Using Packet Symmetry to Curtail Malicious Traffic

Jon Crowcroft
Christian Kreibich(mostly), Andrew Warfield, Steven Hand, Ian Pratt
The Computer Laboratory
University of Cambridge
http://www.cl.cam.ac.uk/~jac22

Any questions?

- To start with:-)

- Btw, we have other work (Manuel Costa/Microsoft) on Worm Containment, which I can talk about if you like)
- But this is most relevant to DOS…->

A word from our sponsor

- Communications Research Network
  - CMI funded (UK/US, +BT/BP et al)
  - Network of industry+academics
    - BT, Cisco, Juniper, Nokia, etc
    - UCL, Cambridge, Oxford, MIT
  - Working Groups
    - Core Edge+Broadband, Interprovider Routing+QoS,
    - Security, Denial-of-Service
    - Open Spectrum, Photonics

What's Malicious

- Anything that's not typical
  - Typically, traffic dynamics can be observed
- What is a very simple, immediate characteristic that can be used:
  - Implicitly, to allow or deny, or
  - limit atypical behaviour at the ingress to the net
- Before its "too late"
  - reactive response is far too slow for DDoS attacks

Smoke and **Mirrors**

- Most flows are roughly symmetric at the packet level
  - Whenever a packet is sent, a packet is received within some reasonable interval (round trip time)
    - This can me measured (and enforced) at the edge router inexpensively
  - It is remarkably robust
    - And surprisingly universal!
  - nicely orthogonal to simple blocking based on default allow/deny at ISP boundaries
    - it doesn't operate on a per-flow level

Ingress versus Egress

- Firewalls ok to stop bad stuff at ingress to sink.
- Too late for DoS - need egress defense near source
- server (e.g Xen) farm v. ISP deployment considerations

Asymmetry metric

- S = ln [(tx+1)/(rx+1)]
  - Seems suitable since it is negative for rx>tx,
  - 0 for tx==rx
  - And positive for tx > rx

- Note, tx and rx are packet count **not** byte counts
- Need to be measured near transmitter
  - otherwise path asymmetry problem or address translation or spoofing problems

