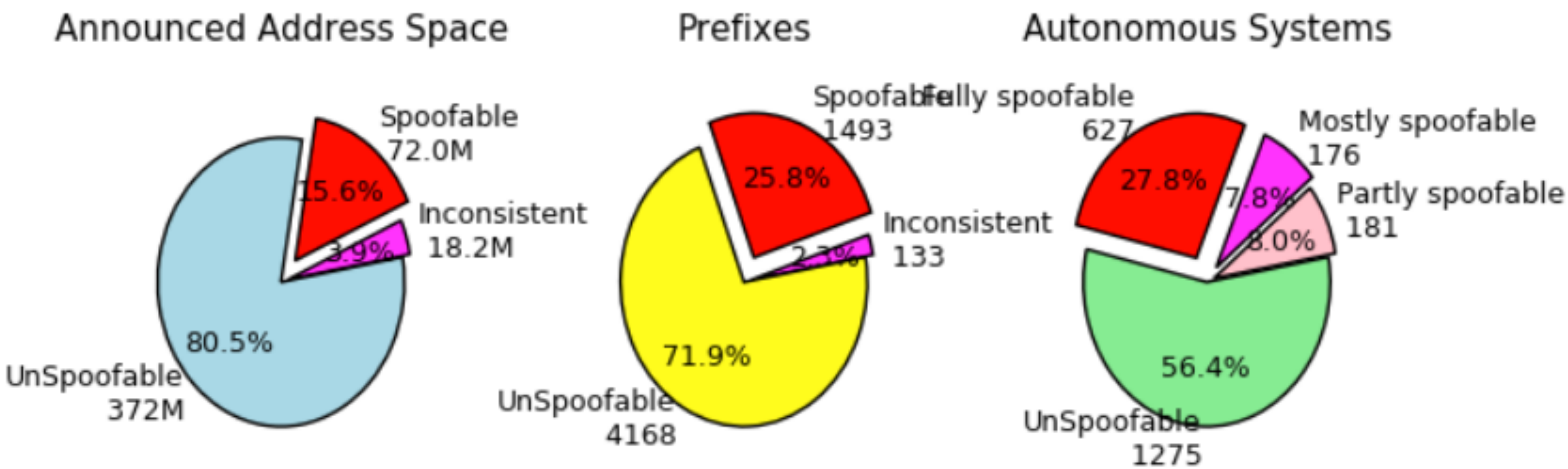
