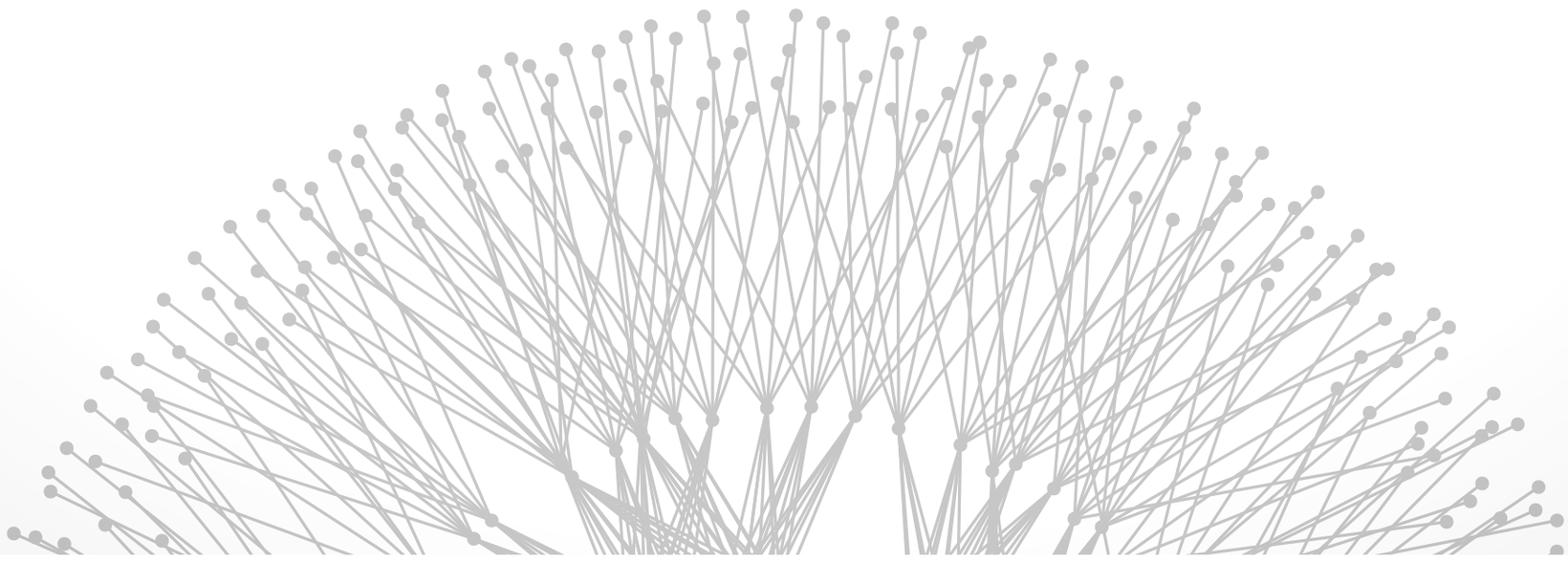
Networking Review & Grand Challenges

Brighten Godfrey

CS 538 August 29 2013



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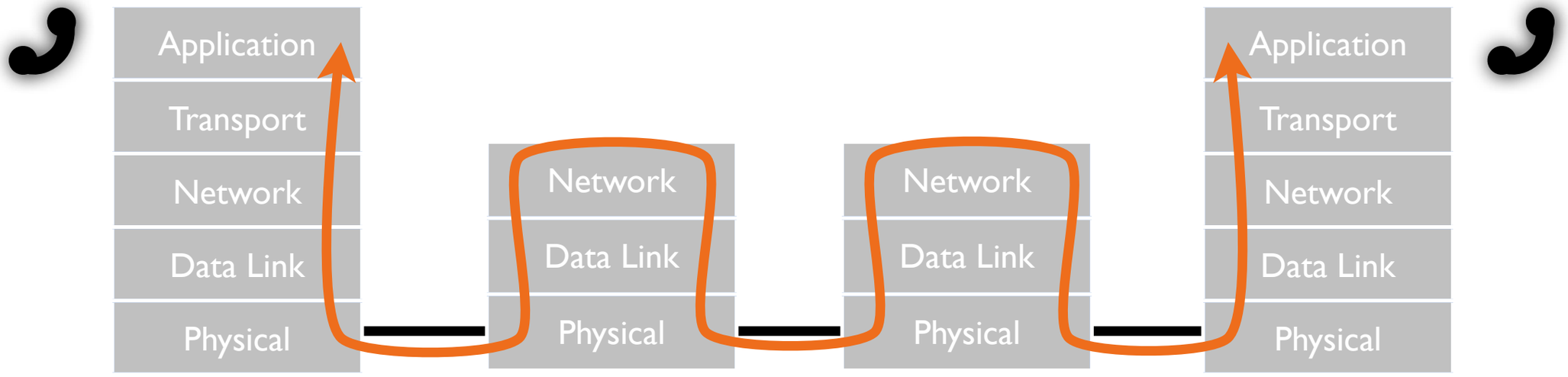
Undergraduate Networking in Three Slides

(including this one)

