Using Packet Symmetry to Curtail Malicious Traffic

Christian Kreibich
christian.kreibich@cl.cam.ac.uk

Andrew Warfield Jon Crowcroft

Steven Hand Ian Pratt

UNIVERSITY OF CAMBRIDGE
Computer Laboratory

The “Bad Traffic” Problem

- Malicious traffic abounds on the Internet
  - Scans, DDoS, botnets, spam, etc...
- So what exactly **is** malicious traffic?
  - It's anomalous
  - It's often high-volume
- Bellovin was right: we really want the Evil-Bit!
  - A **simple**, **immediate** characteristic
  - That **allows**, **denies**, or at least **limits** atypical behaviour at the net ingress
- And use it proactively!
  - Reactive responses to DDoS are too slow and complicated

Packet Symmetry

- At the packet level, most flows are roughly symmetric
  - Well-behaved flows do see bidirectional traffic
  - For n > 0 packets sent you get m > 0 packets back within a reasonable interval
  - Response traffic is a receiver consent signal!
  - Easy to measure and enforce at the source
  - Remarkably robust
  - And surprisingly universal

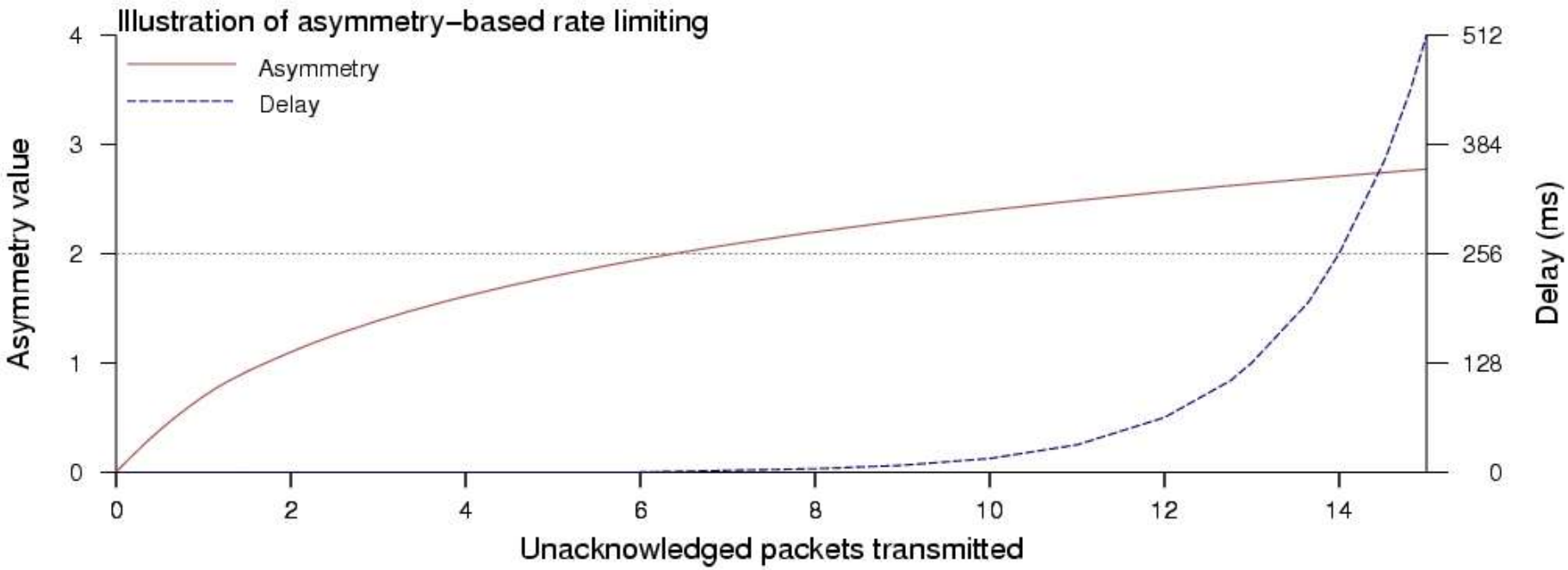
A Metric for Symmetry

$$S = \ln \frac{(tx+1)}{(rx+1)}$$

* Small. Simple. Elegant.
* Zero for tx = rx, symmetric around it
* Remains tractable as asymmetry grows
* Note: tx and rx are **packet counts**, not byte counts
* Needs to be measured near transmitter to avoid
  * potential path asymmetry
  * source identification difficulty (NAT, spoofing)