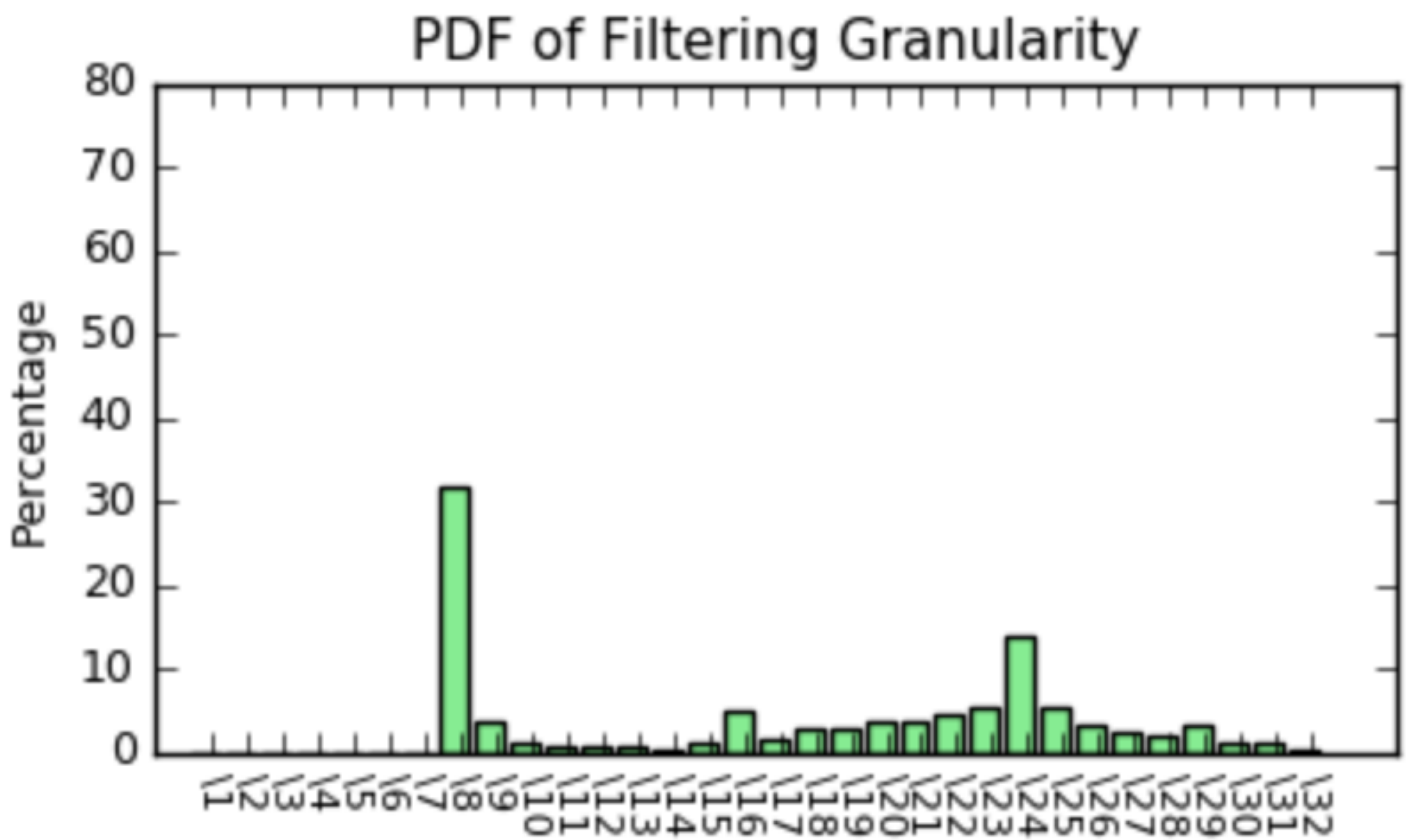
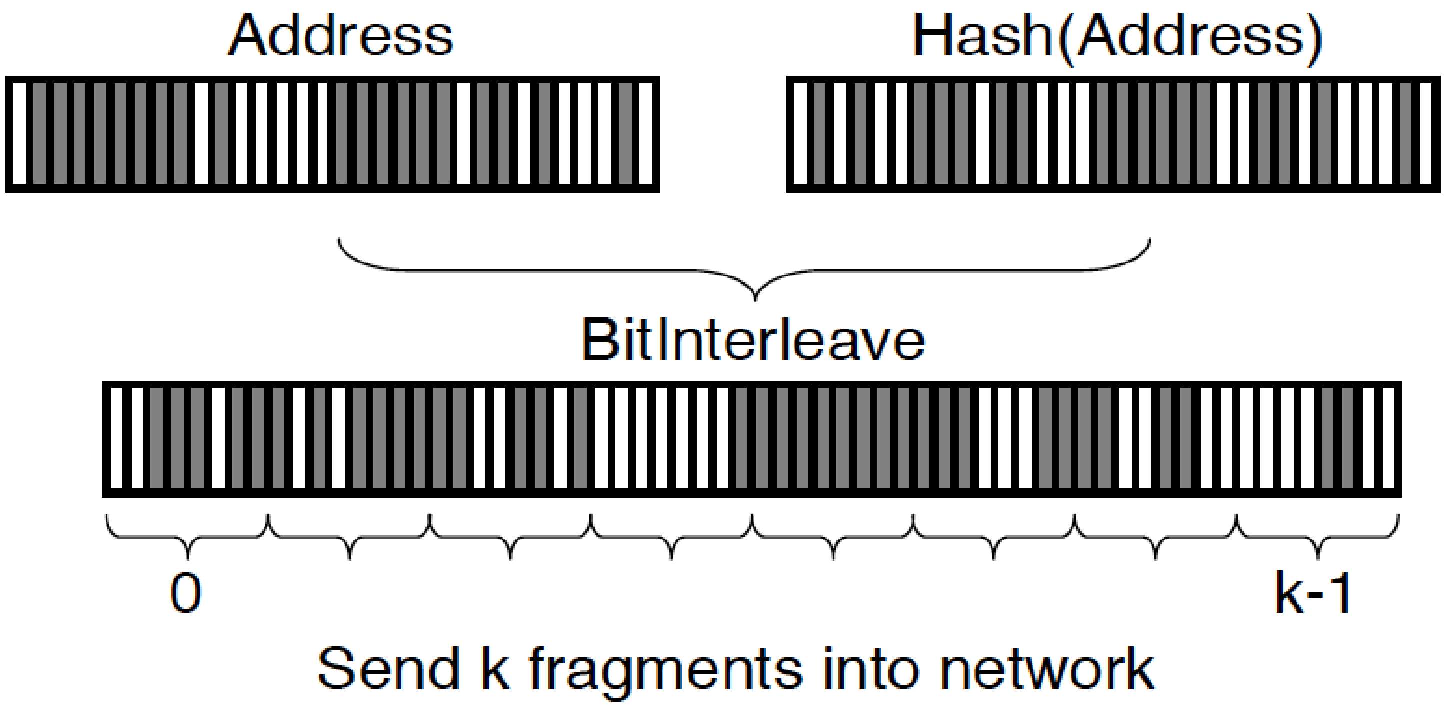
