Facilitating Fluffy Forensics

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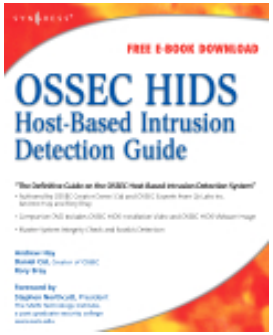
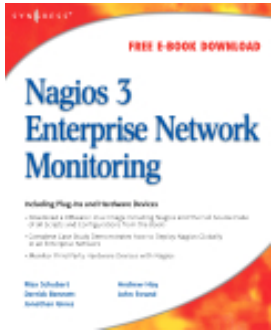
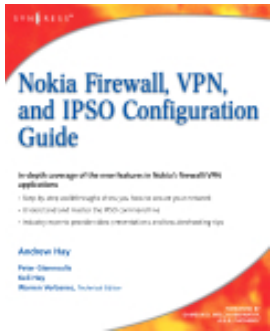
Who Are You?

- Andrew Hay, Director of Security Research at Inc.
- Former
  - Senior Industry Analyst @ 451 Research
  - Security Analyst @ UofL and a bank in Bermuda
  - Product, Program and Engineering Manager @ Q1 Labs







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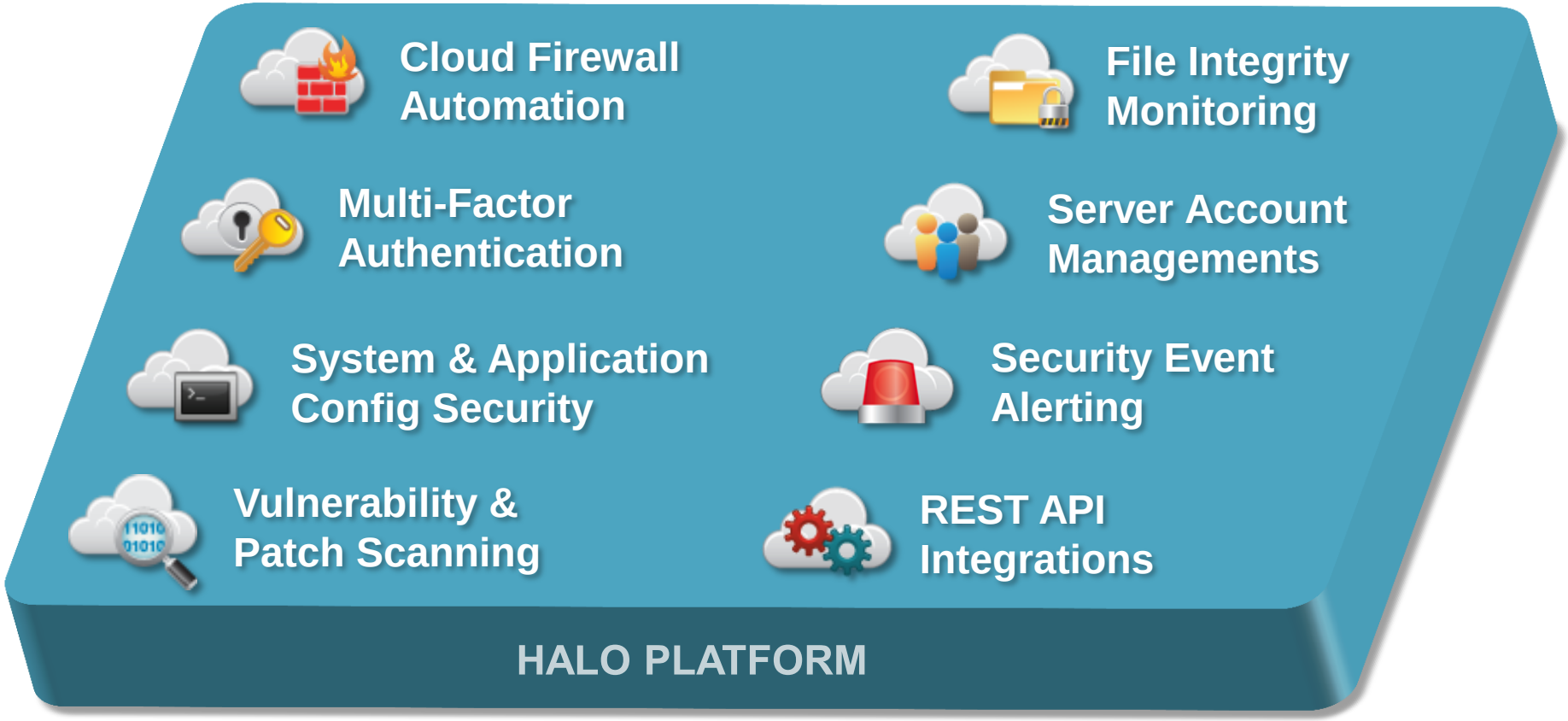
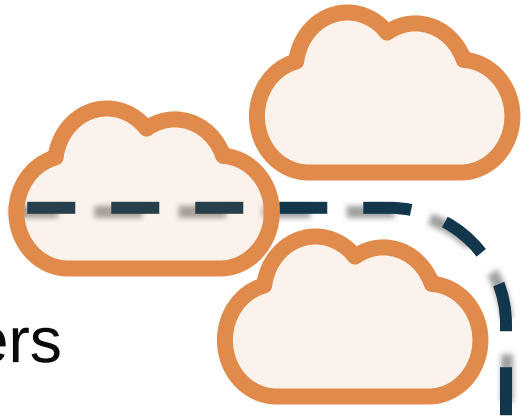
CloudPassage Halo Security Platform



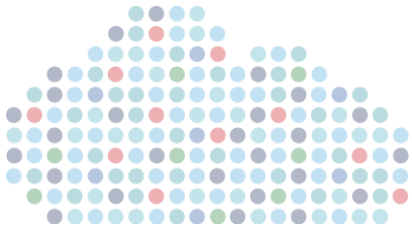
Purpose-built for clouds, metered SaaS delivery, transparent operation anywhere

Overview

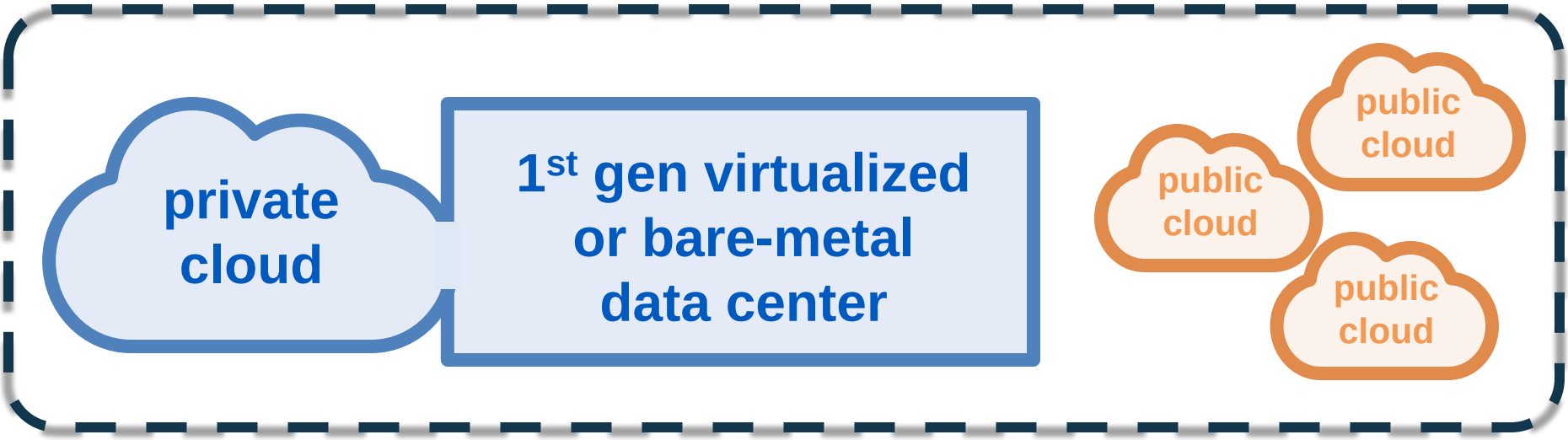


- Cloud architectural challenges for responders
- Legal issues and chain-of-custody
- How existing forensics/IR tools can help
  - and what they can do better
- Introducing *Coromandel*
- Advantages of conducting forensics/IR in cloud environments

Cloud Architectural Challenges For Responders



Cloud Architectures



Cloud means many things to many people

- Private, public, or hybrid?
- SaaS, PaaS, or IaaS?
- On-prem, off-site, hosted?
- Single tenant, multi-tenant?

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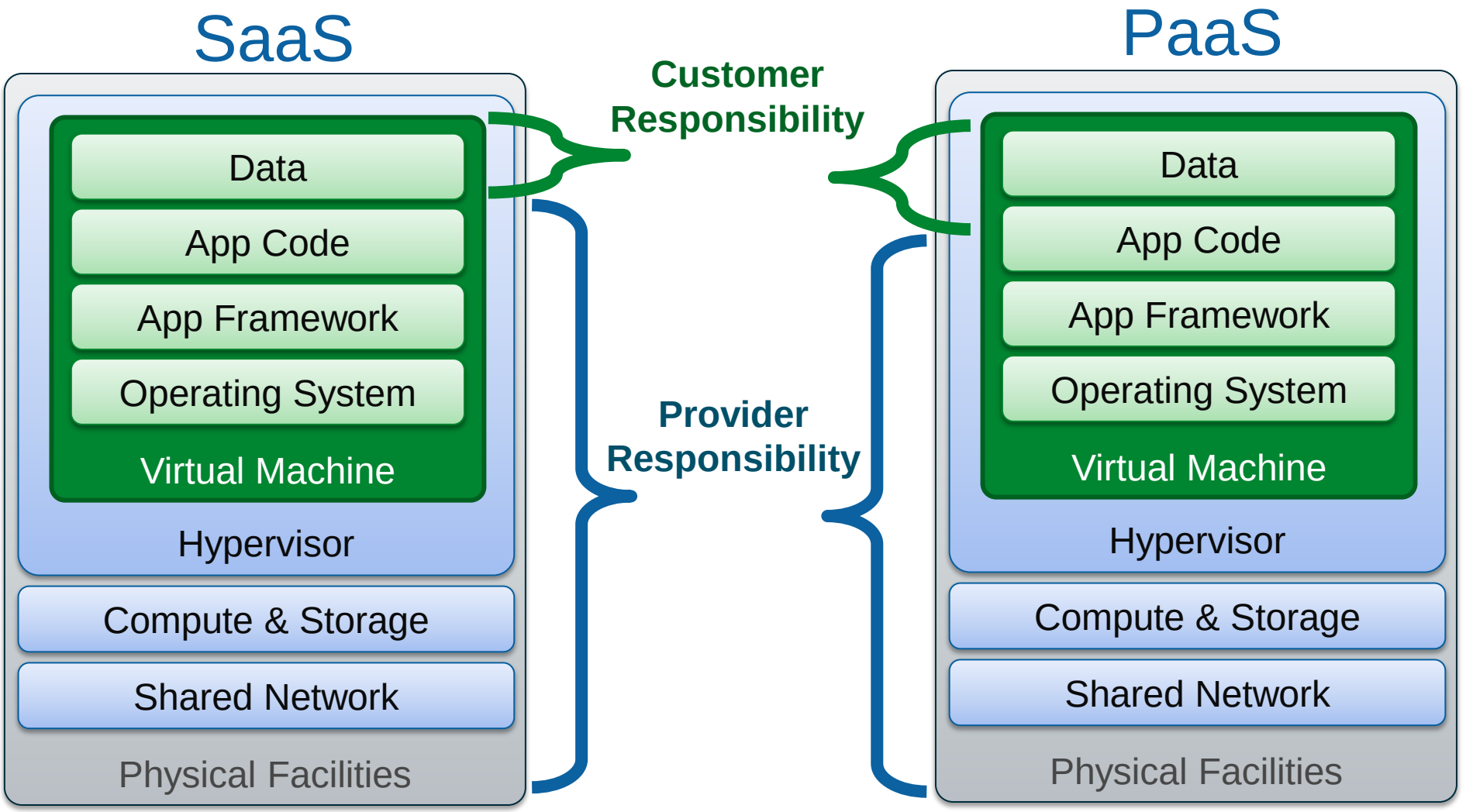
Cloud Security Responsibility



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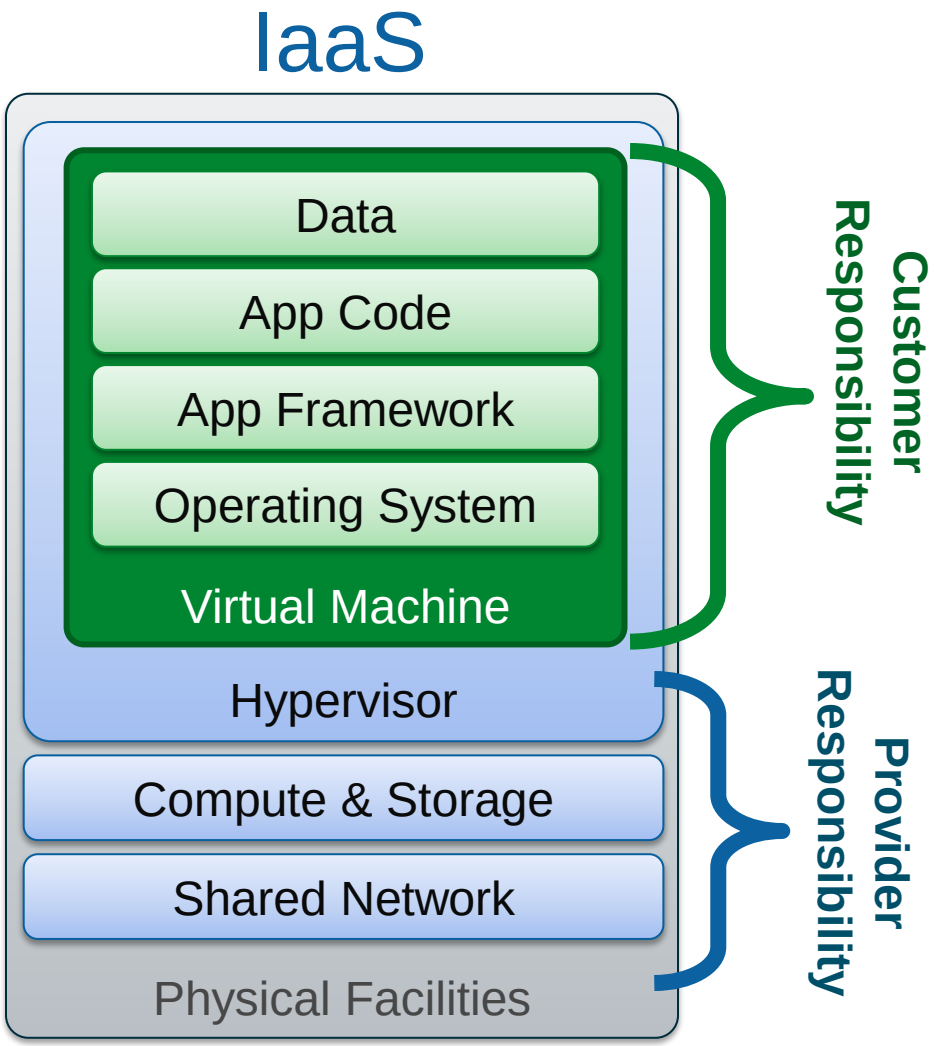
Cloud Security Responsibility

AWS Shared Responsibility Model

"…the **customer should assume responsibility and management** of, but not limited to, the guest operating system…and associated application software..."

"it is possible for customers to **enhance security** and/or meet more stringent compliance requirements **with the addition of… host based firewalls, host based intrusion detection/prevention**, encryption and key management."

Amazon Web Services: Overview of Security Processes



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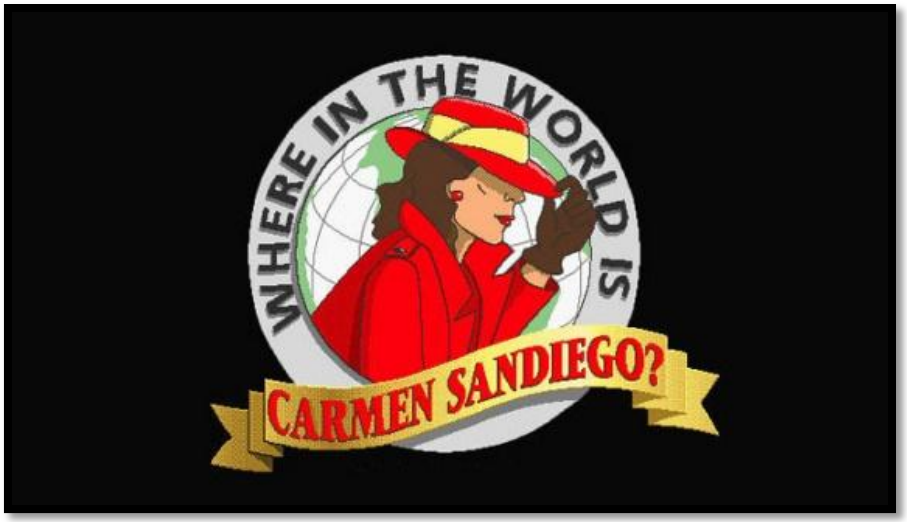
5 Major Challenges

- Data residence
- Physical acquisition
- Instance isolation
- Hypervisor introspection & data integrity
- Lack of CSP collaboration/support

Data Residence

- Need to know where the data is
- This adds validity to your investigation
- This, in turn, makes your results more credible



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Data Residence: AWS

Q: Where is my data stored?

