# Traffic policing in eBPF: applying token bucket algorithm

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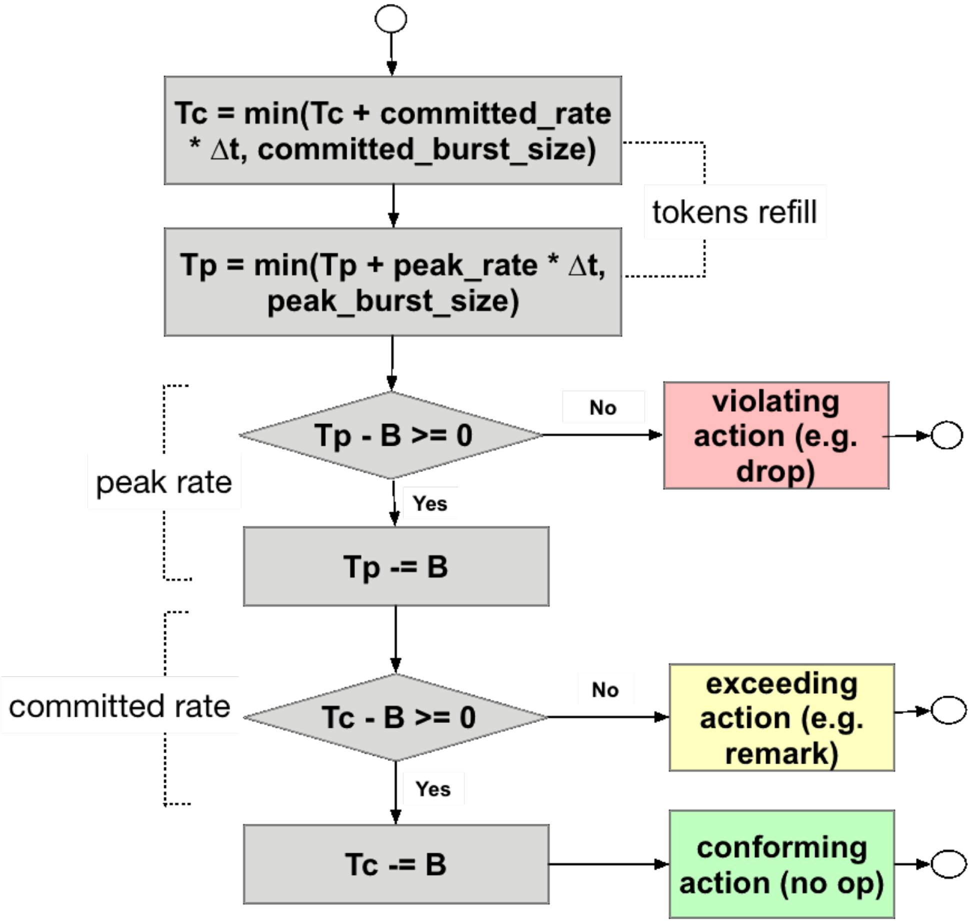
## Shaping vs. Policing

| Shaping | Policing |
| --- | --- |
| Buffers exceeding packets | No buffering, instant action: drop or remark |
| Latency increase due to buffering | No latency increase, but drops may cause retransmits (e.g. in TCP) |
| Smooths traffic burstiness, output rate doesn’t deviate much | Bursts are propagated |
| Drops packets anyway when buffer capacity is reached. Buffer increasing causes higher latency | |
| Linux Traffic Control: queuing disciplines, e.g. tc htb | Switch side policers,<br>eBPF-based traffic policing |

# Traffic policing in eBPF: applying token bucket algorithm

RFC 2698, naive implementation

## Two rate three color marker




## eBPF program in TC egress chain

```
_u64 delta_t = packet_ts -
  bucket->timestamp;
bucket->tokens += delta_t * rate_bps /
  NS_IN_SEC;
bucket->tokens = MIN(bucket->tokens,
  burst_size);
bucket->timestamp = packet_ts;
__u64 tokens_spent = 8 * skb->len;
/* TC_ACT_SHOT if no enough tokens */
__sync_fetch_and_add(bucket->tokens,
(-1) * tokens_spent);
return TC_ACT_UNSPEC;
```

Does this code produce the desired rate?

