R2-D2: Filter Rule set Decomposition and Distribution in Software Defined Networks
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Background and Motivation

Context

- Large number of filtering rules due to the increasing number of hosts and applications.
- Increase in number of attacks that affect entries in access-control lists (ACL).
- Expensive and power-hungry ternary content-addressable memory (TCAM).

Research question

How to decompose and distribute filtering rules on a set of limited size switch tables?

Overview of Longest prefix matching (LPM) representation

<table>
<thead>
<tr>
<th>Rule</th>
<th>Address field</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0 0 * *</td>
<td>A₁</td>
</tr>
<tr>
<td>2</td>
<td>0 0 0 *</td>
<td>A₂</td>
</tr>
</tbody>
</table>

Table: Example of a rule set in a switch table.

If a switch receives a packet with 0001 as address

Prioritized list strategy : Rule 1 is first, \( A_1 \) is applied.

LPM strategy : Rule 2 is most specific, \( A_2 \) is applied.

Rule Representation

- Single field filtering.
- Sufficient for blacklists.
- Rules represented in a binary tree.
- One rule at most on each tree node.

Figure: Compact representation of rules prefixes (00*,01*,0*,1*) in a binary tree.

Decomposition Algorithm

- Input a set of rules and switches.
- Search the binary tree in order to find the best candidates.
- All rules present in the chosen node and all nodes below it will be added to the switch.
- Minimize the number of generated rules by merging old forward rules with the ones from the best candidates.
- No rule duplication.

Evaluation

- 12 sets of data generated using ClassBench.
- Percentage of forward action field between 0 and 100%.
- Rules with same action type have zero overhead.
- Around 15% overhead on 8 switches path length.

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