Amazon S3 offers storage in the US Standard, US West (Oregon), US West (Northern California), EU (Ireland), Asia Pacific (Singapore), Asia Pacific (Tokyo), Asia Pacific (Sydney), South America (Sao Paulo), and AWS GovCloud (US) Regions. You specify a Region when you create your Amazon S3 bucket. Within that Region, your objects are redundantly stored on multiple devices across multiple facilities.

Source: http://aws.amazon.com/s3/faqs/#Where_is_my_data_stored

Data Residence: Windows Azure

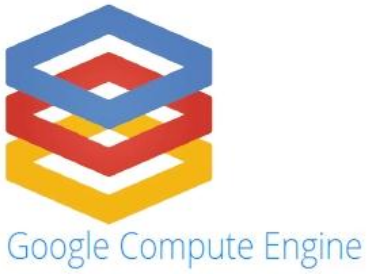
Location of Customer Data

Windows Azure™

Microsoft may transfer Customer Data within a major geographic region (e.g., within Europe) for data redundancy or other purposes. For example, Windows Azure Storage geo-replication feature will replicate Windows Azure Blob and Table data, at no additional cost, between two sub-regions within the same major region for enhanced data durability in case of a major data center disaster. However, customers can choose to disable this feature.

Source: http://www.windowsazure.com/en-us/support/trust-center/privacy/

Data Residence: GCE

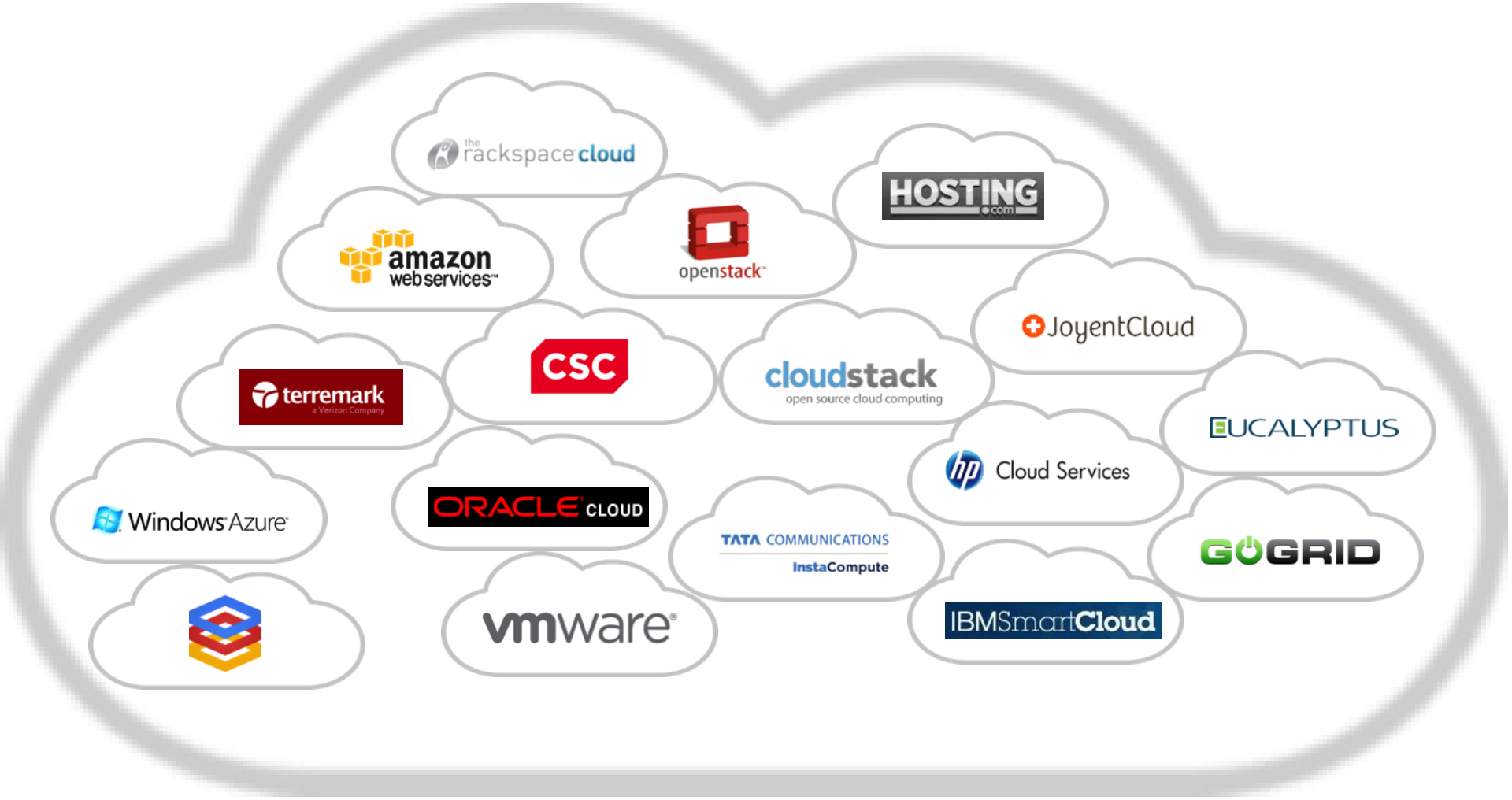


Q: Do I have the option of using a regional data center in selected countries?

Yes, Google Compute Engine offers datacenter options in Europe and within the United States. These datacenter options are designed to provide low latency connectivity options from those regions, however **at this time selection of datacenter will make no guarantee that project data at rest is kept only in that region**.

Source: https://developers.google.com/compute/docs/faq#zones

Multi-Cloud Data Residence?



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Catching Clouds is Hard Work

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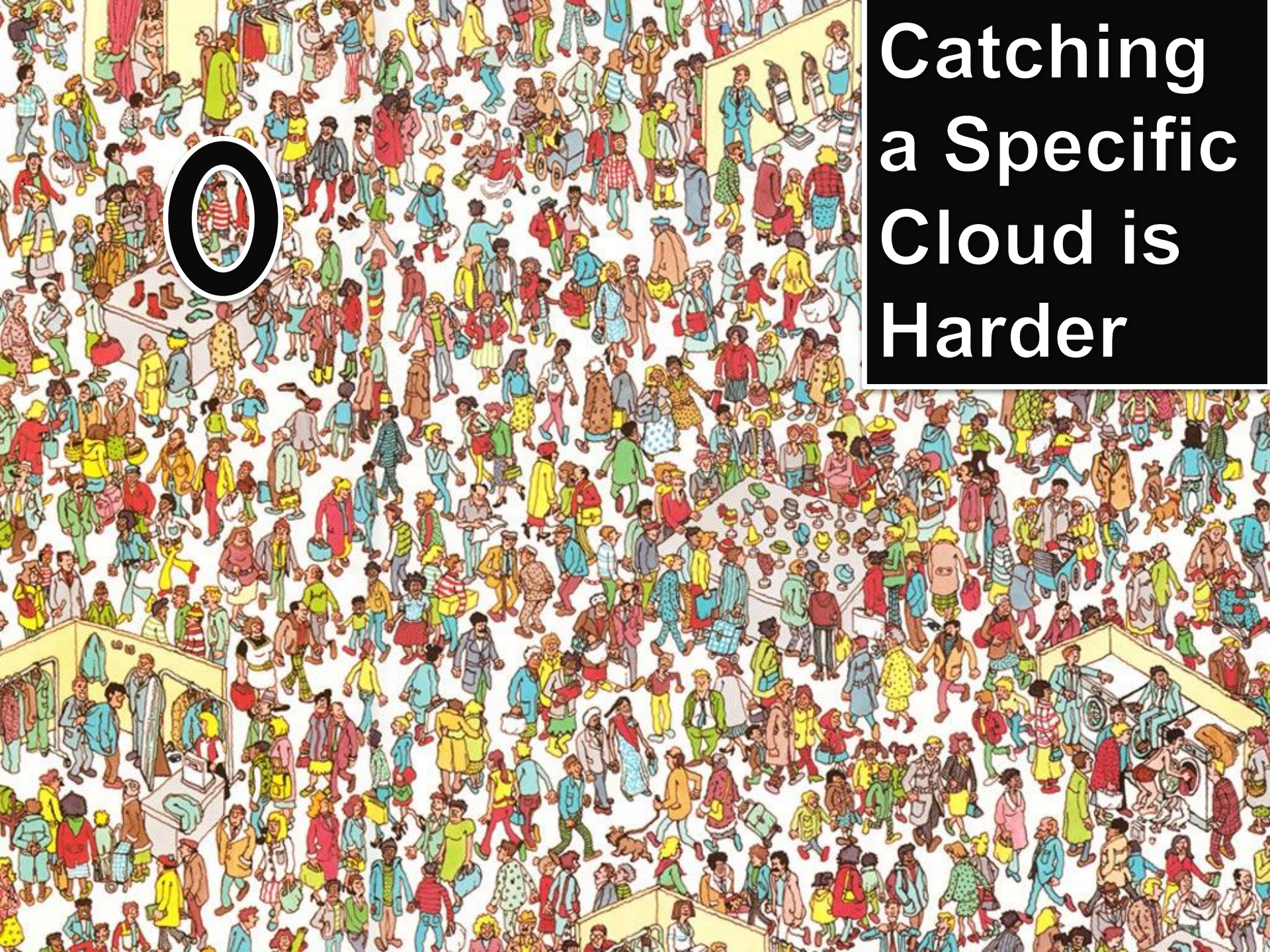
Catching
a Specific
Cloud is
Harder

Physical Acquisition

- Unless you own the cloud architecture…
- Or have the bent the CSP to your will…
- You may be stuck with snapshots and/or logical imaging

Image Acquisition: AWS

- There are 3 ways that I know of
  1. Snapshot the EBS volume, mount, and copy locally
  2. Have AWS ship you the data from S3 on physical device
  3. Use AMI Tools to compress, encrypt, and sign a snapshot

Image Acquisition: AWS EBS

- Launch a clean Amazon Linux AMI
- Stop the instance of the root volume you wish to capture
- Detach the /dev/sda1 volume
- Create a snapshot of the now detached /dev/sda1 volume
- Attach the /dev/sda1 volume to the new AMI as /dev/sdf (don’t mount)

Image Acquisition: AWS EBS

- Create a new EBS volume the same size as the root volume you wish to capture
- Attach this new volume as /dev/sdg
- Then use these commands:
  - sudo mkfs -t ext3 /dev/sdg
  - sudo mkdir /vol1
  - sudo mount /dev/sdg /vol1
  - sudo chown ec2-user /vol1
- Use dd to make an image of /dev/sdf
  - sudo dd if=/dev/sdf | gzip -c > /vol1/sda1.img.gz

Image Acquisition: AWS EBS

- Create a new EBS volume the same si
  root volume
- Use dd to make an image of /dev/sdf
  - sudo dd if=/dev/sdf | gzip -c > /vol1/sda1.img.gz

Replies

Reply

Re: Creating a forensic image

Posted by: Lance@AWS

Posted on: Jan 5, 2012 6:39 PM

in response to: Albatross Digital, LLC

Hi Albatross Digital,

If I understand your need correctly, I would consider using dd to make an image of the EBS root volume (ie.. /dev/sda1) you wish to capture.

Here is a list of operations I would perform:

Image Acquisition: AWS S3

- Amazon provides a service to export data from S3 onto a physical device and ship it to the requestor
- Customer must provide the storage device and is billed $80 per storage device handled plus $2.49 per data-loading hour
- In EBS or S3 methods it is impossible to verify the integrity of the forensic disk image*

Source: J. Dykstra, A.T. Sherman / Digital Investigation 9 (2012) S90–S98

Image Acquisition: AWS S3 + AMI Tools

- ec2-bundle-vol
  - Creates a bundled AMI by compressing, encrypting and signing a snapshot of the local machine's root file system
- ec2-migrate-bundle
  - Copies a bundled AMI from one Region to another
- ec2-download-bundle
  - Downloads the specified bundles from S3 storage

Dykstra/Sherman Experiment

- Experiment by J. Dykstra, A.T. Sherman
  1. Manual installation of EnCase Servlet and FTK Agent
  2. Used VM introspection for complete drive image
  3. AWS Export process (ship a drive)

Experiment	Tool	Evidence collected	Time (hrs)	Trust required
1	EnCase	Success	12	OS, HV, Host, Hardware, Network
1	FTK	Success	12	OS, HV, Host, Hardware, Network
1	FTK Imager (disk)	Success	12	OS, HV, Host, Hardware, Network
1	Fastdump	Success	2	OS, HV, Host, Hardware, Network
1	Memoryze	Success	2	OS, HV, Host, Hardware, Network
1	FTK Imager (memory)	Success	2	OS, HV, Host, Hardware, Network
1	Volume Block Copy	Success	14	OS (imaging machine), HV, Host, Hardware, Network
2	Agent Injection	Success	1	HV, Host, Hardware, Network
3	AWS Export	Success	120	AWS Technician, Technician's Host, Hardware and Software, AWS Hardware, AWS Software

Source: J. Dykstra, A.T. Sherman / Digital Investigation 9 (2012) S90–S98

Introspection & Data Integrity

- Introspection is not new
  - First introduced by T. Garfinkel and M. Rosenblum in *A Virtual Machine Introspection Based Architecture for Intrusion Detection*
- Way to look into current state of the guest virtual machine
  - e.g. covert, low-level access to read find processes and threads, recover files mapped in memory, and extract information about the Windows registry

Introspection & Data Integrity

- Enabled by provider
- Transparent to tenant and server instance
- Great for forensic acquisition
  - but hard to prove integrity

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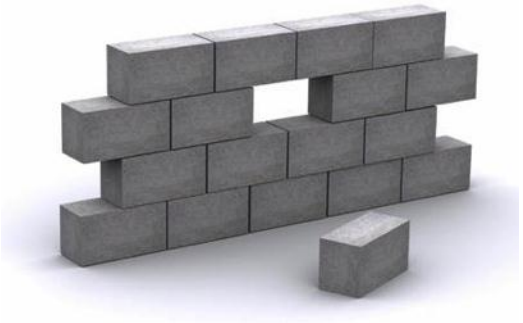
Instance Isolation

- **Several conditions must be met in order for a cloud instance to be successfully isolated:**
  - **Location:** The physical location of the instance is known
  - **Incoming & Outgoing Blocking:** The instance is blocked from sending/receiving communications to/from the outside world



Source: Waldo Delport and Martin Olivier - *Isolating Instances In Cloud Forensics*

Instance Isolation

- **Several conditions must be met in order for a cloud instance to be successfully isolated:**
  - **Collection:** Evidence from the instance can be gathered
  - **Non-Contamination:** Evidence from the instance is not contaminated by the isolation process
  - **Separation:** Information unrelated to the incident is not part of the isolation process

Source: Waldo Delport and Martin Olivier - *Isolating Instances In Cloud Forensics*

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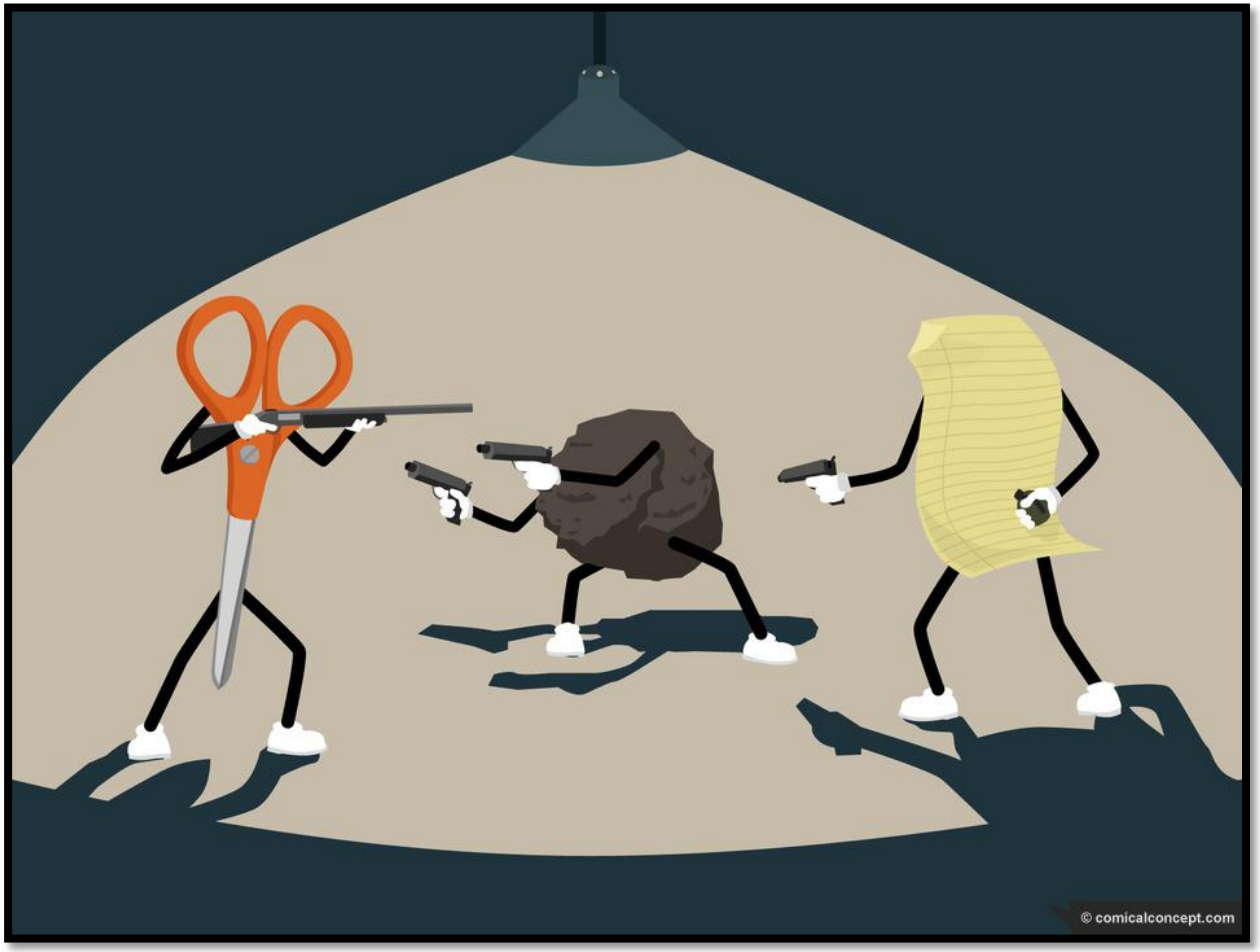
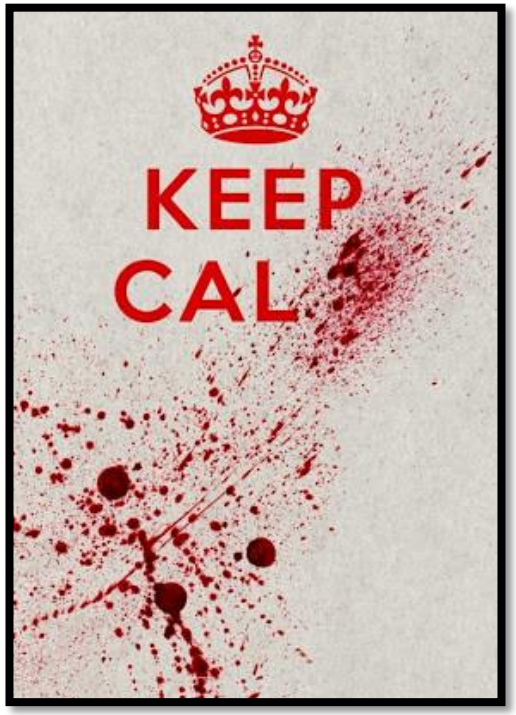
CSP Collaboration/Support

