



```
root@k8s-1:/home/vagrant# kubectl get services
NAME               TYPE        CLUSTER-IP      EXTERNAL-IP   PORT(S)   AGE
kubernetes         ClusterIP   10.233.0.1      <none>        443/TCP   42m
nginx-deployment   ClusterIP   10.233.25.138   <none>        81/TCP    2s
```

Figure 13.5: The overflown port got exposed.

```
root@k8s-1:/home/vagrant# curl 10.233.25.138:81
<!DOCTYPE html>
<html>
<head>
<title>Welcome to nginx!</title>
...
```

comby on kubernetes

```
func (sh *suffixHandler) interpret(...) (...) {
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comby on kubernetes

```
:[[v]], err := strconv.ParseInt(:[1], :[2], 64)
```

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comby on kubernetes

```
:[[v]], err := strconv.ParseInt(:[1], :[2], 64) :[rest]
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}
```

comby on kubernetes

```
:[[v]], err := strconv.ParseInt(:[1], :[2], 64) :[rest]
```

```
:[rest] stops matching
inside {...}
```

```
func (sh *suffixHandler) interpret(...) (...) {
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```

comby on kubernetes

```
:[[v]], err := strconv.ParseInt(:[1], :[2], 64) :[rest]
```

```
where match :[rest] {
| “int32(:[arg])” -> :[arg] == :[[v]]
}
```

NESTED MATCH RULE ON INT32(...) FUNCTION

comby on kubernetes

```
:[[v]], err := strconv.ParseInt(:[1], :[2], 64) :[rest]
```

```
where match :[rest] {
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comby on kubernetes

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```

```
where match :[rest] {
| “int32(:[arg])” -> :[arg] == :[[v]]
}
```

ARGUMENT MUST EQUAL PREVIOUS VARIABLE

comby on kubernetes

```
:[[v]], err := strconv.ParseInt(:[1], :[2], 64) :[rest]
```

```
where match :[rest] {
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```
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}
```

Equal

comby on kubernetes

```
:[[v]], err := strconv.ParseInt(:[1], :[2], 64) :[rest]
```

```
where match :[rest] {
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comby on kubernetes

```
:[[v]], err := strconv.ParseInt(:[1], :[2], 64) :[rest]
```

```
where match :[rest] {
| “int32(:[arg])” -> :[arg] == :[[v]]
}
```

comby on kubernetes

```
:[[v]], err := strconv.ParseInt(:[1], :[2], 64) :[rest]
```

```
where match :[rest] {
| “int32(:[arg])” -> :[arg] == :[[v]]
| “int16(:[arg])” -> :[arg] == :[[v]]
}
```

ADDITIONAL “OR” CASES

comby on the command line

Find video file at the link

https://drive.google.com/open?id=184f_0nxCRyHFi9LFQCeqJin-oA0So5gp

Structural code search: an easier way to search syntax trees

COMBY

- Effort
- Generality
- Complexity
- Precision
- Speed

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Structural code search: an easier way to search syntax trees

Assembly, Bash, C/C++, C#, Clojure, CSS, Dart, Elm, Elixir, Erlang, Fortran, F#, Go, Haskell, HTML/XML, Java, Javascript, JSX, JSON, Julia, LaTeX, Lisp, Nim, OCaml, Pascal, PHP, Python, Reason, Ruby, Rust, Scala, SQL, Swift, Plain Text, TSX, Typescript

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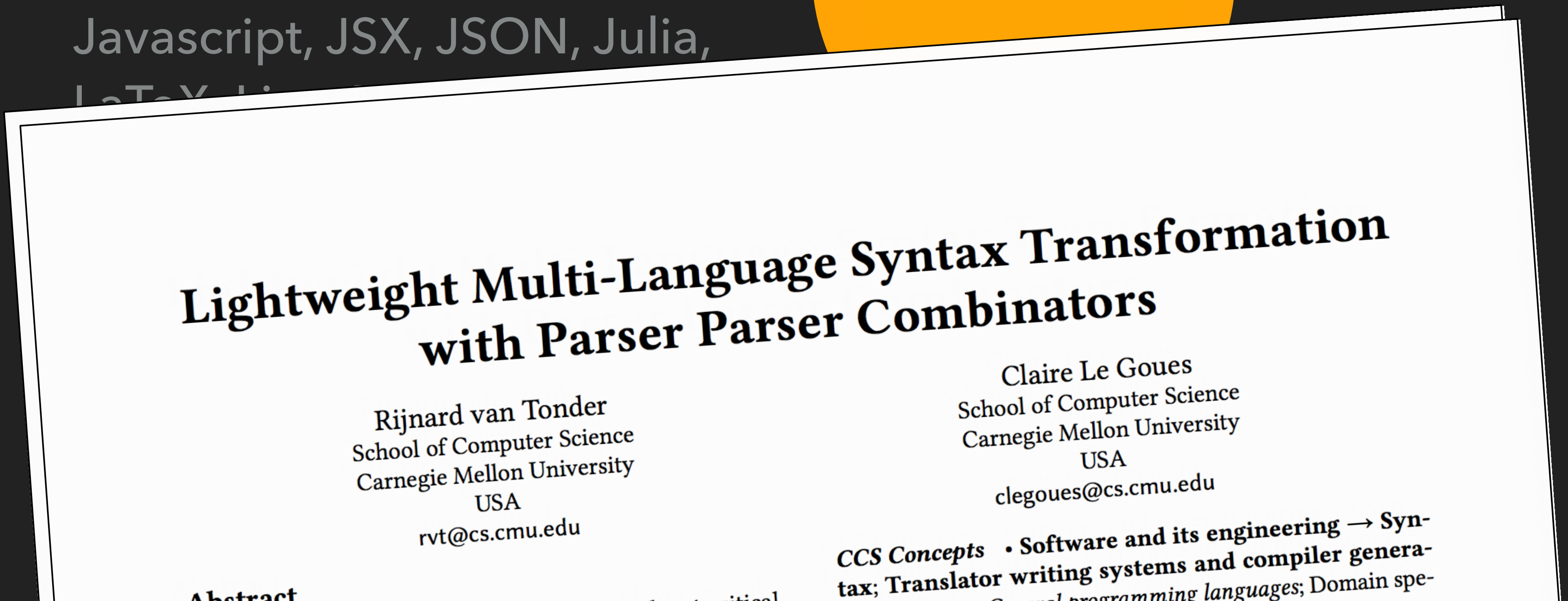