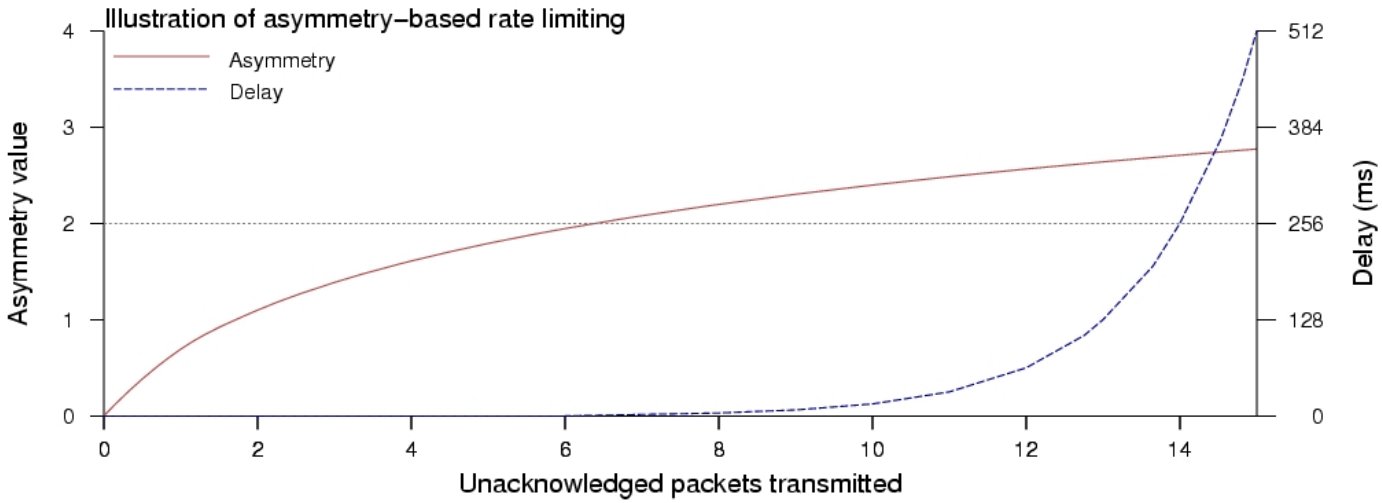
- Action is to delay, then drop

Prototypical Implementation

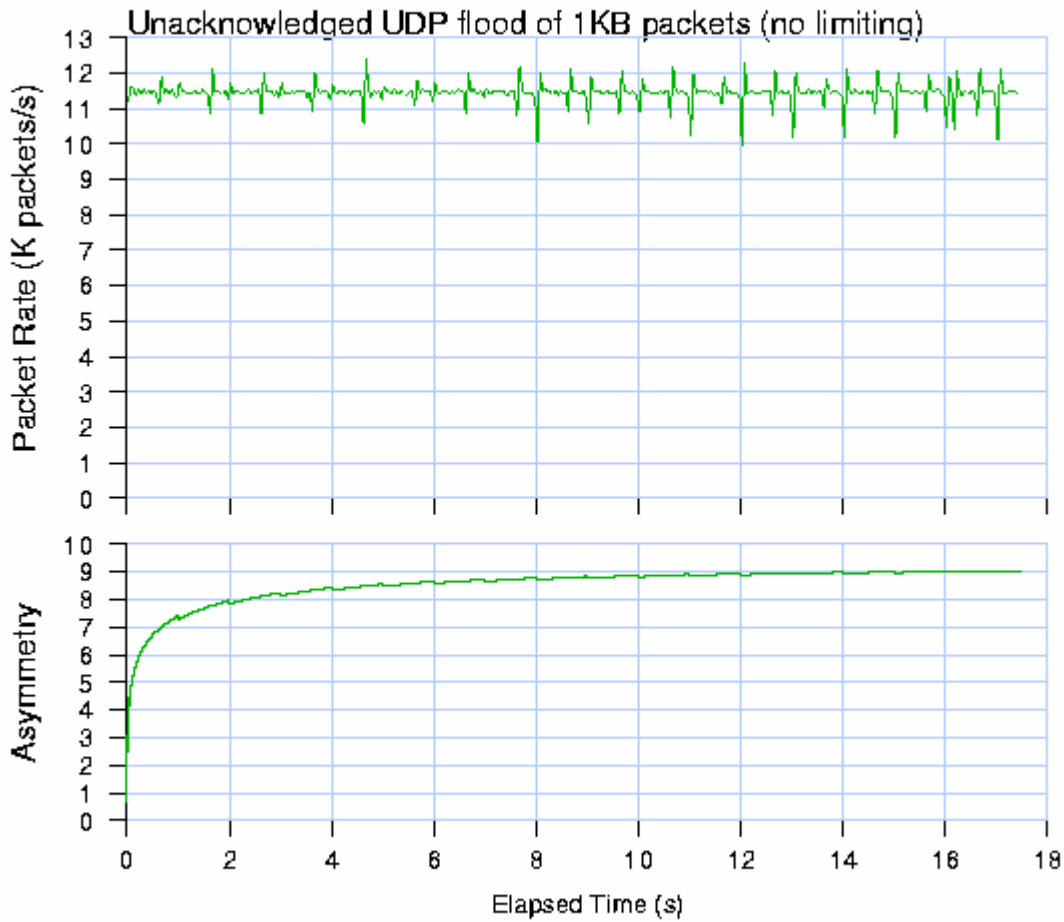
- Linux netfilter/iptables, Libipq
- Choose threshold S = 2 (asymmetry of 8 times)
  - If S > 2, delay nth subsequent packet by 2^n ms
  - If S goes below 2, decay delay back to zero.

