Recent Developments in the Real World

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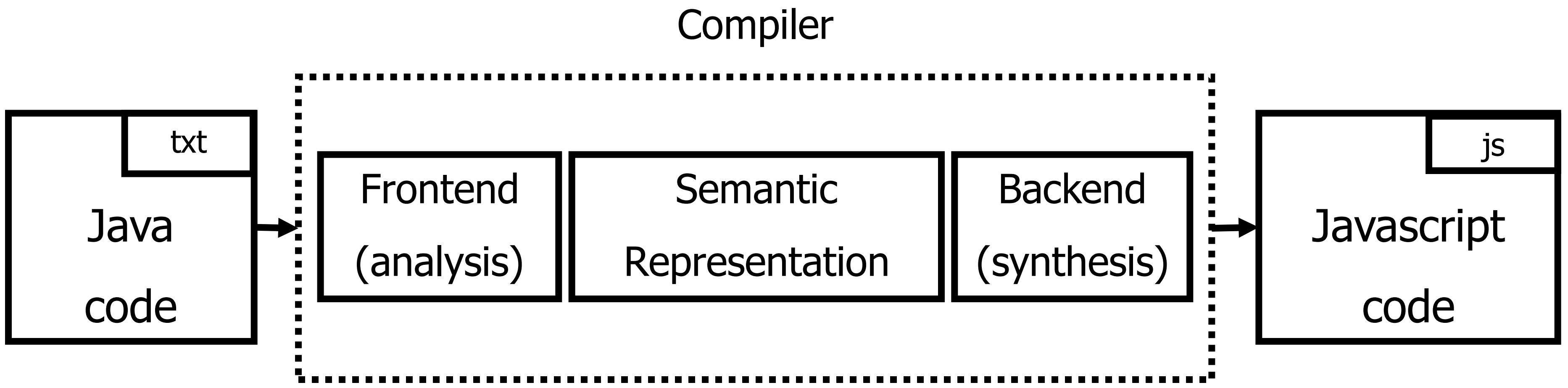
Technion

Meanwhile, In the real world

- new hardware
  - Multi-core, GPU, Accelerators
- new compilers for new languages
- new compilers for old languages
  - e.g., Java->JavaScript
- new uses of compiler technology
- new performance criteria

Google Web Toolkit



GWT Compiler Optimization

```
public class ShapeExample implements EntryPoint {
  private static final double SIDE_LEN_SMALL = 2;
  private final Shape shape = new SmallSquare();
  public static abstract class Shape {
    public abstract double getArea();
  }
  public static abstract class Square extends Shape {
    public double getArea() { return getSideLength() * getSideLength(); }
    public abstract double getSideLength();
  }
  public static class SmallSquare extends Square {
    public double getSideLength() { return SIDE_LEN_SMALL; }
  }
  public void onModuleLoad() {
    Shape shape = getShape();
    Window.alert("Area is " + shape.getArea());
  }
  private Shape getShape() { return shape; }
```

(source: http://dl.google.com/io/2009/pres/Th_1045_TheStoryofyourCompile-ReadingtheTeaLeavesoftheGWTCompilerforanOptimizedFuture.pdf)

GWT Compiler Optimization

```
public class ShapeExample implements EntryPoint {
  public void onModuleLoad() {
    Window.alert("Area is 4.0");
  }
```

(source: http://dl.google.com/io/2009/pres/Th_1045_TheStoryofyourCompile-ReadingtheTeaLeavesoftheGWTCompilerforanOptimizedFuture.pdf)