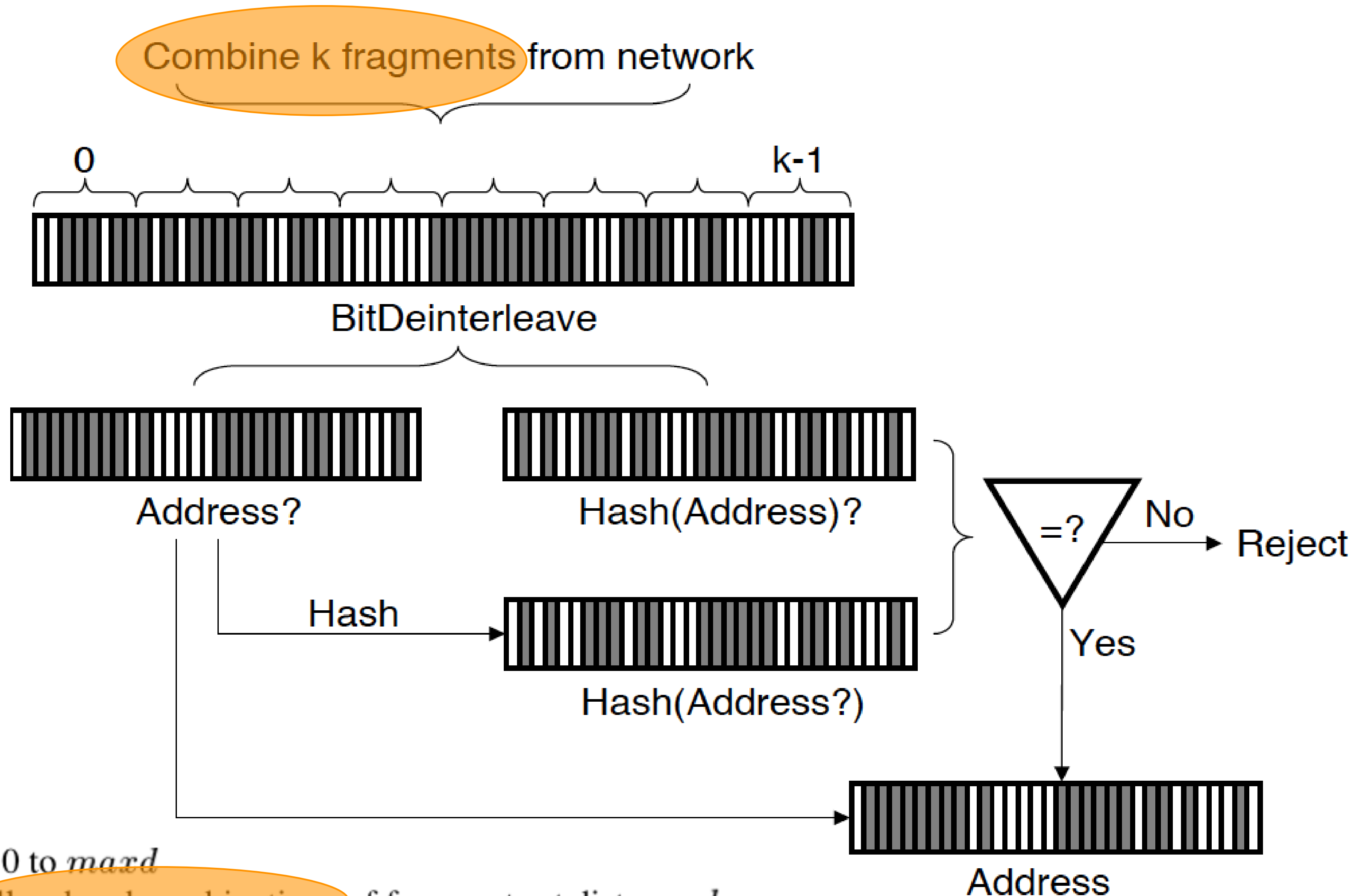

