

Security and Privacy in Cloud Computing

Ragib Hasan
Johns Hopkins University
en.600.412 Spring 2010

Lecture 3
02/15/2010

Mapping/topology Attacks

Lecture Goal

- Learn about mapping attacks
- Discuss different techniques and mitigation strategies
- Analyze the practicality and impact

Reading:

Hey, You, Get Off of My Cloud: Exploring Information Leakage in Third-Party Compute Clouds, Ristenpart et al., CCS 2009

Why Cloud Computing brings new threats?

Traditional system security mostly means keeping bad guys out

The attacker needs to either compromise the auth/access control system, or impersonate existing users

Why Cloud Computing brings new threats?

But clouds allow **co-tenancy** :

Multiple independent users share the same physical infrastructure

So, an attacker can legitimately be in the same physical machine as the target

Challenges for the attacker

How to find out **where** the target is located

How to be **co-located** with the target in the same (physical) machine

How to gather information about the target

Hey, You, Get Off of My Cloud: Exploring Information Leakage in Third-Party Compute Clouds, Ristenpart et al., CCS 2009

- First work on cloud cartography
- Attack launched against commercially available "real" cloud (Amazon EC2)
- Claims up to 40% success in co-residence with target VM

Strategy

- Map the cloud infrastructure to find where the target is located
- Use various heuristics to determine co-residency of two VMs
- Launch probe VMs trying to be co-resident with target VMs
- Exploit cross-VM leakage to gather info about target

Threat model

Attacker model

- Cloud infrastructure provider is trustworthy
- Cloud insiders are trustworthy
- Attacker is a malicious third party who can legitimately the cloud provider as a client

Assets

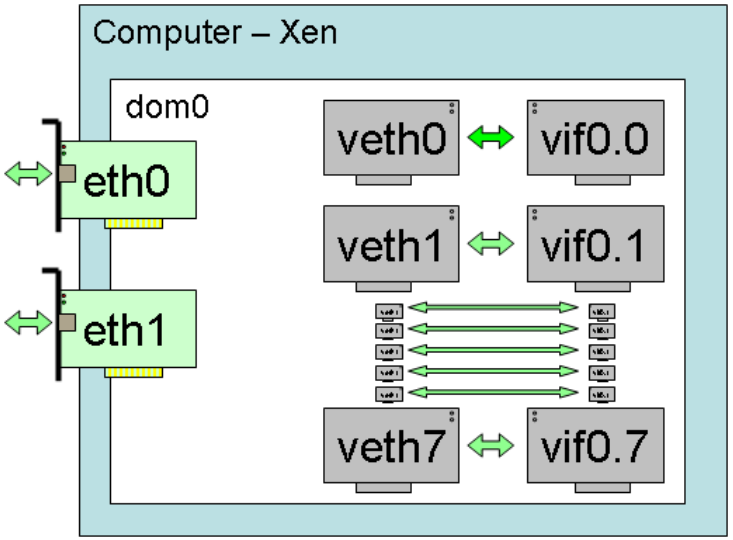
- Confidentiality aware services run on cloud
- Availability of services run on cloud

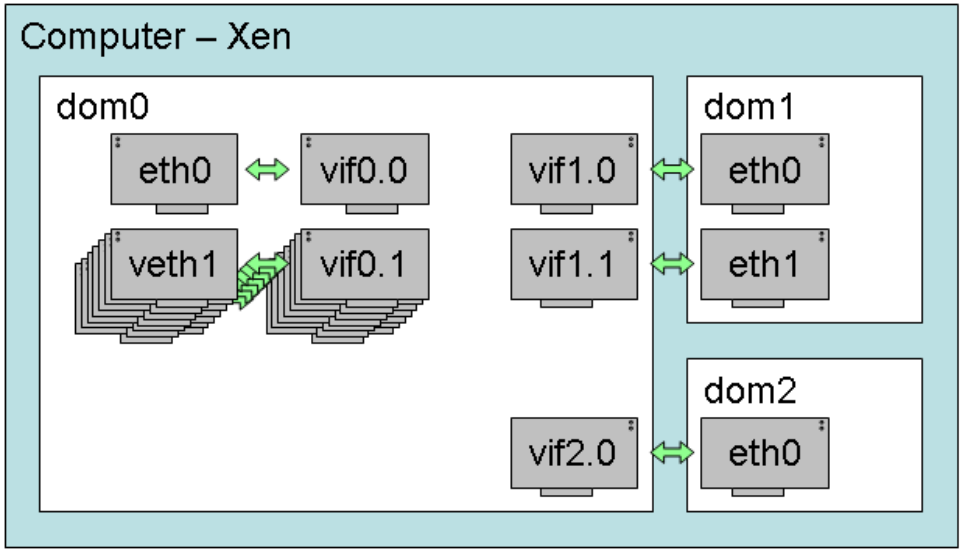
Tools of the trade

- Nmap, hping, wget for network probing
- Amazon EC2's own DNS to map dns names to IPs