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## Advancing naive implementation

Problem:
Updates are in the kernel space. Data race with multi CPU. Getting and adding tokens into a bucket must be executed as an atomic action.

Solution or not?

- Critical section in eBPF program
- Per CPU eBPF data structures
- Update tokens from the user space
  What if burst duration is in microseconds?
- Data structures shared between CPUs: lru_hash, array

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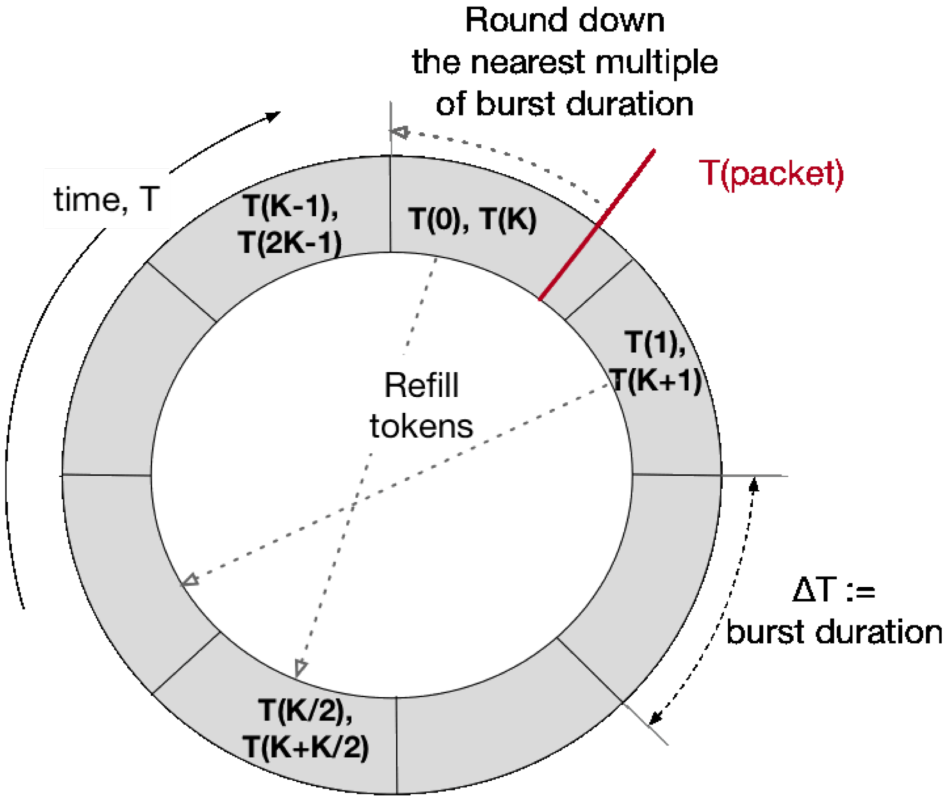
## Hackish working implementation: kernel space only, eBPF array

Key idea: refill tokens in a future bucket, take tokens from the current bucket.




```
__u64 packet_ts = bpf_ktime_get_ns();
__u64 burst_dur = burst_size * NS_IN_SEC /
  rate_bps;
__u32 refill_tbuck_idx = (packet_ts +
(K >> 1) * burst_dur) / burst_dur % K;
__s64* refill_tokens = bpf_map_lookup_elem(
  tbuck_arr, &refill_tbuck_idx);
if (refill_tokens) *refill_tokens =
burst_size;
__u32 curr_tbuck_idx = packet_ts /
burst_dur % K;
/* Subtract tokens from curr_tbuck_idx
bucket */
```