- Let's see some data

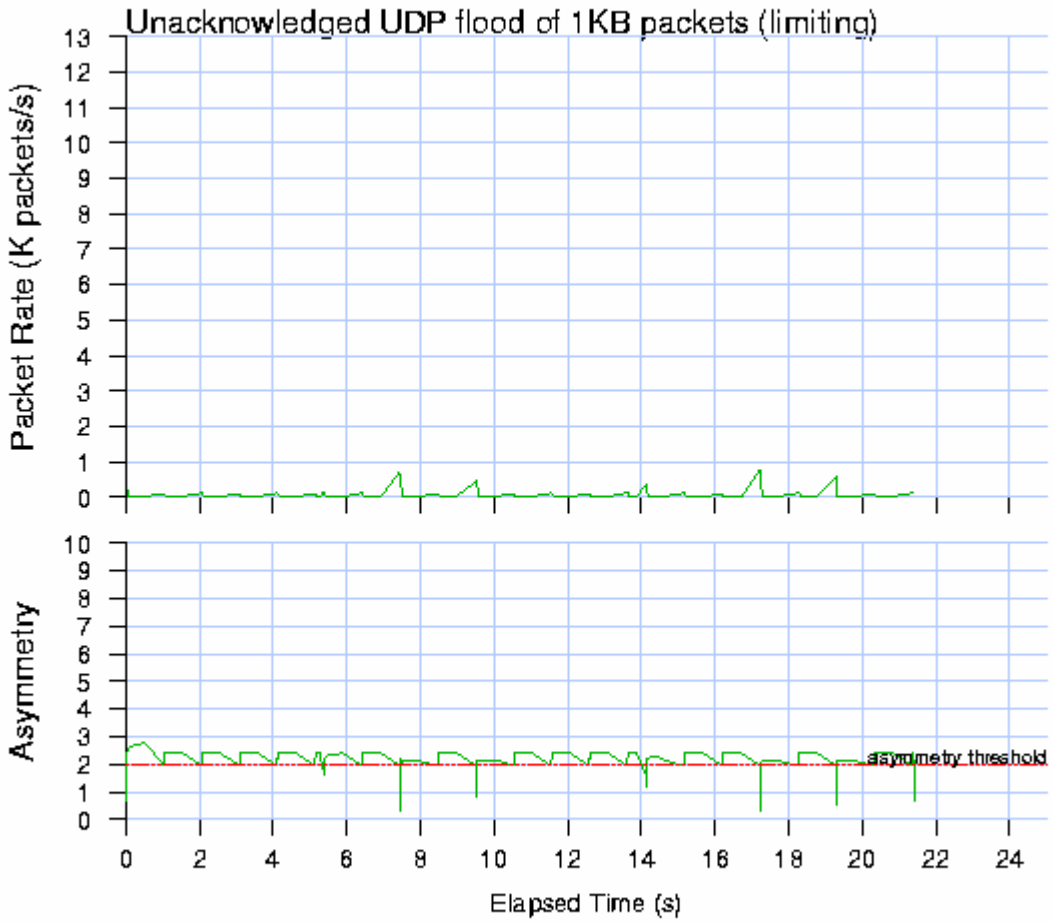
Delay imposed on asymmetric flows



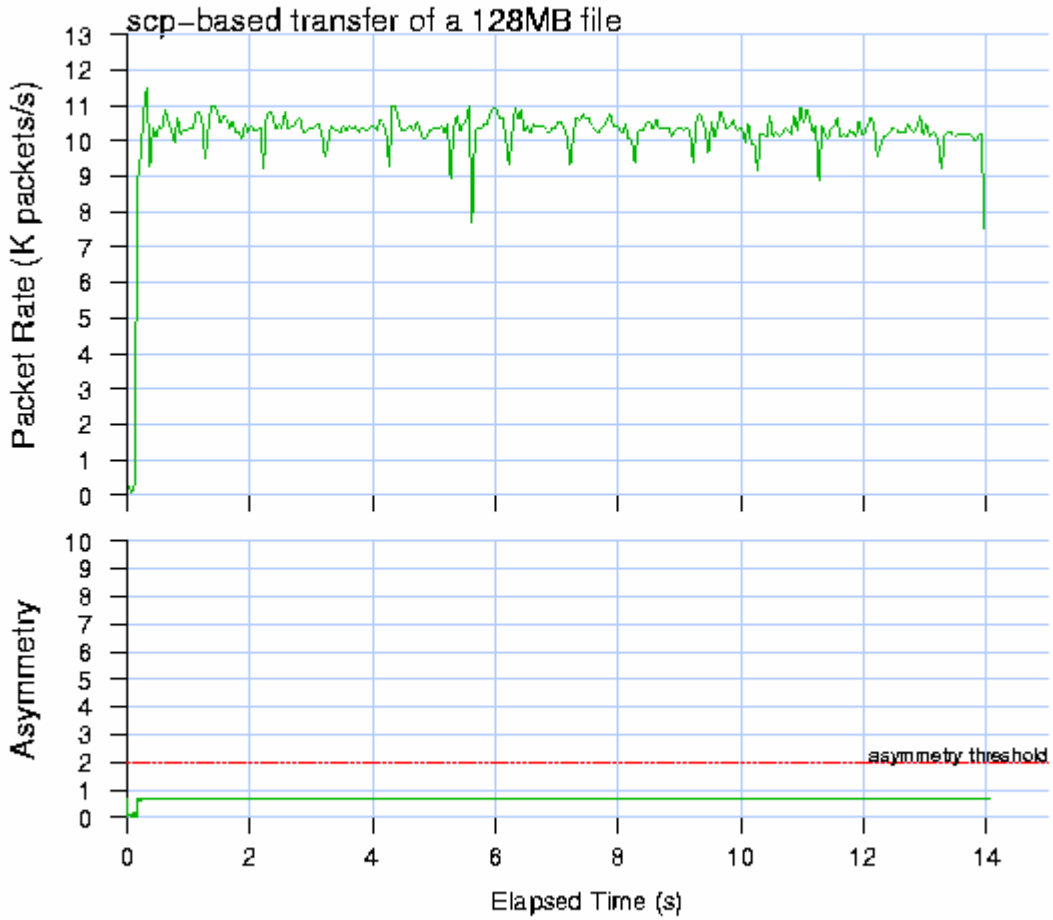
A UDP Flood


Unacknowledged UDP flood of 1KB packets (no limiting)
Packet Rate (K packets/s)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
Asymmetry
0
1
2
3
4
5
6
7
8
9
10
0
2
4
6
8
10
12
14
16
18
Elapsed Time (s)

