Dynamic Binary Instrumentation for Deobfuscation and Unpacking

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November 18, 2009

Outline

1. What is DBI
   - Tools and related work
   - What is DBI
2. How it works
   - Full control without emulation
   - How to achieve full control
   - Pros and cons
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   - Building a Javascript DBI engine
   - Adding deobfuscation
   - Problems
4. Demo: x86 unpacking (and stuff)

Tools and related work

The most famous (general purpose) DBI tools are currently:

- Pin (by Intel, proprietary)
- Valgrind (FOSS)
- DynamoRIO (by VMware, FOSS)

Some reverse engineering projects are now using DBI:

- for vulnerability research (Microsoft's SAGE, Sogeti's Fuzzgrind)
- for exploit development (Sean Heelan)
- for unpacking (Piotr Bania, Danny Quist)

What is DBI

Definition

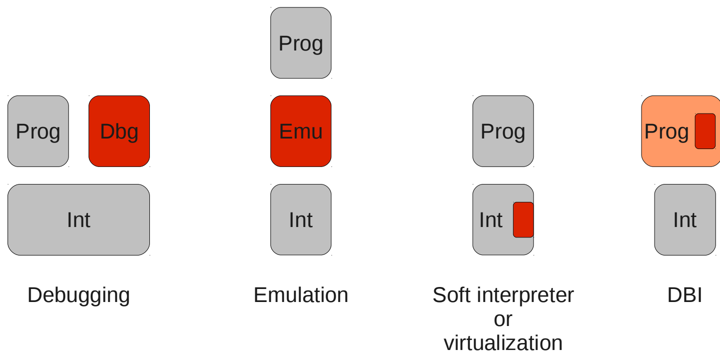
(informal) Dynamic Binary Instrumentation is

- a program transformation
- that gives you full control over the execution of a program
- with no need for architectural support

Note that:

- virtualization *does not provide full control*
- emulation (== interpretation) is *not a program transformation*
- debugging *requires architectural support*
- dynamic binary translation matches this definition, so QEMU can be seen as a whole-system DBI engine

Overview



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Full control without emulation

DBI achieves the same level of control as an emulator (== interpreter), but

- DBI relies on a pre-existing, unmodified interpreter
- so there is no need to know / support the full semantics of the architecture (for x86, this is a massive benefit)
- and no requirement for debugging support (could be interesting for GPUs)

How to achieve full control

Define a static analysis `f(code)` that returns `instrumented_code`:

1. parse code
2. (modify user-defined program points)
3. if `new_code` can potentially be executed, replace it with `f(new_code)`
4. run `f(code)`

This can be seen as JIT compilation...
... or as virus-like program infection (hijack the entry point and retain control)

Pros and cons

Pros:

- it is a program transformation
- performance

Cons:

- it is a program transformation
- performance

...huh?

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Building a Javascript DBI engine

```
instrument = function (script) {
  var result = script;
  result = result.replace(
    /eval\(/g,
    "instrument("
  );

  // additional result.replace() will
  // instrument the initial script

  return eval(result);
}
```

Adding deobfuscation

Malicious scripts often use `document.write()` to add other scripts and invisible iframes in hacked pages.
Let's instrument that:

```
result = result.replace(
  /document.write\(/g,
  "log("
);
```

(note to self: do the demo)

Adding more deobfuscation

Other interesting program points in malicious Javascript:

- changes to `location.href`
- calls to `new Image()`
- calls to `new ActiveXObject()`
- calls to `setTimeout()` and `setInterval()` (sometimes used instead of `eval()`)
- (add your favorite tricks here)

(note to self: do the other demo)

Problems

To make this operational, we need to:

- replace tokens, not regexps in strings
- prevent other ways to execute dynamic code (`new Function()`, `top/window/self/parent.eval()`...)
- manage code introspection
- make the instrumenter self-instrumentable

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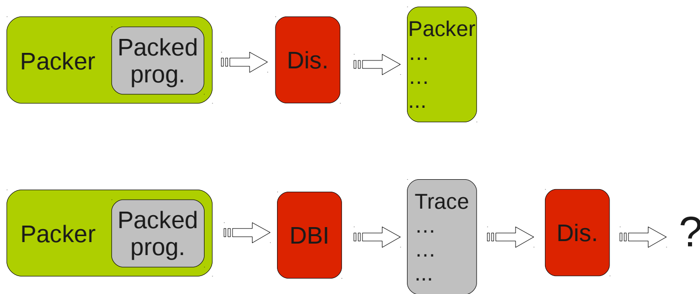
x86 unpacking

What happens when you extract a run trace with DBI and import it in a disassembler?



Malware analysis

Pin has not been made for malware analysis, but...

- it can successfully instrument many packers (14/16 tested): AcProtect, Aspack, Expressor, FSG, Mew, Molebox, Npack, Packman, Pec2, Pelock, RLPack, UPX, Winupack, Yoda Protector...
- it works on approximately 80% of malware samples (tested on 100k samples)

Full results posted at http://indefinitestudies.org

Conclusion

Instrumentation is a high-level, elegant approach to solve low-level problems.

- it is a mix of static and dynamic analysis
- it will work on any language / architecture
- it is algorithmically sound (unlike event-based approaches such as debugging)
- *Outrageous claim*: it is the fastest method for fine-grained analysis

Conclusion Bis

I GPL'd the tools for the conference:

- Crême Brûlée (Javascript DBI): http://code.google.com/p/cremebrulee/
- TarteTatinTools (TraceSurfer and other pintools): http://code.google.com/p/tartetatintools/