# New Tool for Discovering Flash Player 0-day Attacks in the Wild from Various Channels

@heisecode

# Agenda

- Who am I
- Background
- Sample Channels
- Tool to identify 0-day

# About me

- Core Member of Trend Micro Zero-Day Discovery Team
- Trend Micro Anti-APT engine developer
- Interested in discovering vulnerabilities and writing exploit.
- Flash/Android/OS X

TREND MICRO

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# Flash Year

- JAVA Click-to-Play
- Browsers’ UAF mitigations
- So Flash Player boom in 2015

# Flash Year

- Zero-day attacks' targets are mostly Flash Player in 2015

CVE-2015-0310

CVE-2015-0311

CVE-2015-0313

CVE-2015-3043

CVE-2015-3113

CVE-2015-5119

CVE-2015-5122

…

…

# Flash Year

- In late 2014, I decided to catch Flash Player zero-day attacks in 2015.

- There were two questions need to solve to achieve the goal.

# Two questions

- How to get effective samples in the wild?

  Try any possible source channel to get effective samples.

- How to identify 0-day from these samples?

  Need a processing tool, fast, low false alert.

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# Sourcing Channels

- Channel 1 - Products' feedback

> Large number of SWF samples from products or engines' detection feedback

> Most effective channel

# Sourcing Channels

- Channel 2 - URL Crawl

> Several exploits integrated in one URL

> Trigger which exploit depends on software version installed in victim's system

> Crawl this kind of URLs may catch other software exploits

# Sourcing Channels

- Channel 3 - VT intelligence

  > SWF samples downloaded from https://www.virustotal.com/intelligence/

  > 0-day sample may be submitted to VT before it is discovered

# Sourcing Channels

- Channel 4 - URL Pattern

  > Exploit Kit or Campaign URLs may have some pattern.

  > Find these kinds of URLs, visit them to detect

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# Need a tool

- Need a tool to identify SWF files or URLs can exploit target version of Flash Player.

  > Low False Alert.

  > Logger for automation.

  > Record exploit event when detect.

  > High performance.

# Advanced Flash Exploit Detector(AFED)

- IE BHO written by C++
- Hook Flash OCX to detect.
- Hook IE event to get current URL name.
- Write detections and behaviors to log.

# Automation Process

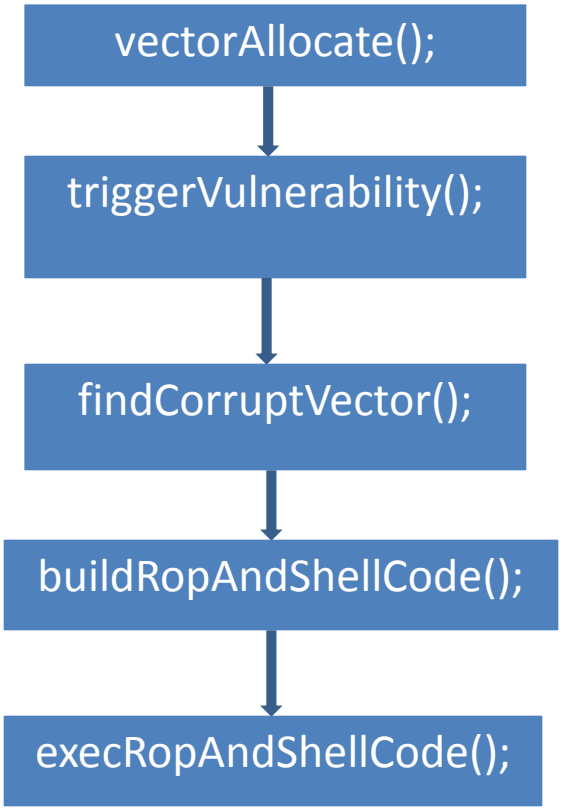
- Simple Python code
- Register AFED using regsvr32.exe
- Every time load a URL in IE, AFED hook Flash OCX to detect
- Kill IE processes to load next URL
- When finished all URLs, parse log file with rules

# How to implement AFED?

- Before vector.<*> mitigation introduced, all Flash Exploits used corrupted vector.<*> to exploit.