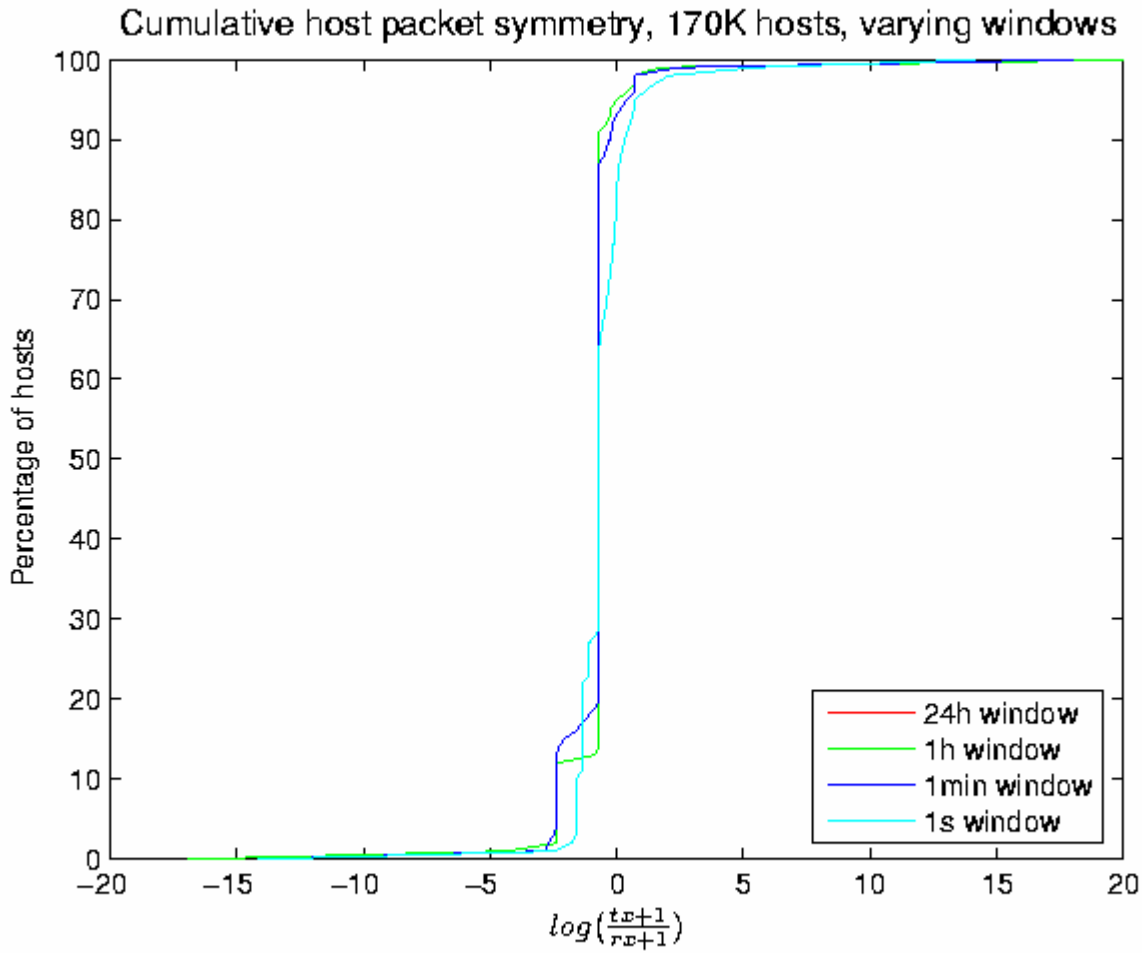
A UDP Flood stemmed



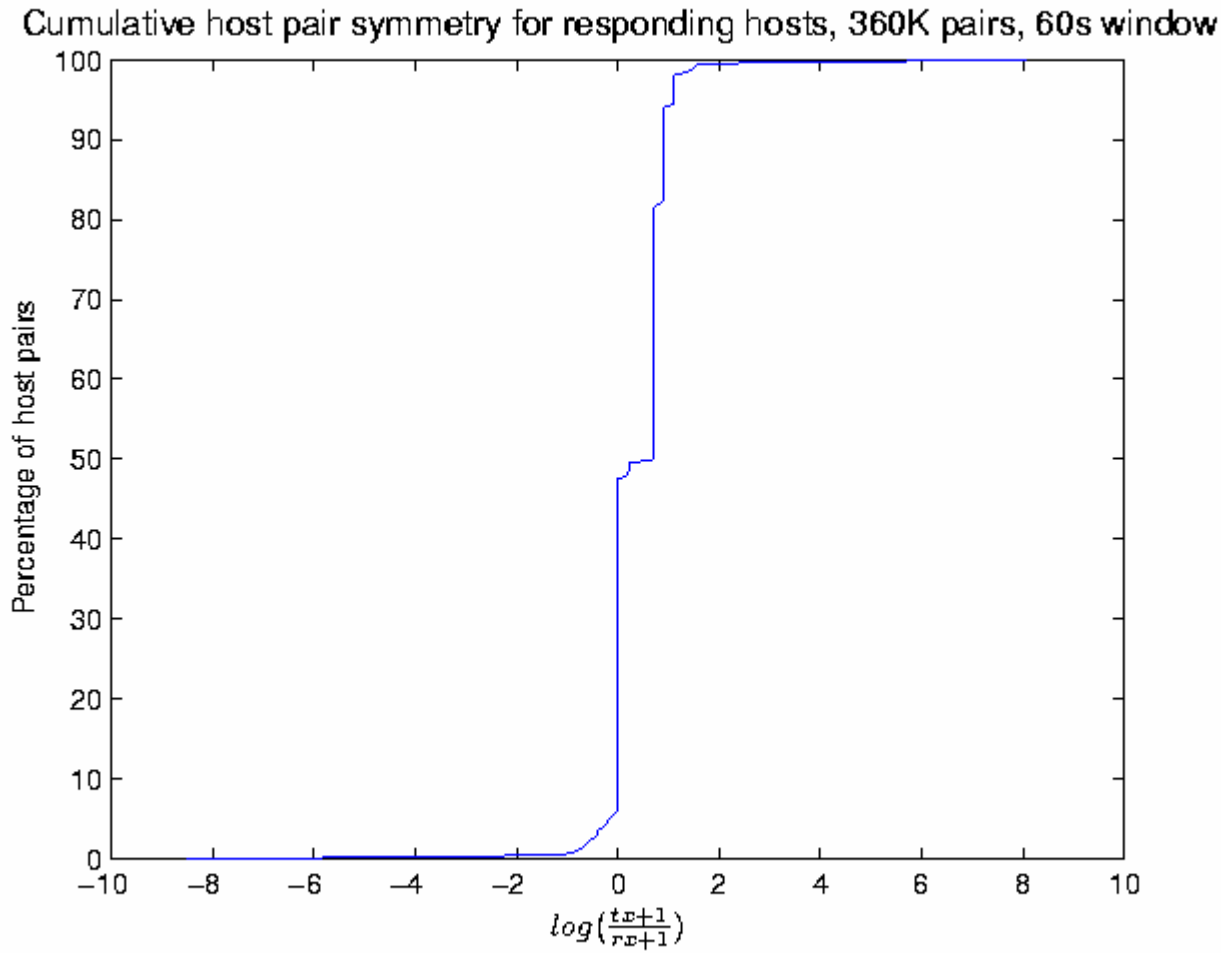
A large, but normal (well behaved) TCP Flow



