Adversary-aware Host Address Mutation

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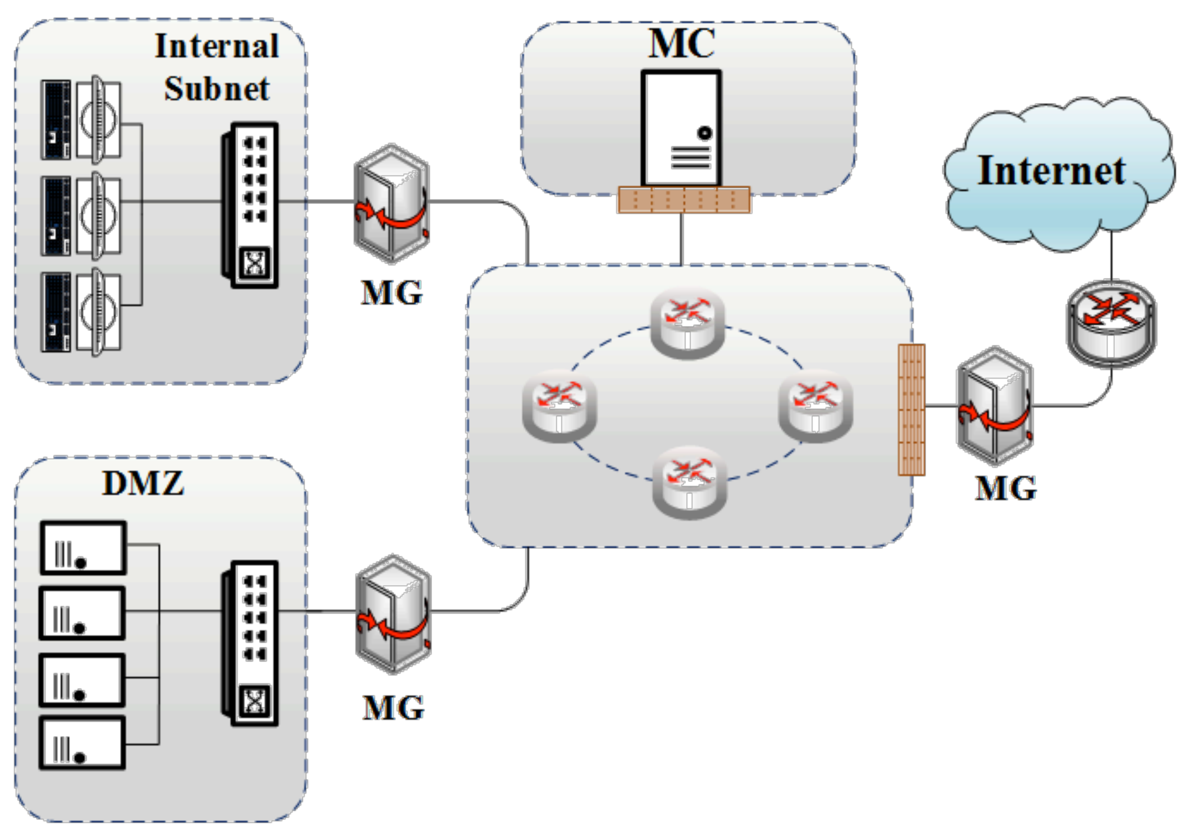
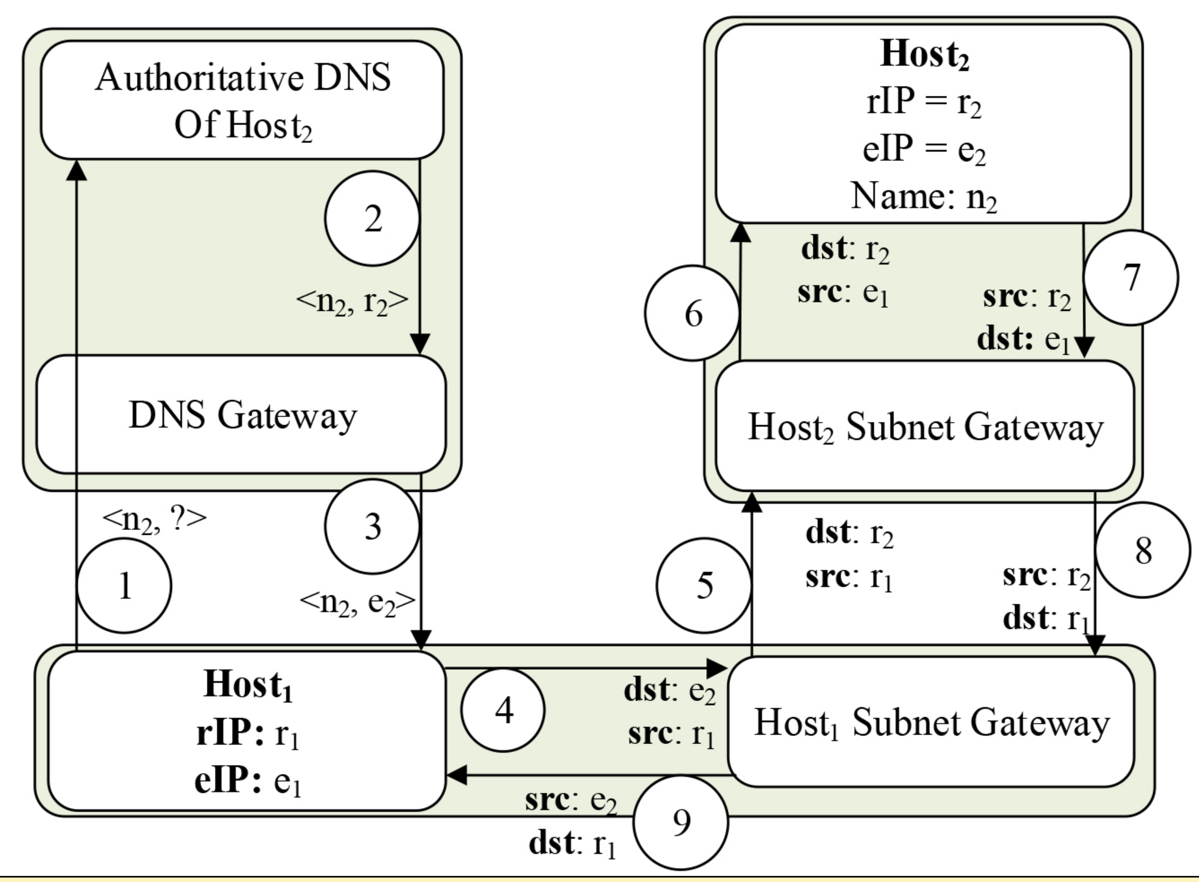
Motivation & Objectives