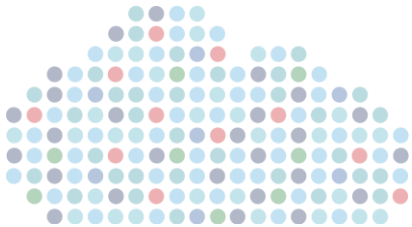


CSP Collaboration/Support

- Most providers have people that can help
- Contracts should indicate level of effort…
  - That you're expected to exert
  - That they're willing to exert
- Ask for:
  - Samples/examples of past investigations
  - Methodologies employed
  - Credentials of staff
  - Interviews with CSP team members



Legal Issues



Legal Issues: I am not a lawyer

- I'm Canadian…

Legal Issues: I am not a lawyer

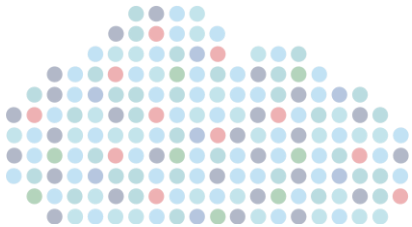
- You don't want legal advice from me (us)…

Legal Issues

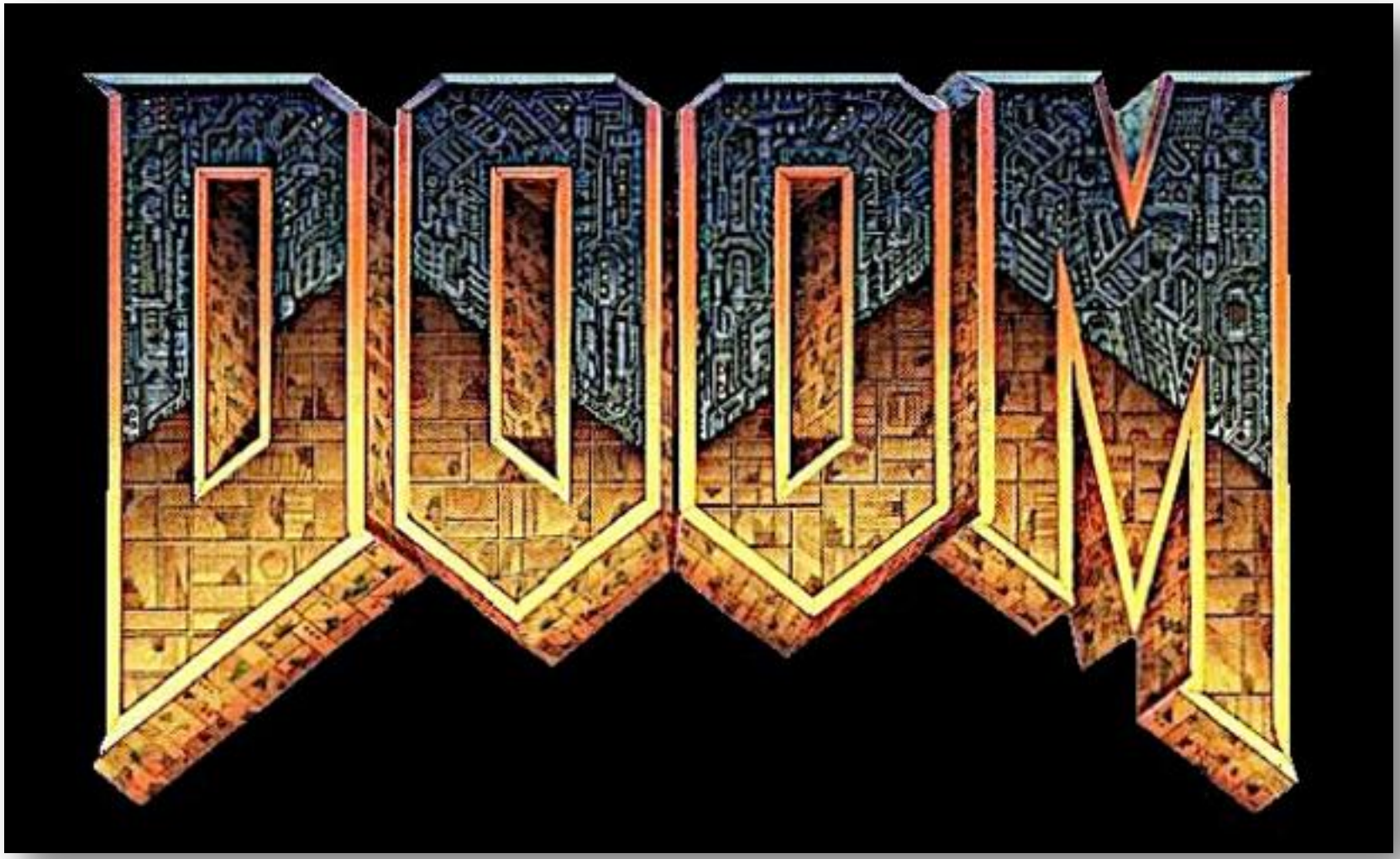
- Expectation of privacy
- Possession, custody, control
- Data preservation
- Jurisdiction
- Seizing Data

How Existing Forensics/IR Tools Can Help

…And What They Can Do Better



It’s Not All…



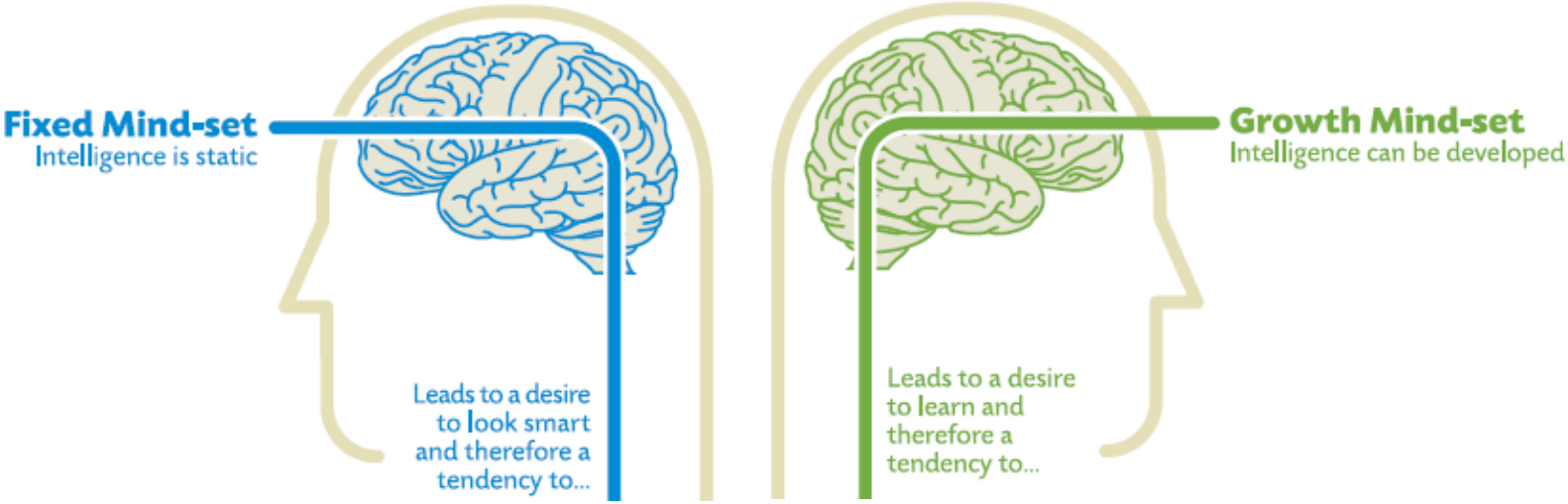
And It's Not All Gloom…

New Architecture, Similar Tools

- Your old tools and techniques may still work
  - Some, but not all

Not Just Technical Challenges

- Biggest challenge is mindset
- Need to grow comfortable with
  - Storing images/data/ off-site (*a.k.a. The Cloud*)
  - Processing off-site (*a.k.a. The Cloud*)
  - Launching off-site analysis consoles in…you guessed it, *The Cloud*!



It’s Not This Easy…

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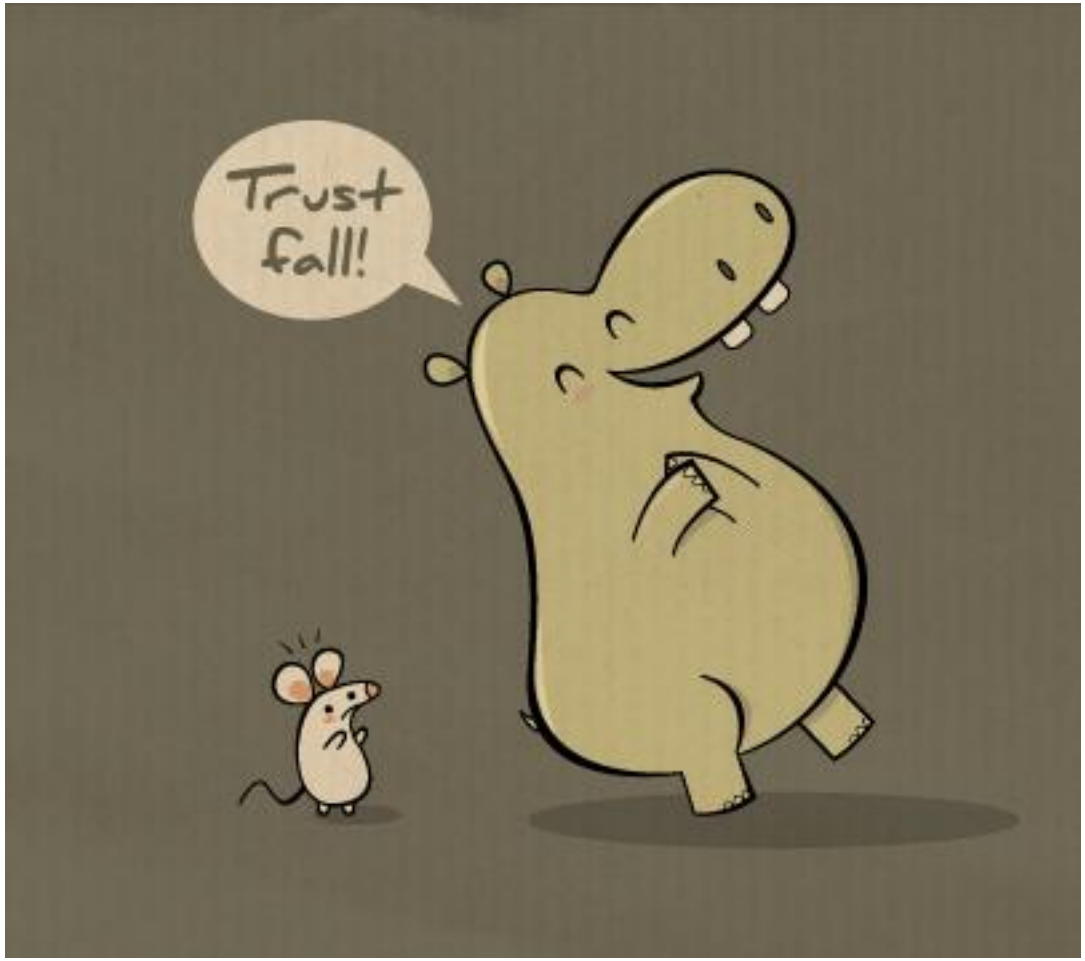
Or Even This Easy…



It’s More Like This…

That Hopefully Doesn't Result In This…

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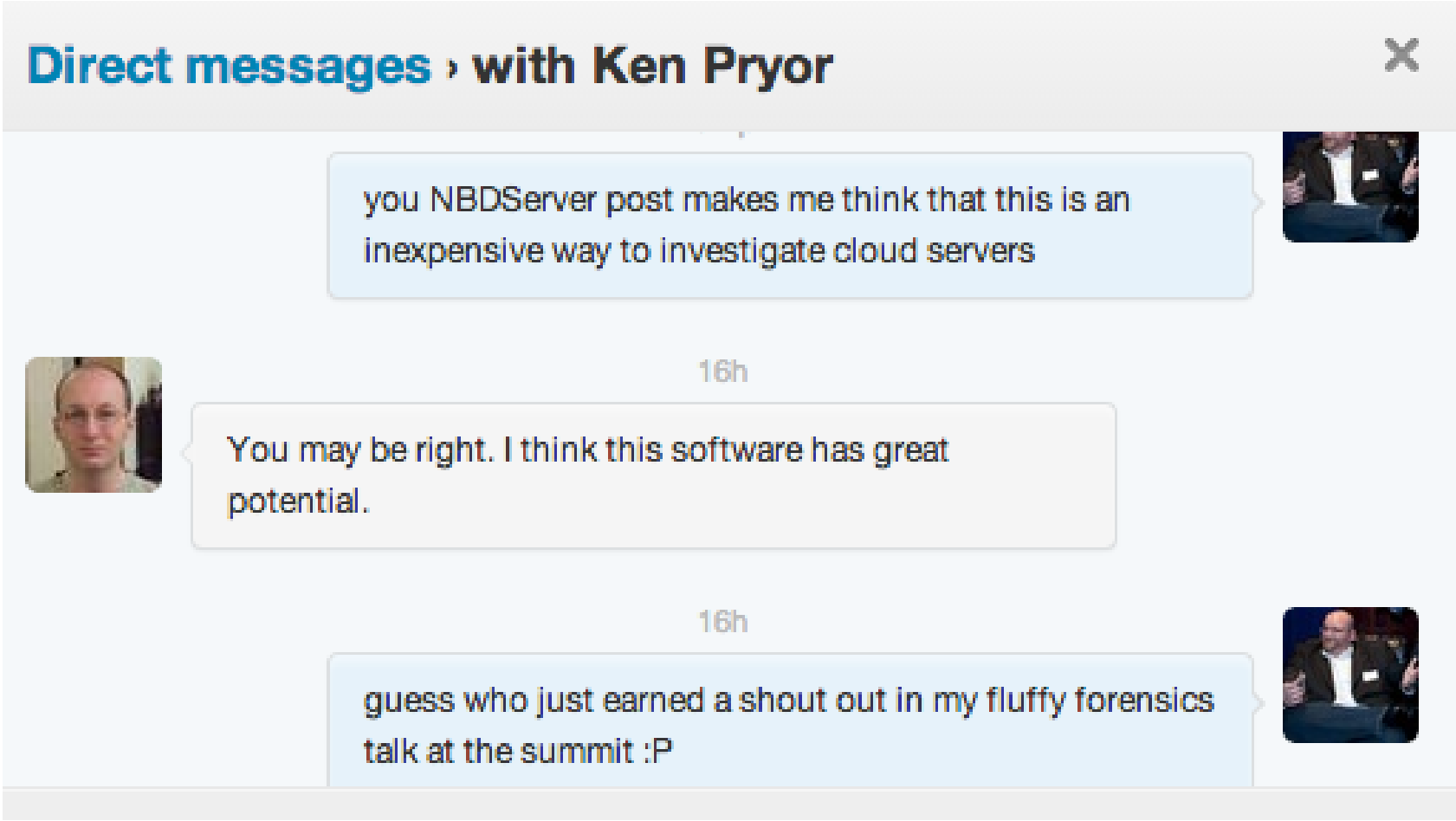
Existing Tools Can Be Used…

e.g. NBDServer

- Serves the (XP, Win 7, Win 2008) server as a read-only network block device
- Also possible to use this tool (w/Volatility) to image the Windows system RAM across the network to your client

https://github.com/jeffbryner/NBDServer

Special Thanks to @KDPryor



Post: http://digiforensics.blogspot.com/2013/04/nbdserver.html

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My Blog Post on NBD

http://blog.cloudpassage.com/2013/04/22/facilitating-fluffy-forensics-part-1/

Cloud Security Blog

← One of these things is not like the others – script

Sending CloudPassage Halo Event Logs to Sumo Logic →

Facilitating Fluffy Forensics – Part 1

Posted on April 22, 2013 by Andrew Hay | Leave a comment

I've always known that CloudPassage Halo could help facilitate forensic acquisition in cloud environments but we've been missing the ability to acquire disk images from target servers in a reliable, repeatable, and free manner.