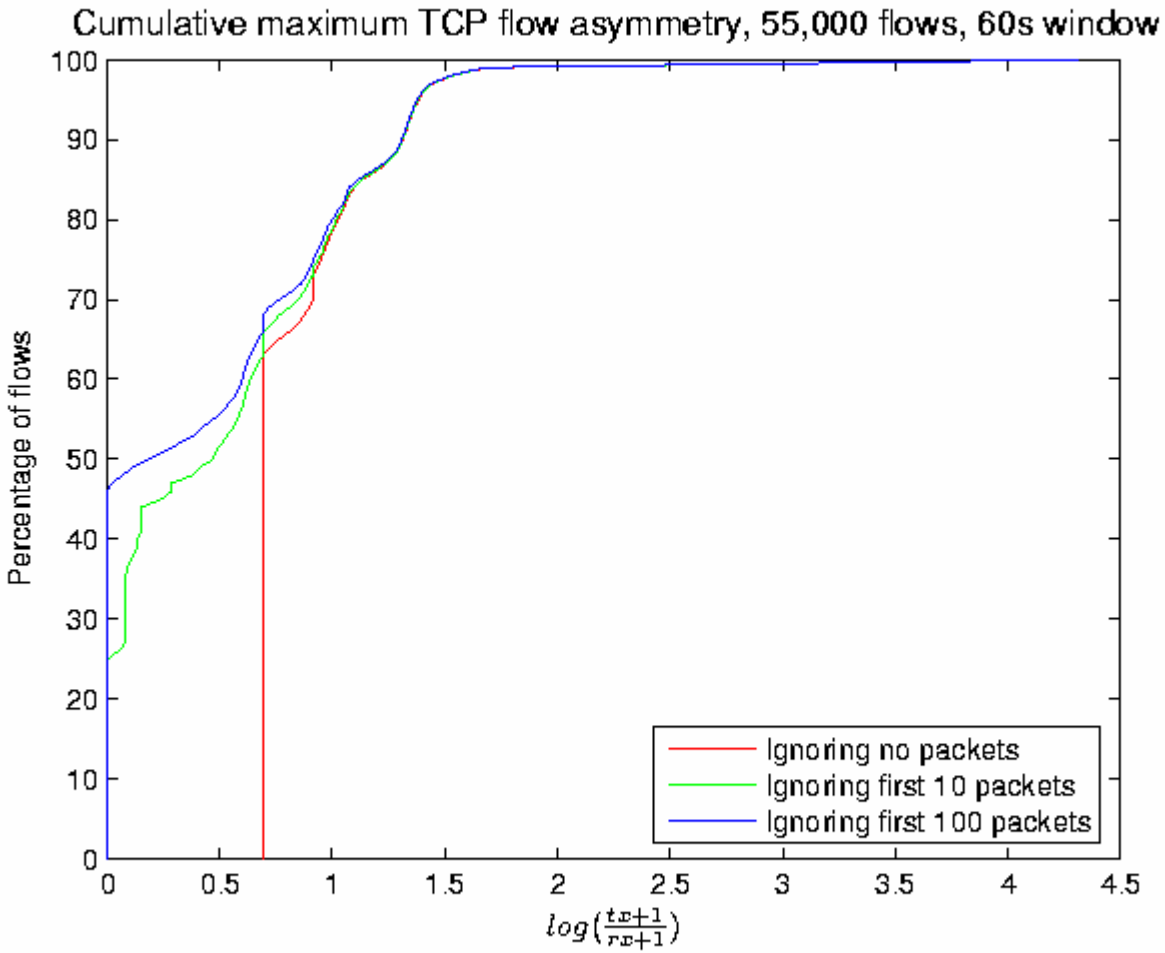
Host based symmetry



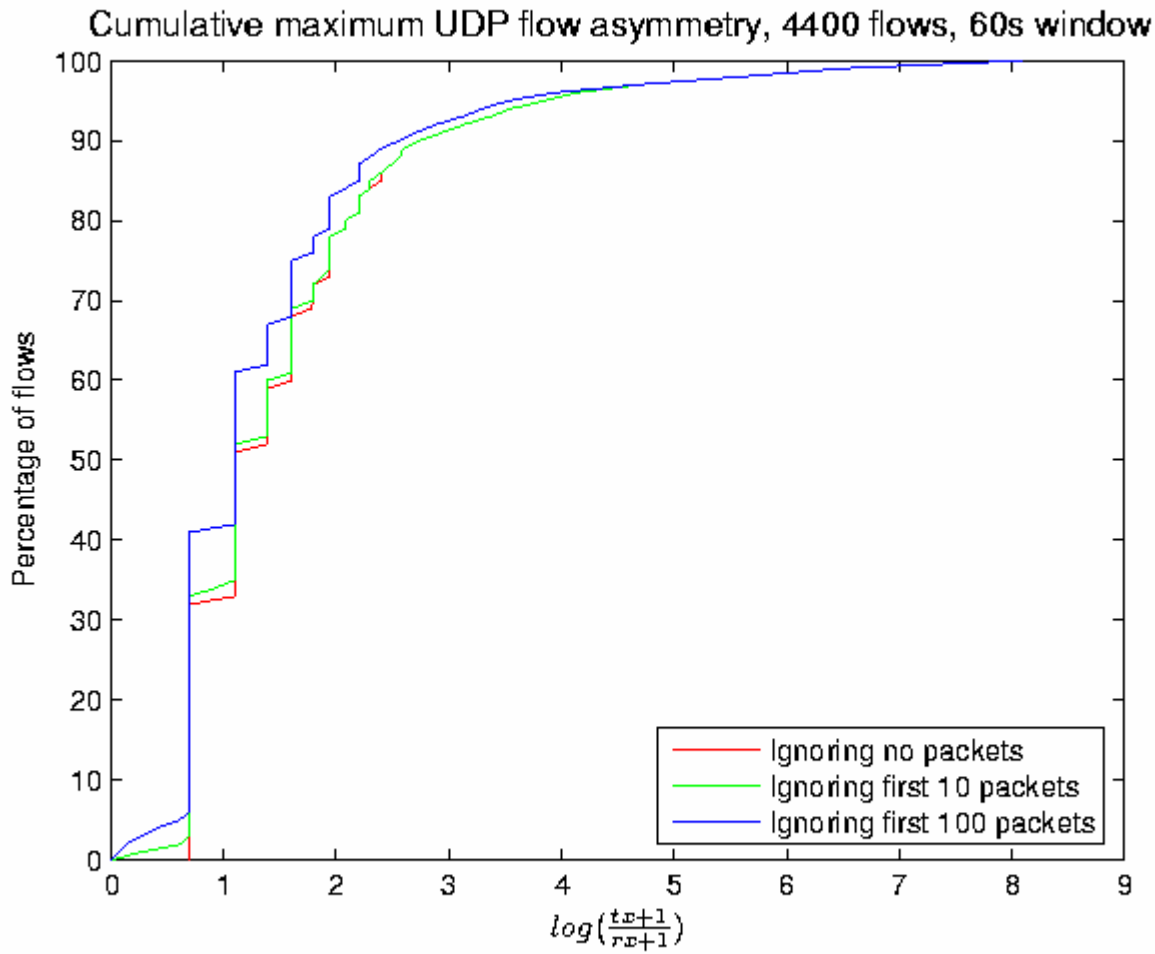
Host pair based symmetry



Flow based symmetry



UDP flow based symmetry



Evasive Manouevres

- Source address spoofing
  - Bad guy can masquerade as a good site
  - But they can't get traffic _back_ so wont work
  - But they might cause good guy to get throttled…so:
- Randomization of IP ID
  - Bad guy cannot tell what IP ID from good guy can do
  - Policer/limiter can check the ID before throttling
- TTL Estimation
  - Bad Guy doesn't know what TTL is from good guy
  - Policer can check TTL is "right" before throttling

Deployment considerations

- Part of Xen toolkit (virtualised device stuff)
- Behoves us to do this as Xen is likely to be deployed in high capacity (dangerous source potential) sites
- Could put in NIC
- Michael Dales (Intel) designed it into his optical switch port controller (Xylinx)
- Also proposed in ADSL DSLAM equipment (simple as part of ATM mux level police/symmetry enforcement in broadband access contention control).