Layering

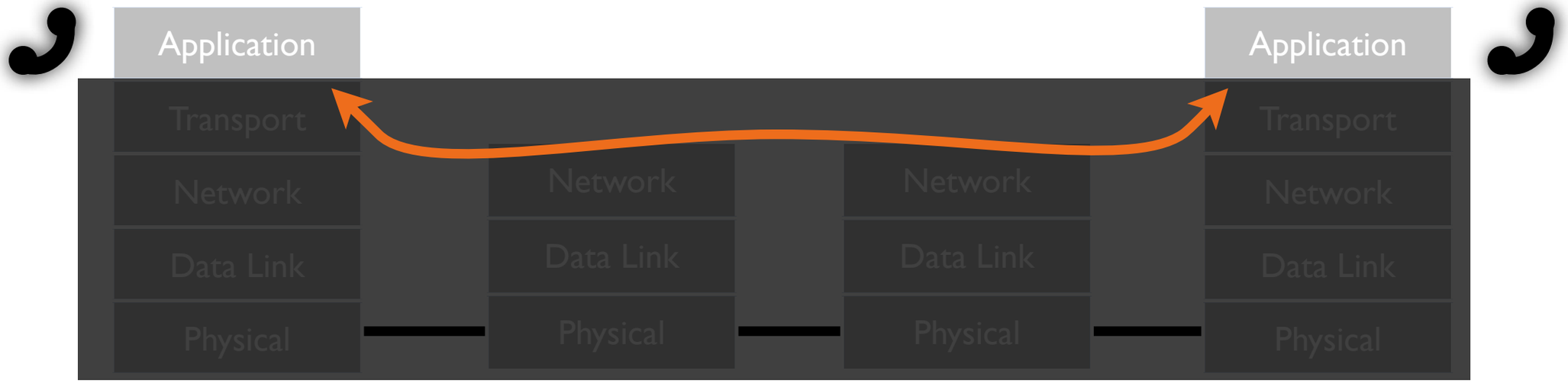


A kind of modularity

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

Layering



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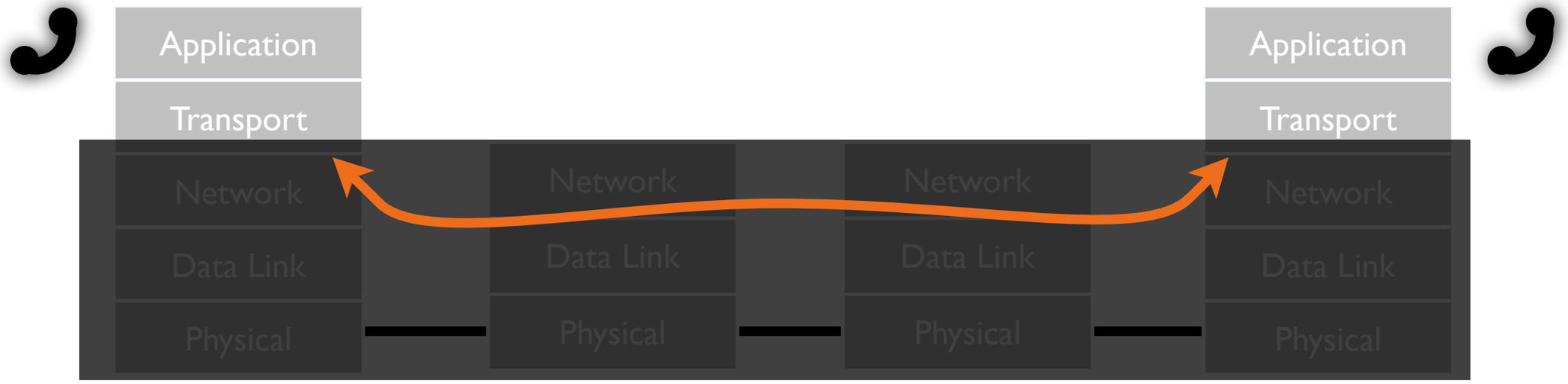

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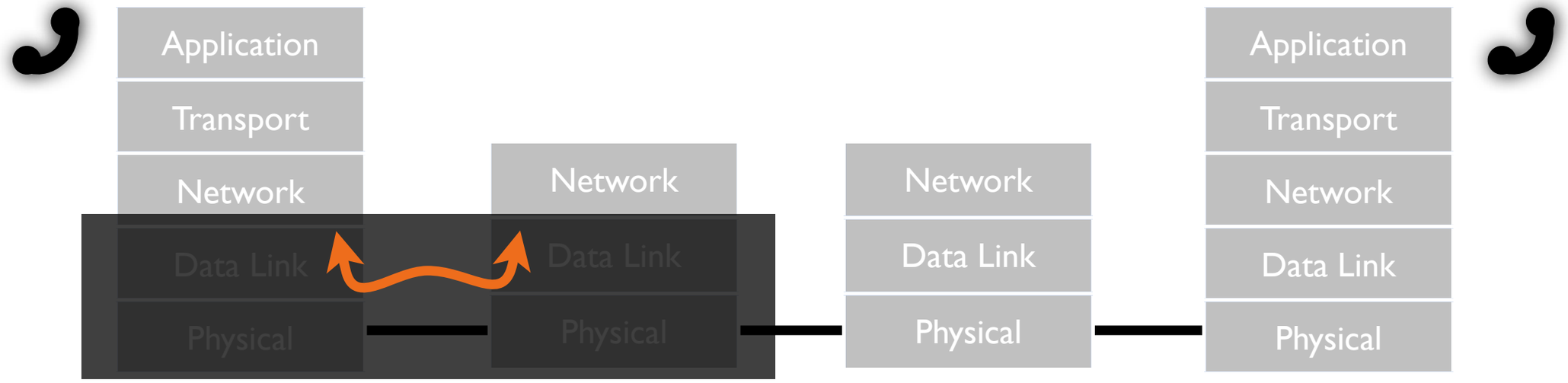

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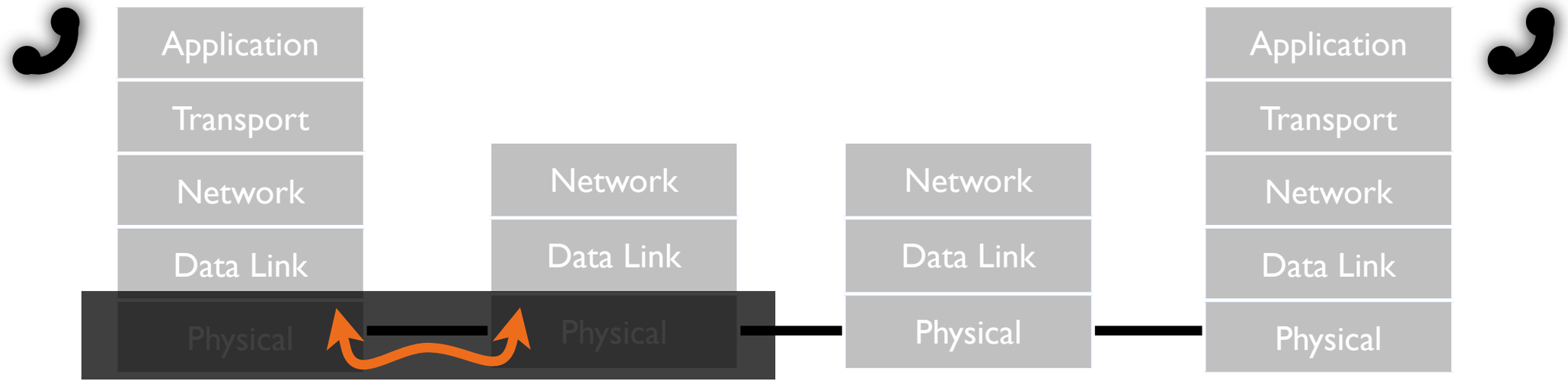