- **Static** and **predictable** behavior of cyber systems a fundamental design **vulnerability**
  - **Reconnaissance** is simple
  - **Evasion** is simple via careful selection of attack parameters
- IP address allocation is mostly **static**
- Several approaches for IP hoping were proposed but they lack effectiveness
  - Based on **DHCP** or **NAT** (DyNAT, NASR): too **infrequent** and **traceable**
  - Uniform mutation limits the effectiveness due to **lack of adaptiveness**
- The goal of adaptive mutation is to **increase benefit,** while **reducing cost.**
- To be adaptive, we must **characterize** adversarial scanning.
- **Ref:** **Adversary-aware IP address randomization for proactive agility against sophisticated attackers**,
- IEEE INFOCOM, May 2015.





Approach: - allocating new IPs from address ranges that have **lower risk**

- Observe the sequence of **unsuccessful probes** generated by network hosts
- Use **statistical hypothesis testing** to estimate their **distribution**

Two **hypotheses**

Non-uniformity: tests if scans are skewed toward certain ranges of address space

Non-repetition: tests if scans are avoiding repeated probing of same IP address

- Changing real IP (rIP) address of hosts disrupts active sessions

Instead, we associate hosts with **ephemeral IP addresses (eIP)**

- Chosen from unused address space
- Automatically translated to/from rIPs at network edges →
  - Not used for routing

- New eIP is announced to clients through **DNS** with short **TTL**

IP addresses are mutated without jeopardizing cyber operation or breaking active sessions