A Penalty for Asymmetry

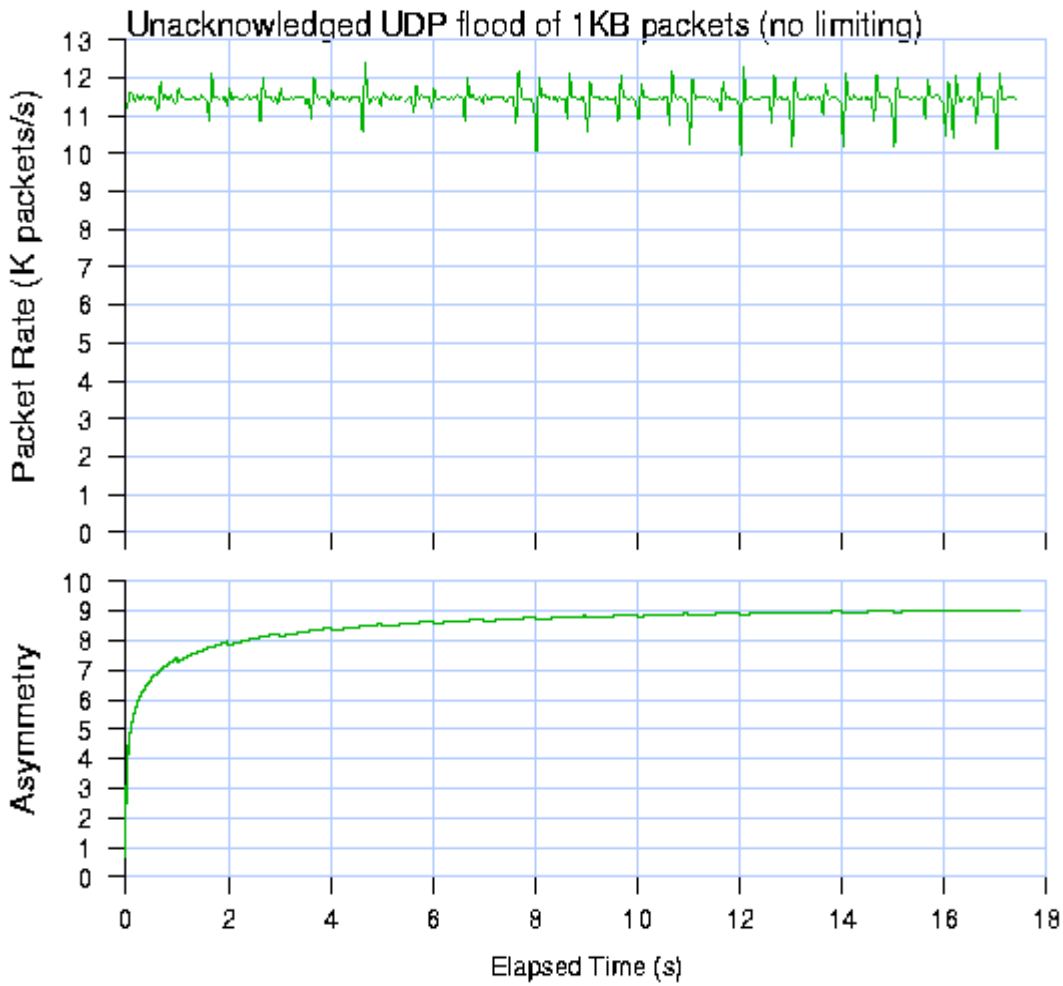
* Delay grows exponentially with asymmetry
* Delay, then drop