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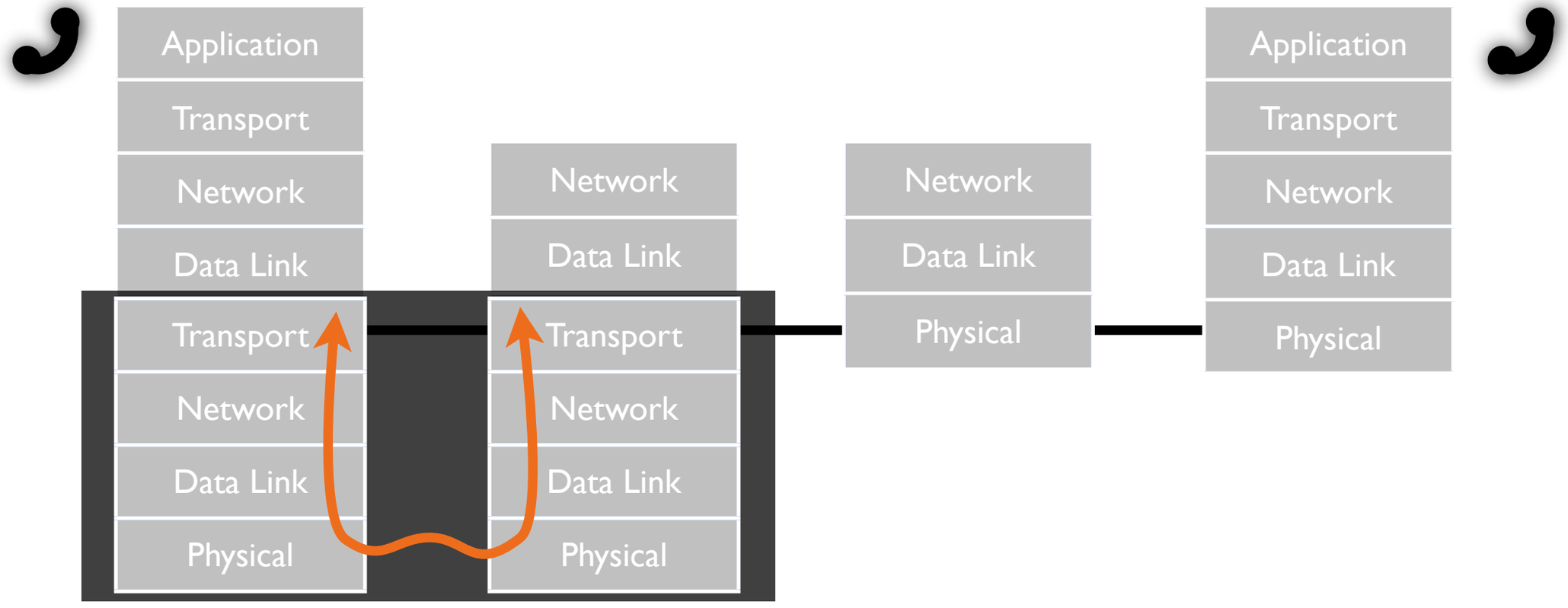


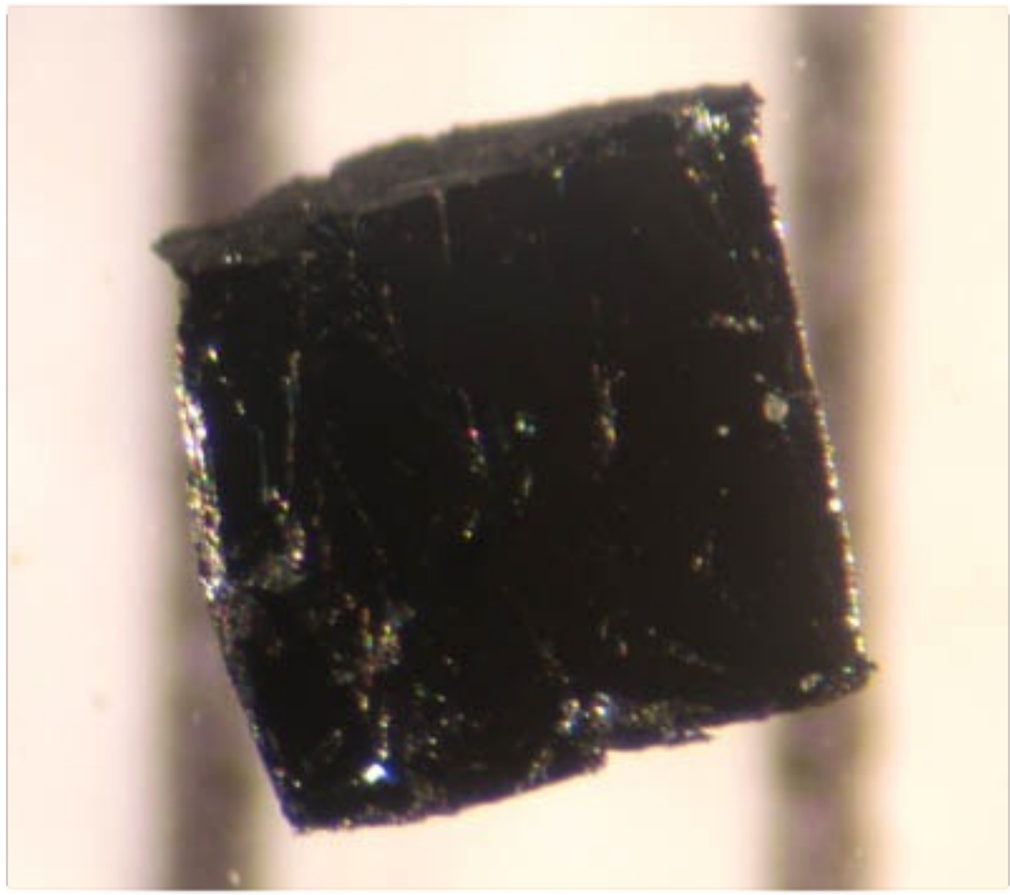
Tunnel

Common functionality & problems

Application	*Anything you want...*	*Life, the universe, and everything*
Transport	Process-level communication	Reliability, flow control, ordering, congestion, ...
Network	Packets across domains	Independent parties, scale, routing
	Packets across networks	Addressing, heterogeneity, routing
Data Link	Packets on a 'wire'	Framing, errors, addressing
Physical	Encoding of bits	Physics

Grand Challenges

Bismuth strontium calcium copper oxide (BSCCO)



[Photo: James Slezak via Wikimedia]

Superconducts up to about -168°C (-271 °F)

High temperature superconductors are 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?