After reading Ken Pryor's excellent NBDServer blog post on Wednesday, April 10th, and while preparing for my SOURCE Boston 2013 talk entitled *Facilitating Fluffy Forensics*, I found myself wondering if the tool might help with investigations in public cloud environments.

http://4n6.tv/4yb

CloudPassage

Existing Tools Can Be Used…

[server] `nbdserver.exe -c 192.168.2.197 -f \\.\PHYSICALDRIVE0 -n0`

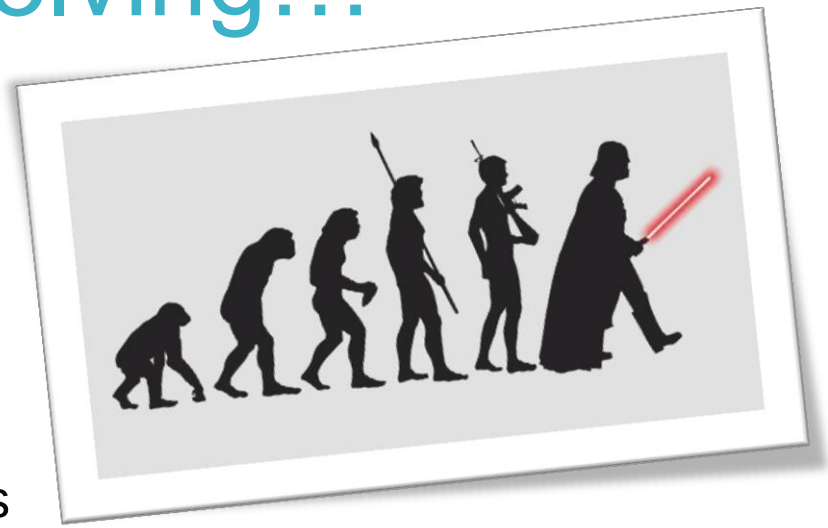
[client] `modprobe nbd`

[client] `nbd-client 192.168.2.157 60000 /dev/nbd0`

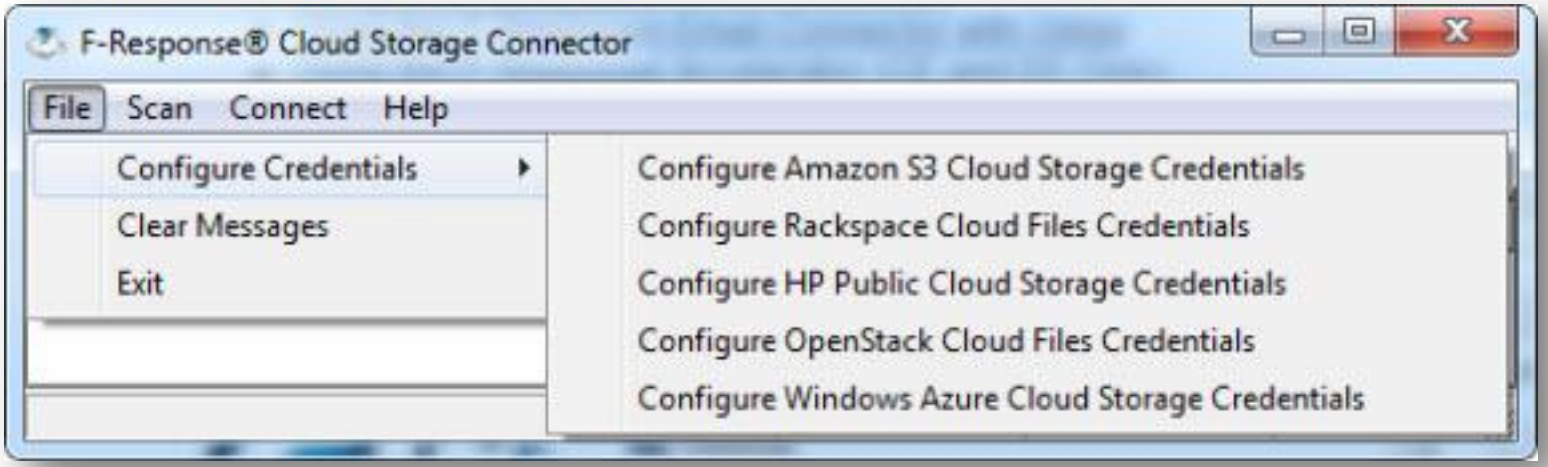
This starts the client, tells it to look for the server on 192.168.2.157, use port 60000 and create the new network block device as /dev/nbd0.

[client] `fls -f ntfs -m C: -r /dev/nbd0 > test.fls`

Existing Tools Are Evolving…



- F-Response 4.0.4
  - And the new Cloud Connector
  - Let's you 'mount'
    - Amazon S3 Buckets
    - HP, Rackspace Cloud Containers
    - Windows Azure Blob Storage Containers



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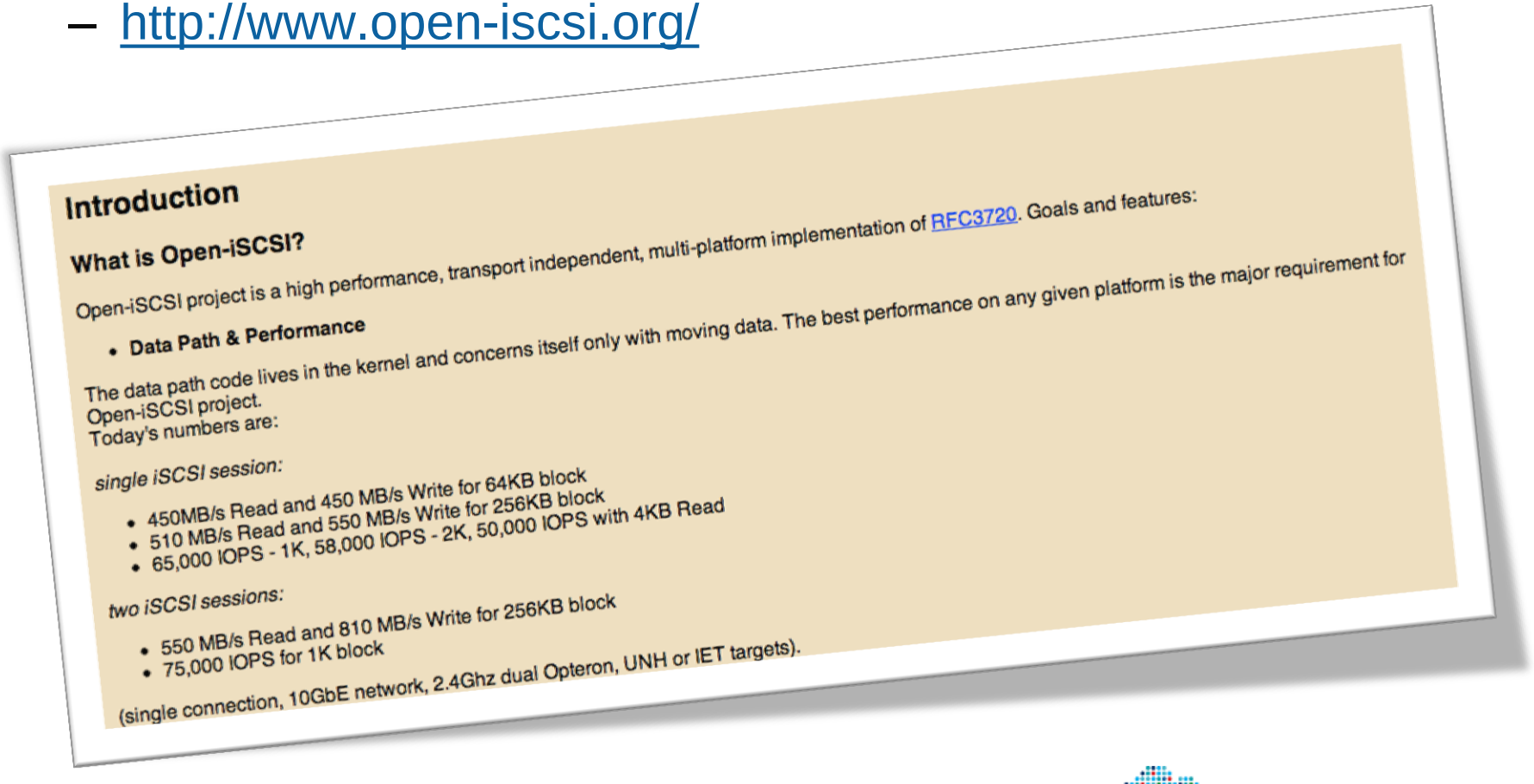
Chad Tilbury's Blog Post

Like many great inventions, the idea behind F-Response is so simple and elegant it is hard not to punish yourself for not thinking of it. Using the iSCSI protocol to provide read-only mounting of remote devices opens up a wealth of options for those of us working in geographically dispersed environments. I have used it for everything from remote imaging to fast forensic triage to live memory analysis. F-Response is vendor-neutral and tool independent, essentially opening up a network pipe to remote devices and allowing the freedom of using nearly any tool in your kit. The product is so good, I really wouldn't blame them for just sitting back and counting their money. Luckily, counting money gets boring fast, so instead the folks at F-Response have kept innovating and adding value. Their latest additions are new "Connector" tools: Database, Cloud, and Email.

REF: http://forensicmethods.com/fresponse-cloud-forensics

Idea

- Open-iSCSI
  - https://github.com/mikechristie/open-iscsi
  - http://www.open-iscsi.org/



Introduction

What is Open-iSCSI?

Open-iSCSI project is a high performance, transport independent, multi-platform implementation of RFC3720. Goals and features:

- **Data Path & Performance**

The data path code lives in the kernel and concerns itself only with moving data. The best performance on any given platform is the major requirement for Open-iSCSI project.
Today's numbers are:

single iSCSI session:

- 450MB/s Read and 450 MB/s Write for 64KB block
- 510 MB/s Read and 550 MB/s Write for 256KB block
- 65,000 IOPS - 1K, 58,000 IOPS - 2K, 50,000 IOPS with 4KB Read

two iSCSI sessions:

- 550 MB/s Read and 810 MB/s Write for 256KB block
- 75,000 IOPS for 1K block

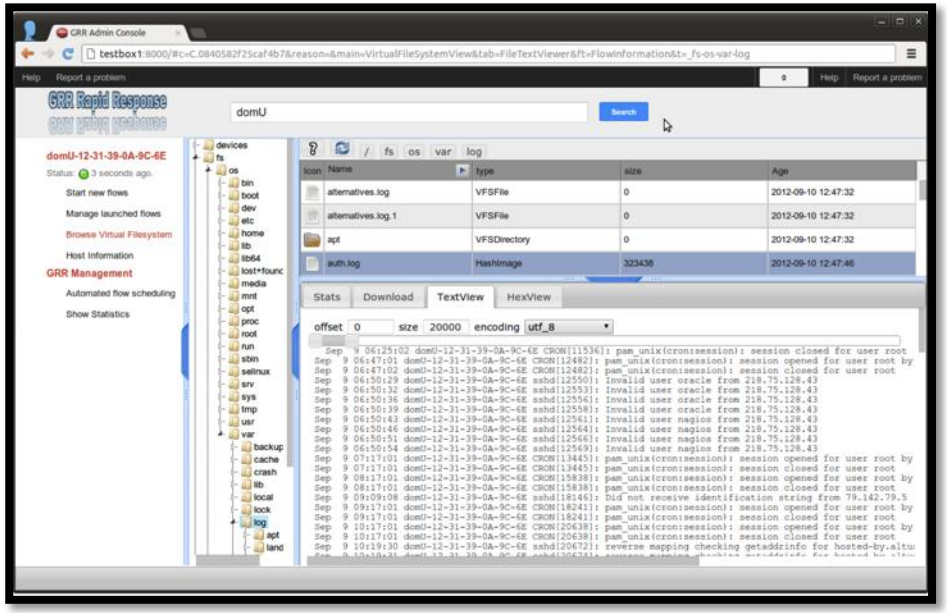
(single connection, 10GbE network, 2.4Ghz dual Opteron, UNH or IET targets).

New Tools Are Popping Up

- GRR
  - Incident Response Framework focused on Remote Live Forensics

Why GRR?

- Tell me if this machine is compromised
  - (while you're at it, check 20000 of them)
- Joe saw something weird, check his machine
  - (p.s. Joe is on holiday in Cambodia and on 3G)
- Why did a packet containing "fooooo" go from A to B?
  - (by the way, we're not sure what A was)
- Forensically acquire 25 machines for analysis
  - (p.s. they're in 5 continents and none are Windows)




```
# wget https://grr.googlecode.com/files/install_script_ubuntu_12.sh
# bash install_script_ubuntu_12.sh 2>&1 | tee grr_install.log
```

Source: Darren Bilby, Google – *GRR Rapid Response* – OSFC2012

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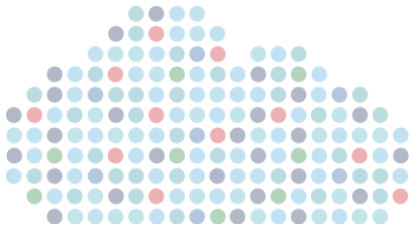
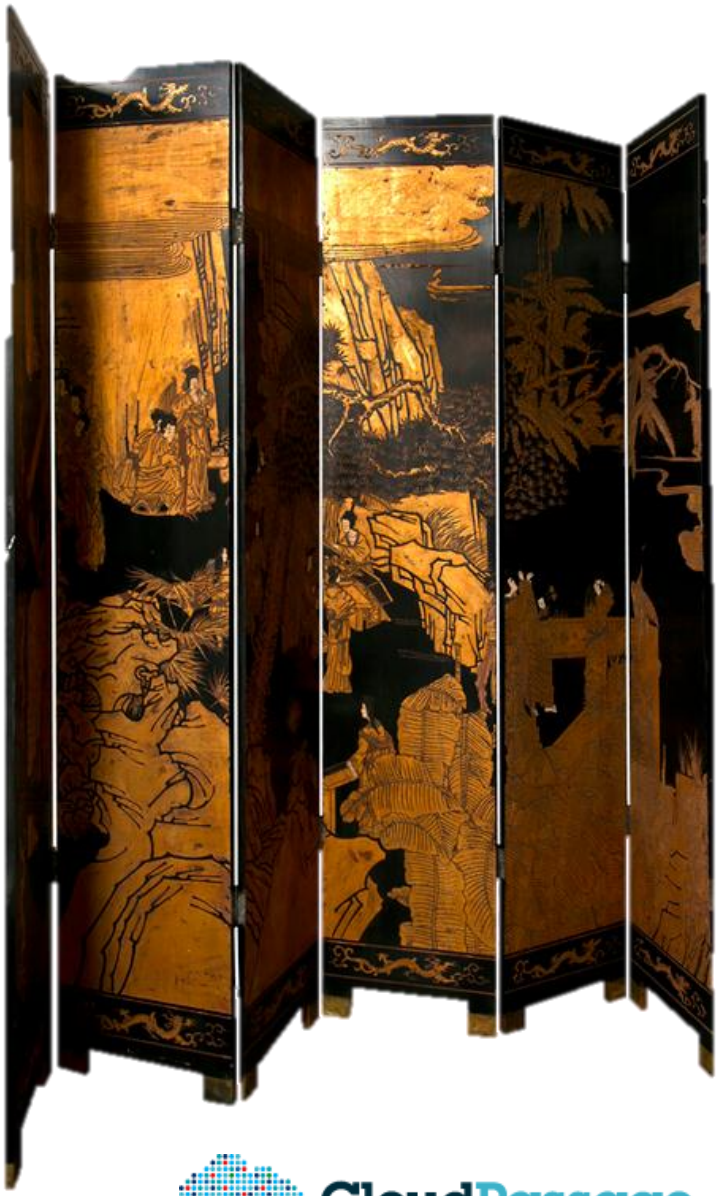
Cloud Instance Isolation with Coromandel



Introducing…Coromandel

- Designed to isolate an individual cloud server instance for analysis
- Investigated without fear of introducing additional artifacts not explicitly introduced by the responder and their tools
- https://github.com/andrewsmhay/coromandel

