CS 294-28: Network Security

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http://inst.eecs.berkeley.edu/~cs294-28/
http://www.icir.org/vern/cs294-28/

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What Is This Class?

- Graduate course on network security
  - Graduate = focus on reading papers, participatory discussion, major project
  - Network security = how do we keep our computer networks functioning as intended & free of abuse
  - Network = heavy emphasis on global Internet
    - Little emphasis on host-side issues
  - *Also: occasional broader scope of Internet security*
    - *Underground economy; spam*

Target Audience

- Course intended to:
  - Provide grounding necessary for pursuing PhD research in network security
  - Provide breadth for those undertaking research in other areas of security or networking
  - Evolve into regular grad offering complementing CS 261
- Not intended to:
  - Summarize Internet security issues / technology / practices

Prerequisites

- EE 122 (undergrad networking) or equivalent
- Basic network security notions
  - Firewalls, public-key crypto, spoofing, buffer overflow attacks
- Basic probability/statistics
- A willingness to thoughtfully read a lot of technical papers & tackle a hefty/meaningful project

Who Am I?

- Recent professor in EECS (2007)
  - Recent = "still learning tricks & the bureaucracy"
  - Also affiliated with *International Computer Science Institute* and the *Lawrence Berkeley National Lab*
- Contact:
  - vern@cs, http://www.icir.org/vern/
  - Office hours M 1:30-2:30PM in 737 Soda
    - And by appointment, sometimes at ICSI
      - http://www.icsi.berkeley.edu/where.html
  - Phone: 643-4209, 666-2882
    - Email works *much* better!
  - Hearing impaired: please be ready to repeat questions & comments!

Who Am I?, con't

- Research focuses on network security & network measurement
- Been around the block
  - 12+ years on both topics
  - PC chair/co-chair of SIGCOMM, USESEC, IEEE S&P ("Oakland"), HotNets
- CCIED = NSF Cybertrust *Center for Internet Epidemiology & Defenses*
  - Large-scale compromise, i.e., worms & now botnets
  - 5 year effort joint w/ UCSD
- "Bro" *network intrusion detection system* (NIDS) running 24x7 at LBNL (since 1996!)

My Perspectives/Biases

- I am an empiricist
  - It can be amazing how different a very large system behaves in practice vs. how you would expect it to …
    - … if you only measure in a confined laboratory environment
- A vital, easily overlooked facet of security is *policy* (and accompanying it: operating within *constraints*)
- Much of network security is necessarily reactive, unprincipled, incomplete

Perspectives/Biases, con't

- The goal is risk management, not bulletproof protection.
  - Much of the effort concerns "raising the bar" and *trading off resources*
  - This applies to research as well as practice
- Key notion of threat model: what you are defending against
  - This can differ from what you'd expect
  - Consider the Department of Energy …

General Research Themes

- All papers have shortcomings
  - Doesn't mean you can't extract value
- For your own work:
  - Frame limitations
  - Be thorough & generous towards prior work
  - Provide insight into tradeoffs
- Methodological issues
  - Gauging data quality
  - Bootstrapping (perhaps) ground truth
  - Partition development vs. assessment data

General Research Themes

- Replication/criticism of prior work is unfortunately very rare
  - Corollary: little research upside to publishing data
- Research does not proceed as presented in a well-written paper
- Topics can heat up excessively
  - Multicast, QoS; Traceback, worm models
  - Crucial task for successful research is problem selection

Network Security Research Themes

- Evasion-proof is not a realistic goal
  - Research progresses in often-pretty-modest steps (*building blocks*)
  - "Raising the bar" has definite utility
  - Today's evasion problem looks different tomorrow
  - But: *do* frame evasion picture
- Field changes very fast
  - Including serendipity
  - You need to figure out how to be nimble

Research Themes, con't

- Beware the problem of Crud
  - Surprising diversity of benign activity
  - Great utility in obtaining real data
- We're constantly trading off
  - Especially false positives vs. negatives
- Beware funding ecosystems (and popular press)
  - E.g., DARPA's need for metrics
- Historically, publishing attacks has been worthwhile
  - But not guaranteed

What's Expected of You?