GC's in networking

An Informal Survey

1. "What I'm working on!"

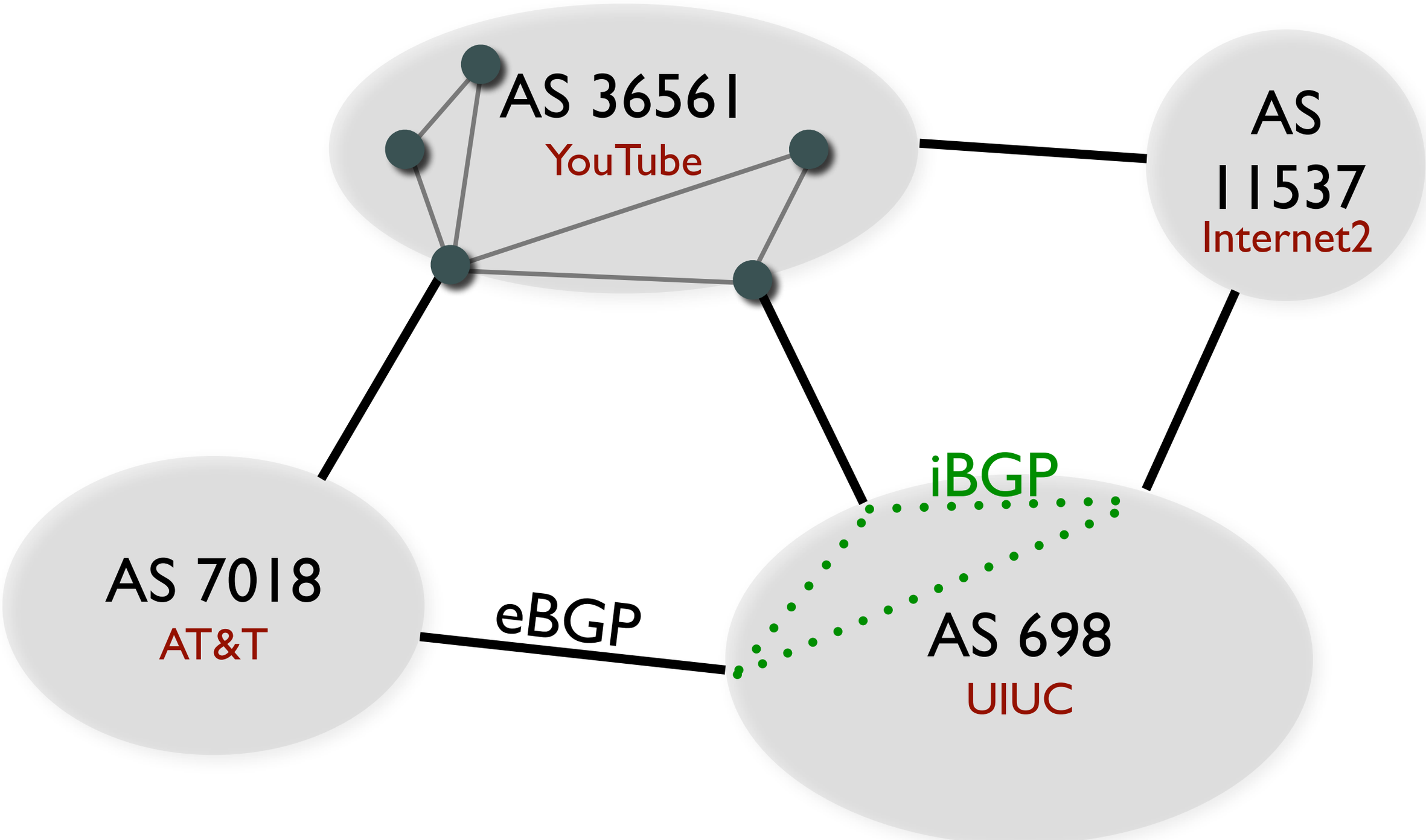
2. High level objectives

- Security & privacy
- Reliability
- Usability

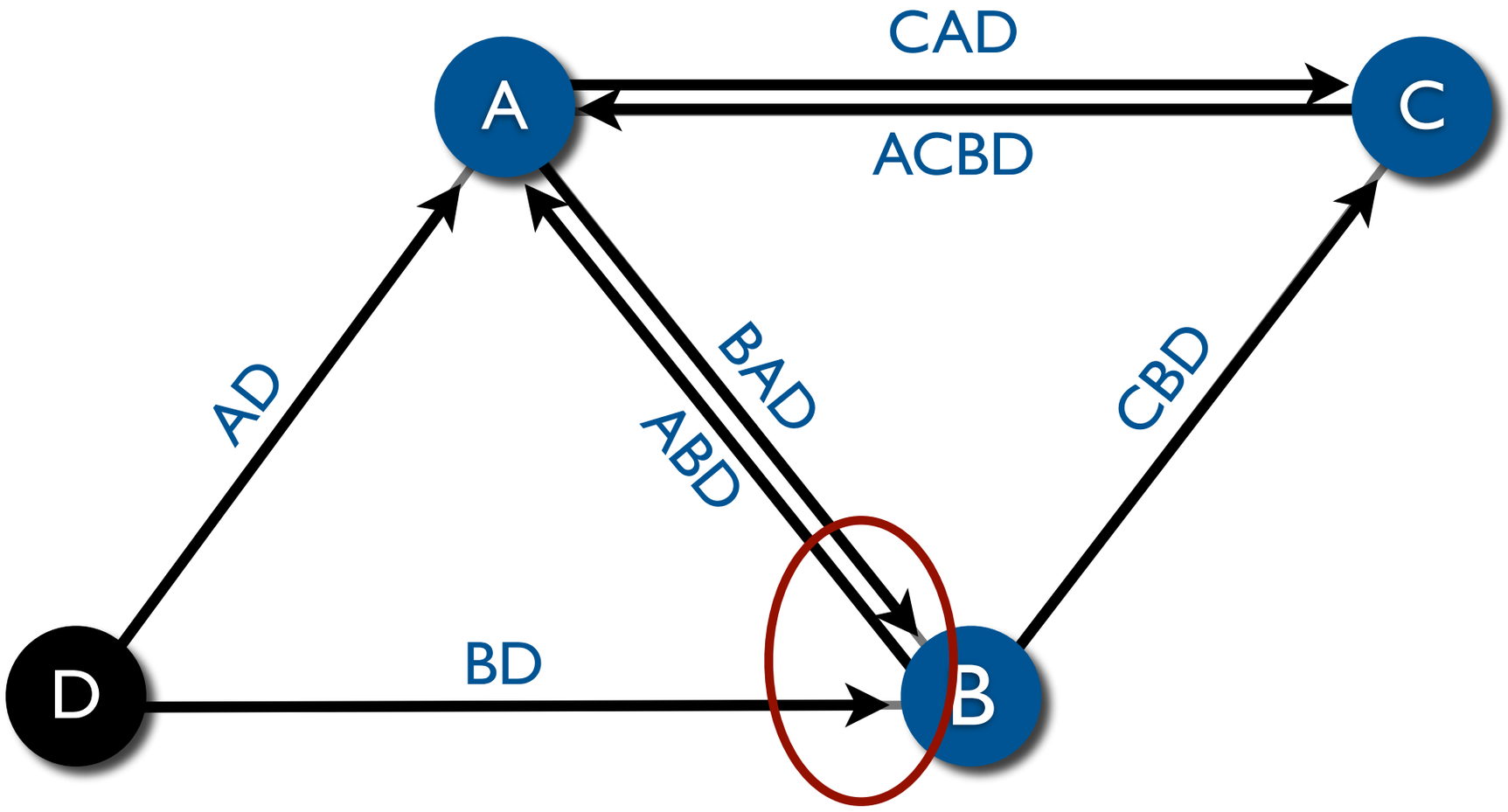