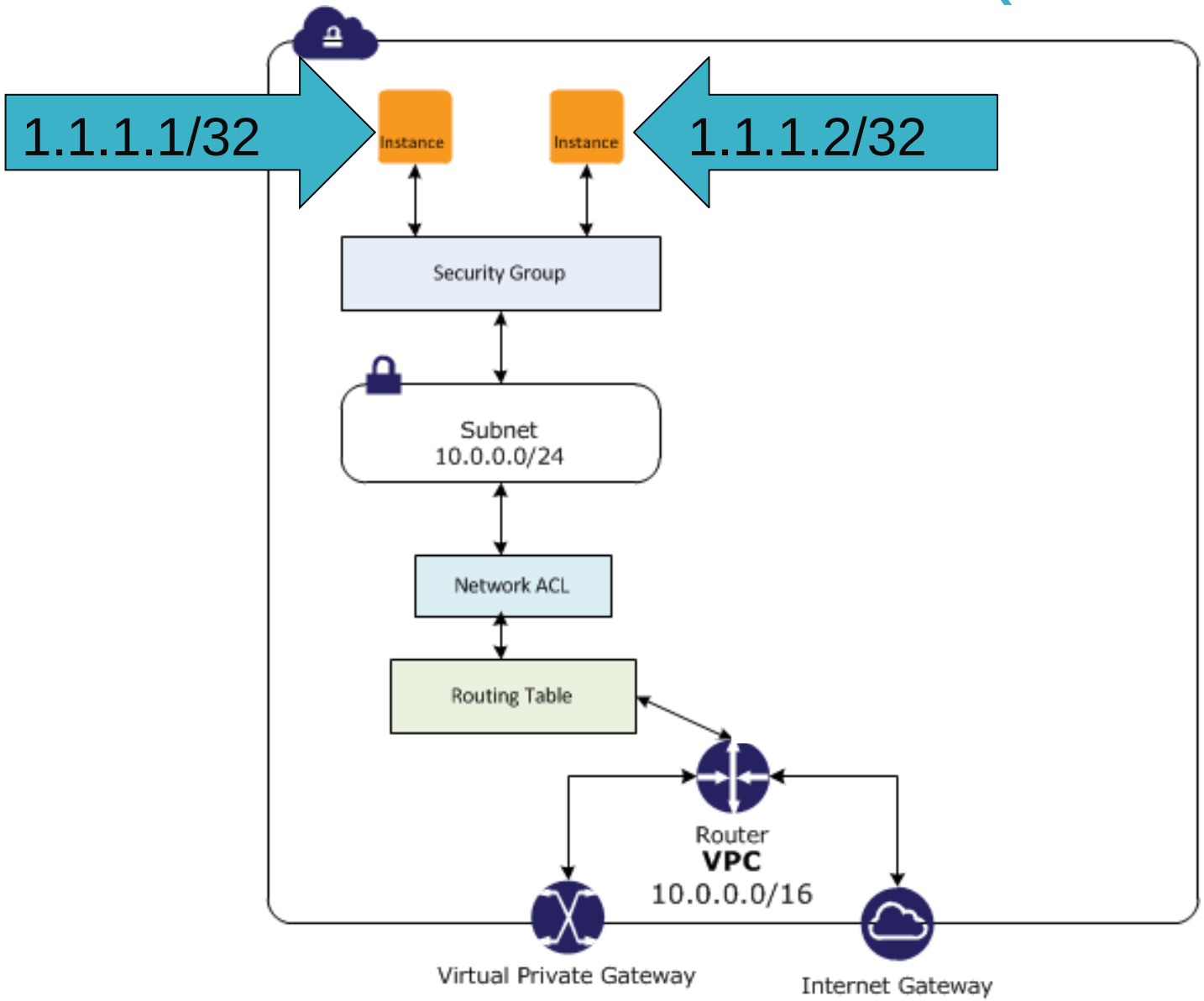


CloudPassage

Coromandel Caveats

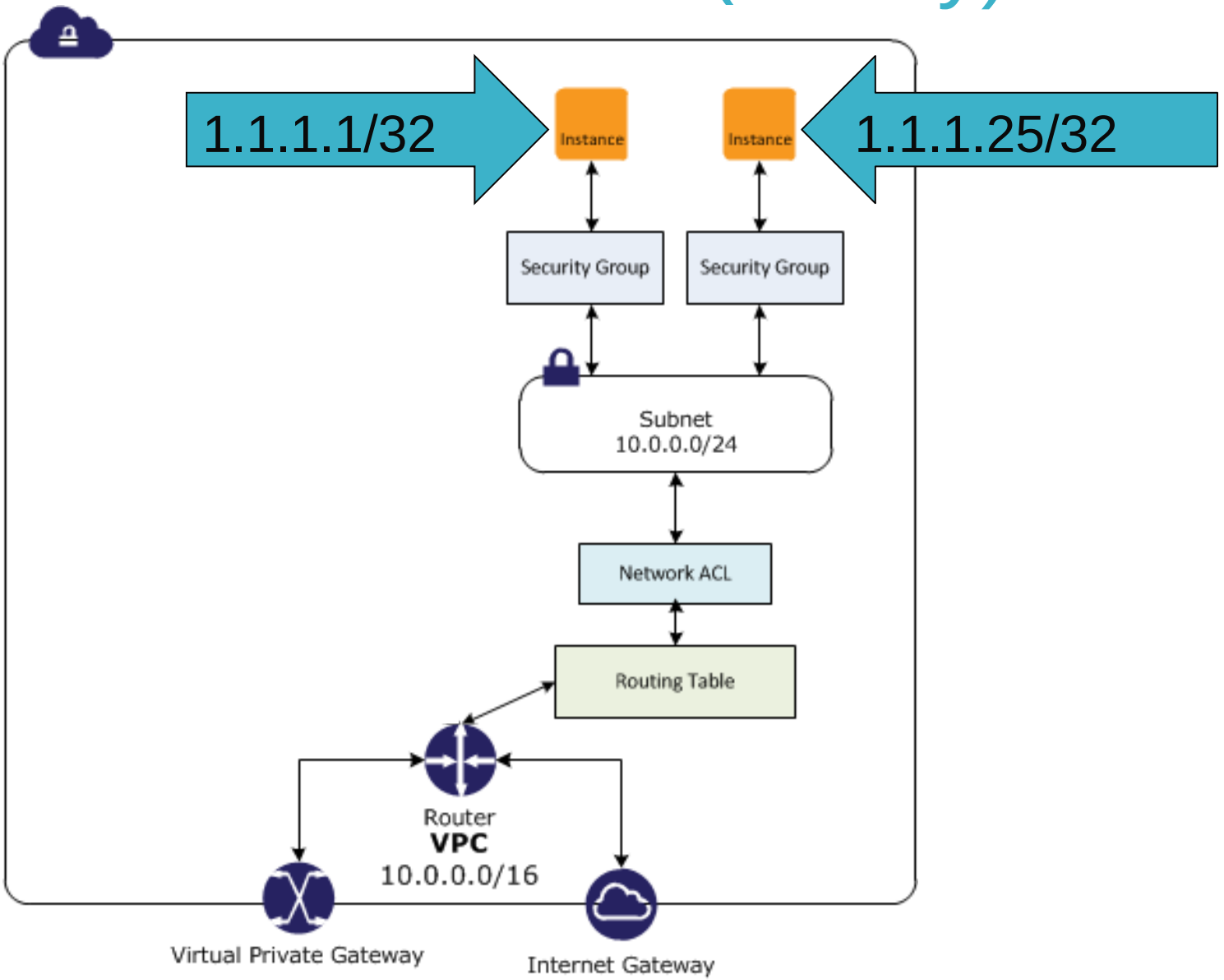
- Written (poorly) in Ruby
- Current version supports Amazon EC2 VPC security groups
- Isolates instances from Internet - but not from each other

How Coromandel Works (Today)



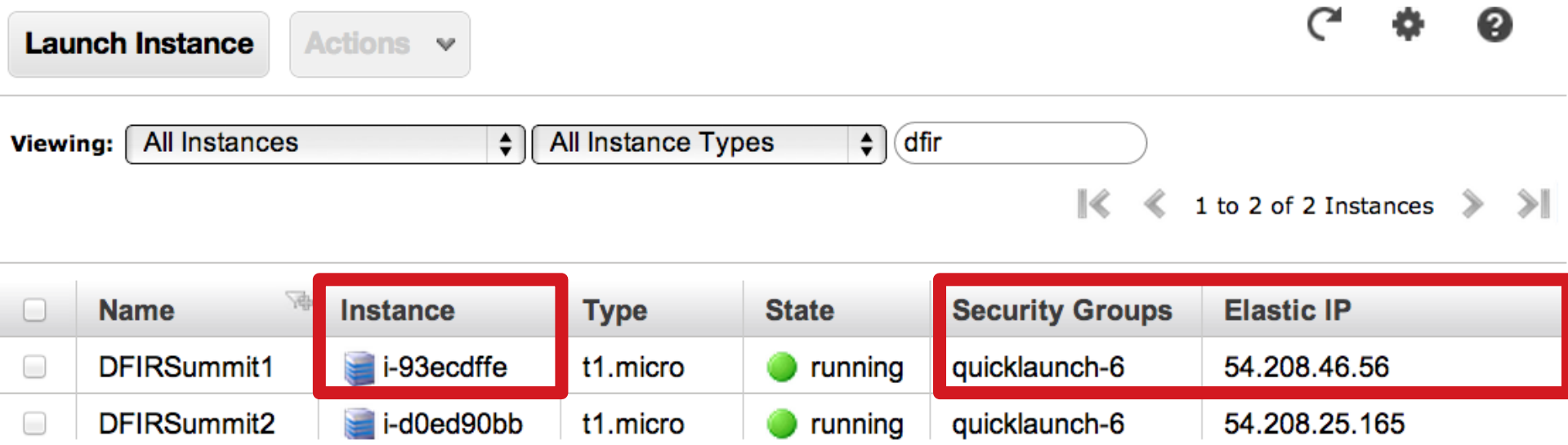
CloudPassage

How Coromandel Works (Today)



CloudPassage

Demo



CloudPassage

Demo

Security Group: quicklaunch-6

Details | **Inbound** | Outbound

TCP Port (Service)	Source	Action
22 (SSH)	0.0.0.0/0	Delete

Security Group: quicklaunch-6

Details | Inbound | **Outbound**

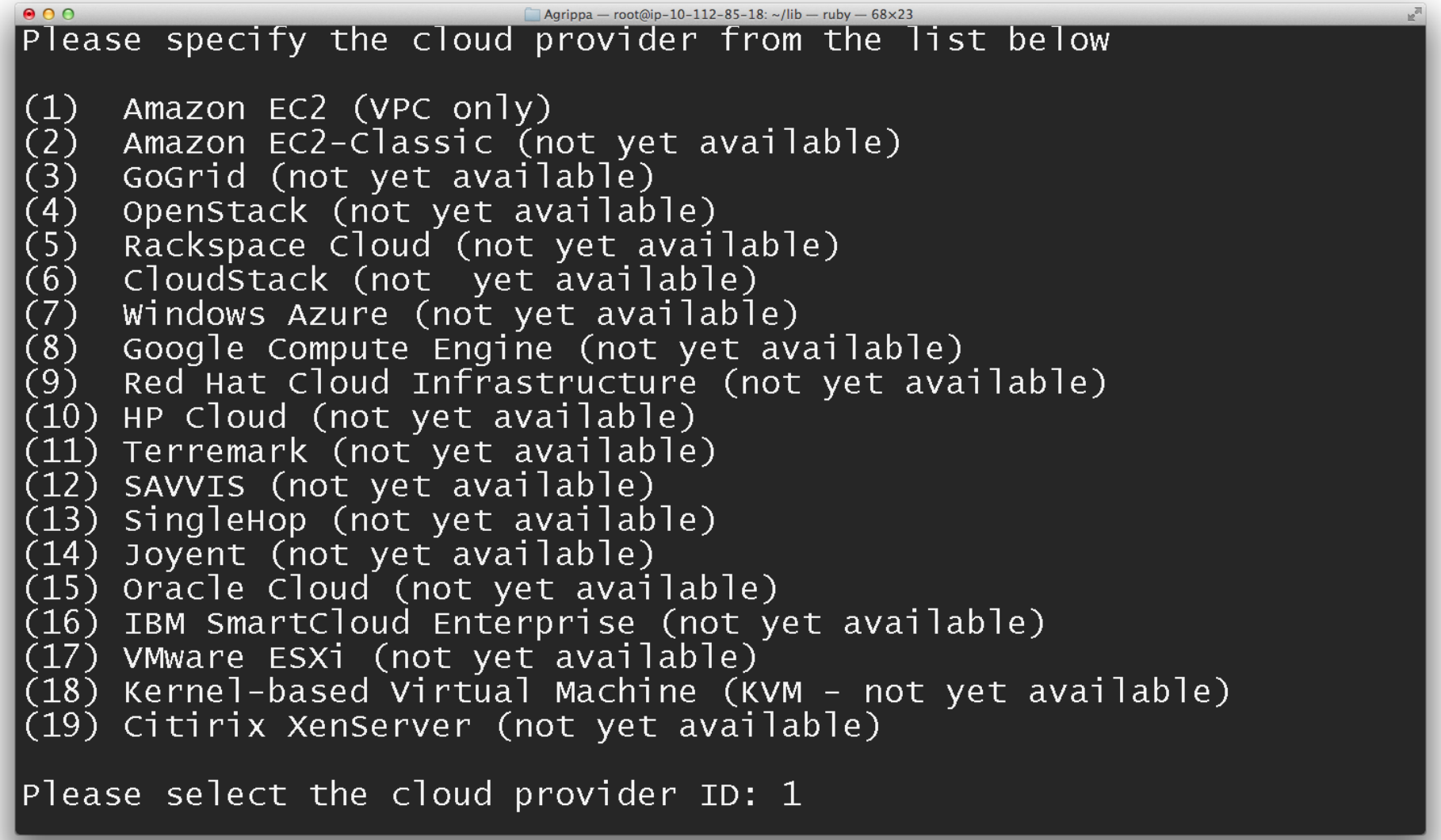
ALL Port (Service)	Destination	Action
ALL	0.0.0.0/0	Delete

CloudPassage

Demo

```
musquodoboit:Agrippa ahay$ ruby coromandel.rb
                                                  _       _
 ___ ___ ___ ___ ___ _____ ___ ___ ___ _| |___|_ |
|  _| . |  _| . |     |  .'|   |  .  |  -_| | |
|___|___|_| |___|_|_|_|__,|_|_|_____|___|_|_|

 Created by: Andrew Hay / @andrewsmhay
 http://github.com/coromandel
```

Demo



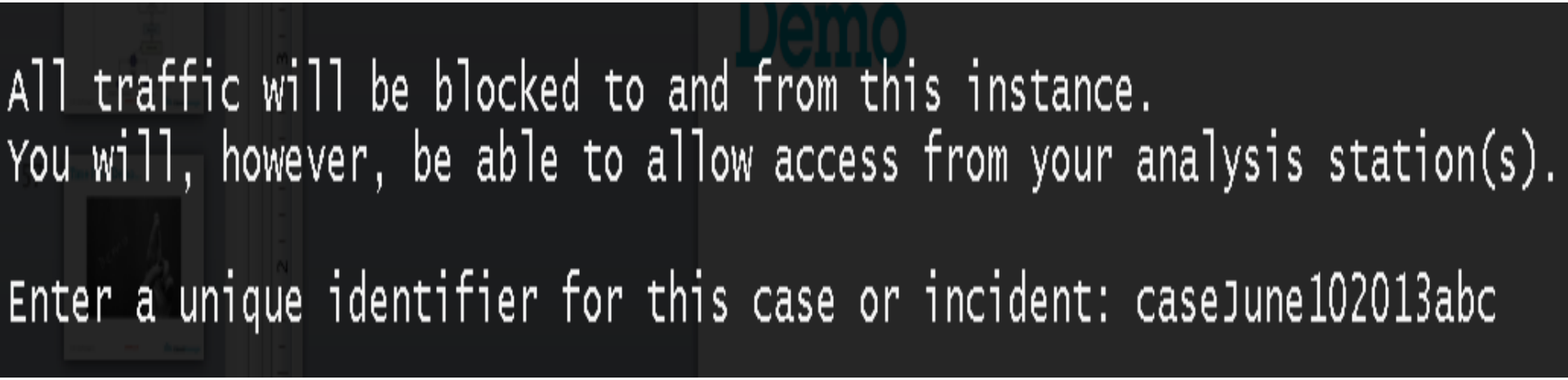
CloudPassage

Demo

```
You Selected Amazon EC2

   Instance    VPC ID        Public DNS                                  Public IP      Internal DNS
1) i-93ecdffe  vpc-15b72f7a  ec2-54-208-46-56.compute-1.amazonaws.com    54.208.46.56   ip-192-168-222-135.ec2.internal
2) i-d0ed90bb  vpc-15b72f7a  ec2-54-208-25-165.compute-1.amazonaws.com   54.208.25.165  ip-192-168-222-224.ec2.internal

Please select the number of the instance to isolate: 1

All traffic will be blocked to and from this instance.
You will, however, be able to allow access from your analysis station(s).

Enter a unique identifier for this case or incident: caseJune102013abc


Enter the IP address(es) of your analysis station(s) (e.g. 1.2.3.4, 5.6.7.8, etc.): 204.11.55.6

Which TCP port(s) do you wish to open (e.g. 80, 22, etc.): 22, 443, 5555

Allow ICMP from analyst station to the target? [Y/N]: Y
```