Sidenote: EC2 configuration

EC2 uses **Xen**, with up to 8 instances per physical machine



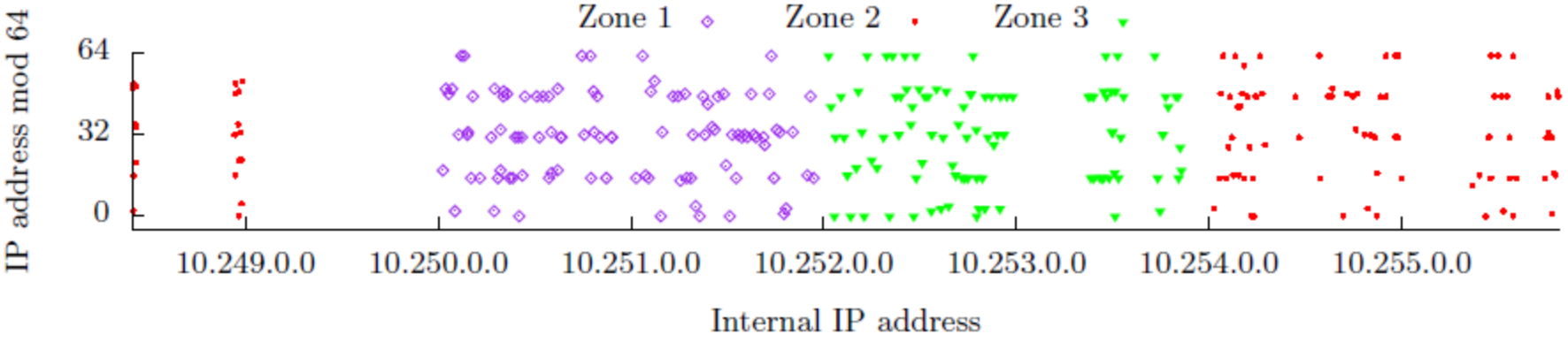


Dom0 is the first instance on the machine, connected to physical adapter

All other instances route to external world via dom0

[Figures from Xen Wiki]

Task 1: Mapping the cloud



Different availability zones use different IP regions.

Each instance has one internal IP and one external IP. Both are static.

For example:

External IP: *75.101.210.100*

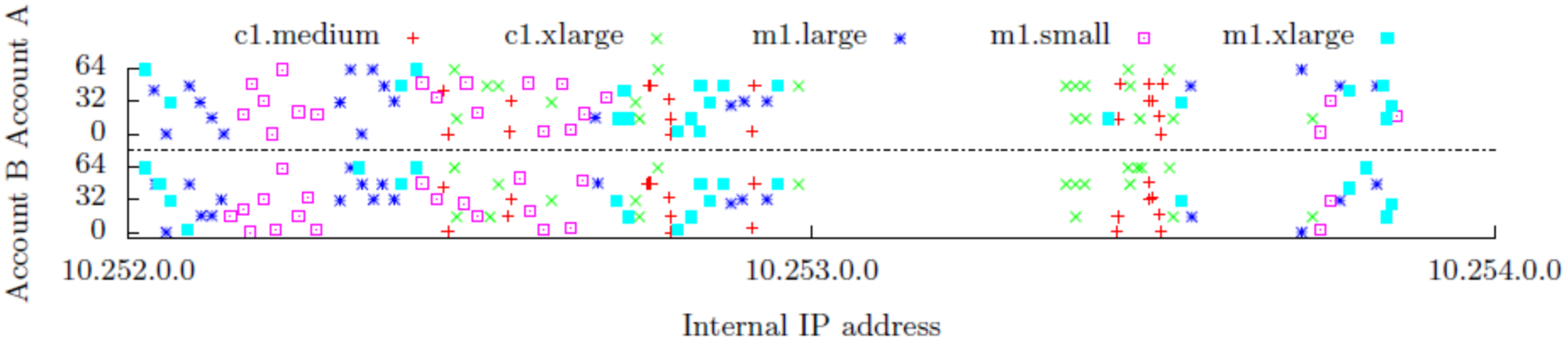
External Name: *ec2-75-101-210-100.computer-1.amazonaws.com*

Internal IP: *10.252.146.52*

Internal Name: *domU-12-31-38-00-8D-C6.computer-1.internal*

Reverse engineering the VM placement schemes provides useful heuristics about EC2's strategy

Task 1: Mapping the Cloud



Finding: same instance type within the same zone = similar IP regions

Reverse engineered mapping decision heuristic:

A /24 inherits any included sampled instance type.

A /24 containing a Dom0 IP address only contains Dom0 IP address.

All /24's between two consecutive Dom0 /24's inherit the former's associated type.