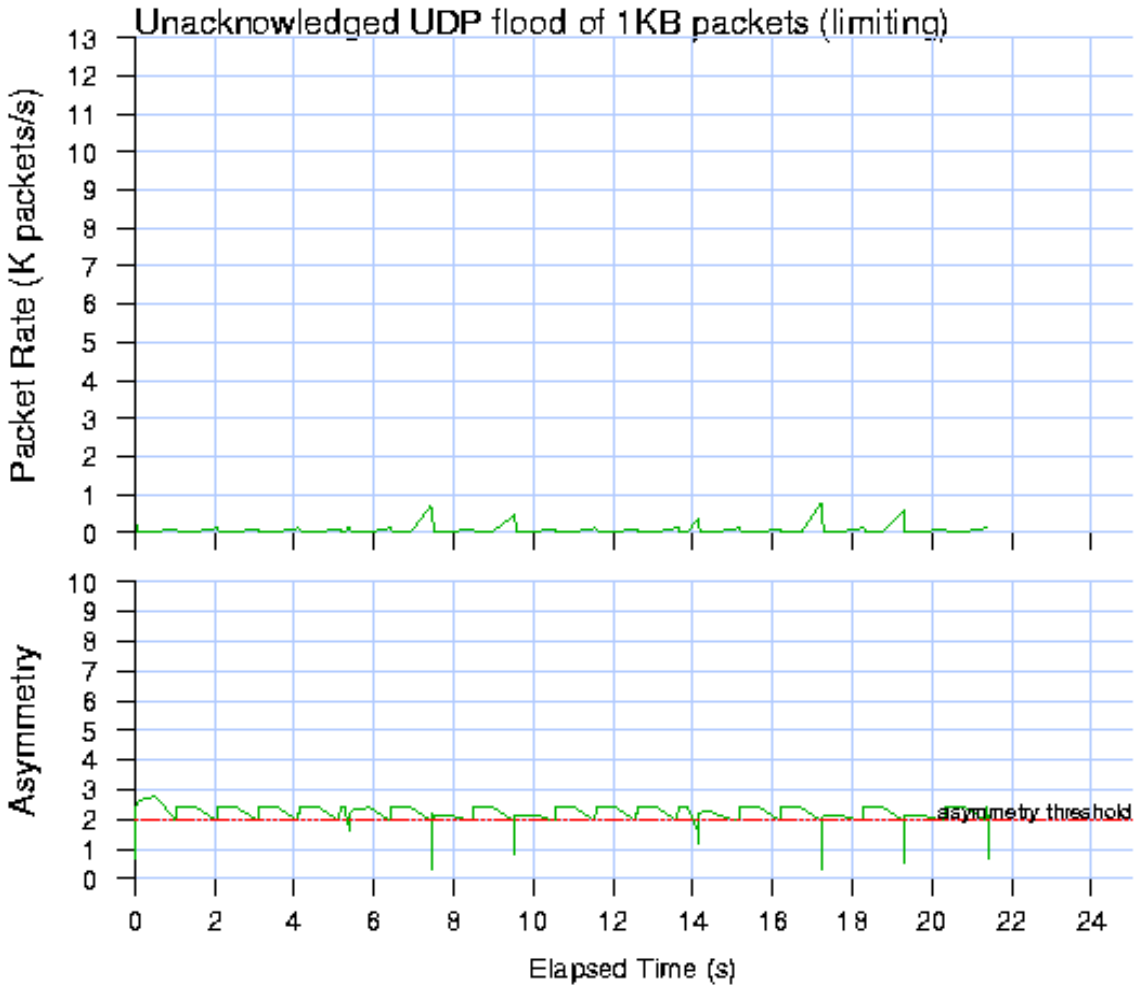
Let's give it a try

- Linux netfilter/iptables, libipq
- We fixed a threshold $S = 2$
  - Asymmetry of 8:1 – quite liberal
  - If $S > 2$
    - Start outstanding-packet counter n
    - Delay nth subsequent packet by 2 ms
  - If S goes below 2, decay delay back to zero
- Let's see some data