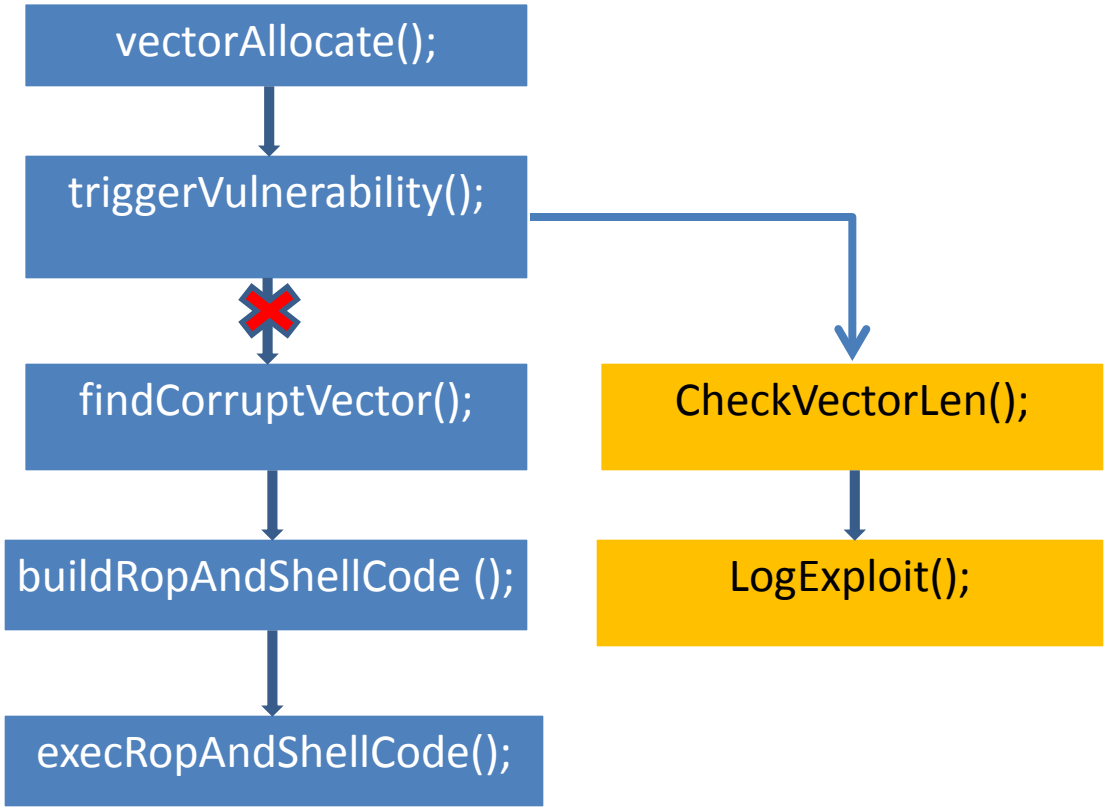
# Typical Exploit Flow Before Mitigation