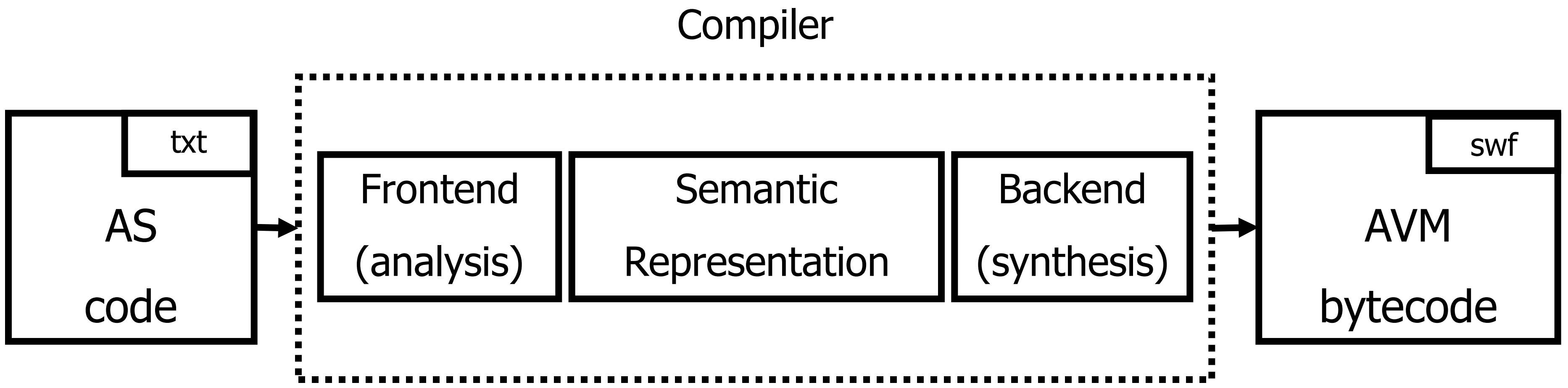
Adobe ActionScript

First introduced in Flash Player 9, **ActionScript 3** is an object-oriented programming (OOP) language based on ECMAScript—the same standard that is the basis for JavaScript—and provides incredible gains in runtime performance and developer productivity. **ActionScript 2**, the version of ActionScript used in Flash Player 8 and earlier, continues to be supported in Flash Player 9 and Flash Player 10.

ActionScript 3.0 introduces a new highly optimized ActionScript Virtual Machine, AVM2, which dramatically exceeds the performance possible with AVM1. As a result, ActionScript 3.0 code executes up to 10 times faster than legacy ActionScript code.

(source: http://www.adobe.com/devnet/actionscript/articles/actionscript3_overview.html)

Adobe ActionScript



Adobe ActionScript: Tamarin

The goal of the "Tamarin" project is to implement a high-performance, open source implementation of the ActionScript™ 3 language, which is based upon and extends ECMAScript 3rd edition (ES3). ActionScript provides many extensions to the ECMAScript language, including packages, namespaces, classes, and optional strict typing of variables.
"Tamarin" implements both a high-performance just-in-time compiler and interpreter.

The Tamarin virtual machine is used within the Adobe® Flash® Player and is also being adopted for use by projects outside Adobe. The Tamarin just-in-time compiler (the "NanoJIT") is a collaboratively developed component used by both Tamarin and Mozilla TraceMonkey. The ActionScript compiler is available as a component from the open source Flex SDK.

Mozilla SpiderMonkey

- SpiderMonkey is a fast interpreter
- runs an untyped bytecode and operates on values of type jsval—type-tagged double-sized values that represent the full range of JavaScript values.
- SpiderMonkey contains two JavaScript Just-In-Time (JIT) compilers, a garbage collector, code implementing the basic behavior of JavaScript values…

- SpiderMonkey's interpreter is mainly a single, tremendously long function that steps through the bytecode one instruction at a time, using a switch statement (or faster alternative, depending on the compiler) to jump to the appropriate chunk of code for the current instruction.

(source: https://developer.mozilla.org/En/SpiderMonkey/Internals)

Mozilla SpiderMonkey: Compiler

- consumes JavaScript source code
- produces a *script* which contains bytecode, source annotations, and a pool of string, number, and identifier literals. The script also contains objects, including any functions defined in the source code, each of which has its own, nested script.