Announced Address Space
Spoofable
72.0M
15.6%
Inconsistent
18.2M
3.9%
80.5%
UnSpoofable
372M
Prefixes
Spoofable
1493
25.8%
Inconsistent
133
2.3%
71.9%
UnSpoofable
4168
Autonomous Systems
Fully spoofable
627
27.8%
Mostly spoofable
176
7.8%
Partly spoofable
181
8.0%
56.4%
UnSpoofable
1275



PDF of Filtering Granularity
Percentage
80
70
60
50
40
30
20
10
0
/1
/2
/3
/4
/5
/6
/7
/8
/9
/10
/11
/12
/13
/14
/15
/16
/17
/18
/19
/20
/21
/22
/23
/24
/25
/26
/27
/28
/29
/30
/31
/32

We define the *approximate trace-back* problem as finding a candidate attack path for each attacker that contains the true attack path as a suffix. We call this the *valid suffix* of the candidate path.


Address
Hash(Address)
BitInterleave
0
k-1
Send k fragments into network




```
for d := 0 to maxd
    for all ordered combinations of fragments at distance d
        construct edge z
        if d ≠ 0 then
            z := z ⊕ last
        if Hash(EvenBits(z)) = OddBits(z) then
            insert edge (z,EvenBits(z),d) into G
            last := EvenBits(z);
```

	Management overhead	Network overhead	Router overhead	Distributed capability	Post-mortem capability	Preventative/ reactive
Ingress filtering	Moderate	Low	Moderate	N/A	N/A	Preventative
Link testing						
Input debugging	High	Low	High	Good	Poor	Reactive
Controlled flooding	Low	High	Low	Poor	Poor	Reactive
Logging	High	Low	High	Excellent	Excellent	Reactive
ICMP Traceback	Low	Low	Low	Good	Excellent	Reactive
Marking	Low	Low	Low	Good	Excellent	Reactive

Table 1: Qualitative comparison of existing schemes for combating anonymous attacks and the probabilistic marking approach we propose.