- Read 2 (sometimes 3) papers/week
  - There is an art here regarding figuring out which facets to spend time on and which not
- Write mini-reviews of each paper
  - Mini-review = a few sentences for each of
    - What are the paper's main contributions?
    - What parts of the paper do you find unclear? *(optional)*
    - What parts of the paper are questionable?
      - E.g., methodology, omissions, relevance, presentation
    - Given the contributions, what issues remain? What related ideas does it bring to mind?
  - Email me your reviews prior to corresponding lecture (**Tue 1PM** for Weds; **Thu 1PM** for Fri)
    - Late = 50% penalty (no credit if after lecture summary)

What's Expected of You?, con't

- Participate in lecture discussion of the paper & the topic
- "Scribe" a couple of lectures/semester
  - Scribe = write up summary of lecture suitable for posting on course web site
  - Due 1 week after lecture
    - Send me LaTeX, HTML or Word (editable)
  - *Inspect syllabus* and tell me which lecture(s) you'd like to scribe (FCFS)
  - # of lectures to scribe depends on final class size

What's Expected of You?, con't

- Undertake a significant project
  - Individually or in a team of two (encouraged)
    - Discuss w/ me if you want a larger team
- Can involve:
  - Measurement study characterizing/exploring a network security issue
  - Substantive analysis/assessment of security issues for a given network system
  - Development of a new mechanism or technique
  - Deep, thoughtful literature survey of an area
  - Develop & assess a new threat

Project, con't

- Proposals due within a few weeks
- *Related Work* writeup due early-to-mid October
- Short status report due a few weeks later
- Class presentations during final lectures
  - Or perhaps instead posters
- Final project due at end of semester
  - Written as a conference-style paper

Project, con't

- Aim high!
  - End result should be workshop-caliber
  - The best should be within shouting distance of publication-caliber
- Find a topic that grabs you
  - Feel free to run preliminary ideas by me

Some Project Ideas - Past Classes

- Securing Firefox's plug-in mechanism
- Measurements of nation-state attacks on a community vs. "routine" malware
- Correctness of a Web ad security safety model
- Measuring "mule spam" (money laundering)
- In what ways does the Internet have "bad neighborhoods"?
- Approaches for safely running other people's code on your trace data

Past Class Projects, con't

- Dynamic firewalls for data centers
- Security analysis of AirBears
- Distributed detection of spam sources
- Detecting "fast flux" DNS domains in real-time
- Literature survey of forensics
- Survey of SCADA security issues
- Efficacy of heuristics for detecting phishing sites

Some Possible Project Resources

- Trace/log analysis *mediation*
- whois data, DNS churn
- Blacklist feeds
- Malware specimens / contained environment

Grading

Homework	25%
Participation	10%
Scribing	15%
Project	50%

FAQ: Can I audit the course?

A: Instead, please take it P/F. To pass, you need to then do a solid job on either homework/participation/scribing, or a project. Let me know up front which you're pursuing. If you're not enrollable as a student, talk to me.

Lecture Format

- Each lecture has at its heart a core paper (sometimes 2)
- For the most part, seminal paper that opened new area or developed key new insight
  - Not "bleeding edge" or comprehensive or perfect
- Lecture will cover main contributions …
- … but then go from there into related considerations (sometimes taken from the optional reading) in an interactive fashion
- What to cover & where to go driven in part by thoughts/considerations from HW writeups

Ethics

- We will be discussing attacks - some quite nasty! - and powerful eavesdropping technology
- None of this is in *any way* an invitation to undertake these in any fashion other than with informed consent of all involved parties
- If in some context there's any question in your mind, come talk with me first
- Oh and: for homeworks, please do your own work

A Look At The (Tentative) Topics

- Denial-of-Service, Traceback, Network Capabilities, DoS Defense
- Network intrusion detection systems, evasion, evaluation
- The threat of worms, distilling signatures, detection mechanisms
- Scanning, forensics, timing analysis

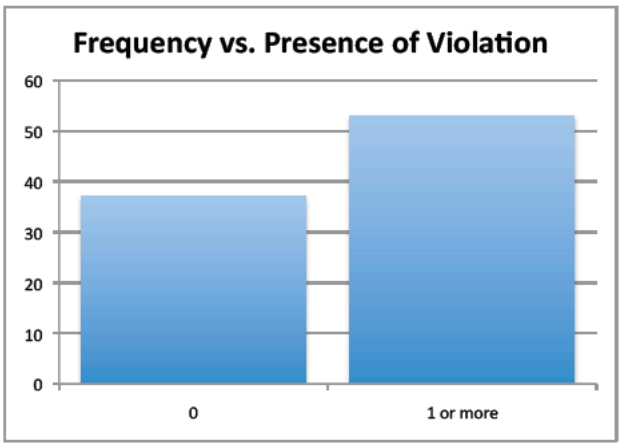
Tentative Topics, con't

- Anonymity
- Architecture
- Web authentication & attacks
- Wireless
- Botnets & Scams

