Sneak-Peek: High Speed Covert Channels in Data Center Networks

Rashid Tahir*, Mohammad Taha Khan☆, Xun Gong*, Adnan Ahmed†, Amerimad Ghassami*, Hasanat Kazmi†, Matthew Caesar*
Fareed Zaffar† and Negar Kiyavash*
University of Illinois at Urbana Champaign* **University of Illinois at Chicago☆**
Lahore University of Management Sciences†

The Problem: Clouds, Businesses and Users

- Modern businesses face an increasing need to store sensitive information on the cloud.
- Clouds are multi-tenant infrastructures that share resources for achieving economies of scale.
- Cloud enterprises employ shared management and statistical multiplexing on physical recourses for efficient utilization.
- The necessity of shared infrastructure leads to the danger of information leakage across tenants.
- Covert and side channels are a concern as they can easily bypass network monitors and cause sensitive data exfiltration.

The Contributions of Our Work

- Construction of a high speed timing based covert channel.
- Derivation of a mathematical model along with analysis of an upper bound on the channel bitrate.
- Empirical evaluations of the achieved bitrate in an in-house environment as well as on EC2 and Azure clouds.
- Discussion of possible mitigation techniques for our channel.

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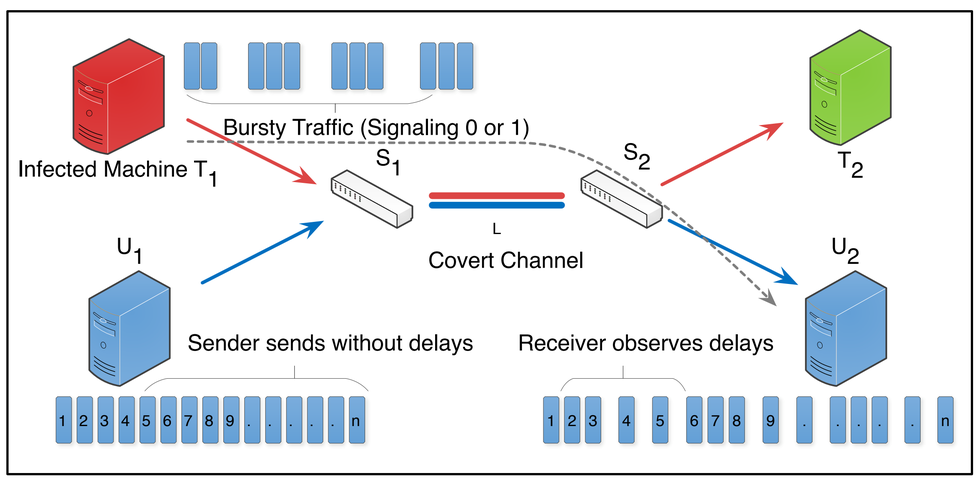
Channel Construction and Analysis

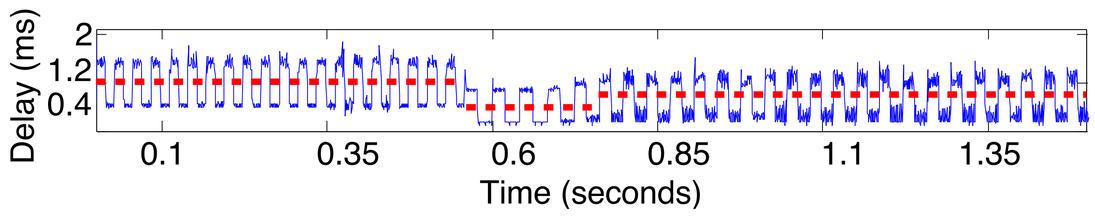
- Our channel is of a unidirectional nature and operates across virtually isolated networks

Covert Channel Message Encoding



- Our channel is modeled as a FIFO queue shared by two packet processes on different networks
- To maintain queue stability, the maximum achievable information rate proposed by our channel is 67% of the bitrate.