CloudPassage

Demo



CloudPassage

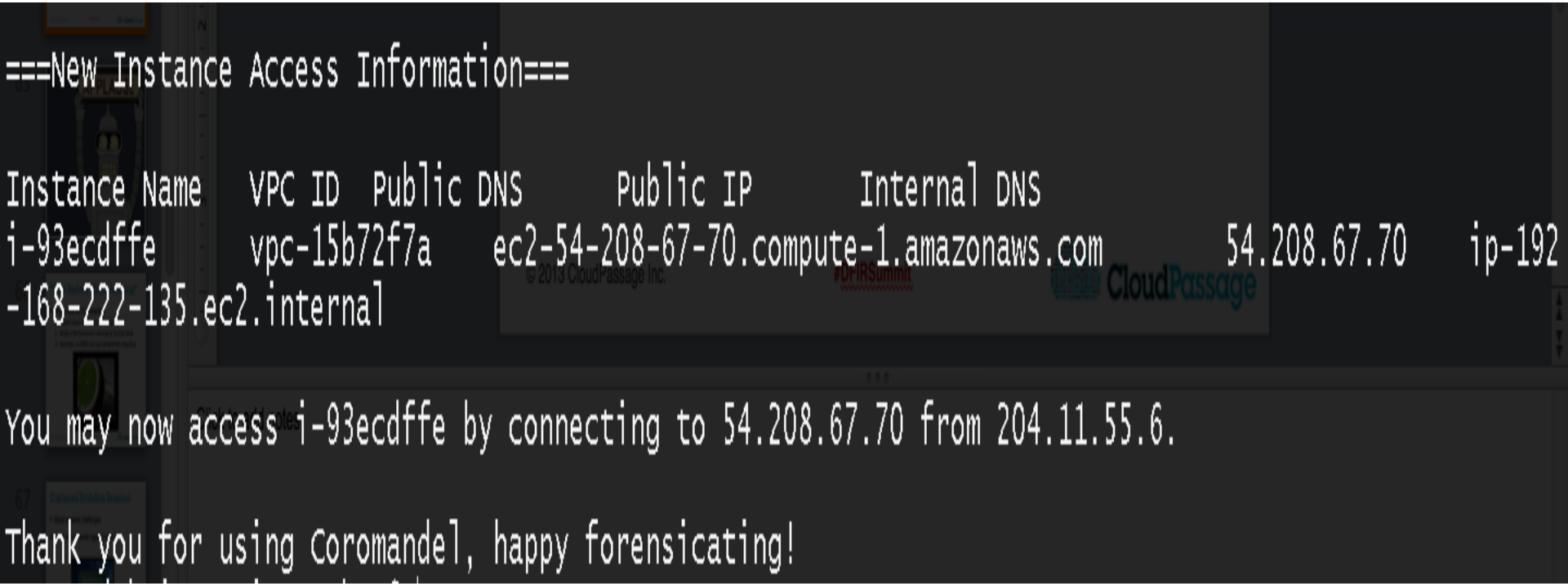
Demo

```
Enter the IP address(es) of your analysis station(s) (e.g. 1.2.3.4, 5.6.7.8, etc.): 204.11.55.6

Which TCP port(s) do you wish to open (e.g. 80, 22, etc.): 22, 443, 5555

Allow ICMP from analyst station to the target? [Y/N]: Y
```

```
===caseJune102013abc===
204.11.55.6 will be allowed to communicate with i-93ecdffe on ports 22, 443, 5555.
```

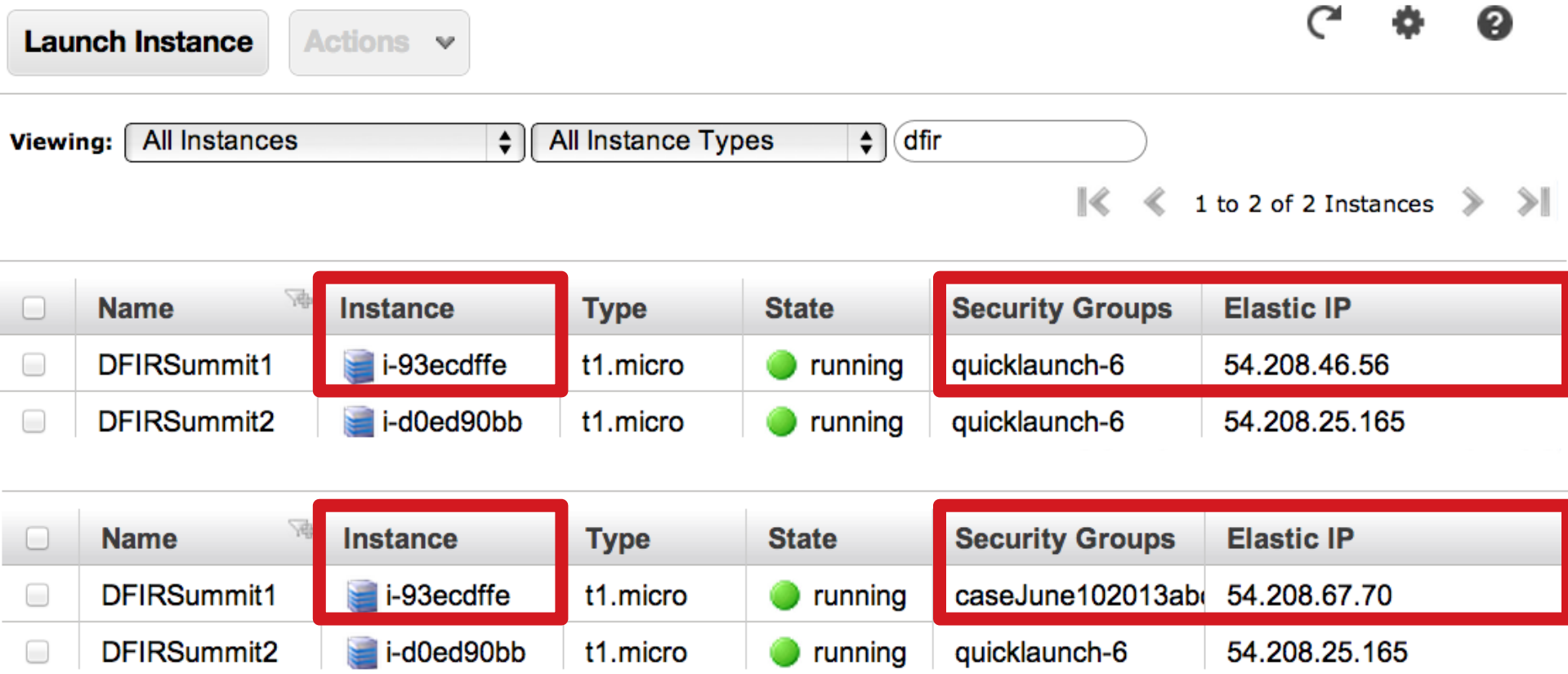

CloudPassage

Demo



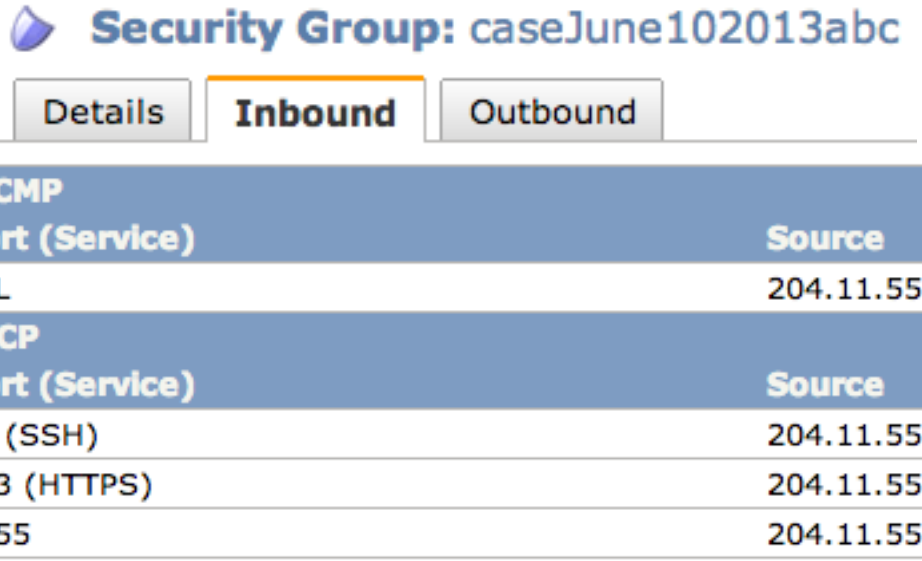
CloudPassage

Demo



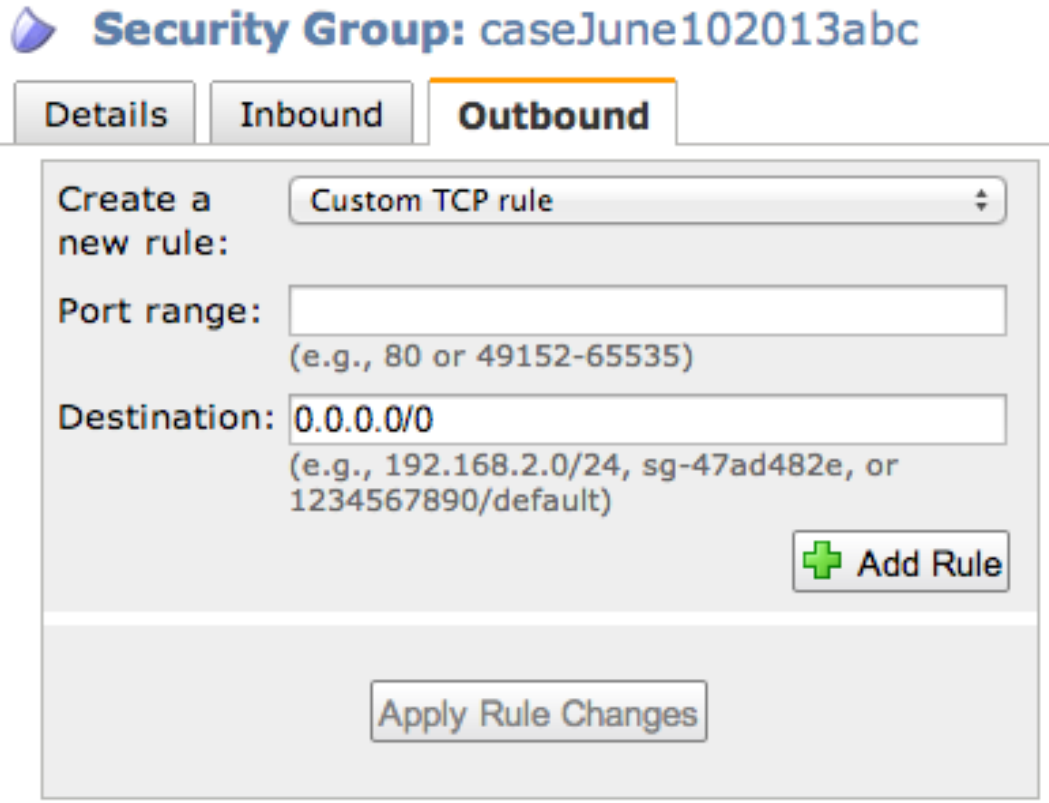
CloudPassage

Demo

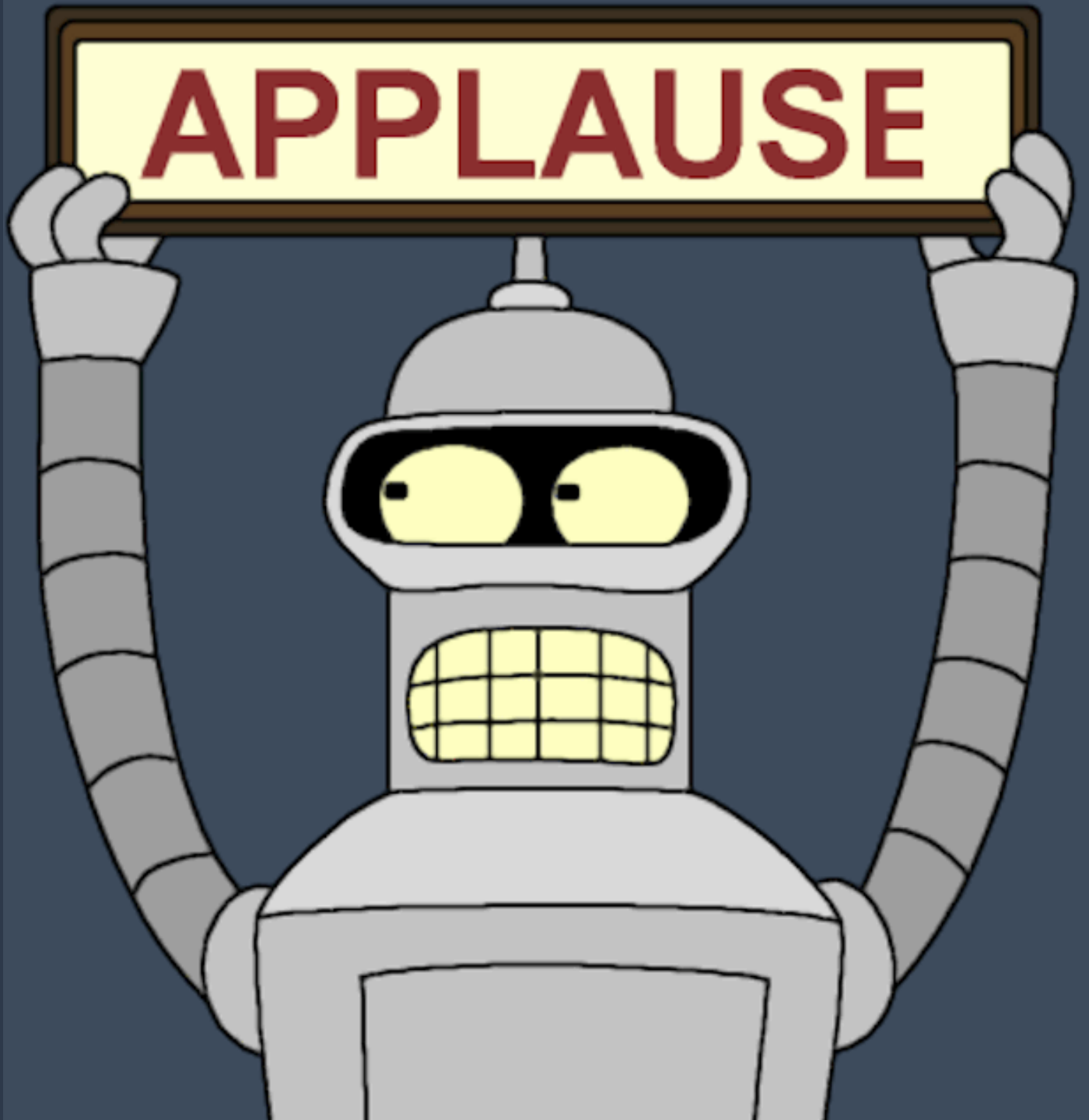


CloudPassage

Demo

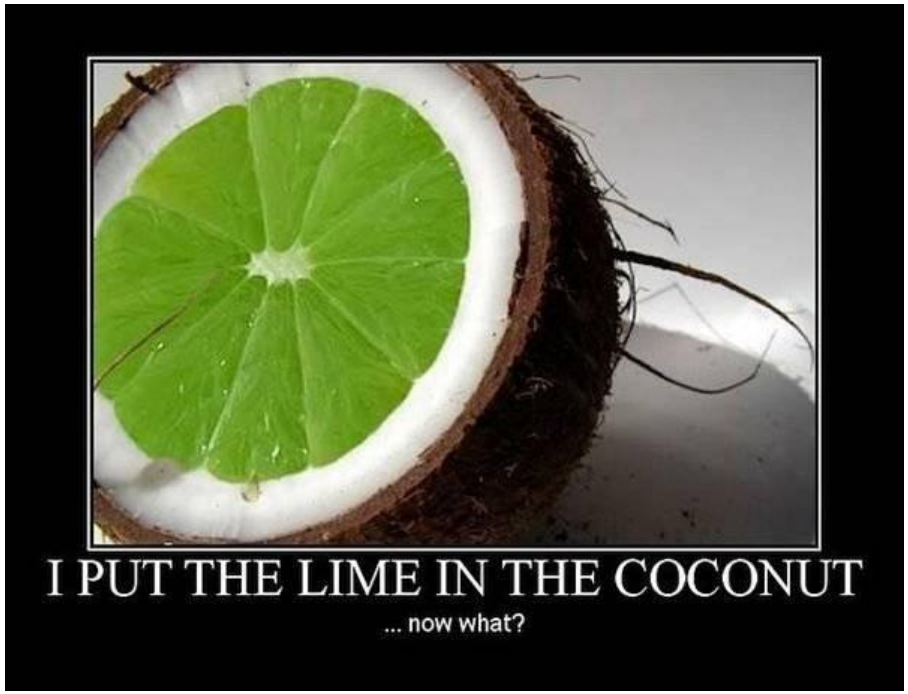


CloudPassage



“Wow Andrew, That’s Amazing!”

