Improving Scalable, Automated Baremetal Malware Analysis

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Agenda

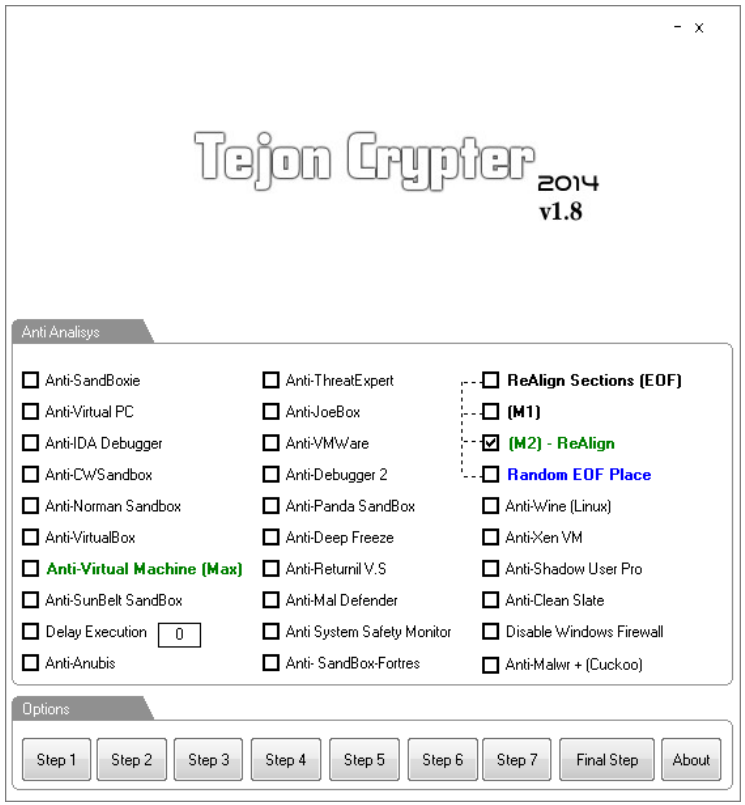
- Baremetal Malware Analysis
  - Motivation, Hardware, Technologies
- Improving Baremetal Malware Analysis
  - Reliability Testing
- Conclusion/Future Work

an introduction to

BAREMETAL MALWARE ANALYSIS

Malware Analysis Detection

- Analysis environment detection has become commoditized



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Detection Cont'd

- In-Guest Tools
  - No higher privilege
  - Exception handling issues
- Emulation (QEMU)
  - No identical instruction execution semantics
- Hardware virtualization extensions
  - Non-privileged side effects

Detecting QEMU

- IRETD with 0x26 prefix

```
#include <stdlib.h>
#include <stdio.h>
#include <windows.h>

int seh_handler(struct
_EXCEPTION_RECORD
*exception_record,
            void *established_frame,
            struct _CONTEXT *context_record,
            void *dispatcher_context)
{
      printf("Malicious code here.\n");
      exit(0);
}
```

```
int main(int argc, char *argv[]) {

      unsigned int handler =
            (unsigned int) seh_handler;

      printf("Attempting QEMU detection.\n");

      __asm("movl %0, %%eax\n\t"
            "pushl %%eax\n\t"::
            "r" (handler): "%eax");

      __asm("pushl %fs:0\n\t"
            "movl %esp, %fs:0\n\t");

      __asm(".byte 0x26, 0xcf");

      __asm("movl %esp, %eax");
      __asm("movl %eax, %fs:0");
      __asm("addl $8, %esp");

      return EXIT_SUCCESS;
}
```

Why Transparency?

- Analysis environment detection commoditized
- Detection vulnerability trend does not suggest decrease over time
- Certain types of detection vulnerabilities automatically discoverable

Baremetal Challenges

- Conceptual
  - Physicalizing virtual machine
- Scalability
  - Cost of hardware
  - Efficiency of processing
- Automation
  - Managing system state
  - Ensuring longevity of hardware

Baremetal Cluster Hardware

- Baremetal Controller
  - Standard 1U Single Socket Server
- Baremetal Non-Virtual Machine (NVM)
  - Inexpensive Half-depth 1U Server
- Cluster Networking
  - Inexpensive Cisco switch
    - 24 10/100Mb ports, 2 1Gb ports

Initial Cluster Technologies

- Linux Device Mapper
  - Create Copy-on-Write block device
- ATA over Ethernet
  - Make CoW device available over network
- g Preboot eXecution Environment
  - Boot NVM into OS on network CoW device
- Intelligent Platform Management Interface
  - Manage NVM system state

NVMTrace

- Software controller for automated baremetal malware analysis
  - Executes each sample in its own sterile, isolated non-virtual machine
- Provides access to NVM disk contents and network traffic
  - Use with your favorite network traffic and disk forensic tools

GTISC NVMTrace Deployment

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GTISC Deployment Cont’d

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evaluation and enhancement of

BAREMETAL MALWARE ANALYSIS

NVMTrace Reliability Testing

- Anecdotal observation indicated potential issue in sample processing
- Subsequent investigation revealed occasional hang during Windows boot
- ATA over Ethernet suspected

ATA over Ethernet (AoE)

- Simple (12 page specification)
  - TFTP-like connection
- Unreliable
  - No packet retransmission, checksumming
- Network analysis confirmed AoE traffic ceases at hang
  - Packet loss or corruption impedes node execution

iSCSI

- Proposed as replacement for AoE
  - Provides reliable transport via TCP
- Candidate implementation must handle atypical use
  - Constant iSCSI LUN add/remove
- Evaluated several iSCSI implementation candidates that did *not* work
  - SCST, STGT, Open-iSCSI
- Eventually tried LIO, which did work

Results

- > 99% of samples in well-known malware set successfully processed using LIO
  - Verified via multiple rounds of testing
- Additional testing with separate, ~200,000 sample dataset
  - Represented 24 hours of real-world collection
  - Virtualization-based processing results used as reference
  - Results reaffirm > 99% success rate
- Subsequent stable production use for months

Conclusion

- Analysis environment detection commoditized, increasingly popular
  - Virtualization still a valuable analysis tool, but can be supplemented
- Advances in hardware make scalable baremetal malware analysis possible
- Baremetal analysis systems must be carefully engineered for reliability

Future Work

- Increase cluster density via Supermicro MicroClouds
  - Yields three-fold increase in processing density
- Real-time disk forensics
  - Examine controller-NVM iSCSI network traffic
  - Record disk-level events as they occur

Acknowledgements

- Artem Dinaburg
  - Environment detection
- Robert Edmonds
  - System architecture
- David Dagon
  - System concept

Questions?

NVMTrace Source Code,
Build Instructions
http://code.google.com/p/nvmtrace