Traffic Analysis of UDP-based Flows in ourmon

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Outline

- problem space - and short ourmon intro
- UDP flow tuple
  - UDP work weight
  - UDP guesstimator
  - problems (DNS and p2p as scanners)
- packet-size based UDP application guessing
- conclusions

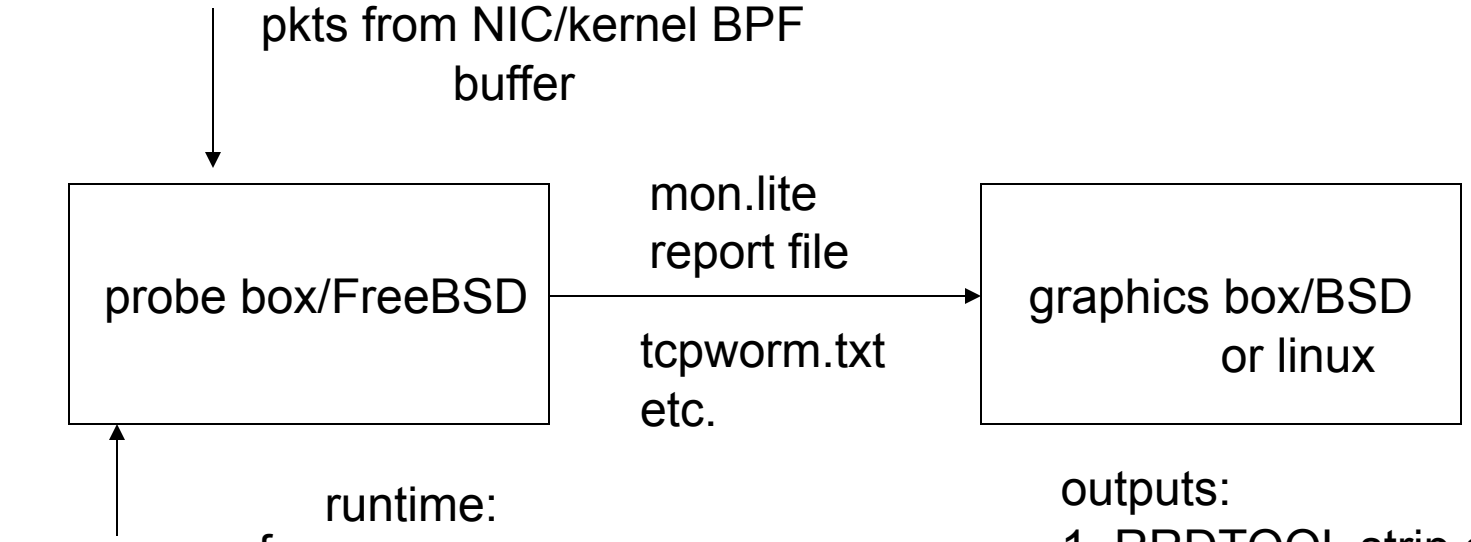
motivation - problem space

- UDP-based DOS attacks certainly exist
- p2p searching courtesy of Distributed Hash Tables on the rise (use UDP to search and TCP to fetch)
  - Kademlia protocol - Maymounkov and D. Mazieres.
- stormworm botnet is UDP/P2P based
  - based on edonkey related protocol (overnet)
- p2p-based apps not just for file-sharing
  - Joost - “cable TV”, Skype - VOIP
- goal: focus on UDP flow activity in terms of security and p2p

brief ourmon intro

- 2 part system: front-end, back-end
  - front-end: packet sniffer, output ASCII files
  - back-end: web-interface with graphs, and aggregated logs
- front-end produces:
  - scalars that produce RRDTOOL web graphs
    - either hardwired or programmable (BPF)
  - various kinds of top-N lists (ourmon flows)
- back-end
  - web access plus graphics processing, log aggregation
  - 30-second view and hourly aggregation views
  - event log for important security events

ourmon architectural breakdown



filters: BPF expressions, lists, some hardwired C filters

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ourmon flow breakdown

- top N traditional (IP.port->IP.port) flows
  - IP, UDP, TCP, ICMP
  - hourly summarizations and web histograms
- IP host centric flows at Layer 4
  - TCP (presented in TCP port report)
  - **UDP (presented in UDP port report) <-----**
    (this is what we are talking about here)
- Layer 7 specific flows now include
  - IRC channels and hosts in channels
  - DNS and ssh flows (spin-off of traditional flows)

UDP port report

- UDP centric top N tuple collected by front-end every 30 seconds
- hourly summarizations made by back-end
- flow tuple fields:
  - IP address - key
  - IP dst address - one sampled IP dst
  - UDP work weight - noise measurement (sort by)
  - SENT - packet count of packets sent
  - RECV - packet count of packets returned to IP
  - ICMPERRORS - icmp errors returned (unreachables in particular)

UDP port report tuple, cont.