- Different than P vs. NP: hard to even define "security"; objectives involve tradeoffs

Unreliability: One Example

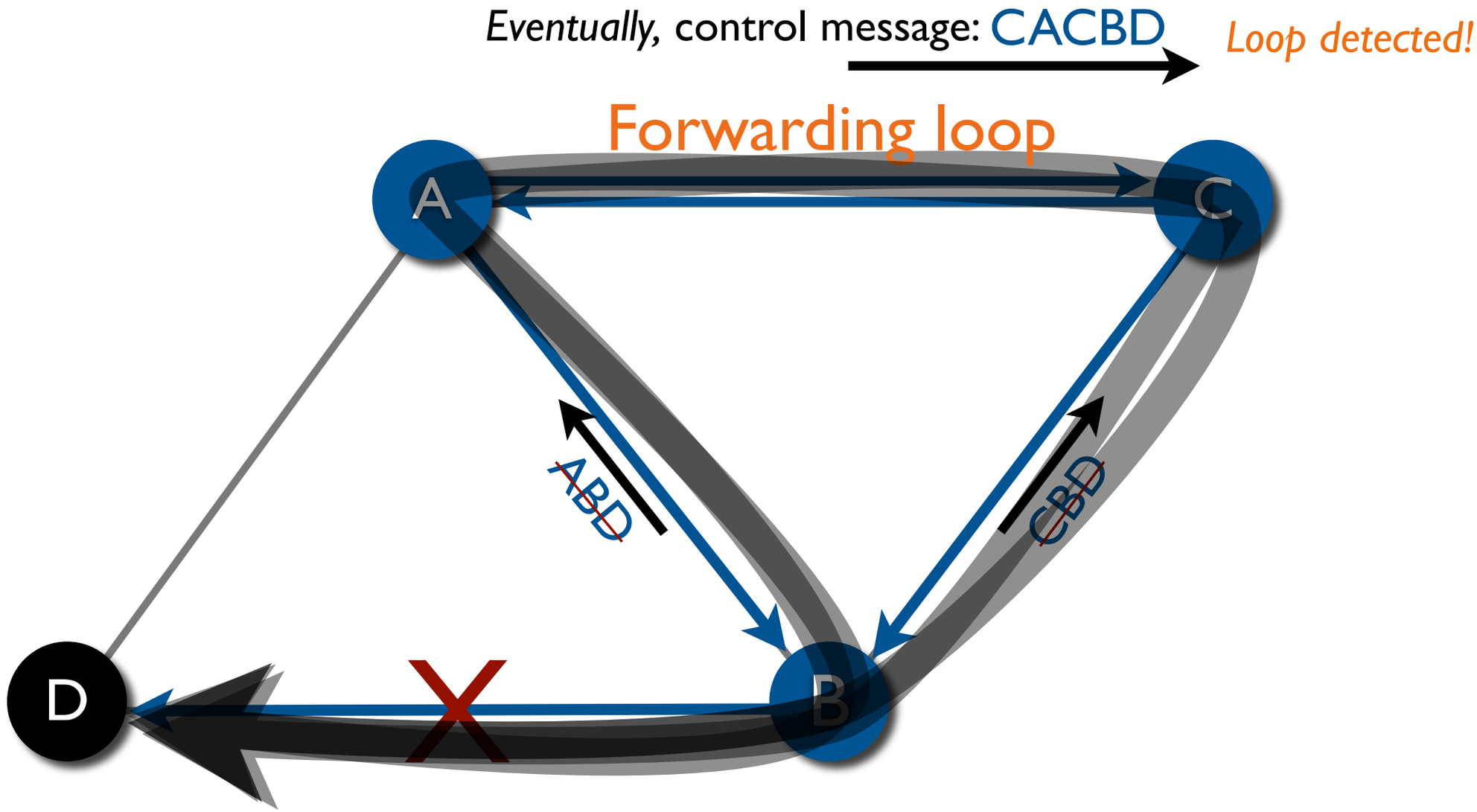
Internet Routing



Border Gateway Protocol



Instability causes outages



- Link state changes
- Router failures
- Config. changes
- ...

