Virtual Machine co-location attacks *

* Based on Slides from Prof. Hassan

http://www.cs.jhu.edu/~ragib/sp10/cs412/lectures/600.412.lecture03.pptx

And

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

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

Overview

- 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

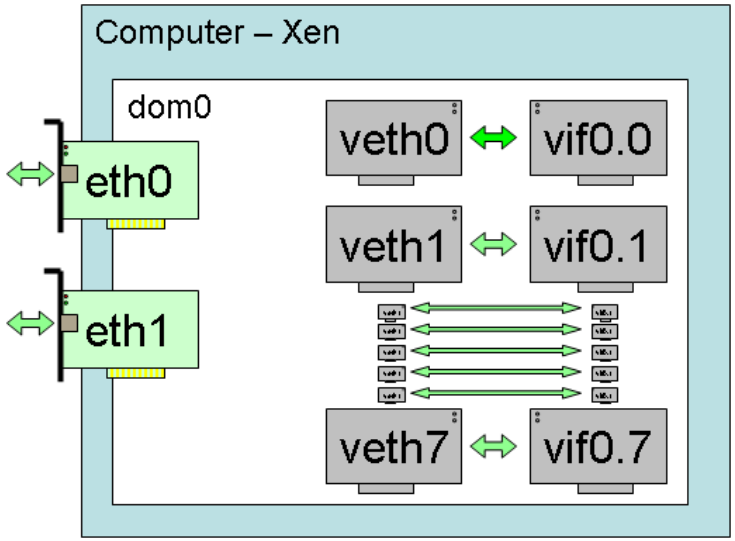
- Confidentiality aware services run on cloud
- Availability of services run on cloud