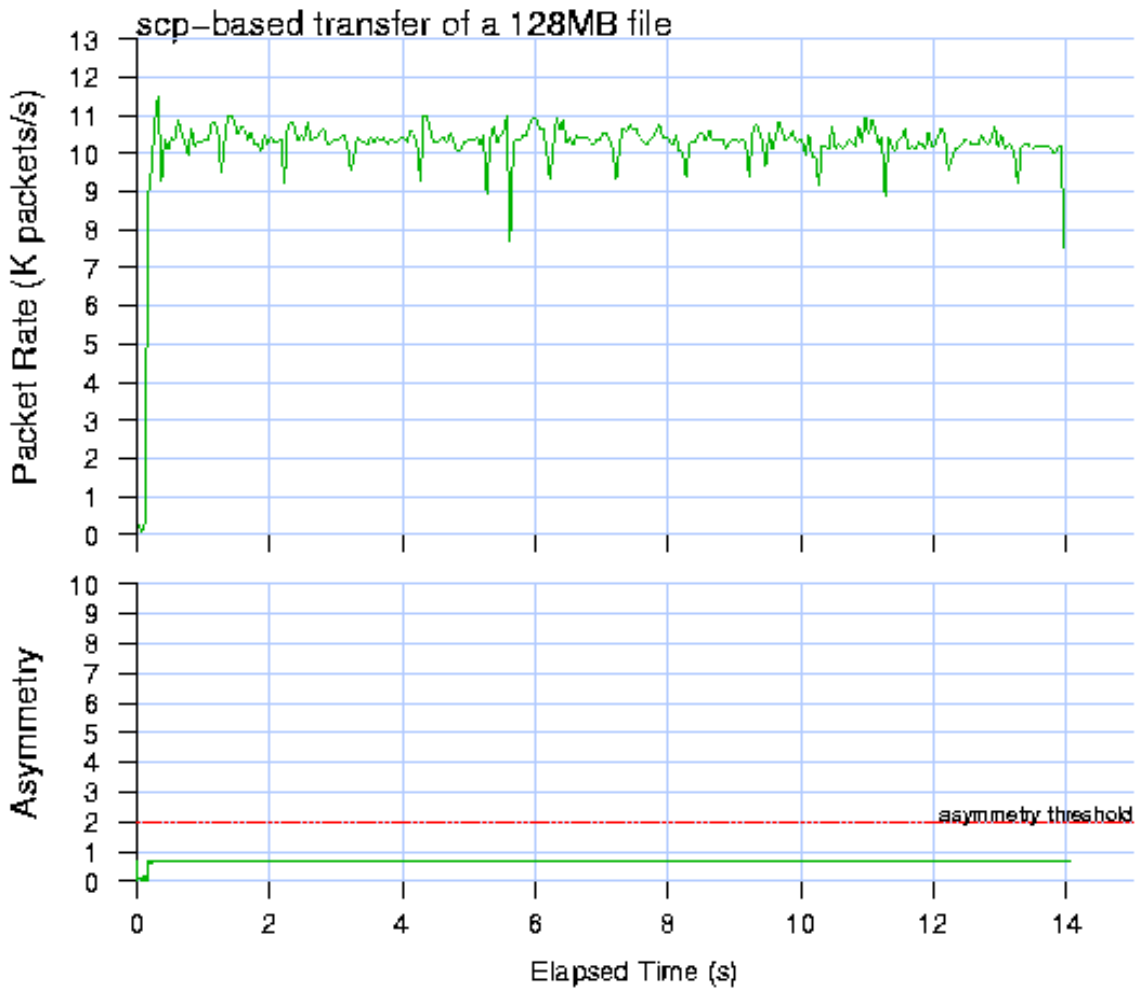
UDP Flood


Unacknowledged UDP flood of 1KB packets (no limiting)
Packet Rate (K packets/s)
Asymmetry
Elapsed Time (s)

