Protecting Kernels from Untrusted Modules using Dynamic Binary Instrumentation

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Kernel modules cannot be trusted

Two thirds of all kernel vulnerabilities reside in kernel modules [CVE 2010].

Kernel modules can be:
- Malicious
- Buggy
- Exploited

Modules can compromise:
- Control-flow integrity
- Data integrity
- Both (e.g. stack integrity)

Goals and Approach

Goals:
- Secure all kernel modules
- Secure pre-compiled binary modules
- No overhead when running in the kernel

Approach:
- Secure modules by modifying their binary code at runtime using DynamoRIO Kernel (DRK)
- Instrument only while the module code is running

Kernel modules will be secured in three steps:
1. Isolate modules in separate protection domains
2. Mediate all control transfers between the kernel and its modules
3. Verify all memory accesses by modules

Existing kernel protection methods

Existing solutions cannot secure against all native kernel modules. They either:

- Secure only virtualized modules (HUKO, Gateway, etc.)
  - ✘ Many native modules cannot be run under virtualization
- Secure only modules whose source code is available (BGI, LXFI, etc.)
  - ✘ Many modules are provided as pre-compiled binaries by third-party vendors

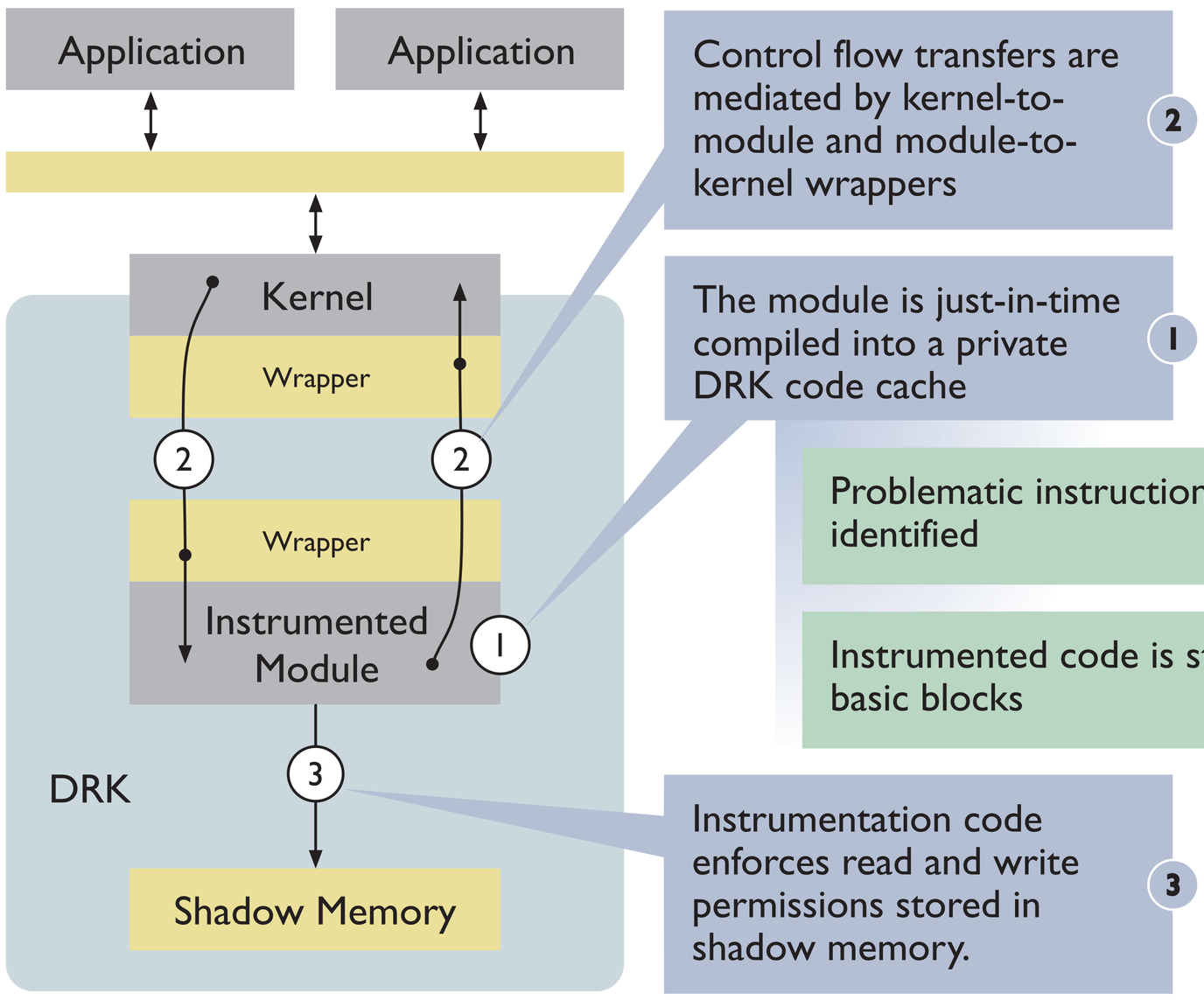
Challenges

Securing kernel modules is challenging:
- ✔ Interrupt handling
- ✔ Complex kernel interface