- The compiler consists of
  - a random-logic rather than table-driven lexical scanner
  - a recursive-descent parser that produces an AST
  - a tree-walking code generator

- The emitter does some constant folding and a few codegen optimizations

(source: https://developer.mozilla.org/En/SpiderMonkey/Internals)

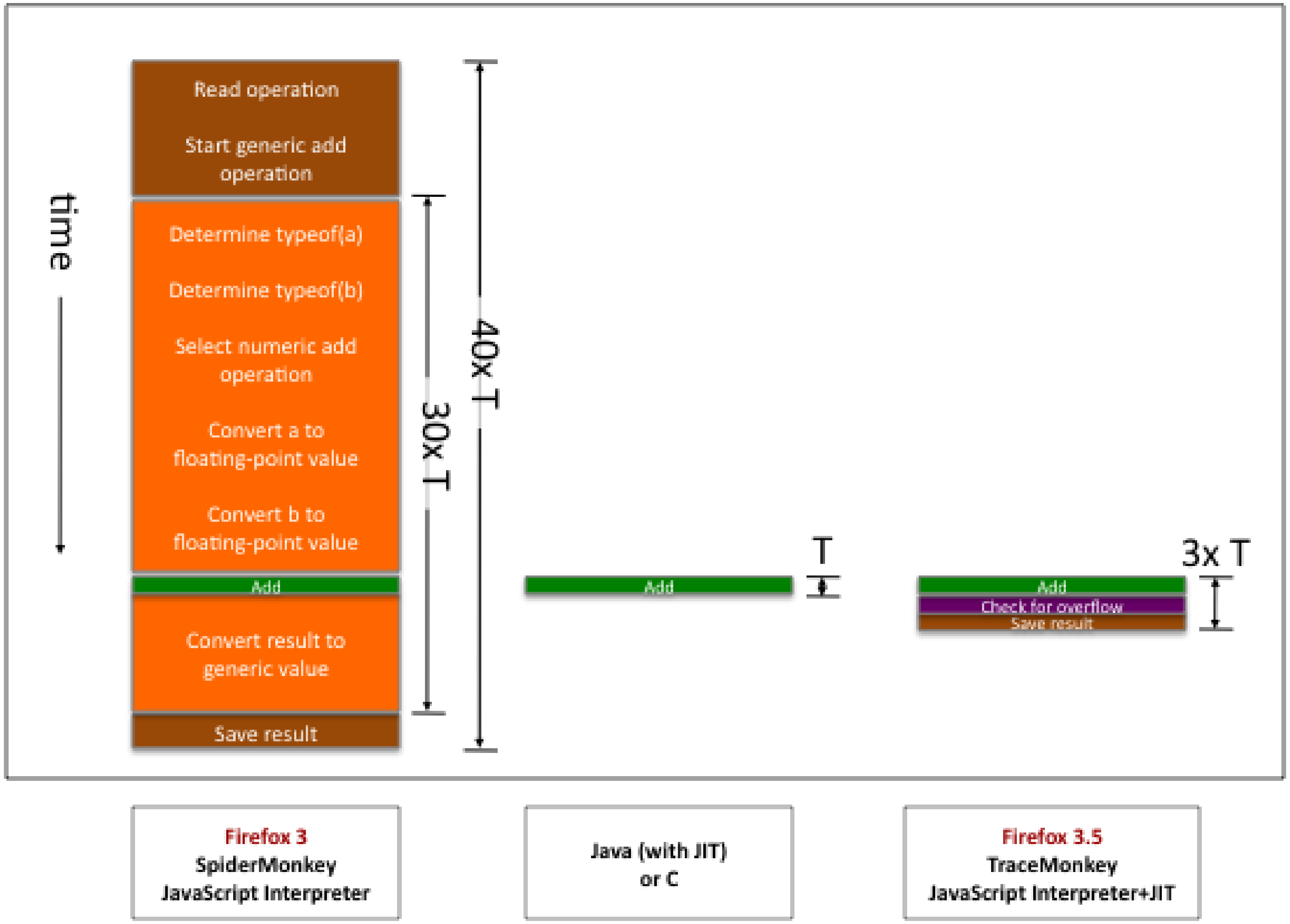
Mozilla SpiderMonkey

- SpiderMonkey contains a just-in-time trace compiler that converts bytecode to machine code for faster execution.
- The JIT works by detecting commonly executed loops, tracing the executed bytecodes in those loops as they run in the interpreter, and then compiling the trace to machine code.
- See the page about the Tracing JIT for more details.