Practical Protocol Considerations

- TCP acks every other packet 99% of the time
- UDP use:
  - DNS, SNMP - request/response
  - RTP/UDP - RTCP reports about 1/6th of RTP
- Counter examples
  - Syslog is only 1 we could find in BSD/Linux/OSX
  - Some Windows apps (DCOM use for Outlook:)
  - Almost all (100%) LAN only by definition:)
  - Consequence of congestion control need in WAN?

Related work

- Other approaches require trace-back and/or push-back
  - Too expensive, too slow and too late
- Deal with symptom not cause!
  - more feasible for ISP as “bit-pipe provider" to deploy symmetry enforcement
  - than to filter traffic based on application-layer characteristics
- More fundamental architectural change
  - Mothy (hotnets 03?) - capability to send
  - Cheriton et al (to appear) - meta-capability
  - Handley/Greenhalgh (sigcomm 05) - asymmetry

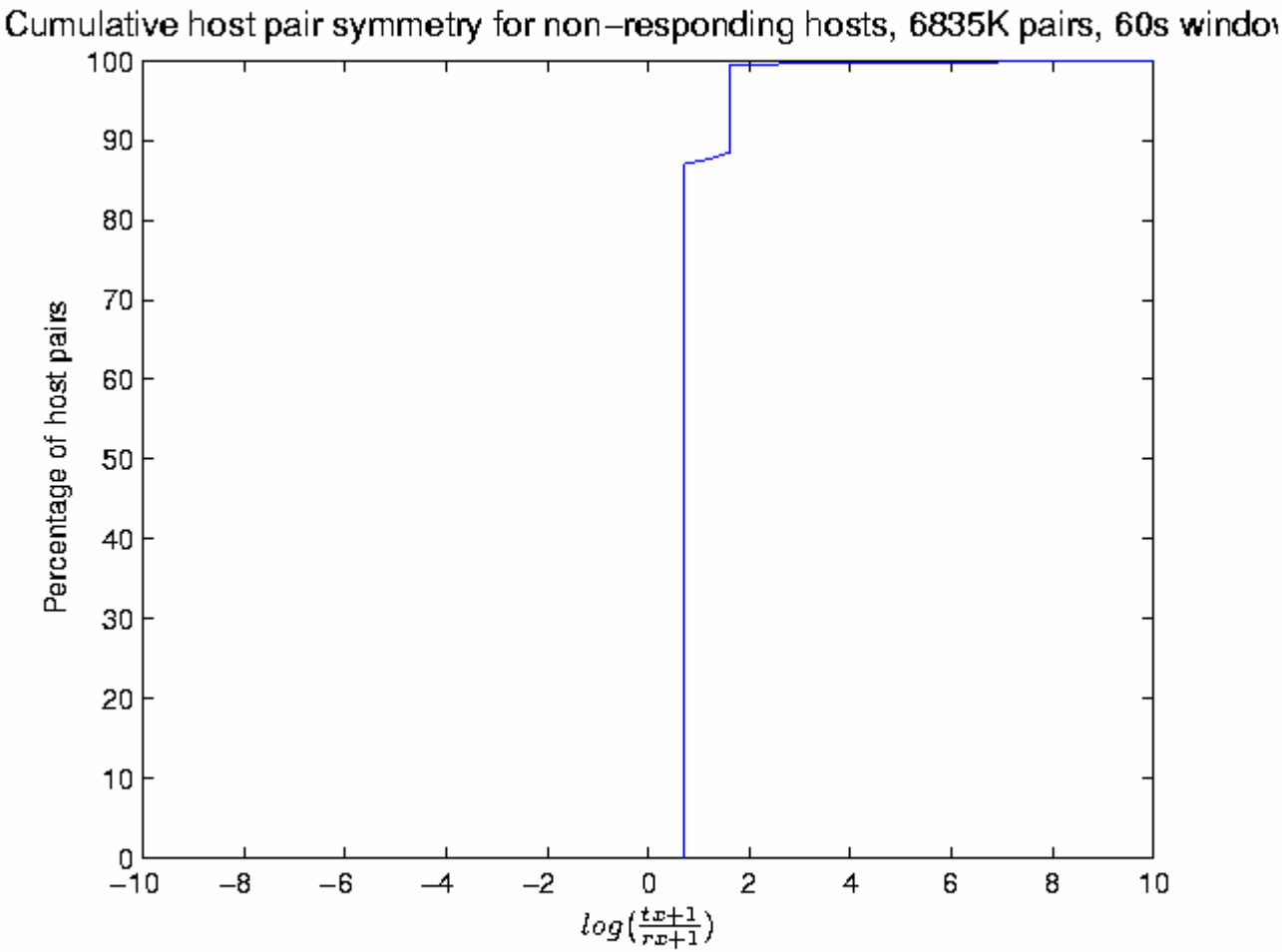
Generalise?