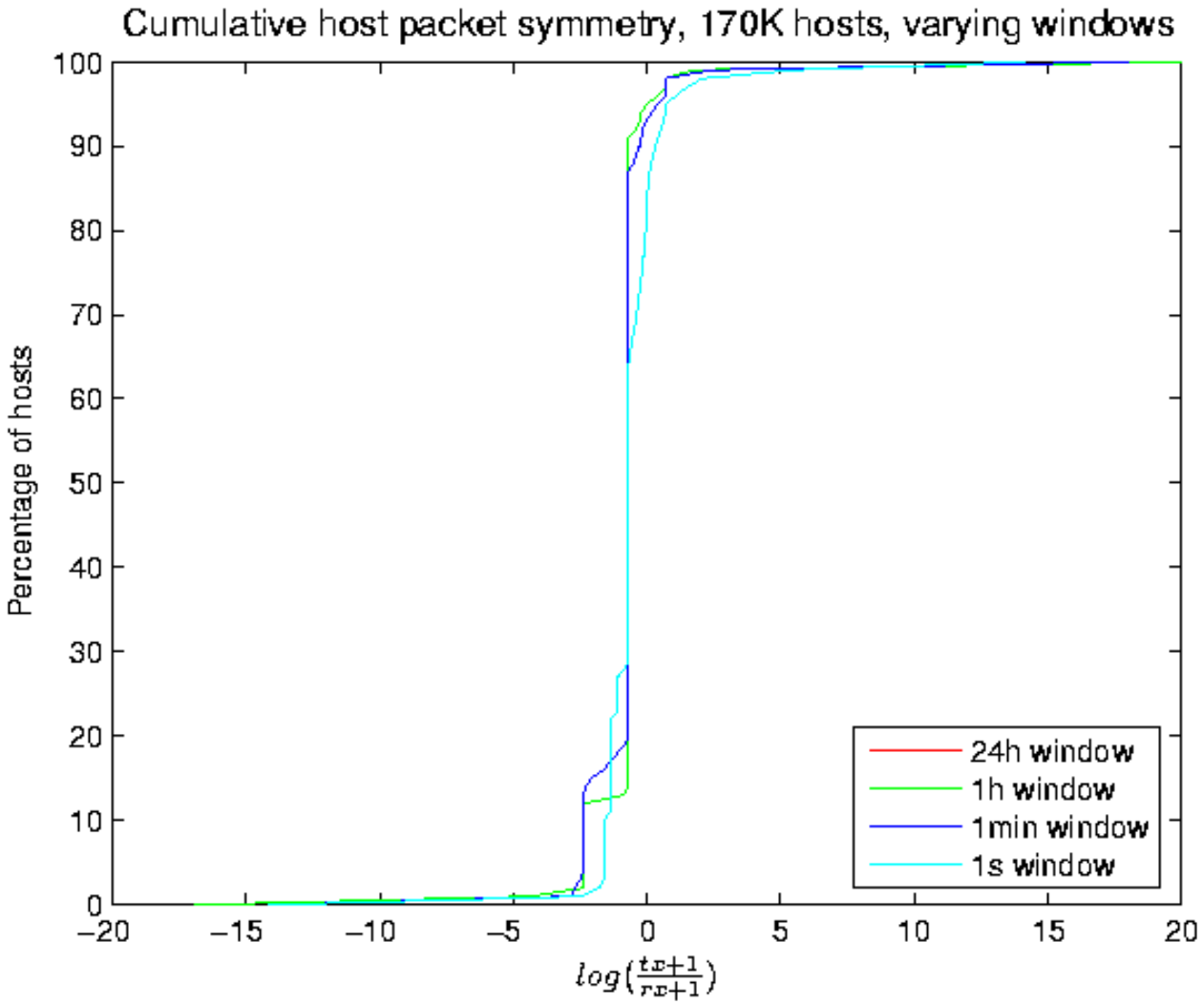
A UDP Flood, no more



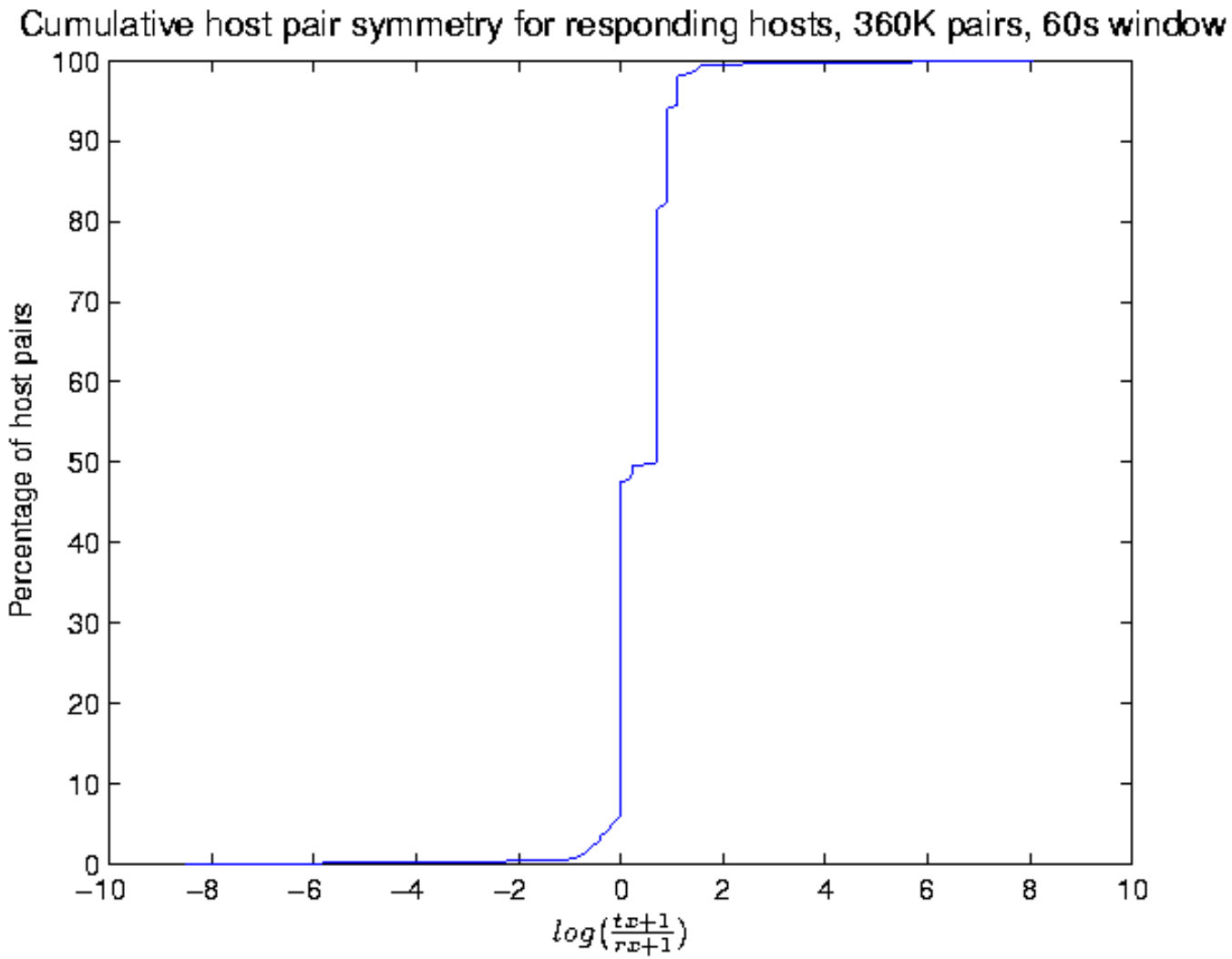
TCP is symmetric



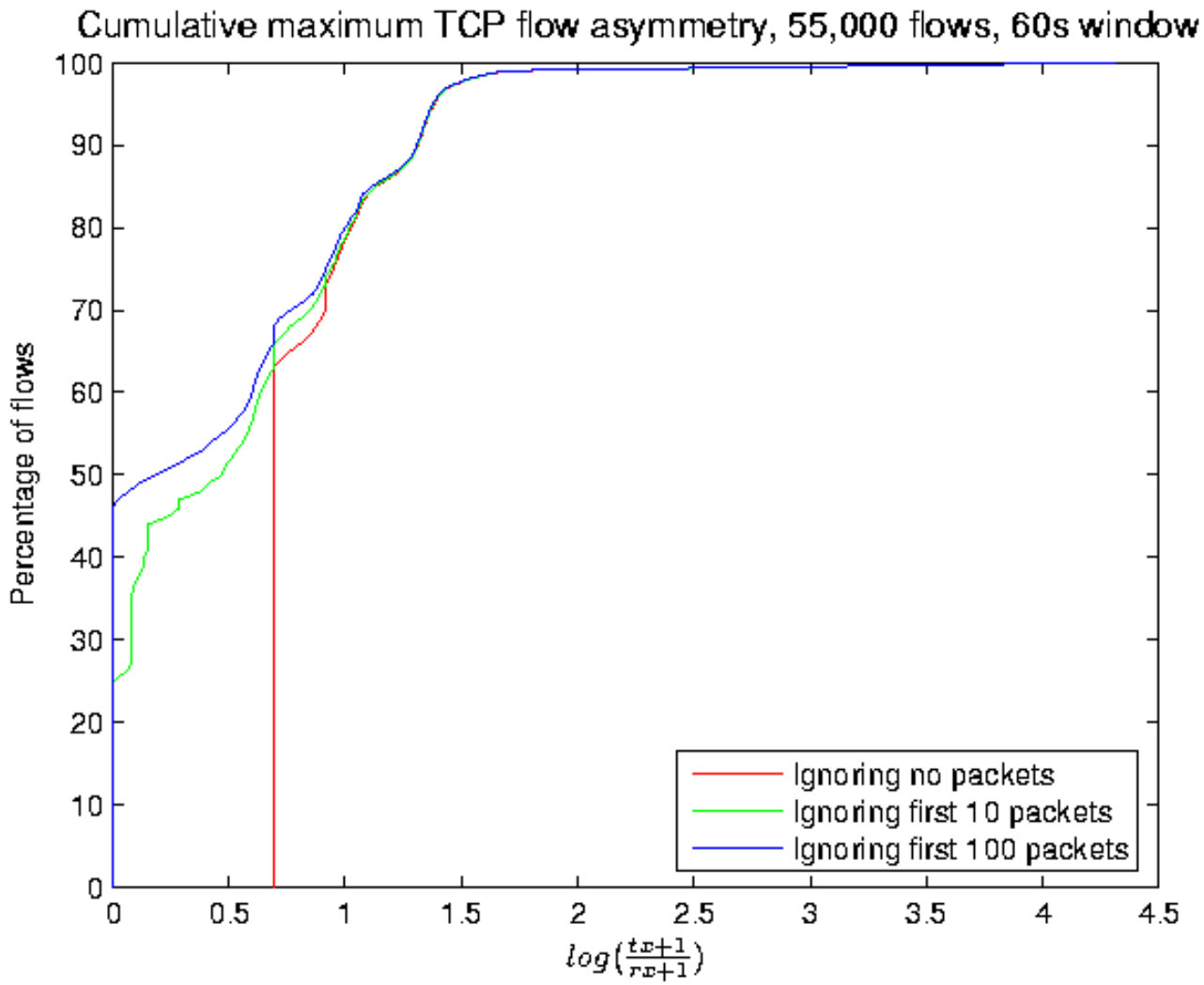
Host-based Symmetry



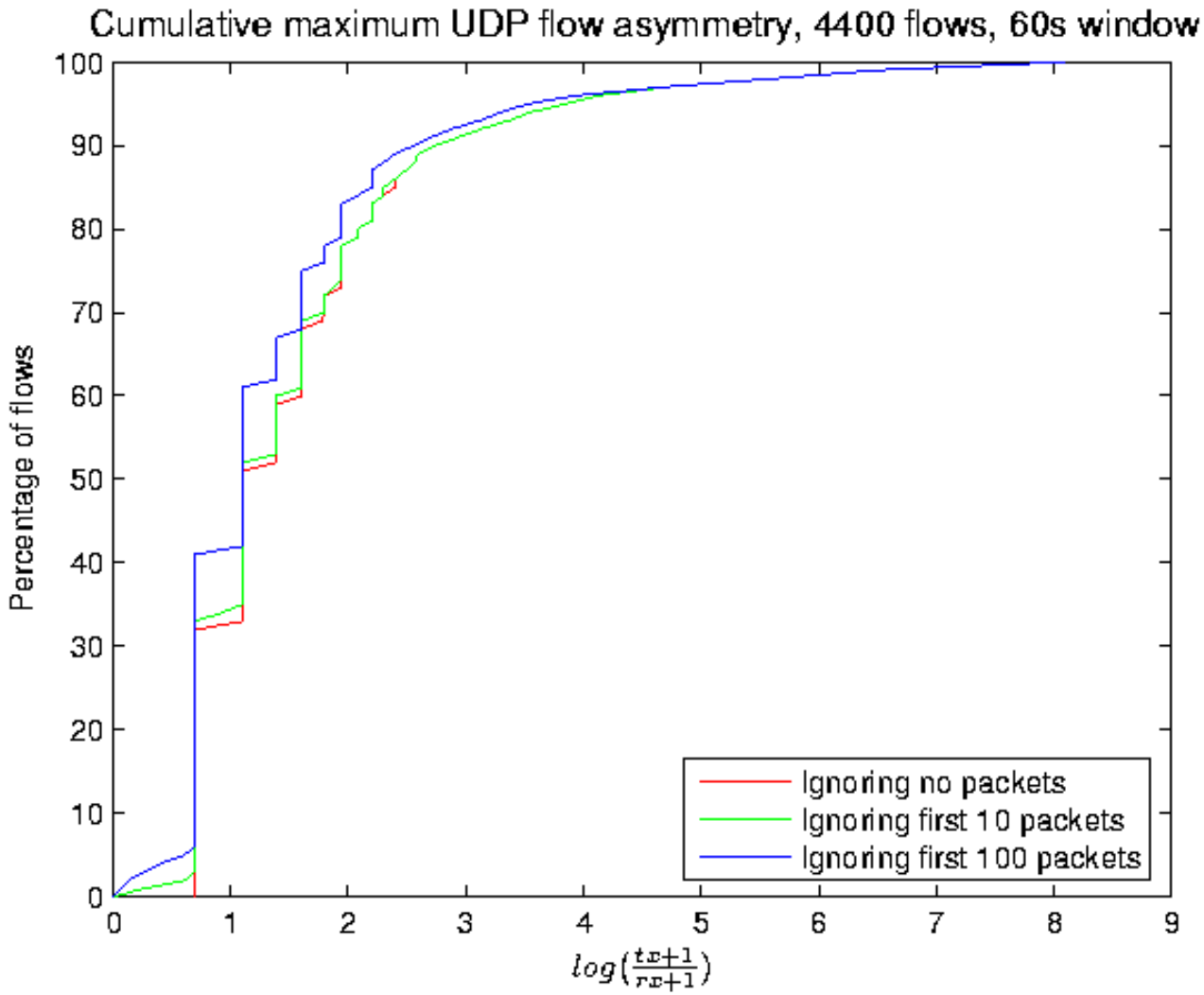
Host-pair Symmetry



Flow-based Symmetry



UDP Flow Symmetry



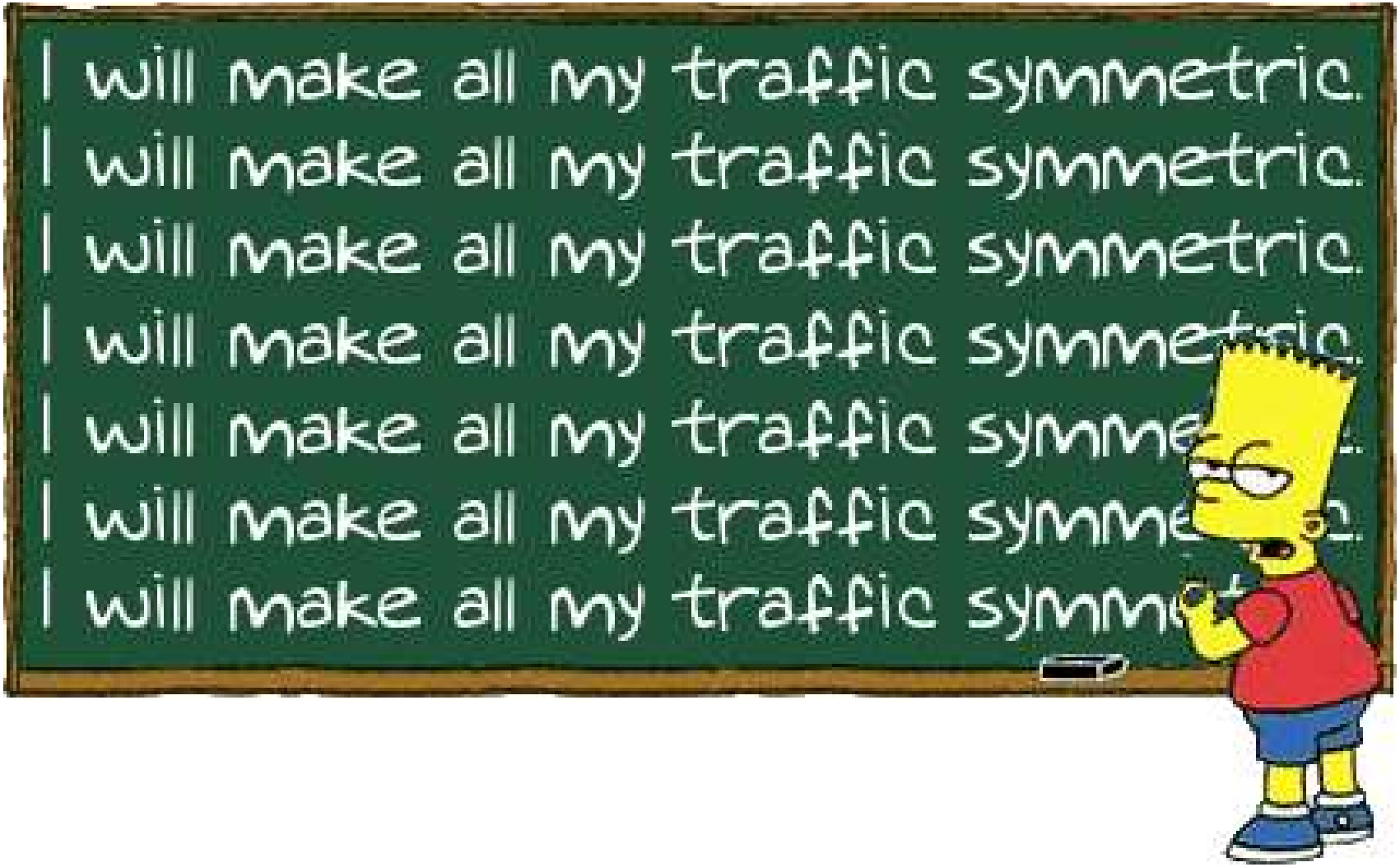
Evasive Manoeuvres

- "Fly under the radar" attacks
  - Reasonably sensitive threshold would make current DDoS levels much harder