Adaptive Decoding Scheme



- The Adaptive decoding algorithms leverages on the following methodologies to minimize channel error rates:
  - **Threshold Evaluation:** Calculating accurate cutoffs for 0's & 1's
  - **Bit Marking:** Synchronizing clocks at the sender and receiver

Channel Evaluation

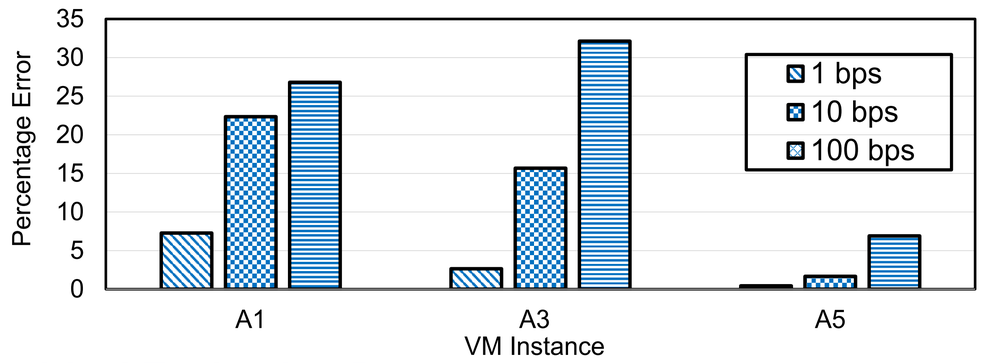
- We use a UDP based scheme to evaluate the covert channel in various environments.
- For a realistic evaluation, cross traffic is generated as temporally spaced UDP and TCP flows of varying duration and size

Achieved Error Rates

- **In House Cloud**

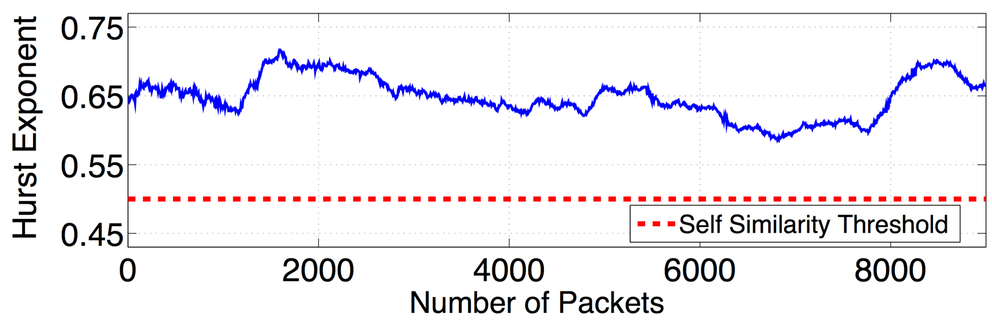
Bit Rate	Error Without Cross Traffic	Error With Cross Traffic (No Message Splitting)	Error With Cross Traffic (Message Splitting)
67	0%	3.30%	0%
134	0%	42.80%	0%
335	0%	Error>80%	8.68%

- **Microsoft Azure**



Empirical Evaluation Parameters

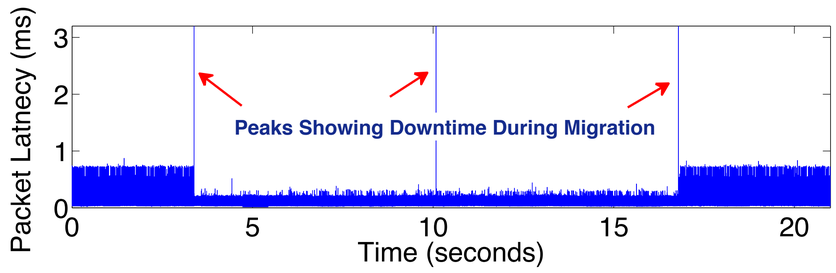
- The Hurst measure of self similarity for our covert channel remains well below the threshold of anomalous behavior.



- To optimize our channel we also consider the following empirical factors:
  - Effect of Total Traffic Load/Network Conditions
  - Effect of Packet Size
  - Effect of Queuing Policy and Hypervisor

Mitigation Techniques

- Leveraging on the over-provisioned paths between nodes and high quality load balancers in data-centers, we suggest "path-hopping" to rate limit the capacity of the covert channel.
- **Flow Selection:** Can be done based on flow similarity, flow timing or just random.
- **Flow Placement:** Performed randomly, or by selecting either the earliest available or least crowded link.



Results From a Random Selection and Random Placement Migration Scheme