- Simplified Exploit Flow



# Detect Flow Before Mitigation

- Ideally

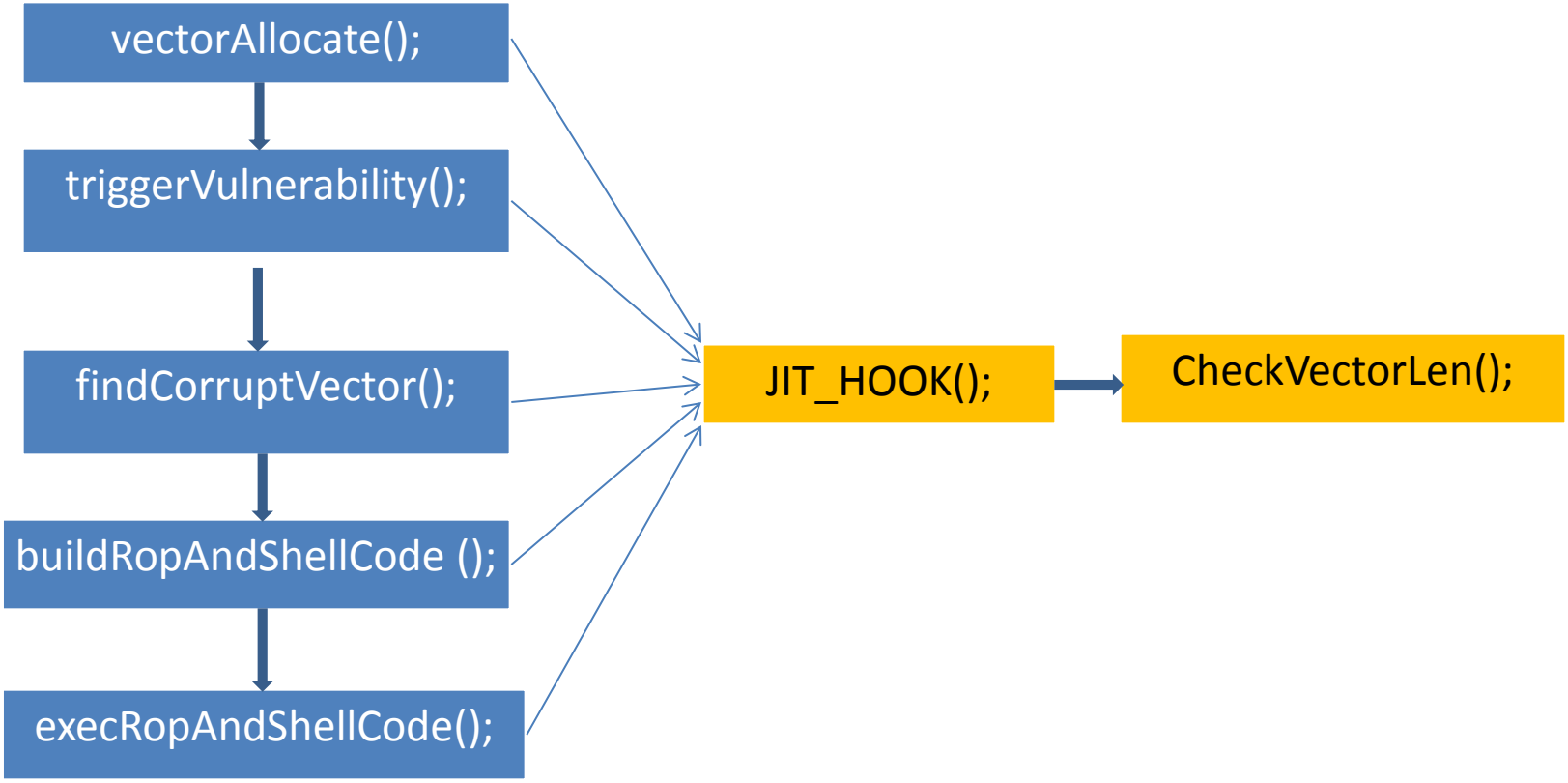


# Hook JIT

- Almost each AS3 method will be JITed before called
- So I hook the JIT point of AVM2
- In hook point, check Vector object length

# Detect Flow Before Mitigation

- So, Practically



# Hook JIT

- Key function

> In AVM2(https://github.com/adobe-flash/avmplus),

BaseExecMgr::verifyJit is the function to verify and emit native code.

```
void BaseExecMgr::verifyJit(MethodInfo* m, MethodSignaturep ms,
        Toplevel *toplevel, AbcEnv* abc_env, OSR *osr)
{
#ifdef VMCFG_HALFMOON
    if (verifyOptimizeJit(m, ms, toplevel, abc_env, osr))
        return; // halfmoon jit worked.
    // hack: force exception table to be re-parsed.
    m->set_abc_exceptions(core->gc, NULL);
    // fall through to CodegenLIR JIT logic.
#endif
    CodegenLIR jit(m, ms, toplevel, osr, &noise);
    PERFM_NTPROF_BEGIN("verify & IR gen");
    verifyCommon(m, ms, toplevel, abc_env, &jit);
    PERFM_NTPROF_END("verify & IR gen");
    GprMethodProc code = jit.emitMD();
    if (code) {
        setJit(m, code);
    } else if (config.jitordie) {
        jit.~CodegenLIR(); // Explicit cleanup since destructor won't run otherwise.
        Exception* e = new (core->GetGC())
                Exception(core, core->newStringLatin1("JIT failed")->atom());
```

# How to check vector length?

- Hook Vector Creating

> Vector.<int>, Vector.<uint>, Vector.<Number> and Vector.<Object>

> Template function, 4 instances in flash binary.

```
template<class OBJ>
OBJ* TypedVectorClass<OBJ>::newVector(uint32_t length, bool fixed)
{
    OBJ* v = (OBJ*)OBJ::create(gc(), ivtable(), prototypePtr());
    v->m_vecClass = this;
    if (length > 0)
        v->set_length(length);
    v->m_fixed = fixed;
    return v;
}
```

# How to check vector length?

- Check Vector length before mitigation

> vec_obj_addr + 0x18  is the ListData which save data.

