Approximate Caches for Packet Classification

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The Motivation:
Packet Classifiers are getting more complex and Flow Identifiers are getting more unwieldy (IPv4→IPv6) So Packet Classification Caches are getting bigger and slower

The Story:
What if we give up accuracy – let’s accept some occasional mistakes. This allows us to save memory and increase performance!

Storing Forwarding Paths:
A Bloom filter can only store 1 bit of information – set membership. For applications more sophisticated than firewalls, we can store more information by using multiple Bloom filters.

So, by using an approximate caching strategy, we can build a cache architecture that’s faster, and more memory efficient than existing exact caching strategies.

Optimizing a Bloom filter: This is the traditional Bloom filter equation – minimizing misclassification probability for a fixed # of elements.

1 - \left(1 - \frac{L}{M}\right)^L

L=# hash levels, M=amount of memory, p= probability, k=# of elements (flows). We prefer to maximize the # of elements for a fixed misclassification probability.

\kappa = -\frac{M}{L} \ln(1 - p^{1/L})

The interesting properties of a Bloom Filter:
1) The # of elements that we can fit in a Bloom filter is scales linearly with the amount of memory

2) The optimal # of hash levels in Bloom filter is dependent only on the misclassification probability, not the amount of memory: \( L = -\log_2 p \)

3) For a misclassification probability of 1 in a billion, optimal dimensioning is \( L = 30 \) hash levels

Bloom filter caches using different number of hash functions: The curve is very smooth near the optimal point.

The # of flows we can store, if we use multiple Bloom filters: The decrease in # of flows is approx. logarithmic with # of Bloom filters

The Payoff: The cache hit rate comparing Bloom filter caching and traditional exact caching.

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