Introducing Sangeetha

Key dates posted

- Assignment release, presentations, …
- Of note: Assignment 1 out Wed., due in a week
- Reading topics still subject to adjustment

No laptop use in lecture please
Undergraduate Networking in Three Slides

(including this one)
Layering

A kind of modularity

Functionality separated into layers

• Layer $n$ implements higher-level functionality by interfacing only with layer $n-1$
• Hides complexity of surrounding layers: enables greater diversity and evolution of modules
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Layering

Tunnel
- VPN
- TOR
- VXLAN
- GRE
- MPLS
- ...

Tunneled Services:
- Application
- Transport
- Network
- Data Link
- Physical
Common functionality & problems

<table>
<thead>
<tr>
<th>Application</th>
<th>Anything you want...</th>
<th>Life, the universe, and everything</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transport</td>
<td>Process-level communication</td>
<td>Reliability, flow control, ordering, congestion, ...</td>
</tr>
<tr>
<td>Network</td>
<td>Packets across domains</td>
<td>Independent parties, scale, routing</td>
</tr>
<tr>
<td></td>
<td>Packets across networks</td>
<td>Addressing, heterogeneity, routing</td>
</tr>
<tr>
<td>Data Link</td>
<td>Packets on a ‘wire’</td>
<td>Framing, errors, addressing</td>
</tr>
<tr>
<td>Physical</td>
<td>Encoding of bits</td>
<td>Physics, analog-to-digital</td>
</tr>
</tbody>
</table>
Grand Challenges
Bismuth strontium calcium copper oxide (BSCCO)

Superconducts up to about \(-168^\circ\text{C}\) \((-271^\circ\text{F})\)

High temperature superconductivity is a "Grand Challenge" for condensed matter physics
Grand Challenges

Widely recognized as among the most important unsolved problems in a field

- P vs. NP
- natural language understanding
- bug-free programs
- moving society to carbon-neutral energy
- preventing cancer
- ...

...
Grand Challenges in networking?

Getting an A in this class?
An Informal Survey

1. “What I’m working on!”

2. High level objectives
   - Security & privacy
   - Reliability
   - Usability
   - Different than P vs. NP: hard to even define “security”; objectives involve tradeoffs
Unreliability: One Example
Border Gateway Protocol
Instability causes outages

Eventually, control message: **CACBD**

Loop detected!

Forwarding loop

- Link state changes
- Router failures
- Config. changes
- Loops
- Detection delay
- Black holes
- ...
Instability causes outages

[F. Wang, Z. M. Mao, J. Wang, L. Gao, R. Bush SIGCOMM’06]
Instability causes outages

[Instability causes outages (F. Wang, Z. M. Mao, J. Wang, L. Gao, R. Bush SIGCOMM’06)]

More outages

Longer outages

(...and higher latency, packet reordering, router CPU load during instability)
Many sources of unreliability

Congestion
  - no end-to-end bandwidth reservations in the Internet

Configuration or software bugs

Failures or delays
  - in network, DNS servers, caches, application servers, ...
Insecurity: one example
Prefix hijacking

Anyone can advertise routes for any IP prefix!

How can hijacker get the advertised routes to actually be used by other ASes?

- Announce more specific (longer) prefix than real owner
- Now everyone’s traffic is “blackholed”

Can protect against this (Secure BGP), but...

- it’s not deployed today
- and even then, can still cleverly (or accidentally) attract traffic and eavesdrop
Man in the Middle (MITM) attack

- Traffic to a destination redirected (not blackholed) through an attacker
- Attacker can watch everything you do without you noticing

What’s the key problem here?

How can attacker forward traffic to destination, if attacker is pretending to be the destination?
Man in the Middle (MITM) attack

- Traffic to a destination redirected (not blackholed) through an attacker
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How can attacker forward traffic to destination, if attacker is pretending to be the destination?

Let’s see how…

[Kapela and Pilosov, DEFCON’08]
A finds legitimate path ABD for 128.2.0.0/16
Hijacking + eavesdropping

1. A finds legitimate path ABD for 128.2.0.0/16

2. A sends semi-bogus announcement of path ABD for 128.2.0.0/17

3. Result:
   - ASes (here B) on real path keep using real path because of loop elimination
   - All other ASes use route through A (/17 beats /16)

4. A forwards traffic to B
Kapela & Pilosov also described how to spoof traceroute information to be even more undetectable.
January 5, 2017 incident

Routes to several pornographic sites (and later Apple iTunes) change

Iranian state ISP
January 5, 2017 incident

Routes to several pornographic sites (and later Apple iTunes) change

Recovery after owner finds out and takes action

Source:
http://dyn.com/blog/iran-leaks-censorship-via-bgp-hijacks/
December 12, 2017 incident

AS 39523 (DV-LINK-AS, Russia) hijacks routes

- 80 IP prefixes from Russian networks and also Google, Apple, Facebook, Microsoft, NTT, Riot Games & more
- Two intervals of about 3 minutes
- Announcement propagated largely via Hurricane Electric

Sources:
https://bgpmon.net/popular-destinations-rerouted-to-russia/

https://dyn.com/blog/recent-russian-routing-leak-was-largely-preventable/
Grand Challenges in networking

An Informal Survey

1. “What I’m working on!”

2. Nebulous high level objectives
   - Security & privacy
   - Complexity
   - Reliability
   - Usability

3. Why does networking lack a crisp Grand Challenge?
   - Infrastructure needs to support highly diverse and dynamic goals, applications, and environments
Meta-challenge:

How do we make the Internet evolvable?
Reviews due by 11:59 pm Tuesday:

- A protocol for packet network intercommunication (Cerf and Kahn, 1974)
- The Design Philosophy of the DARPA Internet Protocols (Clark, 1988)
For those of you looking for project teams, tell us

- Your technical background
- Areas you’re interested in studying, if you have ideas