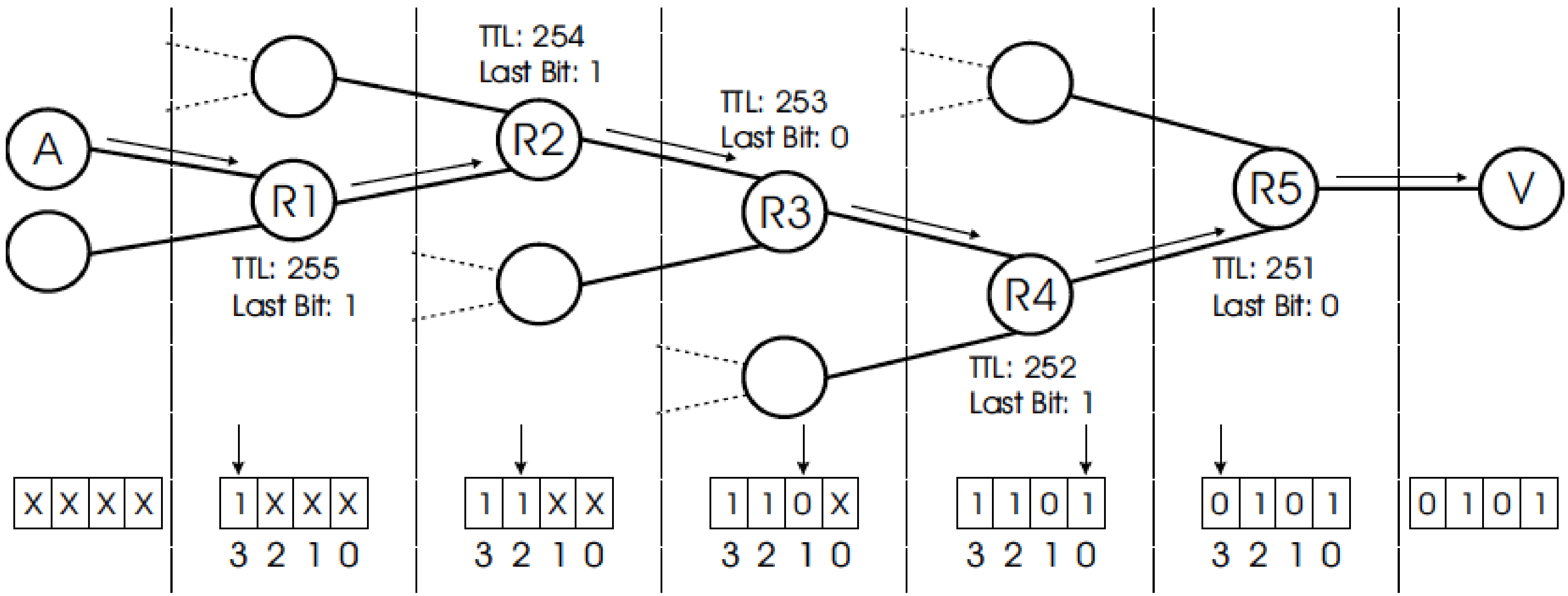


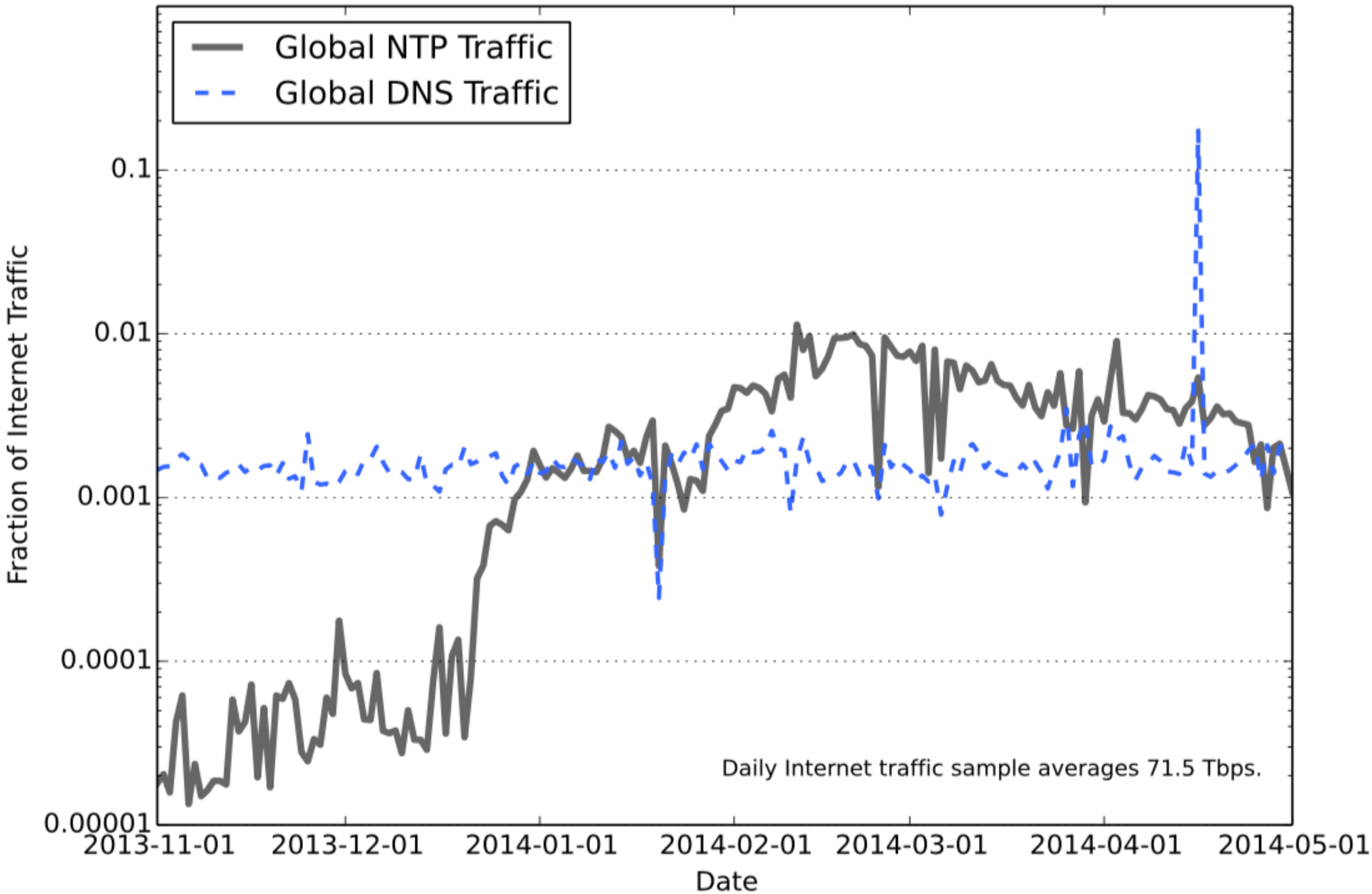
Figure 3. Example of our initial marking scheme. The packet travels from the attacker A to the victim V across the routers R1 to R5. Each router uses the TTL value of the packet to index into the IP identification field to insert its marking. In this example we show a 1-bit marking in a 4-bit field for simplicity.

```
% dig +dnssec berkeley.edu
```