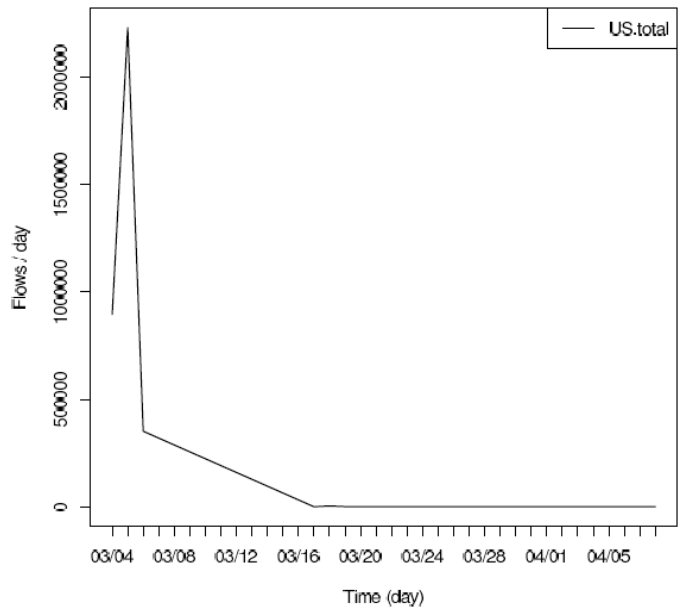
Non-Technical Topics

- Research "culture":
  - What's required in technical argument vs. what you can do thinly or omit
  - Realities of access to data
  - Publication venues, program committee ("PC") etiquette & workings, authorship inclusion and ordering, plagiarism, short papers vs. long
  - Writing cogent papers …
  - How funding works

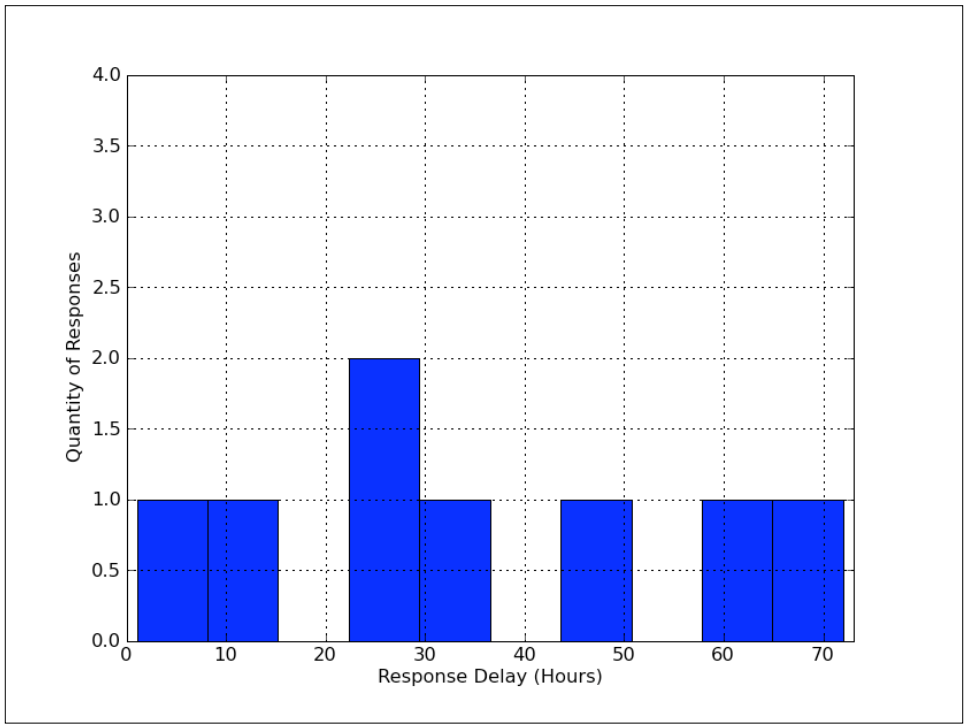
  ? Suggestions for others?