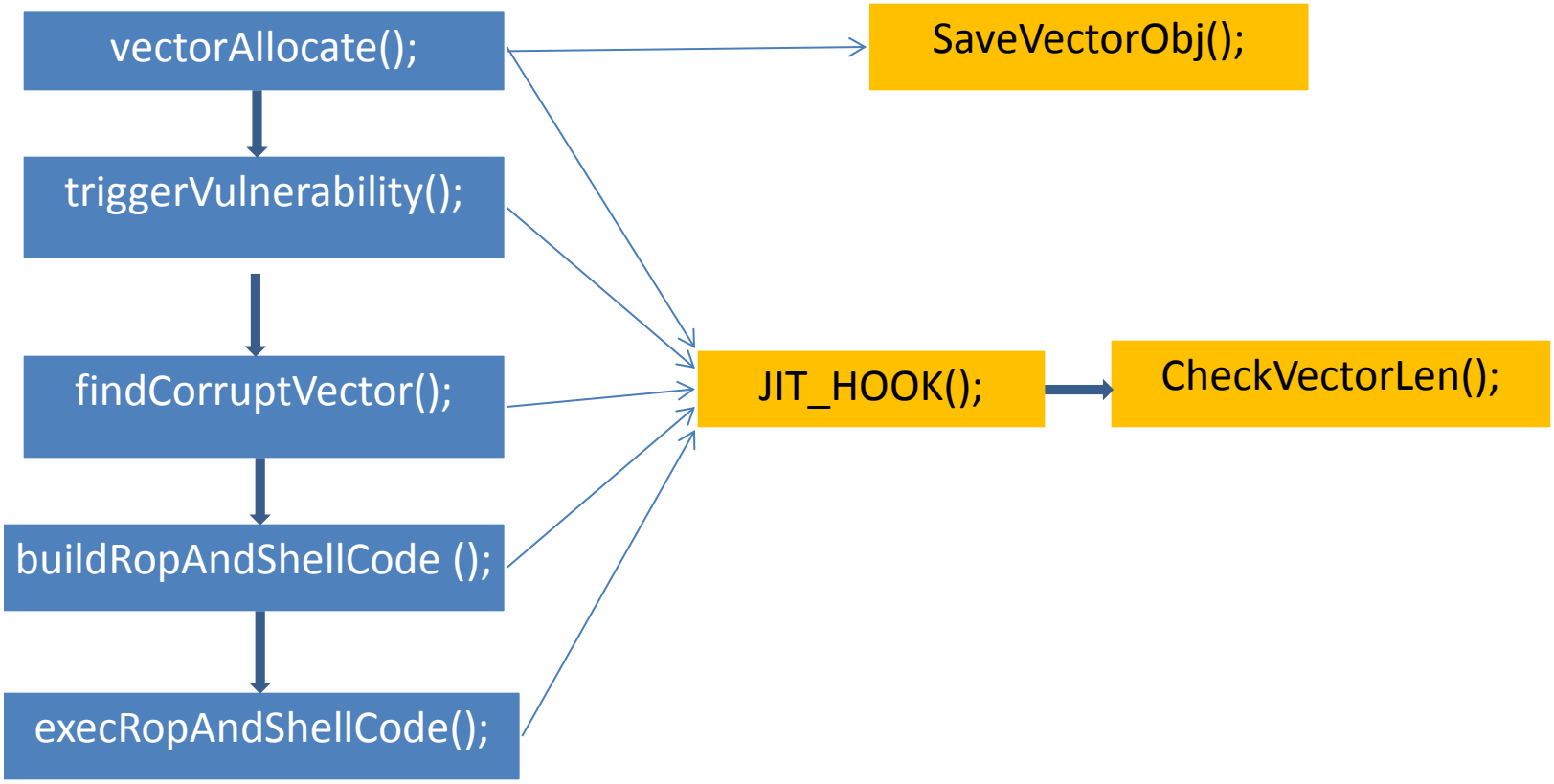
> poi(poi(vec_obj_addr + 0x18) ) is vector length

```
template<class STORAGE, uint32_t slop>
struct ListData
{
    uint32_t    len;            // Invariant: Must *never* exceed kListMaxLength
    MMgc::GC*   _gc;
    STORAGE     entries[1];     // Lying: Really holds capacity()

    // add an empty, inlined ctor to avoid spurious warnings in MSVC2008
    REALLY_INLINE explicit ListData() {}
```