69-byte query

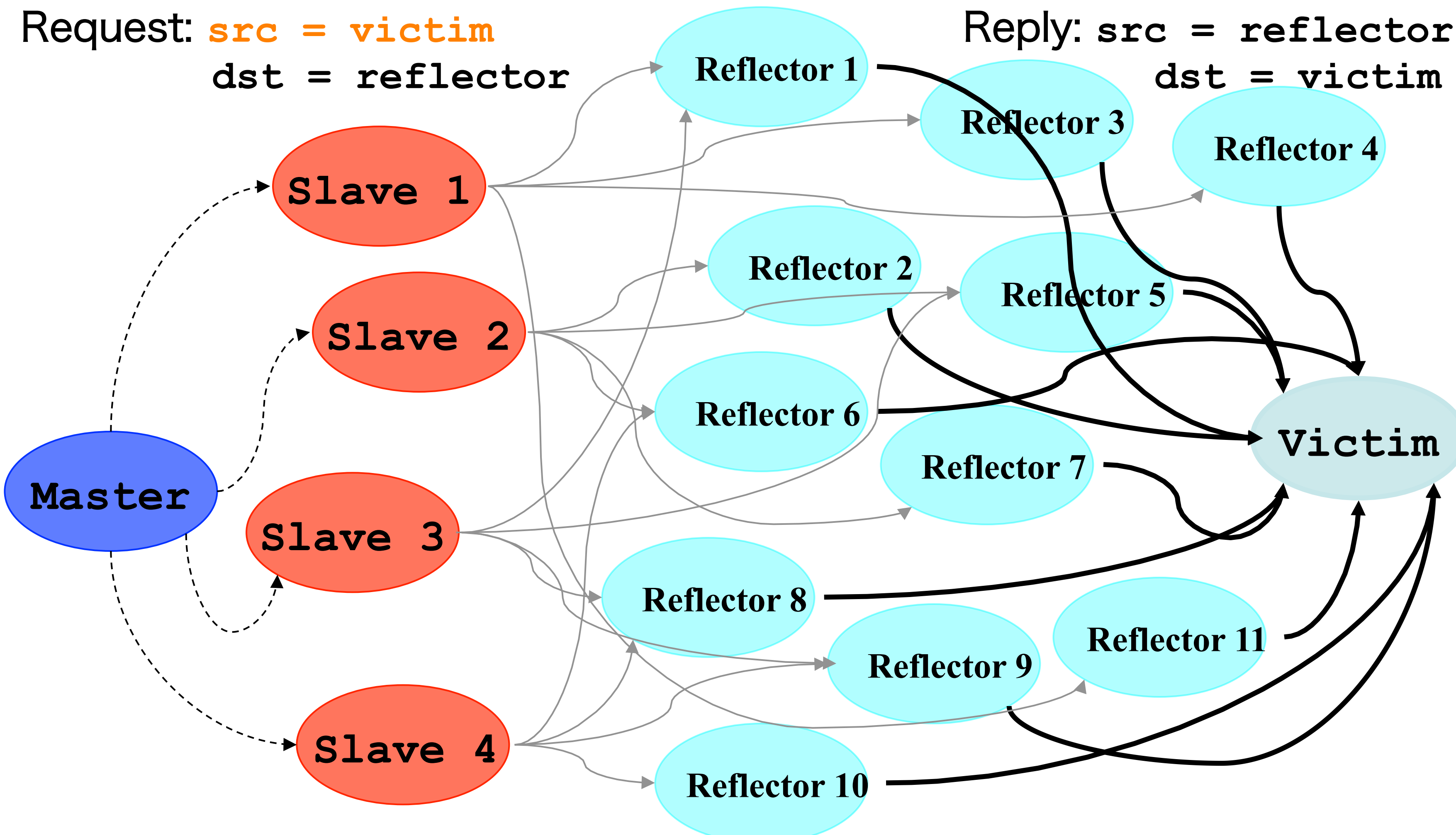
```
% dig +dnssec berkeley.edu

; <<>> DiG 9.8.3-P1 <<>> +dnssec berkeley.edu
;; global options: +cmd
;; Got answer:
;; ->>HEADER<<- opcode: QUERY, status: NOERROR, id: 60422
;; flags: qr rd ra; QUERY: 1, ANSWER: 3, AUTHORITY: 8, ADDITIONAL: 27

;; OPT PSEUDOSECTION:
; EDNS: version: 0, flags: do; udp: 4096
;; QUESTION SECTION:
;berkeley.edu.                  IN      A

;; ANSWER SECTION:
berkeley.edu.           198     IN      A       128.32.203.137
berkeley.edu.           198     IN      RRSIG   A 10 2 300 20160906161321 20160902155734 20552 berkeley.edu. C6rreK8RPffJjJbMuoAj3jQP5Koez6nEPjumLRZtOcPYO8bXHVmNrSf5 R/Q1/hf0uK9B
berkeley.edu.           198     IN      RRSIG   A 10 2 300 20160906161321 20160902155734 55763 berkeley.edu. E2C1U8B1vWNLXTLk5WX47VatSKqrxQbW2396REcJ0M4bndqwKHTJrrHS Qr9VI64G+Gj6

;; AUTHORITY SECTION:
berkeley.edu.           10536   IN      NS      sns-pb.isc.org.
berkeley.edu.           10536   IN      NS      aodns1.berkeley.edu.
berkeley.edu.           10536   IN      NS      phloem.uoregon.edu.
berkeley.edu.           10536   IN      NS      adns1.berkeley.edu.
berkeley.edu.           10536   IN      NS      aodns2.berkeley.edu.
berkeley.edu.           10536   IN      NS      adns2.berkeley.edu.
berkeley.edu.           10012   IN      RRSIG   NS 10 2 10800 20160906161321 20160902155734 20552 berkeley.edu. ghIrnq0rISbm8RWxJcF/pR9zCa3QXrpPJftcdSYpTk/I6LFYjKK5B10F OwVyKG3Nu
berkeley.edu.           10012   IN      RRSIG   NS 10 2 10800 20160906161321 20160902155734 55763 berkeley.edu. rL2T1w4RWVZpu/zUIhigwT7sSSwJZp8gnbY4u1ZNcLr73a3ue3XBjGrf x2xDKt/AP

;; ADDITIONAL SECTION:
aodns2.berkeley.edu.    6294    IN      A       128.253.35.148
phloem.uoregon.edu.     75123   IN      A       128.223.32.35