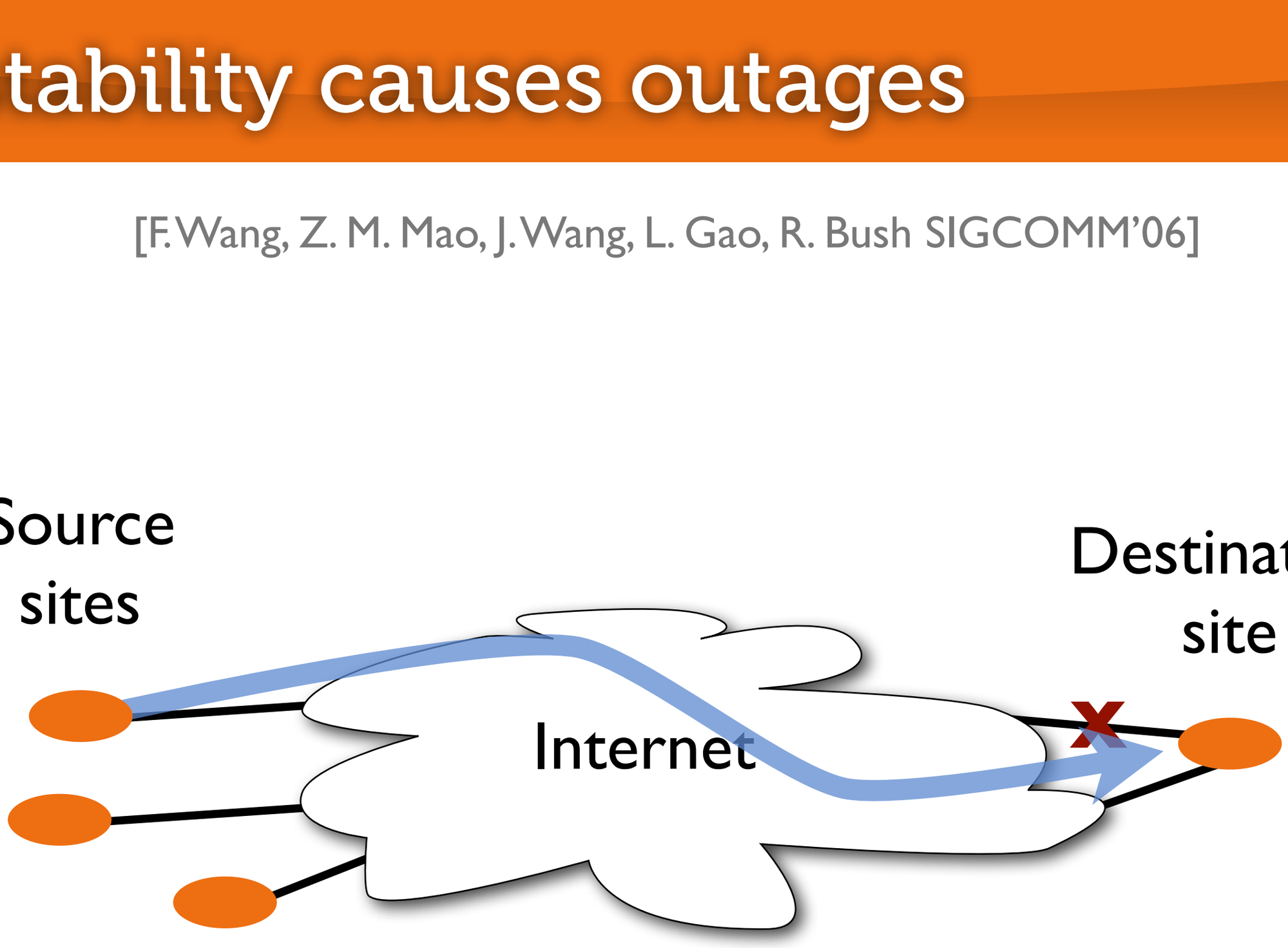
⟹

- Loops
- Detection delay
- Black holes

⟹ FAIL

Instability causes outages

[F. Wang, Z. M. Mao, J. Wang, L. Gao, R. Bush SIGCOMM'06]



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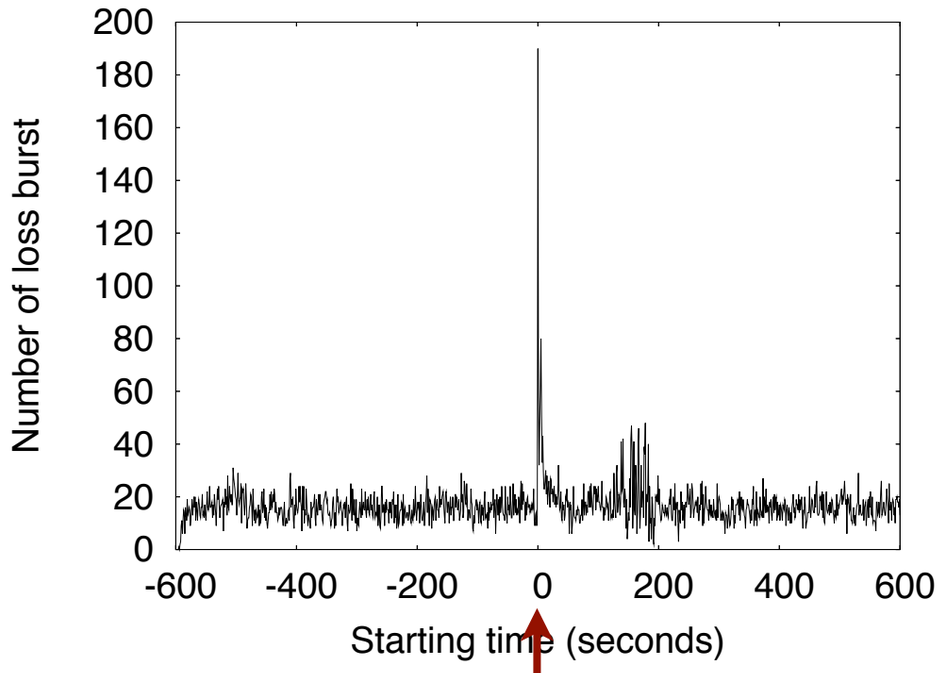
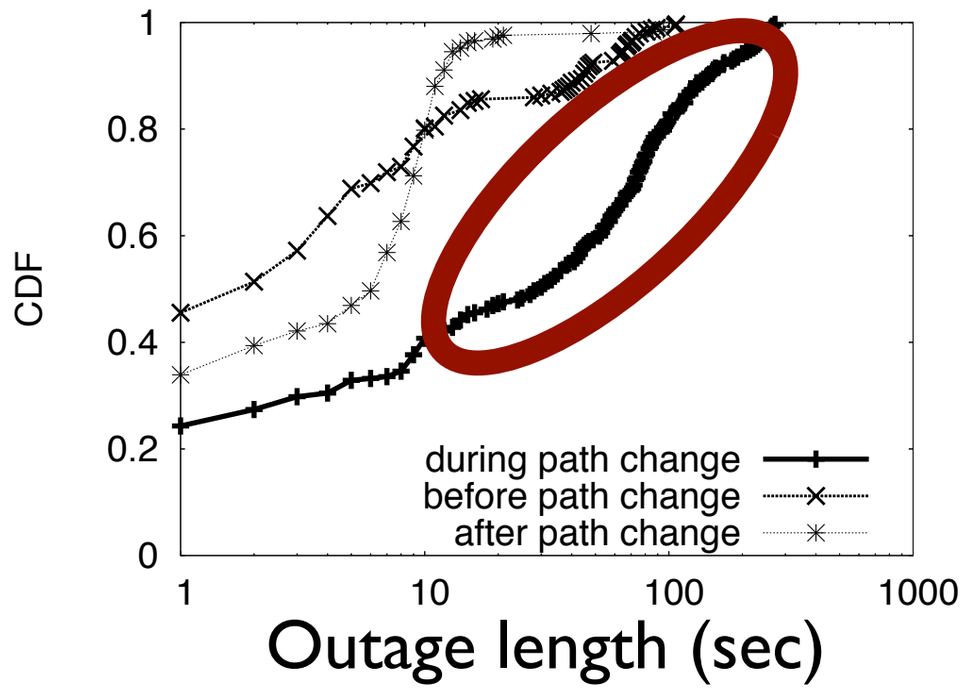
[F. Wang, Z. M. Mao, J. Wang, L. Gao, R. Bush SIGCOMM'06]