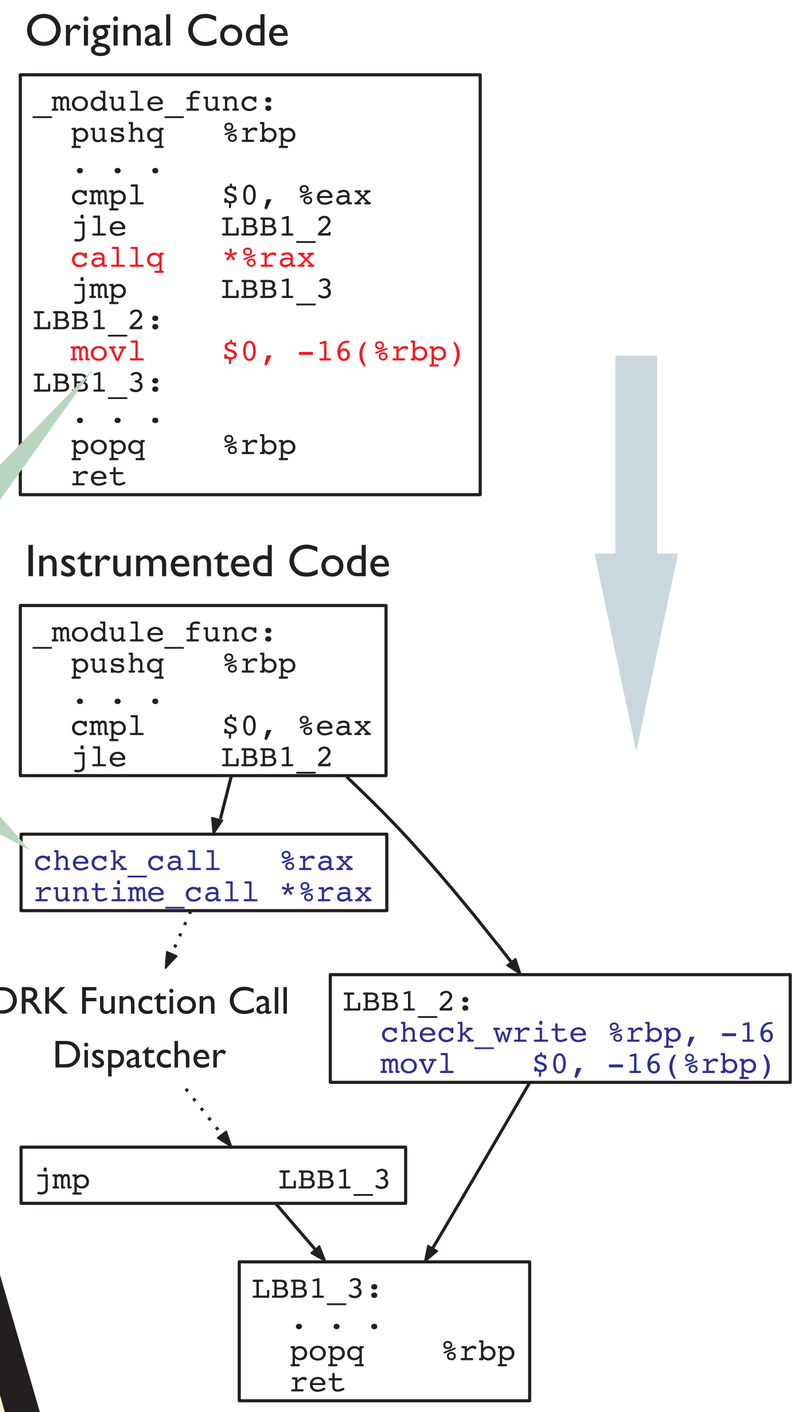
- ✘ Sensitive kernel data exposed through shared data, macros, etc.
  - BGI and LXFI lead the way

- ✘ Difficult to maintain integrity of kernel stack
  - Call/return consistency is manageable
  - Data consistency is challenging

Architecture



Dynamic Binary Instrumentation



Summary

- Protect the kernel from malicious or misbehaving modules
- Use DynamoRIO Kernel to secure pre-compiled binary modules
- Run non-module kernel code natively without overhead