phloem.uoregon.edu.     13252   IN      AAAA    2001:468:d01:20::80df:2023
adns2.berkeley.edu.     6294    IN      A       128.32.136.14
adns2.berkeley.edu.     7474    IN      AAAA    2607:f140:ffff:fffe::e
sns-pb.isc.org.         6524    IN      A       192.5.4.1
sns-pb.isc.org.         46194   IN      AAAA    2001:500:2e::1
aodns1.berkeley.edu.    6294    IN      A       192.35.225.133
aodns1.berkeley.edu.    2523    IN      AAAA    2607:f010:3f8:8000::ff:fe00:53
adns1.berkeley.edu.     1959    IN      A       128.32.136.3
adns1.berkeley.edu.     7474    IN      AAAA    2607:f140:ffff:fffe::3
aodns2.berkeley.edu.    6294    IN      RRSIG   A 10 3 10800 20160906163122 20160902154100 20552 berkeley.edu. Lw8t2yxfTFfwLThv0x/JZdAdCPk3O7Zr+rMVzG44fpLmn6SWH4/EG2IA sx2CjQEd3/
aodns2.berkeley.edu.    6294    IN      RRSIG   A 10 3 10800 20160906163122 20160902154100 55763 berkeley.edu. eLeO4M4BGzB0NYRtif8DpozUSSeQrucZoc6FpyGhlUHv8kfTncsXK3xw dWSGwhDzzq
adns2.berkeley.edu.     6294    IN      RRSIG   A 10 3 10800 20160906155418 20160902145750 20552 berkeley.edu. WK0+3QlDd/6kujgkcJc3d5QJMyD9VWwQM2xGE9kYQ/IW5l155c2zxG6X Q7XD2KfQRO
adns2.berkeley.edu.     6294    IN      RRSIG   A 10 3 10800 20160906155418 20160902145750 55763 berkeley.edu. hET89n7x16PWr6QYD9YdDUDZWyHMkNDE9xSRnuIgex+C37rnlncSolYj HlAdQKHCEj
adns2.berkeley.edu.     10229   IN      RRSIG   AAAA 10 3 10800 20160906154405 20160902150354 20552 berkeley.edu. jXP79E6IykchNV3DxbvONtNC8HmgWKK5HoOFgxHauDvkYiPEi66/6xNJ thY2v2a
adns2.berkeley.edu.     10229   IN      RRSIG   AAAA 10 3 10800 20160906154405 20160902150354 55763 berkeley.edu. bCCo55hQ/7NHVbSpjb/ZCit8G8gs15wL6lATL8ihILFDZrIMxQy5gklG vUSnzKD
sns-pb.isc.org.         6524    IN      RRSIG   A 5 3 7200 20160928233609 20160829233609 13953 isc.org. dulq1tz21MYEi962AAk2BT5cHeR2vd0HjePEE2S2ABY0JfqX/s+zDRai A/EKRiGDrj38iBp6o