- What’s next for Coromandel?
  1. Expand cloud service provider support
  2. Isolate individual server instances at the host level
  3. Automate via SIEM and log management integration



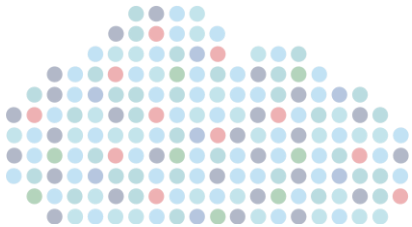
CloudPassage

Continued Evolution Required

- Cloud presents challenges
- Cloud also presents opportunities

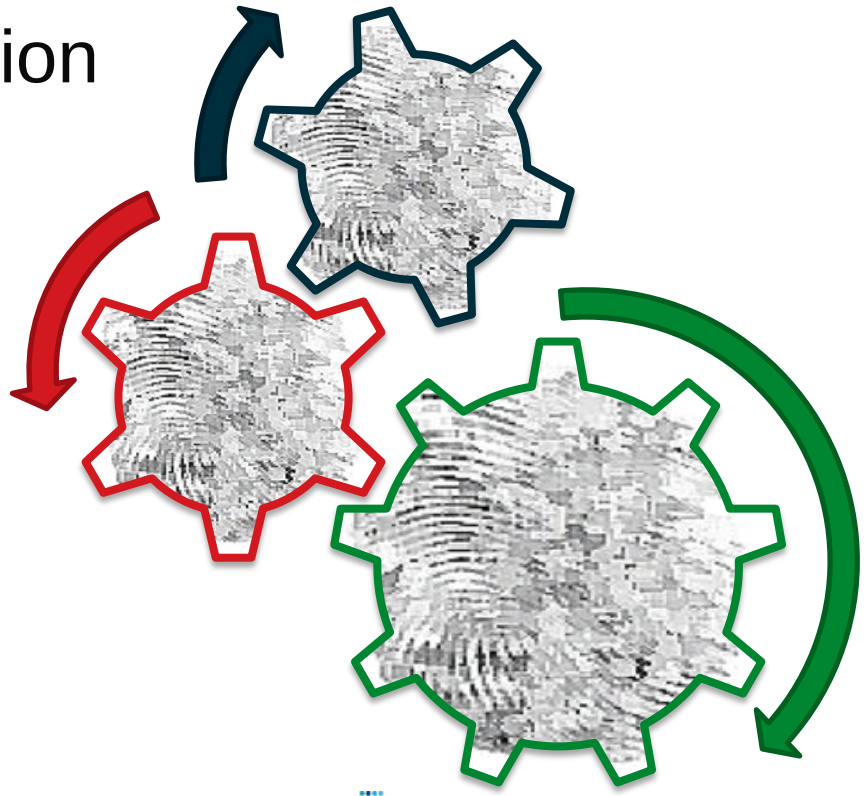
CloudPassage

Advantages Of Conducting Forensics/IR In Cloud Environments



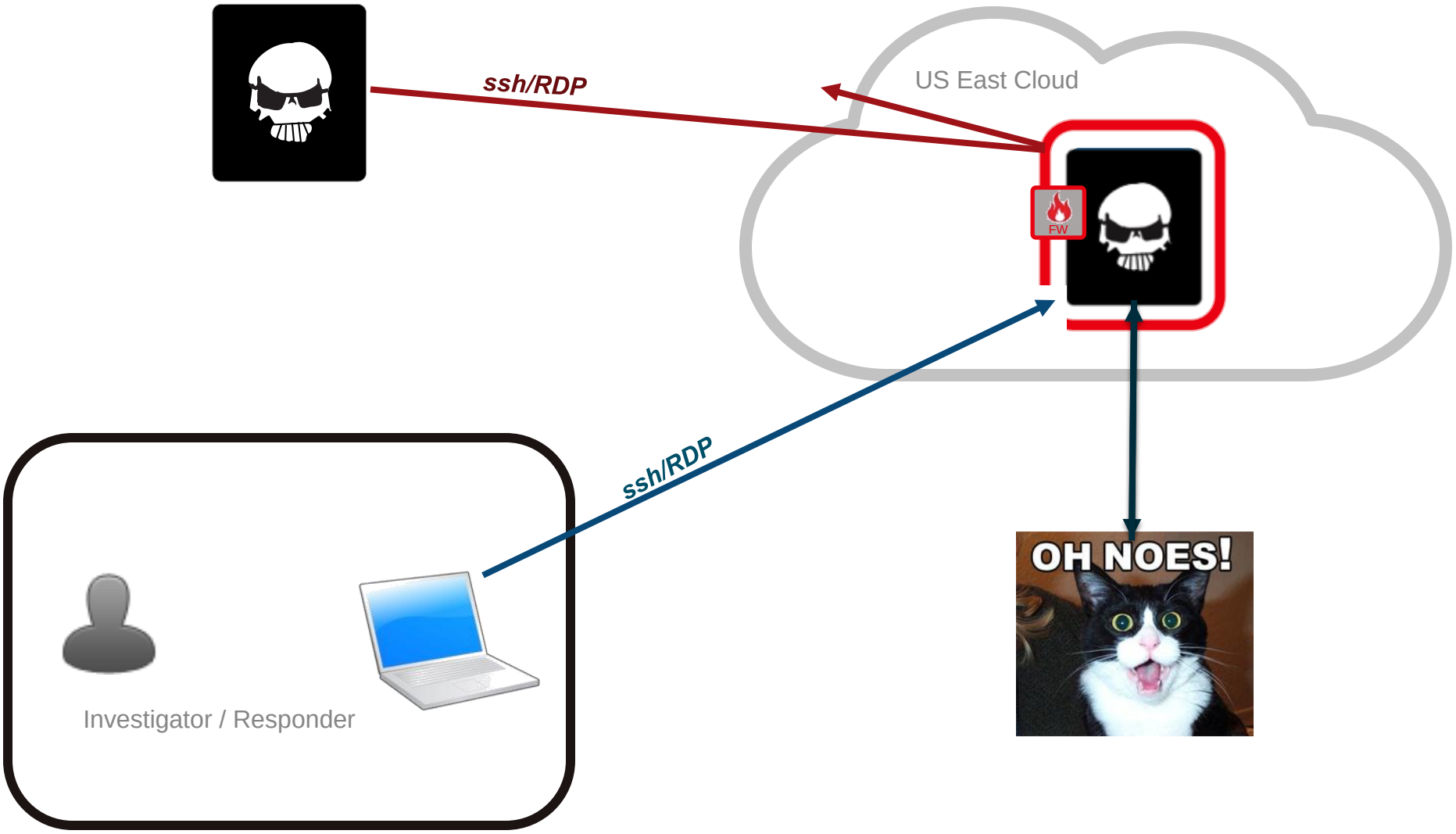
Advantages (now and future)

- Automated instance isolation
- On-demand forensic workbenches
- Automated timeline generation
- Dynamic analysis ‘workers’
- Distributed file carving
- Multi-cloud analysis