Task #2: Determining co-residence

- **Co-residence**: Check to determine if a given VM is placed in the same physical machine as another VM

- Network based check:
  - Match Dom0 IP addresses, check packet RTT, close IP addresses (within 7, since each machine has 8 VMs at most)
  - Traceroute provides Dom0 of target
  - No false positives found during experiments

Task #3: Making a probe VM co-resident with target VM

Brute force scheme

- **Idea**: figure out target's availability zone and type
- Launch many probe instances in the same area

- Success rate: 8.4%

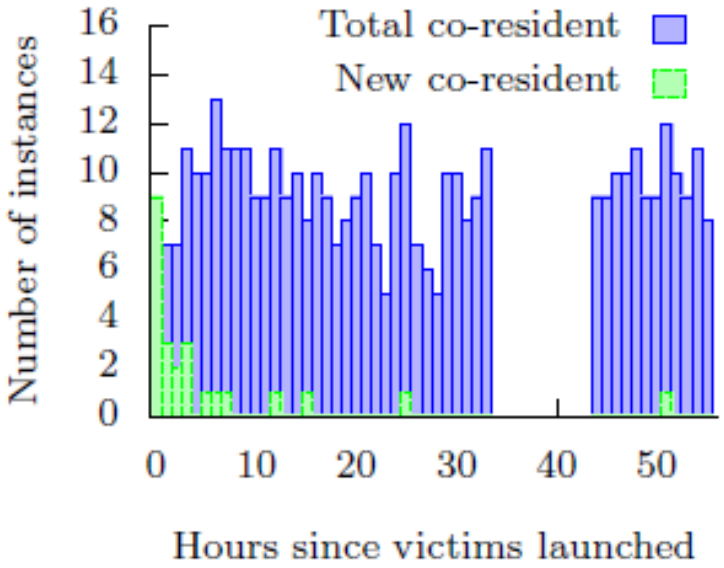
Task #3: Making a probe VM co-resident with target VM

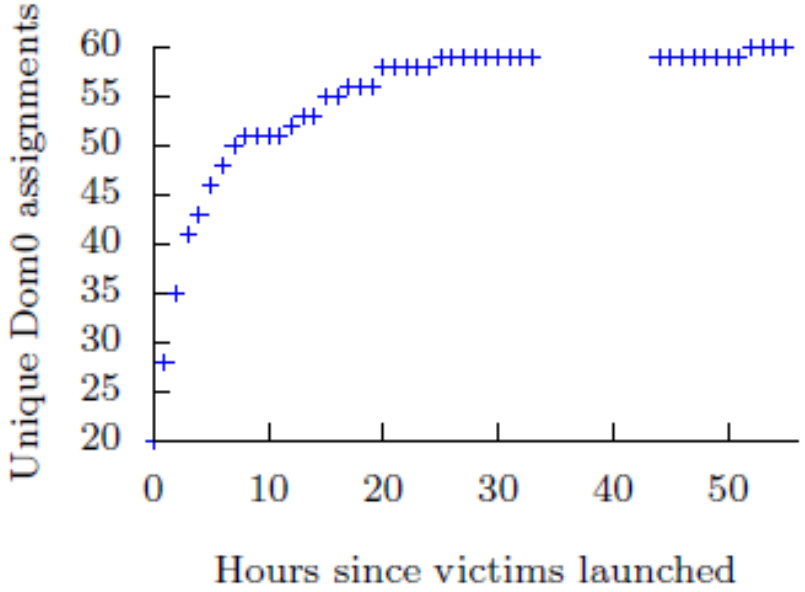
Smarter strategy: utilize locality

- **Idea**: VM instances launched right after target are likely to be co-resident with the target

- Paper claims 40% success rate

Task #3: Making a probe VM co-resident with target VM





Window of opportunity is quite large, measured in days

Task #4: Gather leaked information

Now that the VM is co-resident with target, what can it do?

- Gather information via side channels
- Perform DoS

Task 4.1: Gathering information

If VM's are separated and secure, the **best** the attacker can do is to gather information

- Measure latency of cache loads
- Use that to determine
  - Co-residence
  - Traffic rates
  - Keystroke timing

Mitigation strategies #1: Mapping

- Use a randomized scheme to allocate IP addresses

- Block some tools (nmap, traceroute)

Mitigation strategies #2: Co-residence checks

- Prevent traceroute (i.e., prevent identification of dom0)

Mitigation strategies #3: Co-location

- Not allow co-residence at all
  - Beneficial for cloud user
  - Not efficient for cloud provider

Mitigation strategies #4: Information leakage

- Prevent cache load attacks?

Discussion

- How is the problem different from other attacks?
- What's so special about clouds?

Discussion

Cons

- Are the side channels *really* effective?

Further Reading

Amazon downplays report highlighting vulnerabilities in its cloud service

Hypothetical example described in report much harder to pull off in reality, company says
TechWorld, Oct 29, 2009. http://bit.ly/dvxEZp