aodns1.berkeley.edu.    6294    IN      RRSIG   A 10 3 10800 20160906152003 20160902151259 20552 berkeley.edu. cMXajdGuQgk6tt6IiC1QAM1232yLT2zFxDWfm0EuW6cJ57OLOVPbEZDq S6hhAKo70d
aodns1.berkeley.edu.    6294    IN      RRSIG   A 10 3 10800 20160906152003 20160902151259 55763 berkeley.edu. pHACF3XdiELFuLPe5kroahEMU0vgnNJ4+sOQ0Z286IPMaMgwrbrN511e M7FMQ0Tr14
aodns1.berkeley.edu.    10229   IN      RRSIG   AAAA 10 3 10800 20160906162655 20160902155822 20552 berkeley.edu. T+LsA9XpW82/HiZUitYPQeP3C59ykP4lfpfafJdeoRBUkJe2z0E+dldU AqY2ox5
aodns1.berkeley.edu.    10229   IN      RRSIG   AAAA 10 3 10800 20160906162655 20160902155822 55763 berkeley.edu. BMsWj9LiDHKW2CJUB6enhlQ91/csxboF7IKyxyVZby11E/P5UDjGxyBY d8ZC0iU
adns1.berkeley.edu.     1959    IN      RRSIG   A 10 3 10800 20160905162046 20160901152849 20552 berkeley.edu. du5i0LVc+8HfbEAs3f3qnRDwXgsQHEW8xgRoSHXfC/KBURr5+Lygkdni XA2fx1+t7m
adns1.berkeley.edu.     1959    IN      RRSIG   A 10 3 10800 20160905162046 20160901152849 55763 berkeley.edu. x6GHsdlKhAAiWQVRI1XJGAfav+xoz1YCK/z+XGARSjW0uW9pPTrTT/HL TXNYU201Rx
adns1.berkeley.edu.     10229   IN      RRSIG   AAAA 10 3 10800 20160906161659 20160902160412 20552 berkeley.edu. I22a0F87Tp22T3bcZX7sPUxzM9BrsoNvEzo7lqTE3Pkp58UmdyL57Azj 2X7j9K5
adns1.berkeley.edu.     10229   IN      RRSIG   AAAA 10 3 10800 20160906161659 20160902160412 55763 berkeley.edu. ce5EKo5g9DCtMWDYeCaqKibWIUMnmXMT2N4A41MRtuvIHI+oxA9mtQhx FuksjfO
```

3419-byte reply



Global NTP Traffic
Global DNS Traffic
Fraction of Internet Traffic
0.1
0.01
0.001
0.0001
0.00001
Daily Internet traffic sample averages 71.5 Tbps.
2013-11-01
2013-12-01
2014-01-01
2014-02-01
2014-03-01
2014-04-01
2014-05-01
Date

Diffuse DDoS: Reflector Attack



Control traffic directs slaves at victim & reflectors

Reflectors send streams of non-spoofed but unsolicited traffic to victim