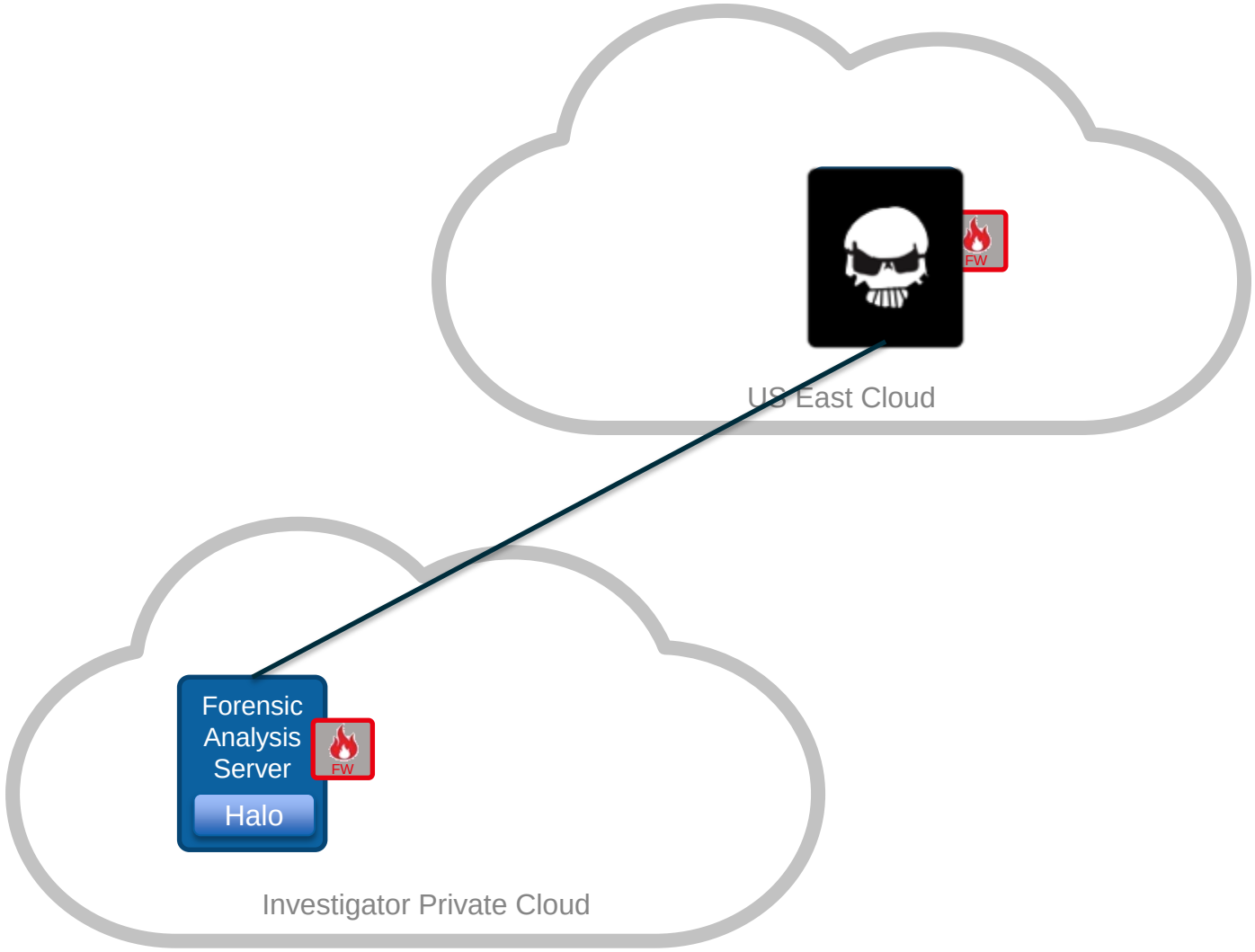
CloudPassage

Automated Instance Isolation



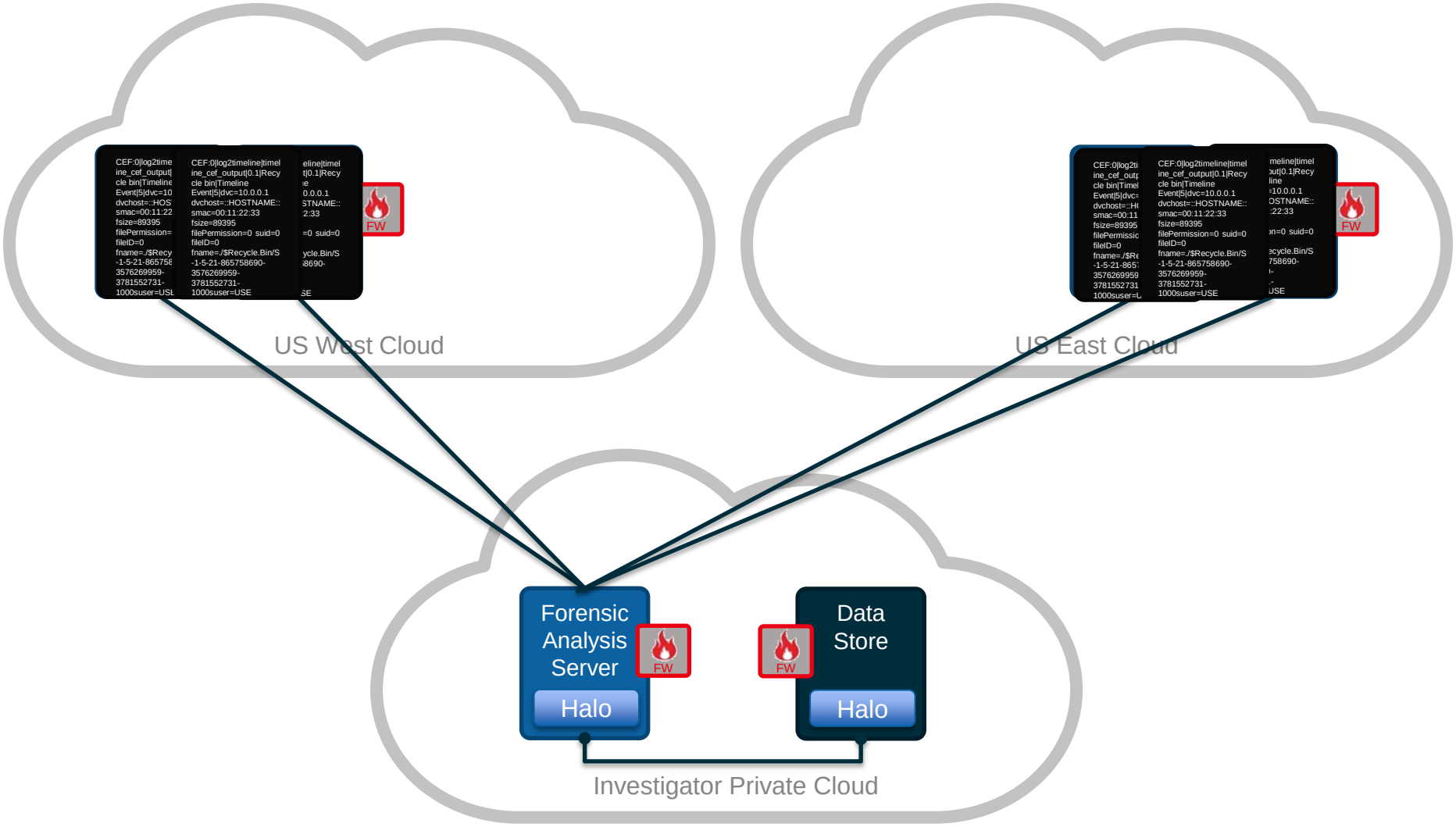
CloudPassage

On-demand Forensic Workbenches



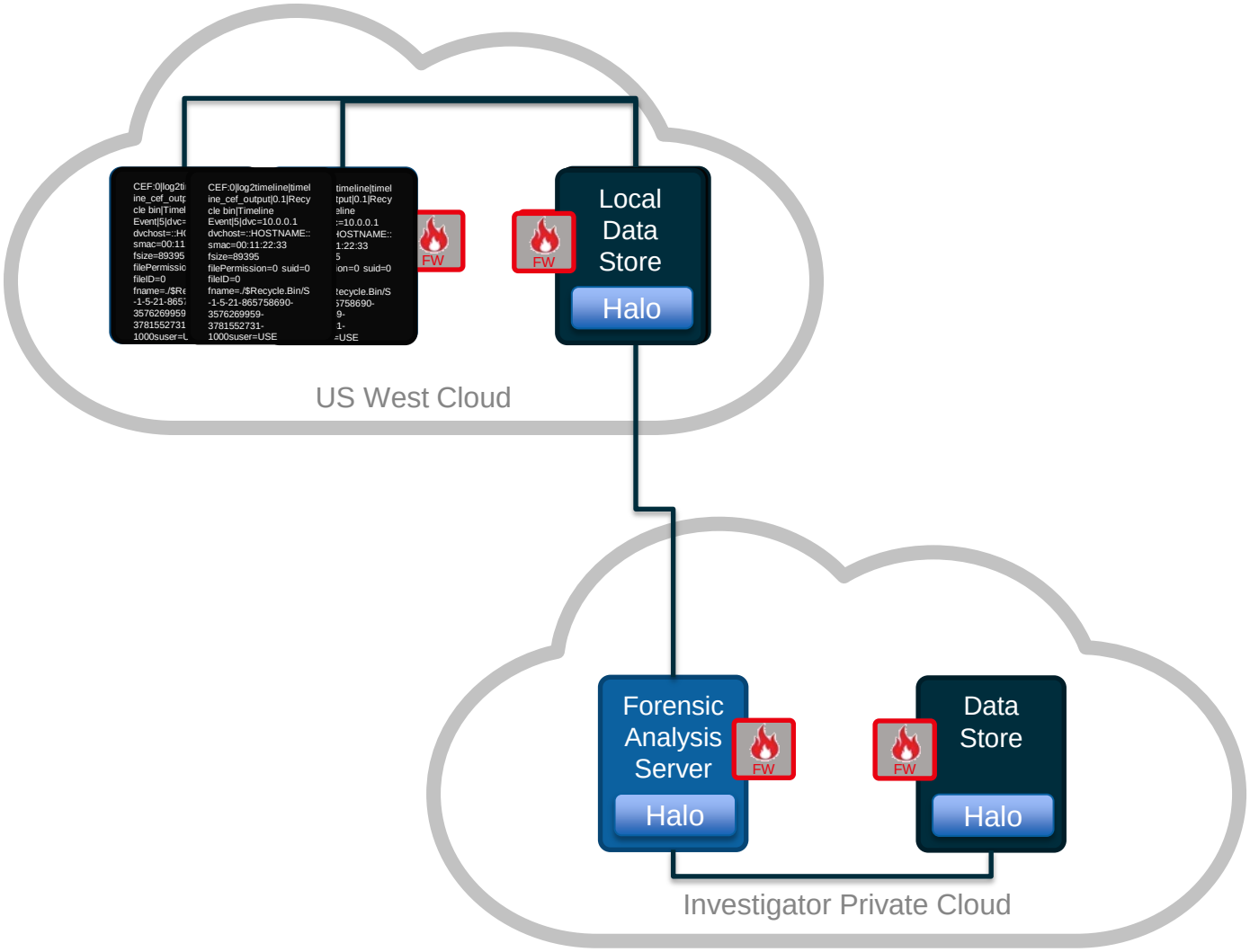
CloudPassage

Automated Timeline Generation



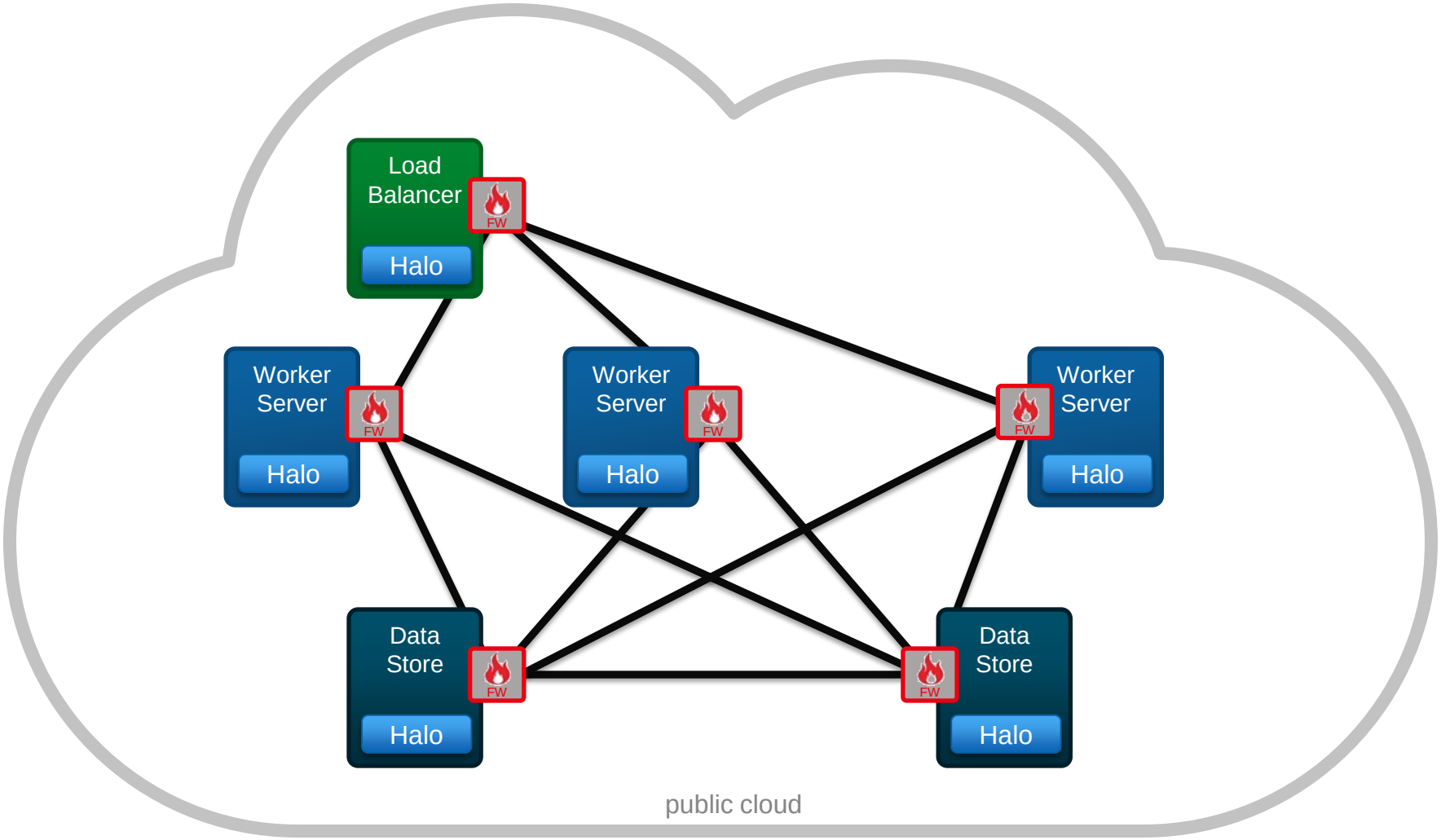
CloudPassage

Automated Timeline Generation



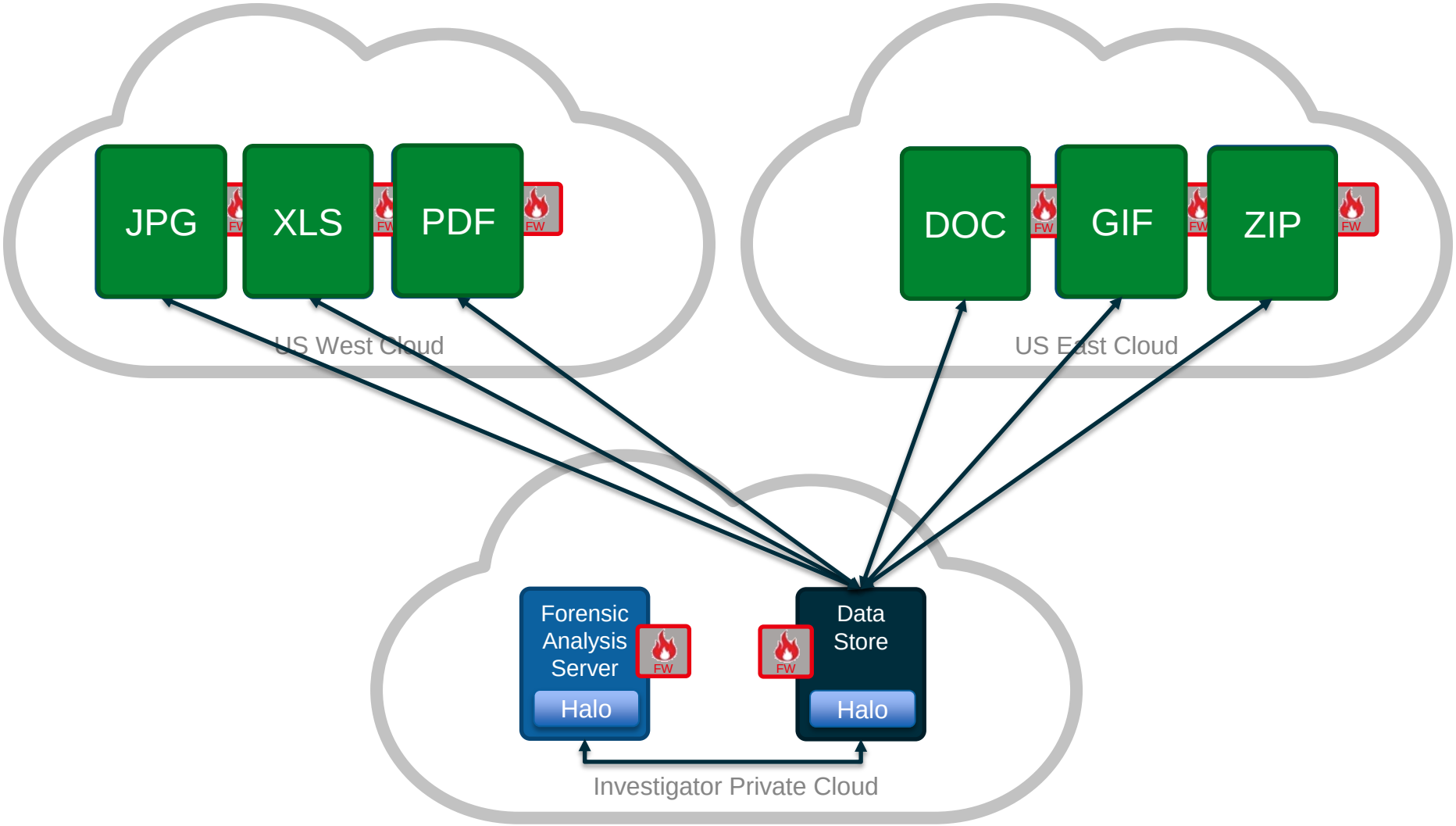
CloudPassage

Dynamic Analysis ‘Workers’



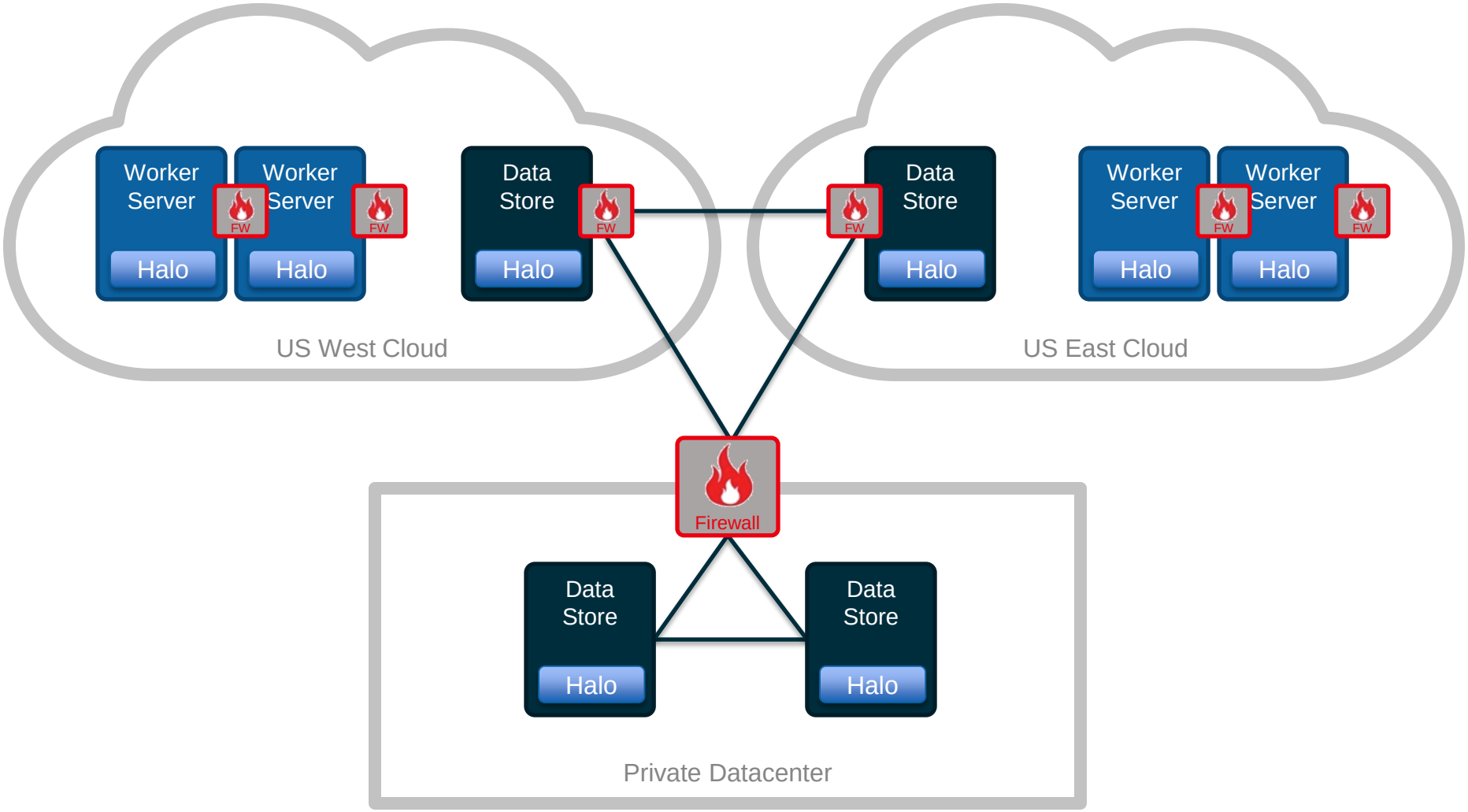
CloudPassage

Distributed File Carving



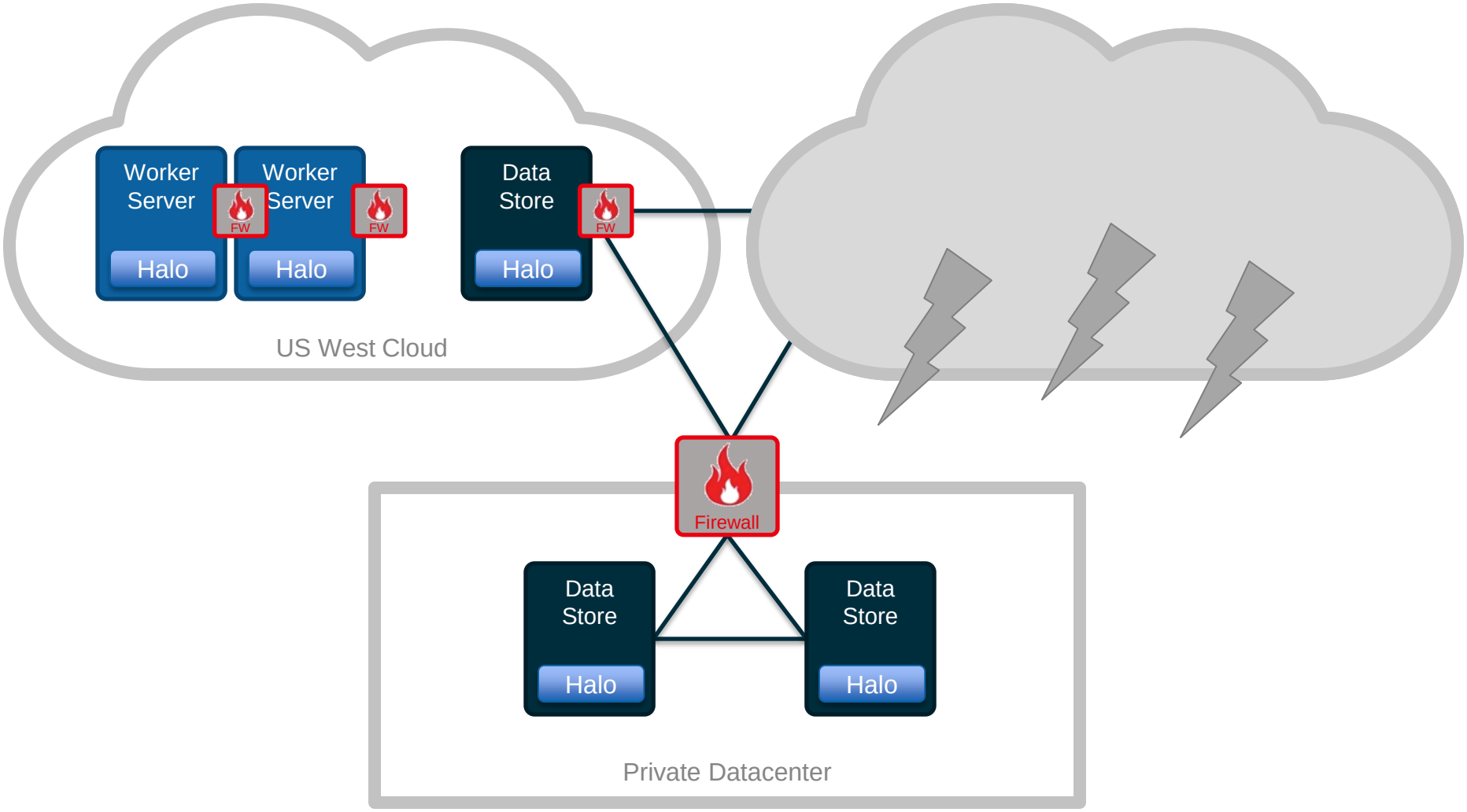
CloudPassage

Multi-Cloud Analysis Servers



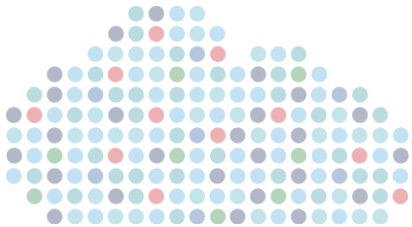
CloudPassage

Multi-Cloud Analysis Servers



CloudPassage

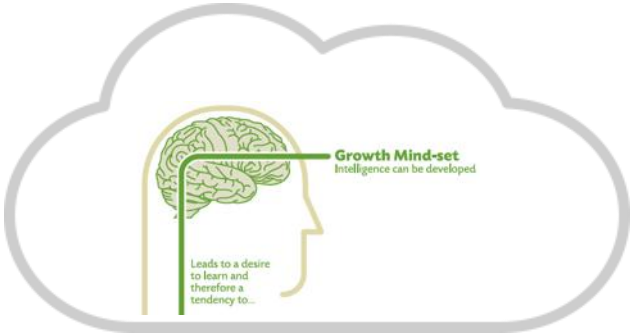
Summary



More Information

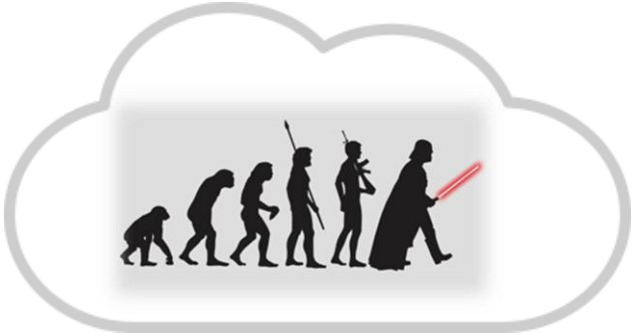
- NIST Special Publication 800-86 - Guide to Integrating Forensic Techniques into Incident Response
  - http://csrc.nist.gov/publications/nistpubs/800-86/SP800-86.pdf
- NIST Cloud Computing Forensic Science Working Group (NCC-FSWG)
  - http://collaborate.nist.gov/twiki-cloud-computing/bin/view/CloudComputing/CloudForensics
- Cloud Forensics Bibliography
  - http://www.forensicswiki.org/wiki/Cloud_Forensics_Bibliography
- https://github.com/andrewsmhay/resources

Summary



Cloud forensics and incident response require an open mind

Cloud can be used to help with complex investigations



Tools need to evolve to better handle dynamic environments

CloudPassage

Thank You

Questions?

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http://blog.cloudpassage.com/author/ahay/