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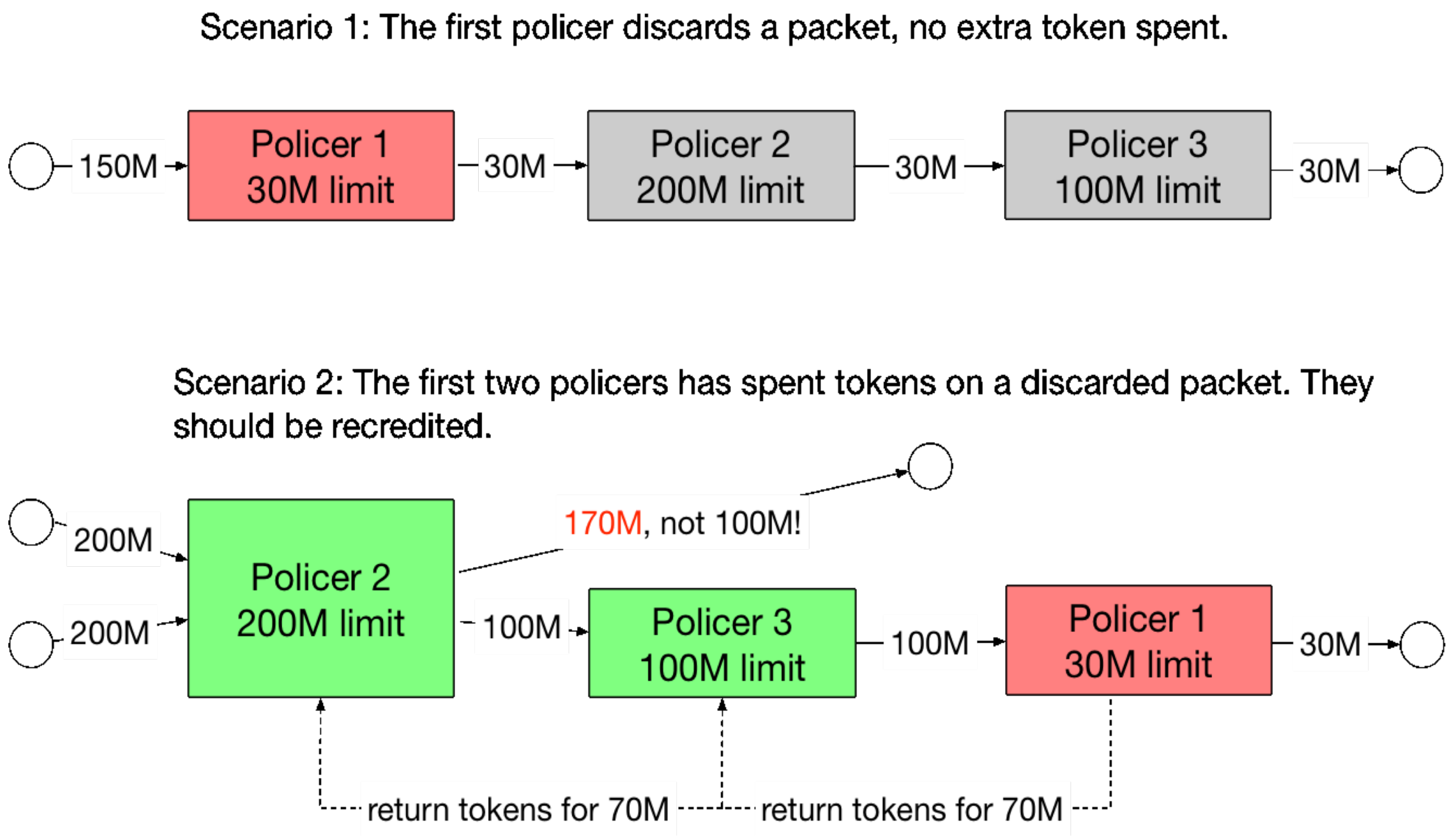
## Policers chaining




- The output rate must not depend on the order of policers
- If a packet is discarded, recredit the preceding policers
- Policers may not belong to the same logical hierarchy. No common root is required, unlike in qdisc HTB

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Limitations

- Heavy hammer
  - TCP congestion control + token bucket + DROP = capped max rate but underutilized average
  - No buffering: drops are inevitable
- Very thin per TCP flow fairness guarantees
  - No handy TCP session information in tc chain
  - N sub buckets and skb->hash % N
- Token bucket + DSCP remark
  - Only for multi-queue network devices
  - Packets may be received in disorder