

Katana: A Userland Toolchain-Oriented Hotpatching System

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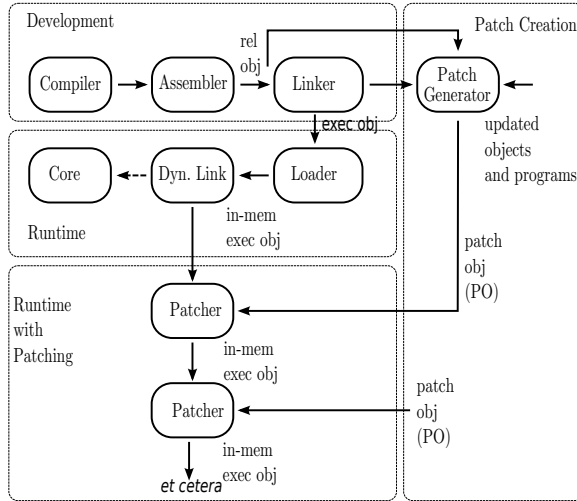
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1 Introduction

Katana aims to provide a hot-patching system for userland. Further it aims to work with existing toolchains and formats so as to be easy to use and to hopefully pave the way for incorporating patching as a standard part of the toolchain. Because of this aim, Katana operates at the object level rather than requiring any access to the source code itself. This has the added bonus of making it, in theory, language agnostic (although no work has been done to test it with anything besides programs written in C). A diagram of software lifecycle with hotpatching is shown below



This document is intended to provide a users guide to Katana, insight into its inner workings, and discussion of its flaws and plans for the future. As the software is not complete, making use of Katana without understanding the inner workings and technical shortcomings is not recommended. Nevertheless, the only sections of this document necessary for “Users’ Guide” purposes are “What Katana Does”, “What Katana Does Not Do (Yet)”, and most importantly “How to Use Katana”.

This document is a work in progress. It is not a polished guide yet.

2 Other Systems

There are other hotpatching systems in existence. The curious are invited to explore Ginseng and Polus. Both of these systems parse the source code, which adds significant complexity to them and results in significant programmer annotation of the code to give hints to the systems. Ginseng uses complicated type-wrappers when patching variables which does not fit cleanly with existing executables and has some impact on the performance of the software. Ginseng is considerably more mature than Katana, however. Neither system is production ready, but Ginseng is probably closer than Katana at the moment.

The system most like Katana in many ways is KSplice, and the curious reader is definitely invited to investigate. KSplice patches the kernel and not userland, does not attempt to patch variables, and creates patches as kernel modules rather than working towards a general ELF-based patch format.

3 What Katana Does

- Runs on x86 and x86-64
- Generates patches for simple programs
- Applies simple patches

4 What Katana Does Not Do (Yet)

- Patch any major programs: it has not yet been demonstrated on anything more than toy examples
- Provide any method to handle opaque data it cannot patch (void*, situations where which action a user would prefer is unclear, etc)
- Patch previously patched processes
- Provide robust operation
- Run on any architectures other than x86 and x86-64
- Tested on any operating system besides GNU/Linux
- Allow for calls in patched code to previously unused functions

- Work for programs which actually make use of some of the large code model features of the x86-64 ABI.
- And much more

See Roadmap for more things which are not complete

5 What Katana May Never Do

- Work on any binary formats besides ELF

6 How to Use Katana

Katana is intended to be used in two stages. The first stage generates a patch object from two different versions of an tree. By an object tree, we mean the set of object files (.o files) and the executable binary they comprise. Katana works completely at the object level, so the source code itself is not strictly required, although all objects must be compiled with debugging information. This step may be done by the software vendor. In the second stage, the patch is applied to a running process. The original source trees are not necessary during patch application, as the patch object contains all information necessary to patch the in-memory process at the object level. It is also possible to view the contents of a patch object in a human-readable way for the purposes of sanity-checking, determining what changes the patch makes, etc.

6.1 Preparing a Package for Patching Support

Katana aims to be much less invasive than other hot-patching system and require minimal work to be used with any project. It does, however, have some requirements.

6.1.1 Source Code Practices

Katana does not look at the source code, therefore unlike several other hot-patching systems, it does not require any annotation in the source code. There are, however, some best practices to follow.

- Avoid the use of `void*` at least for global variables (since Katana does not currently patch local variables, preferring to wait until any functions using changed variables are no longer on the stack). Since it is typeless and opaque, it is very hard to analyze and patch.
- Avoid unnamed types. i.e., instead of `typedef struct {...} Foo;` use `typedef struct Foo_ {...} Foo;.`
- Avoid accessing structure members by offsets instead of by the member names. As long as you keep all the code where you do this up to date, it should not be a problem, but katana cannot detect when you do this.

6.1.2 Compilation/Linking

Required CFLAGS:

- `-g`

Recommended CFLAGS:

- `-ffunction-sections`
- `-fdata-sections`

Recommended LDFLAGS:

- `-emit-relocs`

6.2 To Generate a Patch

Let the location of your project be `/project`. You must have two versions of your software available: the version identical to the running software which must be hotpatched, call it `v0`, and the version to which you wish to hotpatch the running software, call it `v1`. Let `foo` be the name of your program. Then `/project/v0/foo` must exist and `/project/v0` must also contain (possibly in subdirectories) all of the object files which contributed to `/project/v0/foo`. The source code itself is immaterial, as Katana does not parse it. Similarly, `/project/v1/foo` must exist and `/project/v1` contain all of the object files contributing to `/project/v1/foo`. Katana is then invoked as

```
katana -g [-o OUTPUT_FILE] /project/v0 /project/v1 foo
or more formally
```

```
katana -g [-o OUTPUT_FILE] OLD_OBJECTS_DIR NEW_OBJECTS_DIR EXECUTABLE_NAME
```

If `-o OUTPUT_FILE` is not specified, the output file will be `OLD_OBJECTS_DIR/EXECUTABLE_NAME.po`

6.3 To Apply a Patch

The process to be patched is running with a pid of PID. It can be patched from its current version to a more recent version by the Patch Object (PO) file PATCH. Katana is then invoked as

```
katana -p [-s] PATCH PID
```

If all goes well, the patcher will run, print out some status messages, and leave your program in better state than it found it. The optional -s flag tells Katana to stop the target program after patching it and detaching from it. This is mostly of use for debugging Katana.

6.4 To View a Patch

One of the goals of Katana and its Patch Object (PO) format is to increase the transparency of patches: a user about to apply a patch should know what it will do. This goal is not yet fully realized, but it is possible to view some information about a patch with

```
katana -l PATCH
```

6.5 See Also

the katana manpage (once it's written, which it is not yet)

7 Patch Object Format

This section of the document is not yet written. It will provide a description and specification of the PO format used by Katana

8 Patch Generation Process

This section of the document is not yet written. It will provide a description of the internal process that Katana uses to generate a patch. Understanding it is not necessary for using Katana.

9 Patch Application Process

This section of the document is not yet written. It will provide a description of the internal process that Katana uses to apply a patch. Understanding it is not necessary for using Katana.

10 Roadmap

This section is highly incomplete. Future goals include

- Better interaction with the heap and dynamically allocated variables
- Better interaction with void*
- More efficient use of .rodata
- Patching already patched processes
- Patch composition
- Patch safety checking: make sure a patch actually corresponds to the process it's being applied to
- Storing warnings from generation inside a patch

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