- L3D - count of unique remote IP addresses in 30-second sample period
- L4D - count of unique remote UDP dst ports
- SIZEINFO - size histogram
  - 5 buckets, <= 40, 90. 200, 1000, 1500
  - (this is L7 payload size)
- SA - running average of sent payload size
- RA - running average of recv. payload size
- APPFLAGS - tags based on L7 regular expressions
  - s for spim, d for DNS, b for Bittorrent, etc.
- PORTSIG - first ten dst ports seen with packet counts expressed as frequency in 30 sec report
  - e.g., [53,100] meaning 100% sent to port 53

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UDP work weight calculation

- per IP host
- **UDP ww = (SENT * ICMPERRORS) + RECV**
  - if ICMPERRORS == 0, then just SENT + RECV
- we sort the top N report by the UDP ww
- basically can divide results up into about 3 bands: (numbers are relative to ethernet speed, 1 Gbit in our case)
  - TOO HIGH (> 10 million in our case)
  - BUSY 1000..1 million (p2p/games/dns servers)
  - LOW (most - e.g., clients doing DNS) < 1000

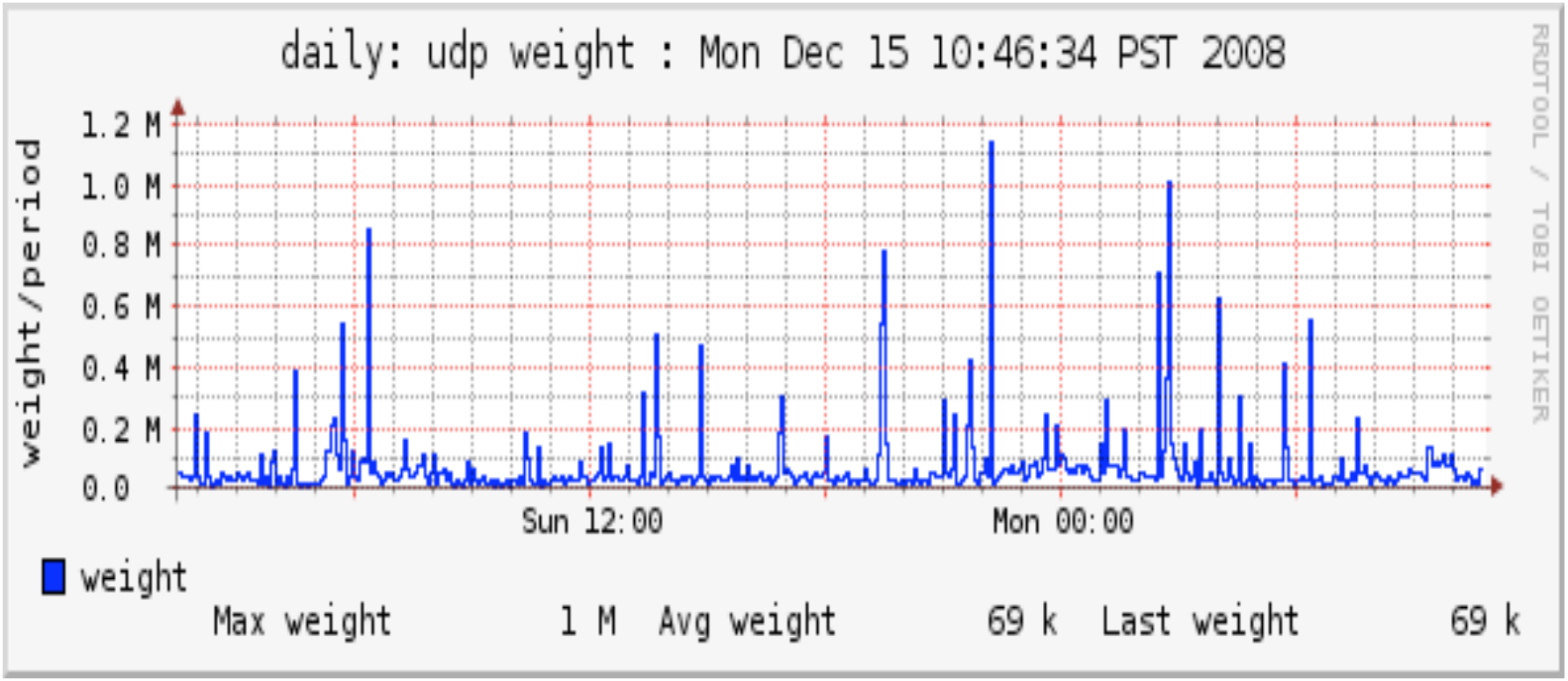
theory behind UDP workweight

- if a host is doing
  - scanning
  - p2p
- it may generate SENT * ERROR packets and hence appear higher in the report
- scanning error generation is obvious
- p2p error generation is because a p2p host has a set of peers, some of which are stale
- if just busy, we add SENT + RECV
  - some hosts may recv more packets then they send
  - e.g., JOOST p2p video apps
- result: big error makers to the top, busy hosts next

some added features of UDP work weight

- we graph the very first tuple (the winner!) over the day, which
  - gives an average distribution
  - shows spikes
  - average day shown in next slide
- if work weight > HIGH THRESHOLD
  - we record N packets with automated tcpdump mechanism
  - this has proved effective at the past in catching DOS attacks sources and targets
  - even when monitoring fails if DOS was too much for probe - so far have always managed to capture sufficient packets

daily graph of top UDP work weights



top single work weight per 30-second period for typical day:
note: peaks here are usually SPIM outside in