- The SpiderMonkey GC is a mark-and-sweep, non-conservative (exact) collector.

(source: https://developer.mozilla.org/En/SpiderMonkey/Internals)

Mozilla TraceMonkey



(source: http://hacks.mozilla.org/2009/07/tracemonkey-overview/)

Mozilla TraceMonkey

- Goal: generate type-specialized code
- Challenges
  – no type declarations
  – statically trying to determine types mostly hopeless

- Idea
  – run the program for a while and observe types
  – use observed types to generate type-specialized code
  – compile traces

- Sounds suspicious?

Mozilla TraceMonkey

- Problem 1: “observing types” + compiling possibly more expensive than running the code in the interpreter

- Solution: only compile code that executes many times
  - “hot code” = loops
  - initially everything runs in the interpreter
  - start tracing a loop once it becomes “hot”

Mozilla TraceMonkey

- Problem 2: past types do not guarantee future types… what happens if types change?
- Solution: insert type-checks into the compiled code
  - if type-check fails, need to recompile for new types
  - code with frequent type changes will suffer some slowdown

Mozilla TraceMonkey

```
function addTo(a, n) {
  for (var i = 0; i < n; ++i)
    a = a + i;
  return a;
}

var t0 = new Date();
var n = addTo(0,
10000000);
print(n);
print(new Date() - t0);
```

```
a = a + i;    // a is an integer number (0 before, 1 after)
++i;          // i is an integer number (1 before, 2 after)
if (!(i < n)) // n is an integer number (10000000)
  break;
```

