Memory Efficient IP Lookups in High-Speed Networks

Motivation
The growth of Internet traffic and speed of network links has direct impact on the required performance of core routers. To handle network traffic with 100 Gbps throughput, routers have to process millions of packets per second. The most time-critical operation in core routers is the Longest Prefix Match (LPM). Current IP lookup algorithms have high memory demands when representing IPv6 prefix sets or introduce very high pre-processing overhead. Therefore, we propose a new LPM algorithm which is able to provide very low memory demands for IPv4/IPv6 lookups.

Summary
- Proposed prefix set representation has the lowest memory requirements in comparison to all existing LPM algorithms
- Large routing tables can fit into the on-chip memory
- HW architecture for this algorithm was also designed and proposed
- The architecture was implemented on Xilinx Virtex-6 FPGA with 140 Gbps throughput
- Published on IEEE conferences:
  - DDECS
  - FPL

Analysis
LPM algorithms analyzed:
- Unibit Trie
- Controlled Prefix Expansion
- Lulea Compressed Tries
- Level Compression Trie
- Tree Bitmap (TBM)
- Shape Shifting Trie (SST)
- Prefix Partitioning

IPv6 prefix sets analysis (using TBM):
Identified 2 significant groups of nodes:
- Leaf nodes with no children
- Internal nodes without prefixes

Algorithm properties:
- Using fixed set of node-types
- Nodes optimized based on analysis results
- Variable length and shape of nodes
- Nodes are mapped to the prefix tree in order to find best coverage of the tree
- In every part of the tree is used the node with the lowest price

Results

- Protocol: IPv4/IPv6
- Prefixes: IPv4_gen_1, IPv4_gen_2, IPv4_gen_3, IPv6_gen_1, IPv6_gen_2, IPv6_gen_3
- Memory requirements [kB]: TBM, SST, Proposed algorithm
- Memory savings:
  - Compared to TBM
  - Compared to SST

Table:

<table>
<thead>
<tr>
<th>Prefixes</th>
<th>Memory requirements [kB]</th>
<th>Memory savings</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>TBM</td>
<td>SST</td>
</tr>
<tr>
<td>IPv4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>220779</td>
<td>712.76</td>
<td>510.13</td>
</tr>
<tr>
<td>442748</td>
<td>1492.76</td>
<td>1096.87</td>
</tr>
<tr>
<td>IPv6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10518</td>
<td>159.43</td>
<td>73.56</td>
</tr>
<tr>
<td>10814</td>
<td>165.82</td>
<td>77.14</td>
</tr>
</tbody>
</table>