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contrived UDP port report (simplified)

IP src	ww	Guess	SENT	RECV	ICMP ERR	L3D / L4D	App flags	portsig
1*	20 million	scan	20000	18000	827	208 / 527	b	many
2	12 million	ipscan	6598	12	1936	600 / 2	s	1026, 1027
3*	49000	p2p	1555	1215	31	1637 / 1297	b	many
4	3321	p2p	2430	891	1	703 / 279	d	53

UDP guesstimator algorithm

- attempt to guess what host is up to based on attributes
- principally on L3D/L4D and workweight
- goal: use only L3 and L4 attributes not L7 attributes and avoid destination port semantics
  - thus it should work if bittorrent is on port 53 and encrypted
- per IP host guess
- basically a decision tree with 3 thresholds
  - WW high threshold - set at 10 million
  - L3D/L4D - p2p counts (say 10 for a low threshold)

rough algorithm

- guess = “unknown”
- if ww > HIGHTHRESHOLD
  - guess = scanner
  - if L4D is HIGH and L3D is LOW
    - guess = portscanner
  - else if L3D is HIGH and L4D is LOW
    - guess = ipscanner
- else if L3D and L4D > P2PTHRESHOLD
  - guess = p2p
- we have HIGHTHRESHOLD at 10million, port thresholds at 10 (might be higher/lower depending on locality)

how well does it work?

- it is really only pointing out obvious attribute aspects but this is helpful to a busy analyst
- two interesting errors
- 1. because DNS servers are typically busy and because they send to many ports, many destinations
  - diagnosed as p2p -- true, but somehow annoying
  - our L7 pattern is complex and is probably sufficient as DNS isn't going to be encrypted
- 2. some p2p hosts -- typically with stale caches may be diagnosed as "scanners"
  - in a sense this is true
  - note that p2p/scanner overlap is a long-standing problem

application guessing - limited experiment

- inspired by Collins, Reiter: Finding Peer-To-Peer File Sharing Using Coarse Network Behaviors, Sept. 2006
- decided to try to use packet sizes to see if we could guess UDP-based applications
- SIZEINFO SA/RA fields used for the most part
  - thus 7 attributes in all, basic sent size histogram + SA,RA
- initially only done if guesstimator guesses “p2p”
  - had to back that off for Skype
- only tested in a lab using Windows Vista and applications (some testing on a MAC)
- culled stats from 30 second UDP port reports
- this information is appended to guess e.g.,
  - p2p:joost

approach

- limited testing - lab only (barring stormworm where we got pcap traces from elsewhere)
- gathered attribute stats and
  - graphed them
  - per attribute choose lower and upper threshold based on >= 90% of samples
  - note that the 1000-1500 byte SIZE attribute was always 0 (not used)
- result coded as decision tree forest
  - really a set of if tests - not if-then-else
  - therefore results could overlap (fuzzy match)

apps/protocols in experiment

application	protocol
edonkey	emule
bittorrent	bittorrent
azureus	bittorrent
utorrent	bittorrent
limewire	gnutella or bittorrent
joost	joost
skype	skype
stormworm (UDP)	emule variant

results?!

- suggestive and interesting but not 100% conclusive that this approach might be valuable
- problems:
  - not enough testing but seemingly worked well barring skype
  - not enough apps (should have included DNS! and probably NTP)
  - we may be finding app classes not particular apps
  - we don't know all the p2p apps on our network
    - it is a university, although bittorrent and gnutella are dominant
  - perhaps should have more buckets, look at recv packet buckets. better threshold estimation, etc.
  - we could not get skype to behave - could catch it sometimes, other times not, not necessarily p2p, not necessarily UDP

conclusions

- UDP centric port tuple is useful for host behavior analysis
  - with simple stats and a top N sort
- UDP ww is a good simple stat
  - helps up track down blatant security problems
  - measure of noise and load
- guesstimator is useful in terms of
  - dividing world into security threats vs p2p based on non-L7 data
  - saving time spent looking at data
  - best to learn DNS servers though
- application guessing
  - promising -- would be nice if researchers elsewhere would pursue it as well

ourmon on sourceforge

- open source
- new release (2.9) including work here expected Spring 2009
  - UDP port report guesstimator etc, plus hourly UDP summarization for port report
  - ssh flow statistics (global site logging)
  - expanded DNS statistics (errors, top N queries)
  - expanded blacklist mechanism (can handle net/mask)
- ourmon.sourceforge.net (version 2.81)
  - currently supports threads in front-end