Lightweight Multi-Language Syntax Transformation with Parser Parser Combinators

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USA
clegoues@cs.cmu.edu

Abstract

CCS Concepts • **Software and its engineering → Syntax; Translator writing systems and compiler genera-**

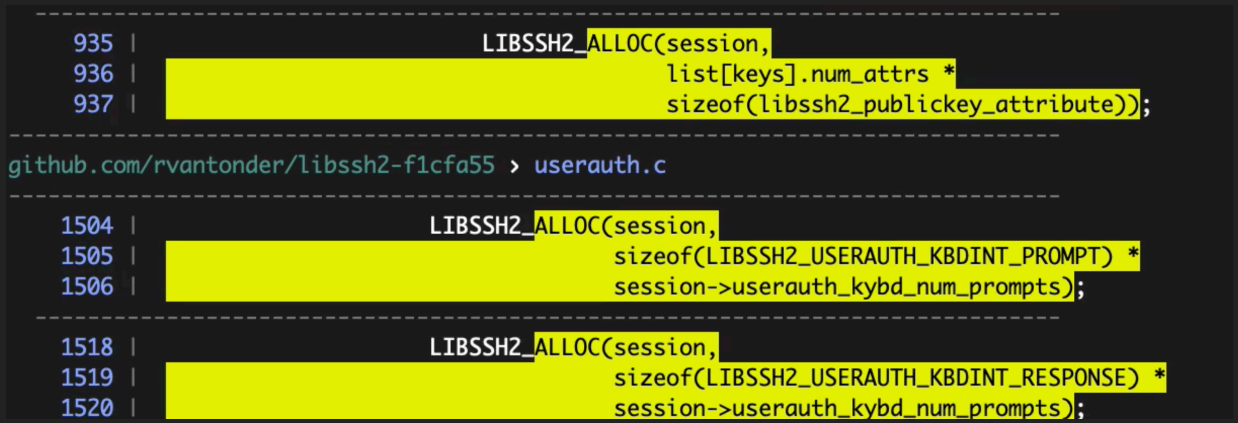
grep example on libssh2

```
ALLOC\([^,]*,[^;]*[*][^;]*\);
```

- Code structure matters
- Can we do better?

comby syntax

```
ALLOC(:[1],:[2]*:[3]);
```



```
                                   LIBSSH2_ALLOC(session,
                                                 list[keys].num_attrs *
                                                 sizeof(libssh2_publickey_attribute));
---------------------------------------------------------------------------------------
github.com/rvantonder/libssh2-f1cfa55 › userauth.c
---------------------------------------------------------------------------------------
                               LIBSSH2_ALLOC(session,
                                             sizeof(LIBSSH2_USERAUTH_KBDINT_PROMPT) *
                                             session->userauth_kybd_num_prompts);
---------------------------------------------------------------------------------------
                               LIBSSH2_ALLOC(session,
                                             sizeof(LIBSSH2_USERAUTH_KBDINT_RESPONSE) *
                                             session->userauth_kybd_num_prompts);
```

comby on kubernetes

```
:[[v]], err := strconv.Atoi(:[1], :[2], 64) :[rest]
```

```
where match :[rest] {
| "int32(:[arg])" -> :[arg] == :[[v]]
}
```

```
func (sh *suffixHandler) interpret(...) (...) {
        // ...
        parsed, err := strconv.ParseInt(string(suffix[1:]), 10, 64)
        if err != nil {
                return 0, 0, DecimalExponent, false
        }
        return 10, int32(parsed), DecimalExponent, true
}
```

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https://comby.dev

https://github.com/comby-tools/comby

https://gitter.im/comby-tools/community

@rvtond