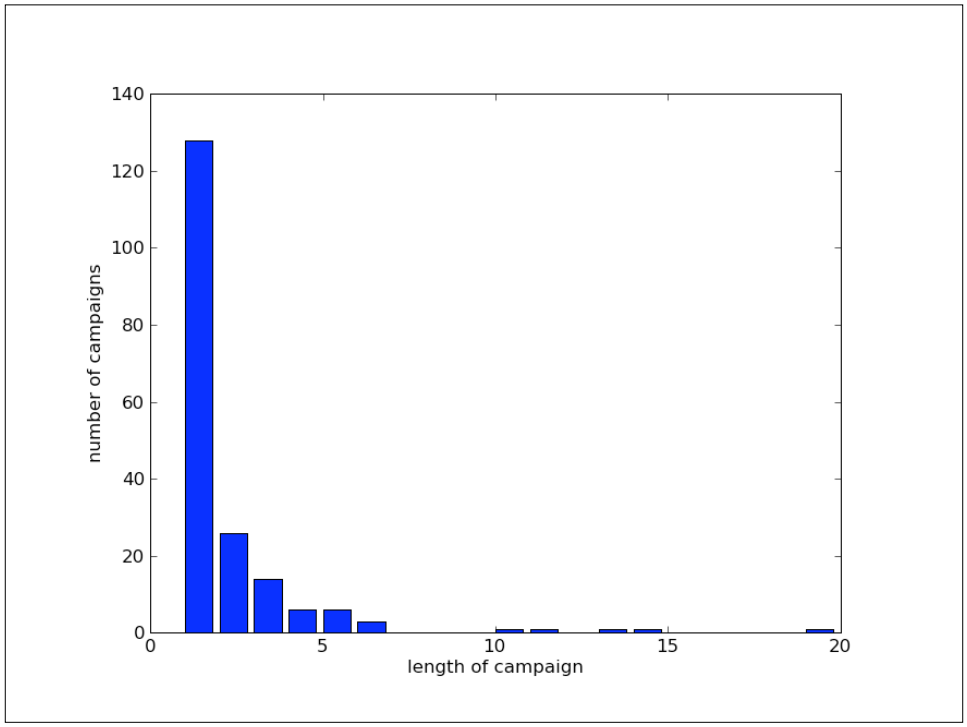


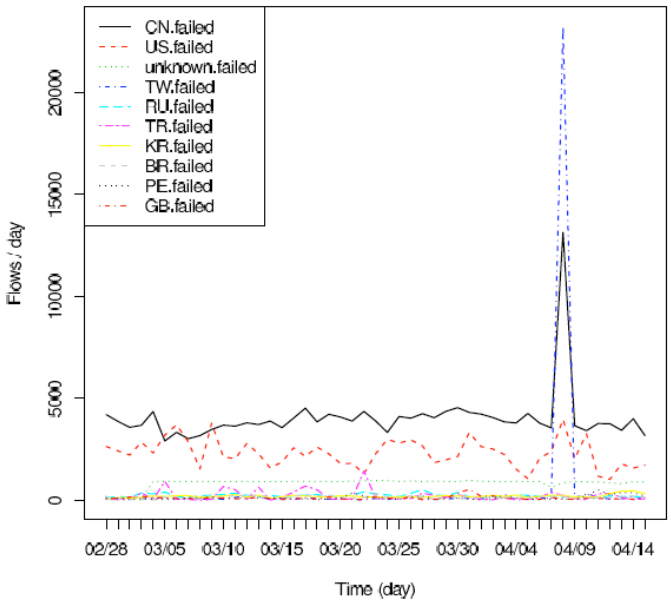
(a) Presence of violations



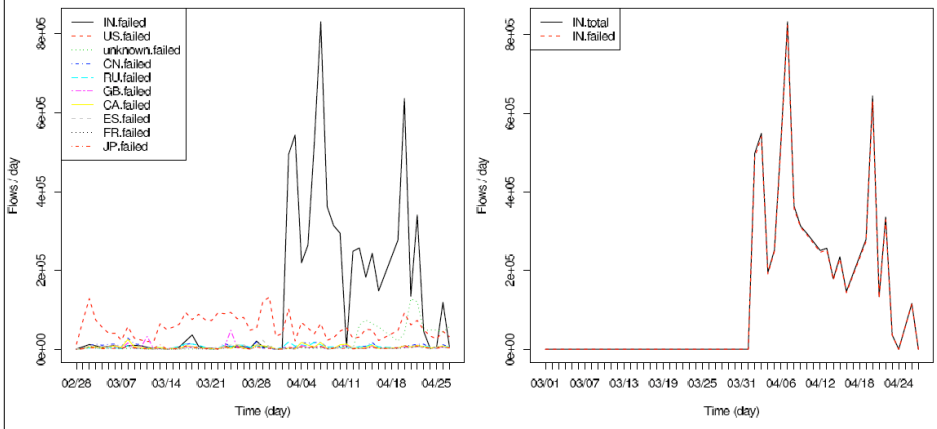
(b) Total traffic for `62.34.164.84`.