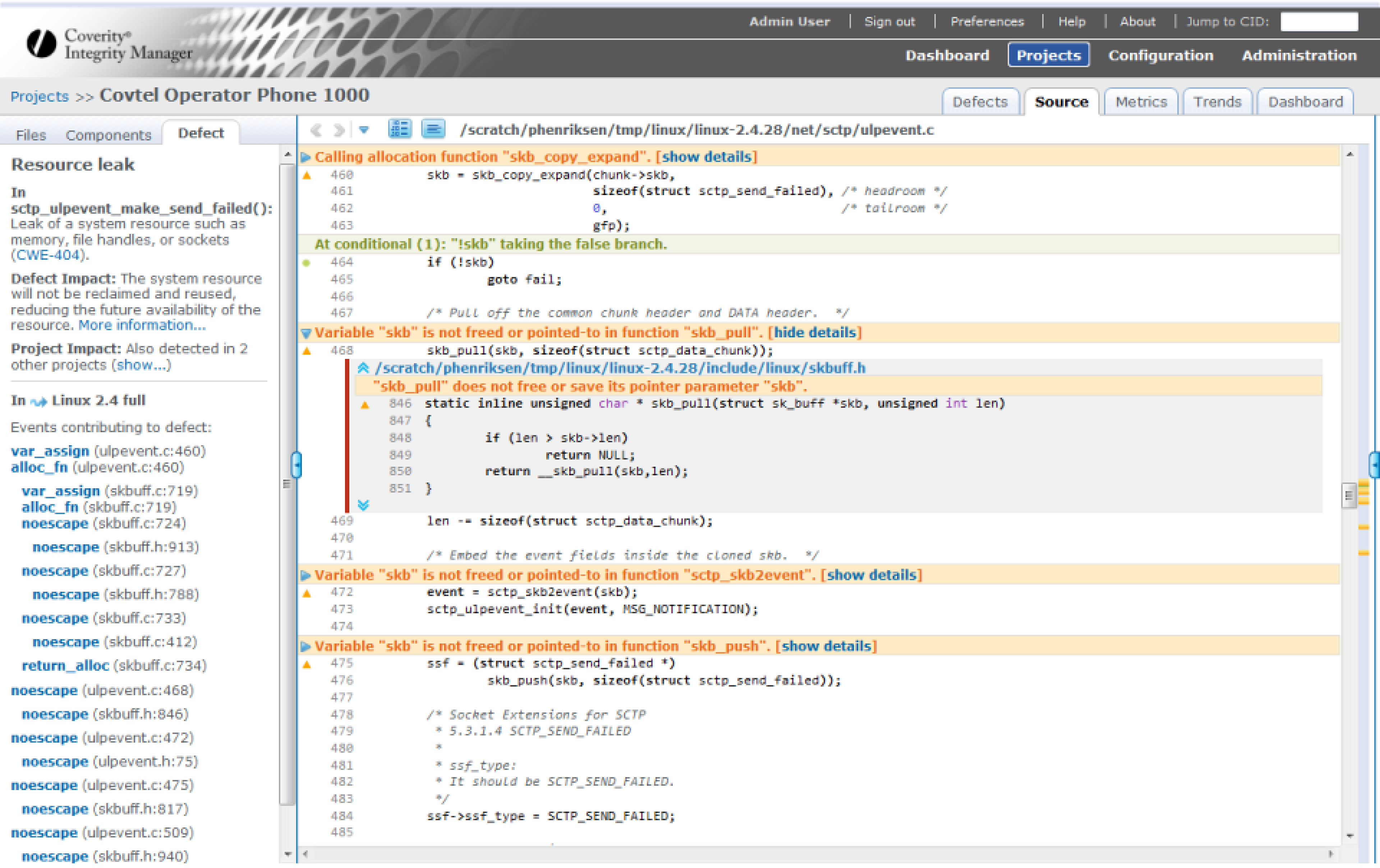
```
trace_1_start:
++i;               // i is an integer number (0 before, 1 after)
temp = a + i;  // a is an integer number (1 before, 2 after)
if (lastOperationOverflowed())
    exit_trace(OVERFLOWED);
a = temp;
if (!(i < n)) // n is an integer number (10000000)
    exit_trace(BRANCHED);
goto trace_1_start;
```

Mozilla TraceMonkey

System	Run Time (ms)
SpiderMonkey (FF3)	990
TraceMonkey (FF3.5)	45
Java (using int)	25
Java (using double)	74
C (using int)	5
C (using double)	15

Static Analysis Tools

- Coverity
- SLAM
- ASTREE
- …


Coverity® Integrity Manager
Admin User | Sign out | Preferences | Help | About | Jump to CID:
Dashboard Projects Configuration Administration
Projects >> Covtel Operator Phone 1000
Defects Source Metrics Trends Dashboard
Files Components Defect

/scratch/phenriksen/tmp/linux/linux-2.4.28/net/sctp/ulpevent.c

Resource leak

In sctp_ulpevent_make_send_failed(): Leak of a system resource such as memory, file handles, or sockets (CWE-404).

Defect Impact: The system resource will not be reclaimed and reused, reducing the future availability of the resource. More information...

Project Impact: Also detected in 2 other projects (show...)

In Linux 2.4 full

Events contributing to defect:

- **var_assign** (ulpevent.c:460)
- **alloc_fn** (ulpevent.c:460)
  - **var_assign** (skbuff.c:719)
  - **alloc_fn** (skbuff.c:719)
  - **noescape** (skbuff.c:724)
    - **noescape** (skbuff.h:913)
  - **noescape** (skbuff.c:727)
    - **noescape** (skbuff.h:788)
  - **noescape** (skbuff.c:733)
    - **noescape** (skbuff.c:412)
  - **return_alloc** (skbuff.c:734)
- **noescape** (ulpevent.c:468)
  - **noescape** (skbuff.h:846)
- **noescape** (ulpevent.c:472)
  - **noescape** (ulpevent.h:75)
- **noescape** (ulpevent.c:475)
  - **noescape** (skbuff.h:817)
- **noescape** (ulpevent.c:509)
  - **noescape** (skbuff.h:940)