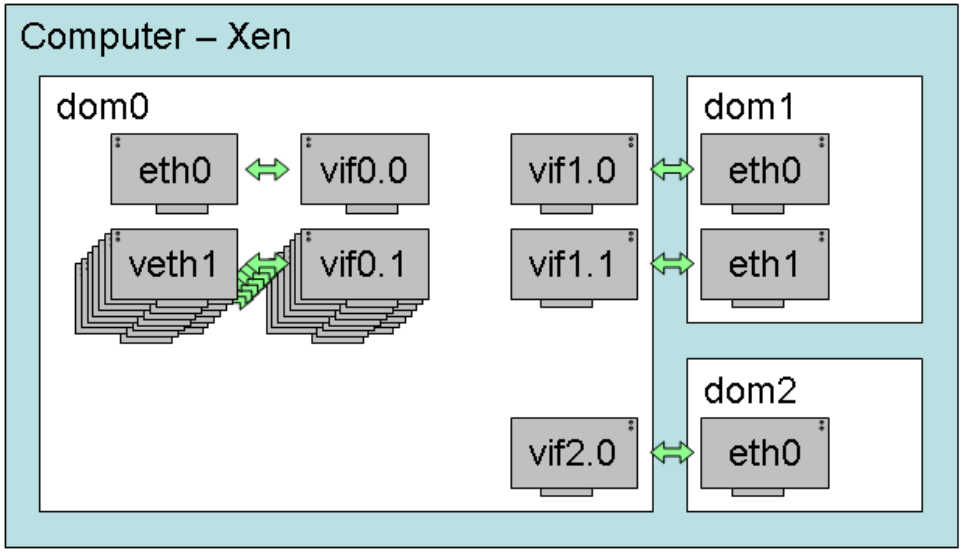
Tools of the trade

- 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

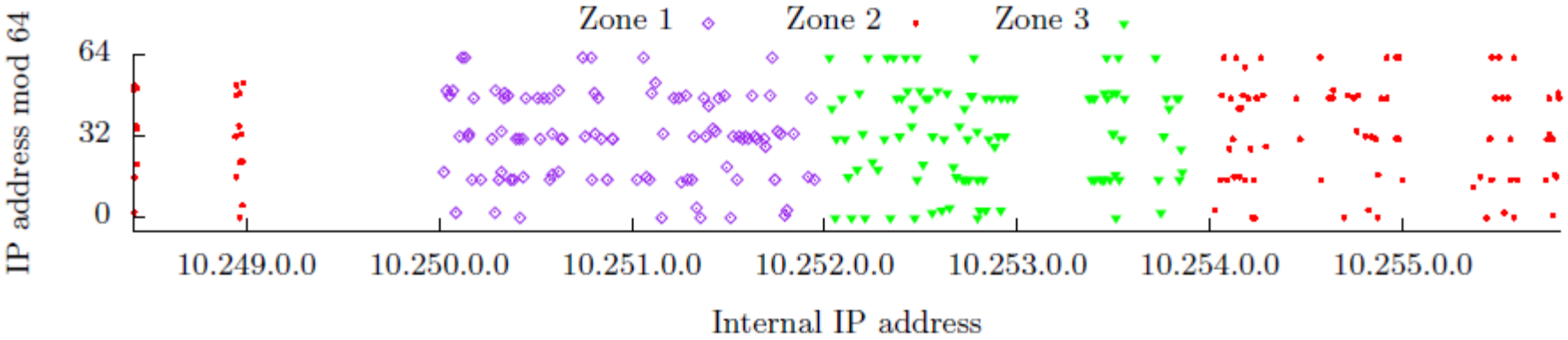




Dom0 is the first instance on the machine, connected to physical adapter

All other instances route to external world via dom0

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*

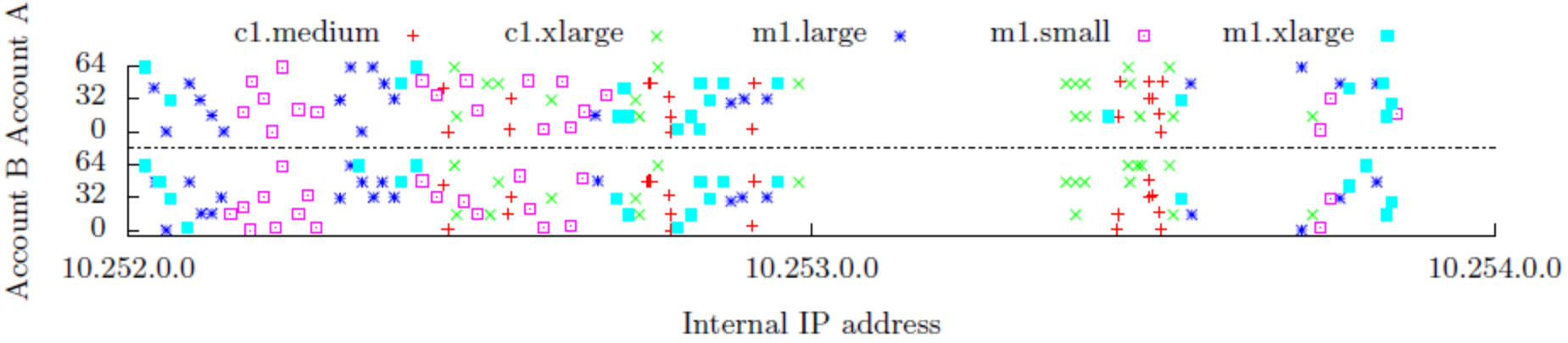
External Name: *ec2-75-101-210-100.computer-1.amazonaws.com*

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.

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%

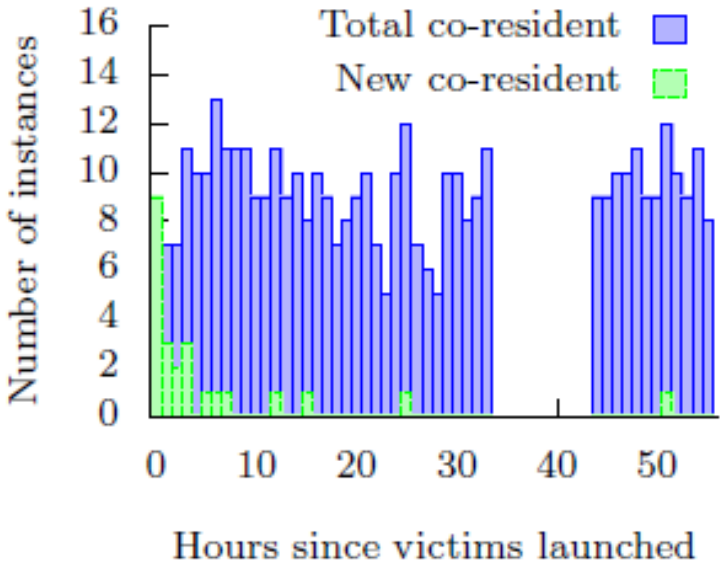
Task #3: Making a probe VM co-resident with target VM

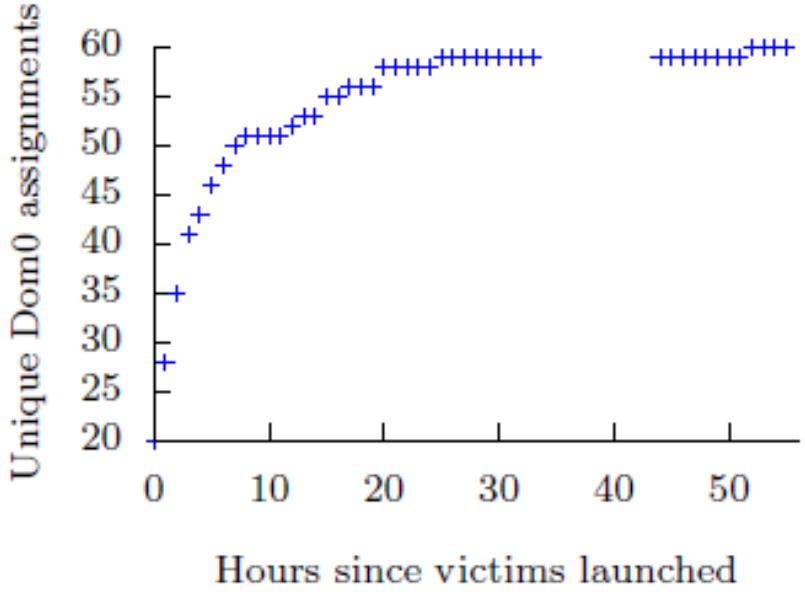
Smarter strategy: utilize locality

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

- Paper claims 40% success rate

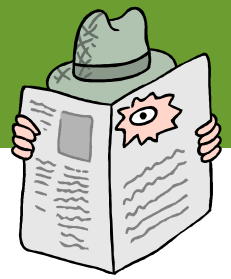
Task #3: Making a probe VM co-resident with target VM





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?