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Minimizing Range Rules for Packet Filtering Using a Double Mask Representation

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Overview

In this work, we introduce a novel representation of packet filtering rules, so called double masks [1], where the first mask is used as an inclusion prefix and the second one for exclusion. An efficient algorithm is developed to compute a set of double masks for a given range.

Background and Motivation

Problem Statement

- Large number of hosts affects the size of routing tables.
- Size of blacklists keeps increasing due to the increase of number of attacks on the Internet.
- Effective filtering to handle the rapidly increasing and the dynamic nature of network traffic.

Overview of double-mask representation

$$192.168.100.96/26/2$$

Example 1

Range [1,14] needs a set of 6 standard prefixes to be represented. However this range can be represented using only two double masks prefixes as shown below:

- simple masks: double masks

$$[1,14] = \begin{cases} \text{simple masks} & \text{double masks} \\ \{000\} & \{0000\} \\ \{01\} & \{0000\}/4 \\ \{001\} & \{0000\}/4 \\ \{011\} & \{0000\}/4 \end{cases}$$

Example 2

Range [1,15] is of form $$[1,2^n - 1]$$ and needs 4 simple masks $$\{0001, 001*, 01*, 1*\}$$ but only one double mask: 0000/0/4.

Benefits of Double Mask

- Reduces the number of entries and therefore packet classification, rules lookup times and memory usage.
- Adds flexibility and efficiency in the deployment of security policies, since the generated rules are easier to manage.
- Makes configurations simpler since we can accept and exclude IPs within the same rule.

Double Mask Computation

The algorithm computes the set of masks for $$[a, b]$$ in a bottom up way, starting from the two nodes binw(a) and binw(b). Then, when reaching node c, the set of computed masks at the siblings of c (i.e., c0 and c1) are combined and the algorithm stops.

- The algorithm is linear in $$|\text{bin}_w(a)| + |\text{bin}_w(b)|$$, where $$|e|$$ is the length of the binary representation of a and b.
- Each range needs at most $$2w - 4$$ masks to be represented.
- Can also be applied to port ranges and for reducing range expansions in TCAM.
- Can be applied after or in combination with known redundancy removal techniques [2] in order to further reduce the number of entries in filtering rule tables.

Experimental Results

- Over 6000 ranges computed from more than 1.5 millions IPs generated in a synthetic way.
- The total number of generated simple masks is 29958.
- We are able to reduce this number by 74% (i.e. 7872 masks).

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References