Calling allocation function "skb_copy_expand". [show details]

```
460         skb = skb_copy_expand(chunk->skb,
461                               sizeof(struct sctp_send_failed), /* headroom */
462                               0,                               /* tailroom */
463                               gfp);
```

At conditional (1): "!skb" taking the false branch.

```
464         if (!skb)
465                 goto fail;
466 
467         /* Pull off the common chunk header and DATA header.  */
```

Variable "skb" is not freed or pointed-to in function "skb_pull". [hide details]

```
468         skb_pull(skb, sizeof(struct sctp_data_chunk));
```

/scratch/phenriksen/tmp/linux/linux-2.4.28/include/linux/skbuff.h

"skb_pull" does not free or save its pointer parameter "skb".

```
846 static inline unsigned char * skb_pull(struct sk_buff *skb, unsigned int len)
847 {
848         if (len > skb->len)
849                 return NULL;
850         return __skb_pull(skb,len);
851 }
```

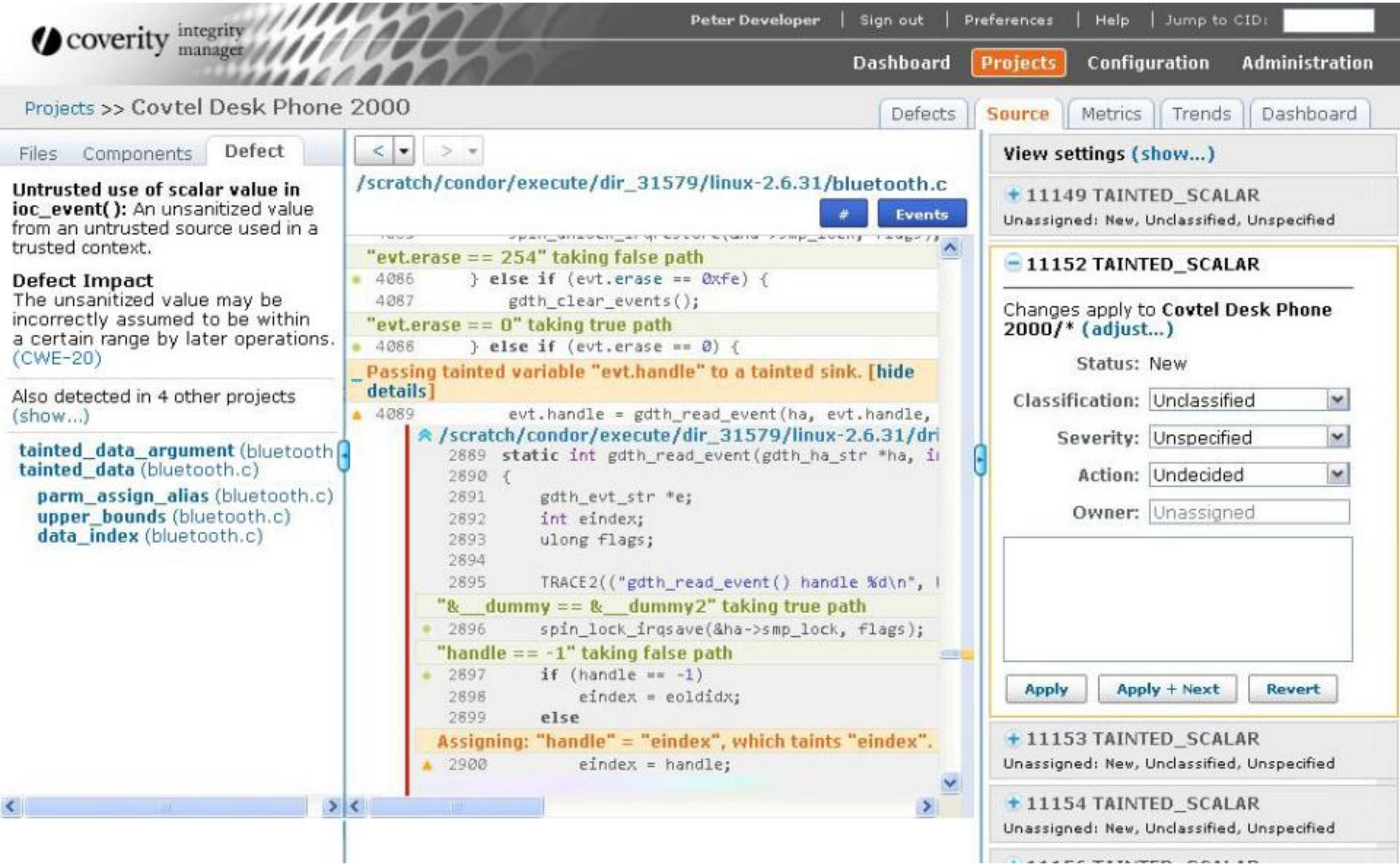
```
469         len -= sizeof(struct sctp_data_chunk);
470 
471         /* Embed the event fields inside the cloned skb.  */
```