Quantity of Responses
Response Delay (Hours)
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
0
10
20
30
40
50
60
70


number of campaigns
length of campaign
0
20
40
60
80
100
120
140
0
5
10
15
20



(a) Failed inbound traffic.



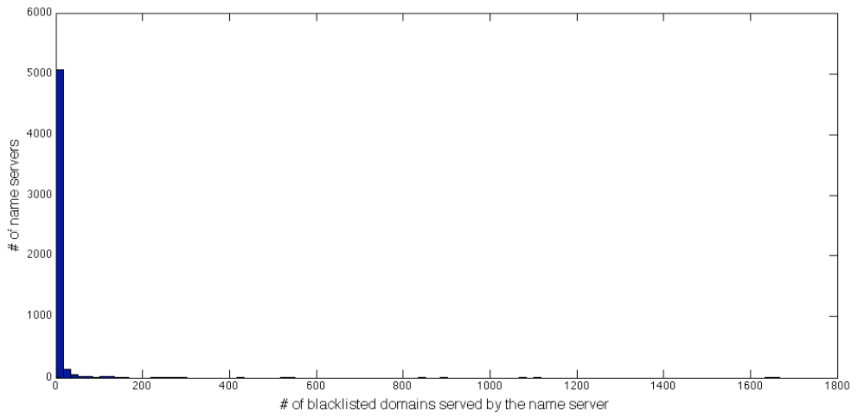
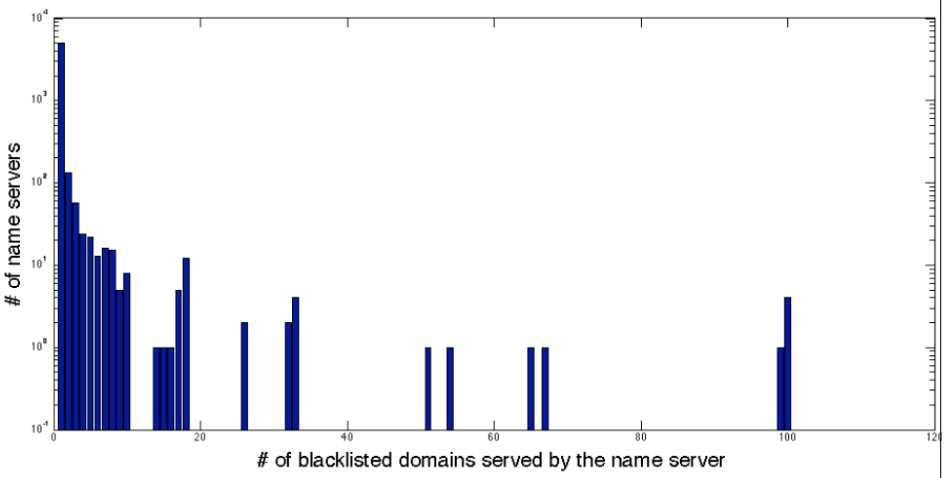
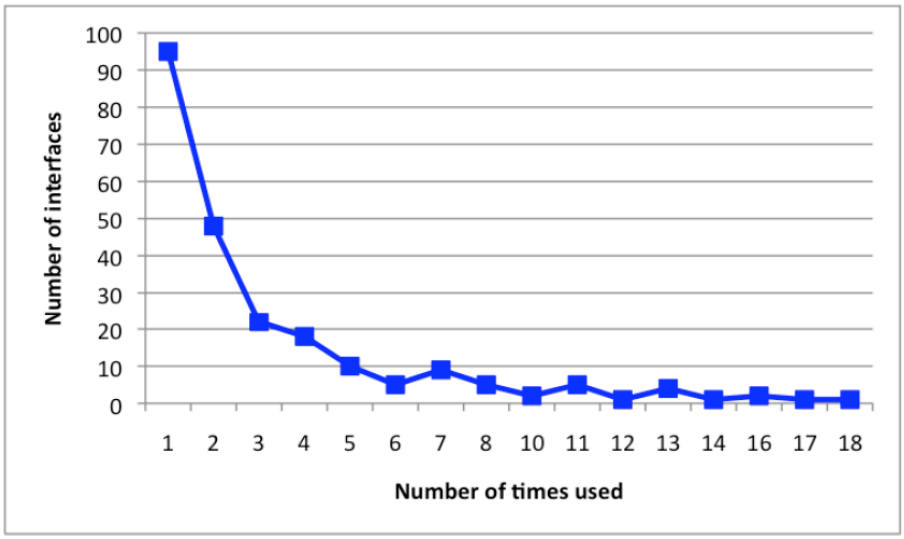
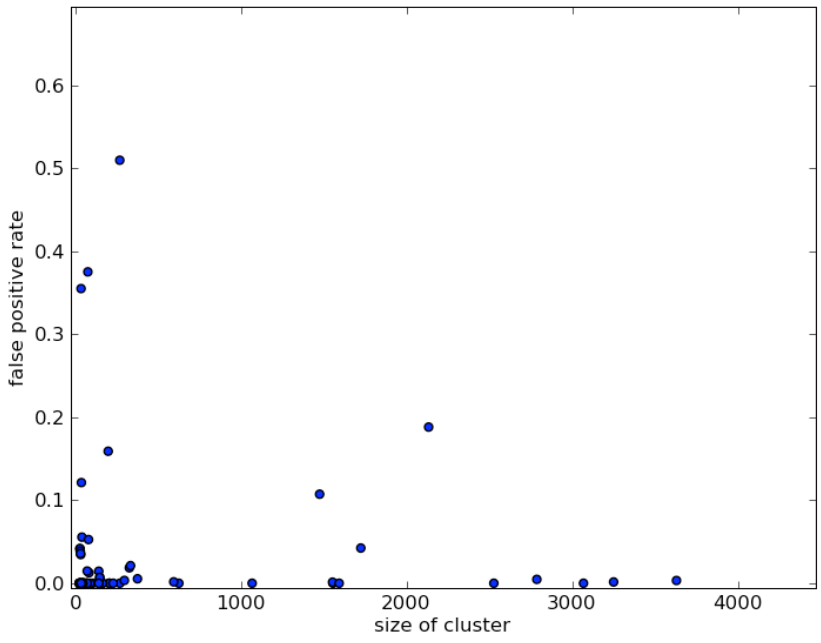