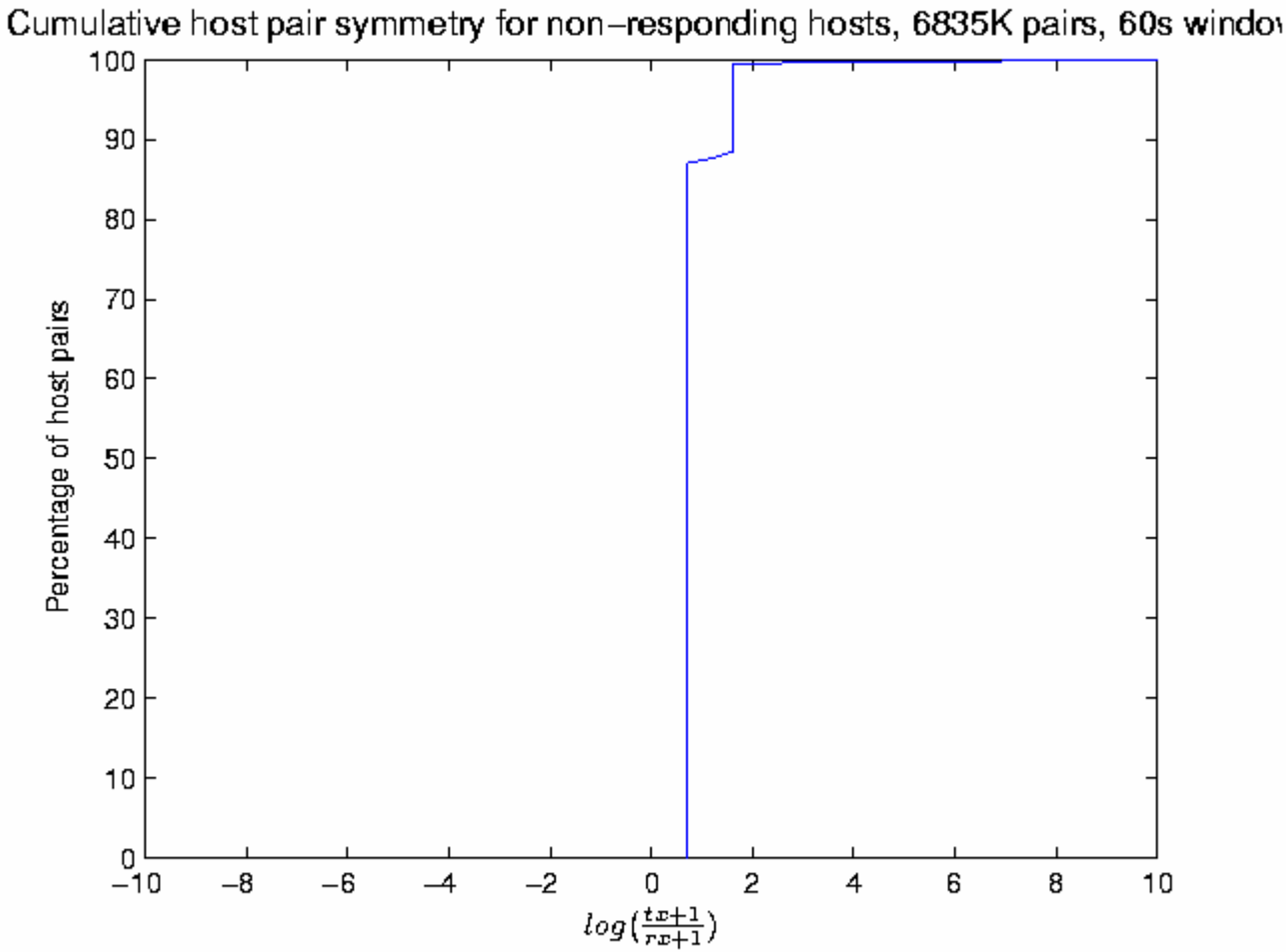
- Should all protocols be mandated symmetric?
  - The "*Well Tempered Internet*" (Steven Hand's piano player:)
  - Is this a design principle for feedback based systems?
  - Argue for both stability and for information theory reasons, hard to see otherwise…
  - Details (state/accuracy and asymmetry tradeoffs) TBD

- Acknowledgements to Mark Allman, Vern Paxson, Chema Gonzales, Juan Caballero, Michael Dales (200 lines of VHDL), Atanu Ghosh, Andrew Moore (traces)

Questions?

- Any?
  - Q1. Can you devise a symmetric attack? (nick mckeown&matthew andrews from bell labs)
    - A1. Yes, but hard for bad guy coordinate, so easy for ISP to detect
  - Q2. What about randomizing the initial slow down value to make it hard to for bad guy to probe for symmetry policers? (Stephen Farrell from TCD asked this one!)
    - A2. Cool!
  - Q3. Isn't there a more general principle in this symmetry idea? (Ted Faber from ISI)
    - A3. Guess so…




Cumulative host pair symmetry for non−responding hosts, 6835K pairs, 60s windo
Percentage of host pairs
100
90
80
70
60
50
40
30
20
10
0
−10
−8
−6
−4
−2
0
2
4
6
8
10
$log(\frac{tx+1}{rx+1})$