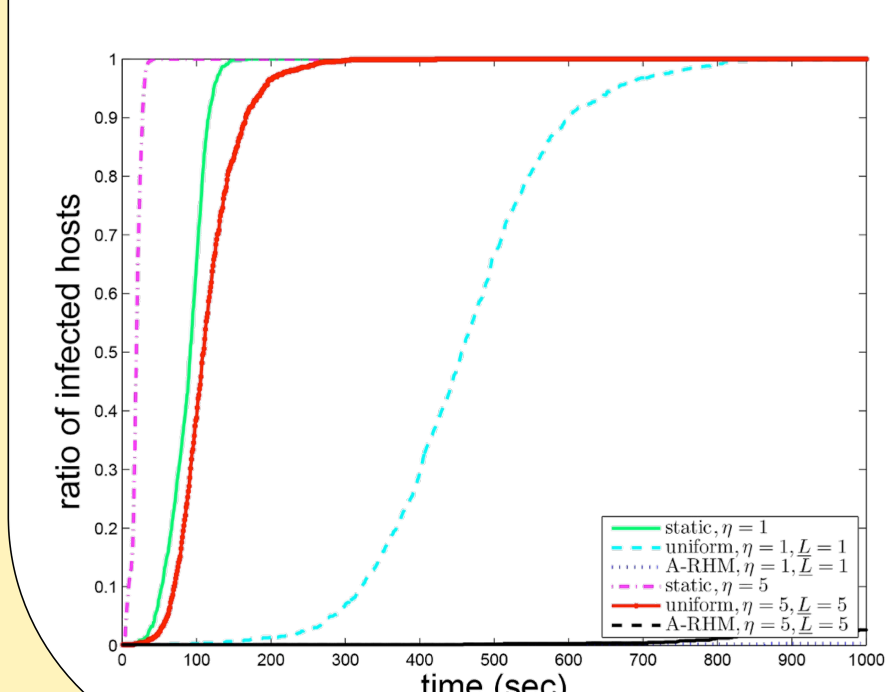
Non-uniformity test

Q1: Are scans **locally concentrated** in specific ranges?

- Increases success rate and decreases detectability
  - e.g. Local-preference, sequential, divide-and-conquer
- Use **Pearson's χ-squared test** to calculate **deviation from uniform distribution** with *p-value* = 0.05
- If deviation is very high, scans are non-uniform

Q2: If accepted, which ranges are more hazardous?

- Ranges with abnormal number of scans (outliers)



Non-repetition test

Q1: Are scanners avoiding/limiting repeated scanning?

- Reduces detectability and scanning budget
  - e.g. Cooperative, divide-and-conquer

Calculate **standard deviation** of scan distribution

- If deviation is very low, repetition is limited

Q2: if accepted, which addresses are more hazardous?

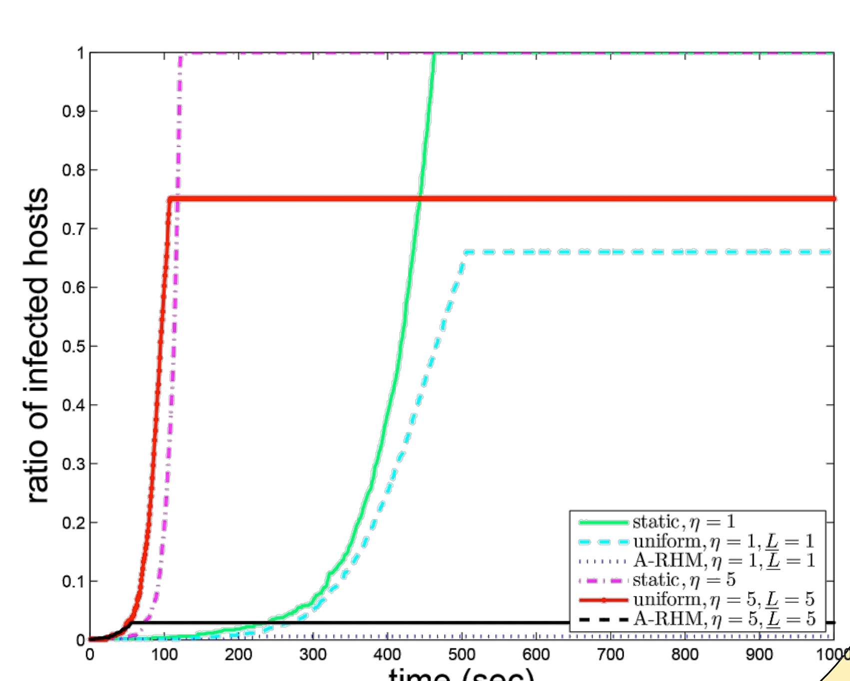
- Addresses with low num. of scans
- Avoid using these addresses as eIPs

Game-changing

Attacker's worst strategy (uniform scanning) in static networks becomes her best in our adaptive network

If attacker uninformed of adaptive mutation → attack is deterred

If attacker informed of adaptive mutation → forced to do uniform scanning → attack becomes more detectable



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