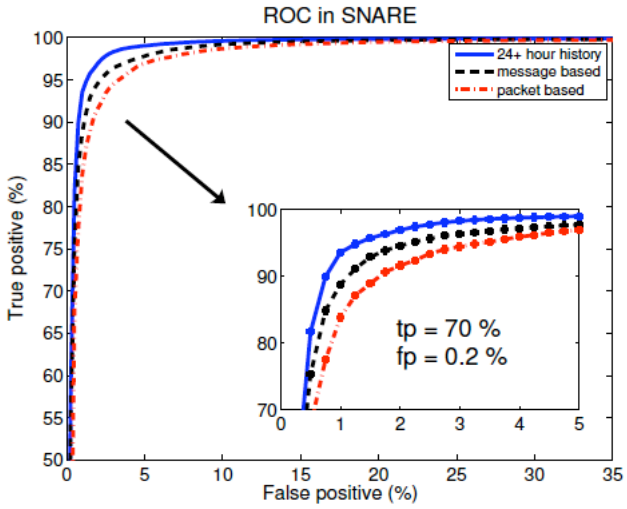
Figure 1: Histogram: Given an IP address, how many blacklisted domains use that IP addr a name server?





(b) **Were there any really popular interfaces?** This graph shows the popularity of interfaces. A large number of interfaces (nearly 100) were only used once, and a very small number of interfaces were used by 50% or more of the extensions.





Give Feedback

- Regarding syllabus
  - Topics/subtopics you'd like explored
  - Particular papers
- Post-lecture
  - We can revisit at beginning of next lecture
- Course mechanics
- Anonymous is fine if you want
  - Either using a remailer
  - Or just a note under my door (737 Soda)

Next Lecture

- Denial-of-Service
- Homework #1 due Thursday 8PM
  - Writeup for “Backscatter” paper
  - Check out the syllabus
  - Join the mailing list
  - Background survey