# Detect Flow Before Mitigation

- So, Finally



# After mitigation introduced

- Use other objects to exploit.

> CVE-2015-7645 used ByteArray based object.

> Overwrite ByteArray length to achieve arbitrary read and write.

> No general exploit object like Vector

# Detect Based on Behaviors

- JIT native code prologues are almost like this:

  > Hook first 9 bytes of JIT native code to record each call.

```
058254f9 55              push    ebp
058254fa 8bec            mov     ebp,esp
058254fc 81ece8000000    sub     esp,0E8h
05825502 899d7cffffff    mov     dword ptr [ebp-84h],ebx
05825508 89b53cffffff    mov     dword ptr [ebp-0C4h],esi
0582550e 89bd38ffffff    mov     dword ptr [ebp-0C8h],edi
```

```
05825033 55              push    ebp
05825034 8bec            mov     ebp,esp
05825036 83ec78          sub     esp,78h
05825039 895dac          mov     dword ptr [ebp-54h],ebx
0582503c 89758c          mov     dword ptr [ebp-74h],esi
0582503f 897d9c          mov     dword ptr [ebp-64h],edi
05825042 8b4d08          mov     ecx,dword ptr [ebp+8]
```

# Detect Based on Behaviors

- AFED can get AS3 method name and JIT native code address by hooking JIT.
- So we can get something like this in log:

```
Call [Function$/createEmptyFunction]
Call [Object$/_dontEnumPrototype]
Call [Object$/_init]
Call [flash.geom::Rectangle]
Call [flash.display::Stage]
Call [flash.display::DisplayObjectContainer]
Call [flash.display::InteractiveObjectVector.<flash.display::Stage3D>]
Call [flash.display::DisplayObject]
Call [flash.events::EventDispatcher]
Call [Main]
Call [flash.display::Sprite]
Call [Main/init]
Call [flash.text::TextField]
Call [flash.display::LoaderInfo]
Call [flash.display::Loader]
Call [Main/HexString2Bin]
Call [Array]
Call [flash.utils::ByteArray]
Call [flash.system::LoaderContext]
Call [flash.display::Loader/loadBytes]
Call [flash.display::Loader/_buildLoaderContext]
Call [ext_fla::MainTimeline]
Call [flash.display::MovieClip bî| ]
Call [flash.accessibility::AccessibilityProperties]
Call [ext_fla::MainTimeline/frame1]
Call [flash.events::Event]
Call [MyClass$/OnLoadEmbedFlashComplete]
Call []
Call [Traits@5ef91f0]
Call [Main$/LogToText]
Call [flash.text::TextField/appendText]
Call [MyOwnBA]
Call [MyExt2]
Call [MyExt1]
Call [flash.utils::ObjectOutput]
```

# Heuristic rules based on behaviors

- For example, ByteArray heapspray.
- AFED will print lots of “Call [flash.utils::ByteArray]” to log. Add this rule when parsing the log.
- Other heuristic rule can be added by analysis from recent exploits or experience.
- Recently, exploits also used BitmapData heapspray.

# Forget one thing

- Hook Flash OCX loading, like Windbg's module load event.
- Hook CoGetClassObject function in urlmon.dll
- IsEqualCLSID(rclsid, CLSID_Flash) to identify Flash OCX is being loaded or not.

# Reference


- “Inside AVM,” Haifei Li
- Google Project zero, http://googleprojectzero.blogspot.tw/2015/07/significant-flash-exploit-mitigations_16.html

# Thank you!