- Botnet collusion is a tricky problem
  - Source address spoofing
    - Increasingly hard with deployed ingress filtering
    - For best effect, apply combined
  - IP ID prevents cross-traffic, unless randomised
  - Bots need to do TTL estimation
- We can raise the bar so things get significantly harder for the bad guys

Deployment Considerations

* Part of Xen toolkit
* Server farm mindset
  * Dangerous source potential
  * Deployment instantly benefits operators
* Could be put in NIC
* Michael Dales (Intel) designed it into his optical switch port controller (Xylinx), 200 lines VHDL
* Also possible in ADSL DSLAM equipment

A Principle


I will make all my traffic symmetric.
I will make all my traffic symmetric.
I will make all my traffic symmetric.
I will make all my traffic symmetric.
I will make all my traffic symme
I will make all my traffic symme
I will make all my traffic symm

Summary

* We propose a traffic shaper that is

  simple, adaptive, always-on, edge-located,

  packet-symmetry driven, ingress-applied

* Symmetry. It's a Good Thing.(TM)

* Left as an exercise for the authors:
  * State vs. accuracy/asymmetry tradeoffs?
  * Problematic traffic? (Certain protocols, RSTs, etc)
  * Second-level effects, e.g. on traffic matrices

* Real deployment planned
  * Cambridge students = lab rats

* Questions?