Variable "skb" is not freed or pointed-to in function "sctp_skb2event". [show details]

```
472         event = sctp_skb2event(skb);
473         sctp_ulpevent_init(event, MSG_NOTIFICATION);
474 
```

Variable "skb" is not freed or pointed-to in function "skb_push". [show details]

```
475         ssf = (struct sctp_send_failed *)
476                 skb_push(skb, sizeof(struct sctp_send_failed));
477 
478         /* Socket Extensions for SCTP
479          * 5.3.1.4 SCTP_SEND_FAILED
480          *
481          * ssf_type:
482          * It should be SCTP_SEND_FAILED.
483          */
484         ssf->ssf_type = SCTP_SEND_FAILED;
485 
```



Projects >> Covtel Desk Phone 2000

Untrusted use of scalar value in ioc_event( ): An unsanitized value from an untrusted source used in a trusted context.

Defect Impact
The unsanitized value may be incorrectly assumed to be within a certain range by later operations. (CWE-20)

Also detected in 4 other projects (show...)

tainted_data_argument (bluetooth
tainted_data (bluetooth.c)
parm_assign_alias (bluetooth.c)
upper_bounds (bluetooth.c)
data_index (bluetooth.c)

/scratch/condor/execute/dir_31579/linux-2.6.31/bluetooth.c

```
"evt.erase == 254" taking false path
        } else if (evt.erase == 0xfe) {
            gdth_clear_events();
"evt.erase == 0" taking true path
        } else if (evt.erase == 0) {
Passing tainted variable "evt.handle" to a tainted sink. [hide details]
            evt.handle = gdth_read_event(ha, evt.handle,
    /scratch/condor/execute/dir_31579/linux-2.6.31/dri
    static int gdth_read_event(gdth_ha_str *ha, i
    {
        gdth_evt_str *e;
        int eindex;
        ulong flags;

        TRACE2(("gdth_read_event() handle %d\n", 
    "&__dummy == &__dummy2" taking true path
        spin_lock_irqsave(&ha->smp_lock, flags);
    "handle == -1" taking false path
        if (handle == -1)
            eindex = eoldidx;
        else
    Assigning: "handle" = "eindex", which taints "eindex".
            eindex = handle;
```

View settings (show...)

11149 TAINTED_SCALAR
Unassigned: New, Unclassified, Unspecified

11152 TAINTED_SCALAR

Changes apply to **Covtel Desk Phone 2000/*** (adjust...)

Status:	New
Classification:	Unclassified
Severity:	Unspecified
Action:	Undecided
Owner:	Unassigned

Apply | Apply + Next | Revert

11153 TAINTED_SCALAR
Unassigned: New, Unclassified, Unspecified

11154 TAINTED_SCALAR
Unassigned: New, Unclassified, Unspecified

Lots and lots of research

- Program Analysis
- Program Synthesis
- …