More outages



Failure injected

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...

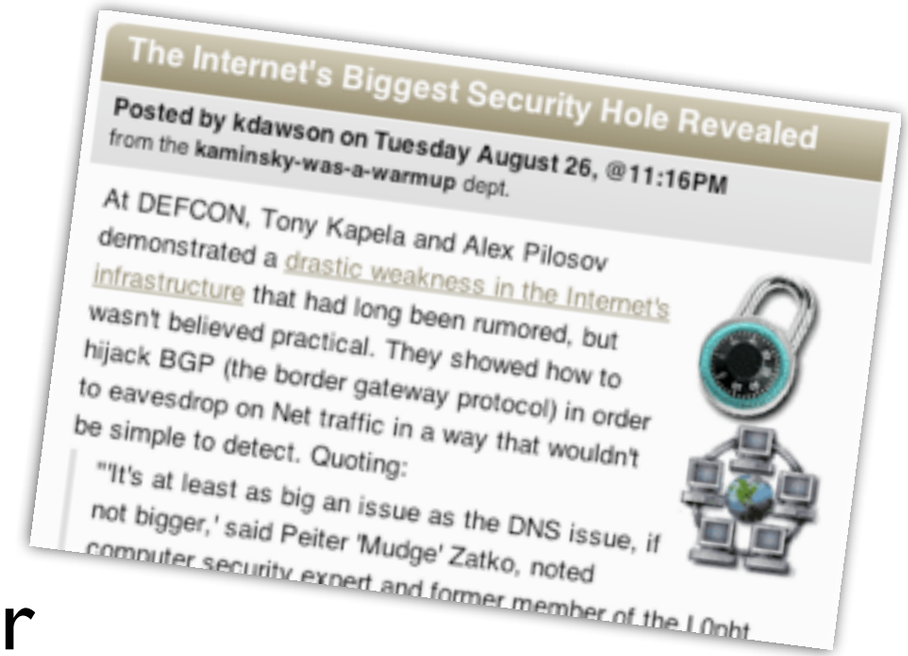
- it's not deployed today
- and even then, can still cleverly (or accidentally) attract traffic and eavesdrop

From hijacking to MITM

August ’08, Kapela and Pilosov

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


The Internet's Biggest Security Hole Revealed

Posted by kdawson on Tuesday August 26, @11:16PM
from the kaminsky-was-a-warmup dept.

At DEFCON, Tony Kapela and Alex Pilosov demonstrated a drastic weakness in the Internet's infrastructure that had long been rumored, but wasn't believed practical. They showed how to hijack BGP (the border gateway protocol) in order to eavesdrop on Net traffic in a way that wouldn't be simple to detect. Quoting:

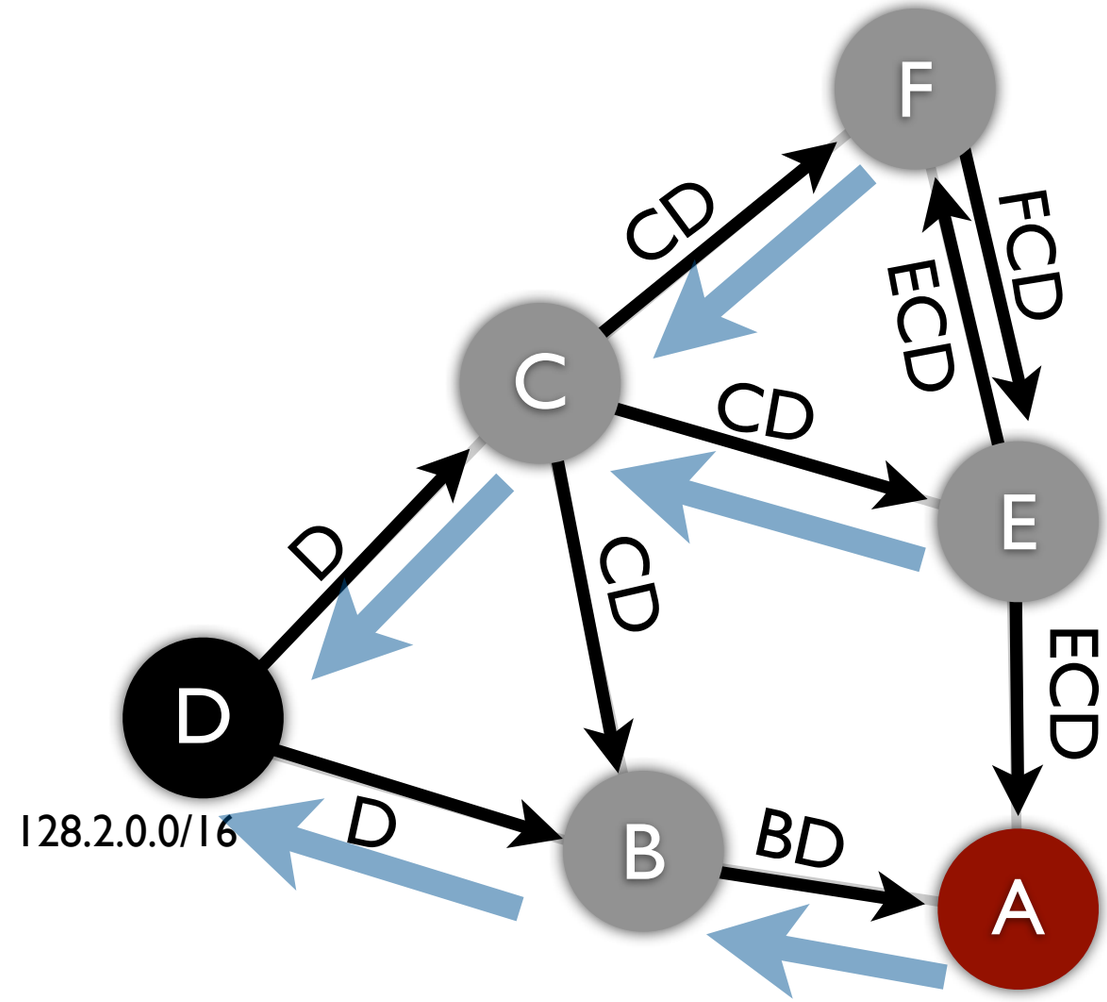
"It's at least as big an issue as the DNS issue, if not bigger,' said Peiter 'Mudge' Zatko, noted computer security expert and former member of the L0pht

What’s the key problem here?

How can attacker forward traffic to destination, if attacker is pretending to *be* the destination?

Hijacking + eavesdropping

1. A finds legitimate path ABD for 128.2.0.0/16

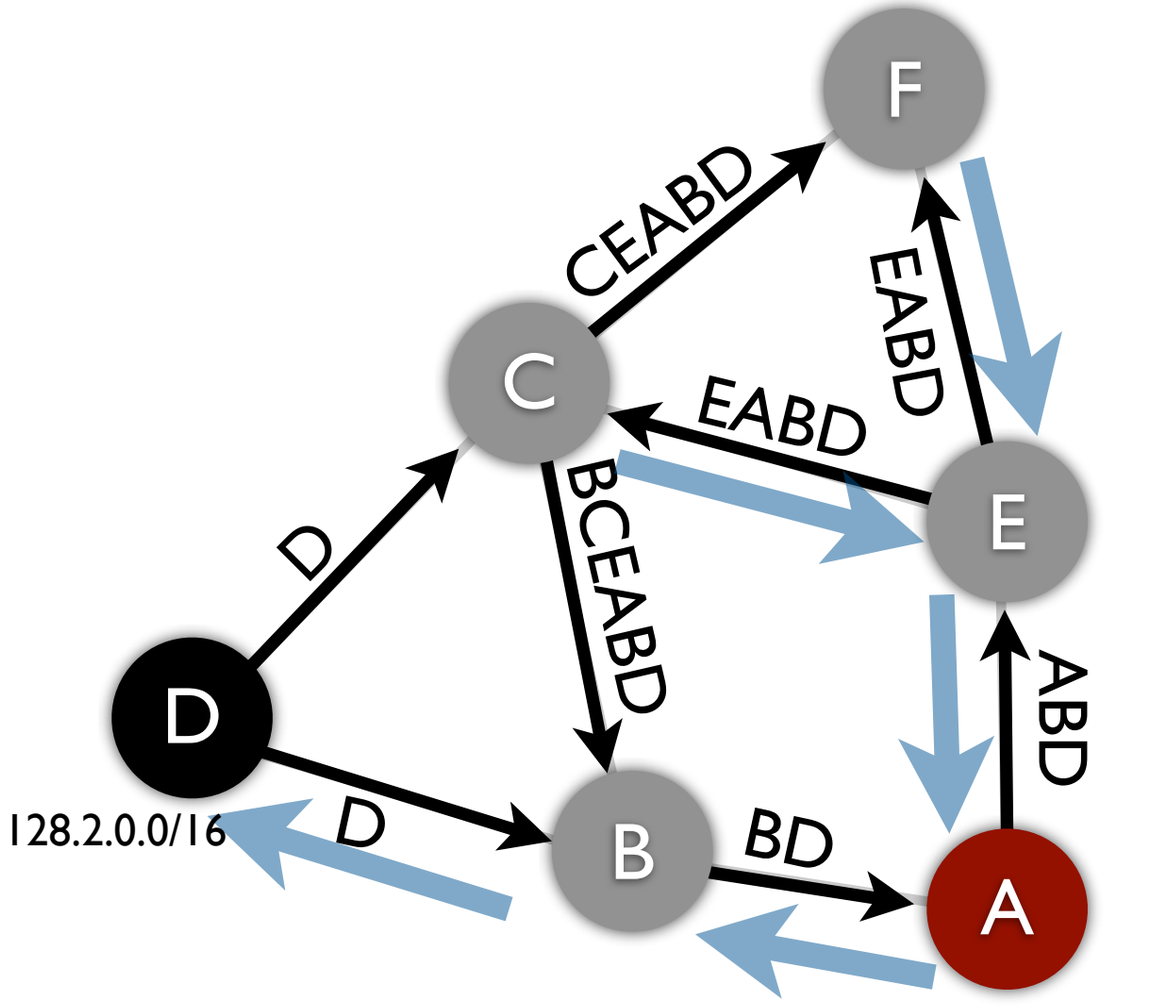


BGP Announcements

Selected routes & flow of data

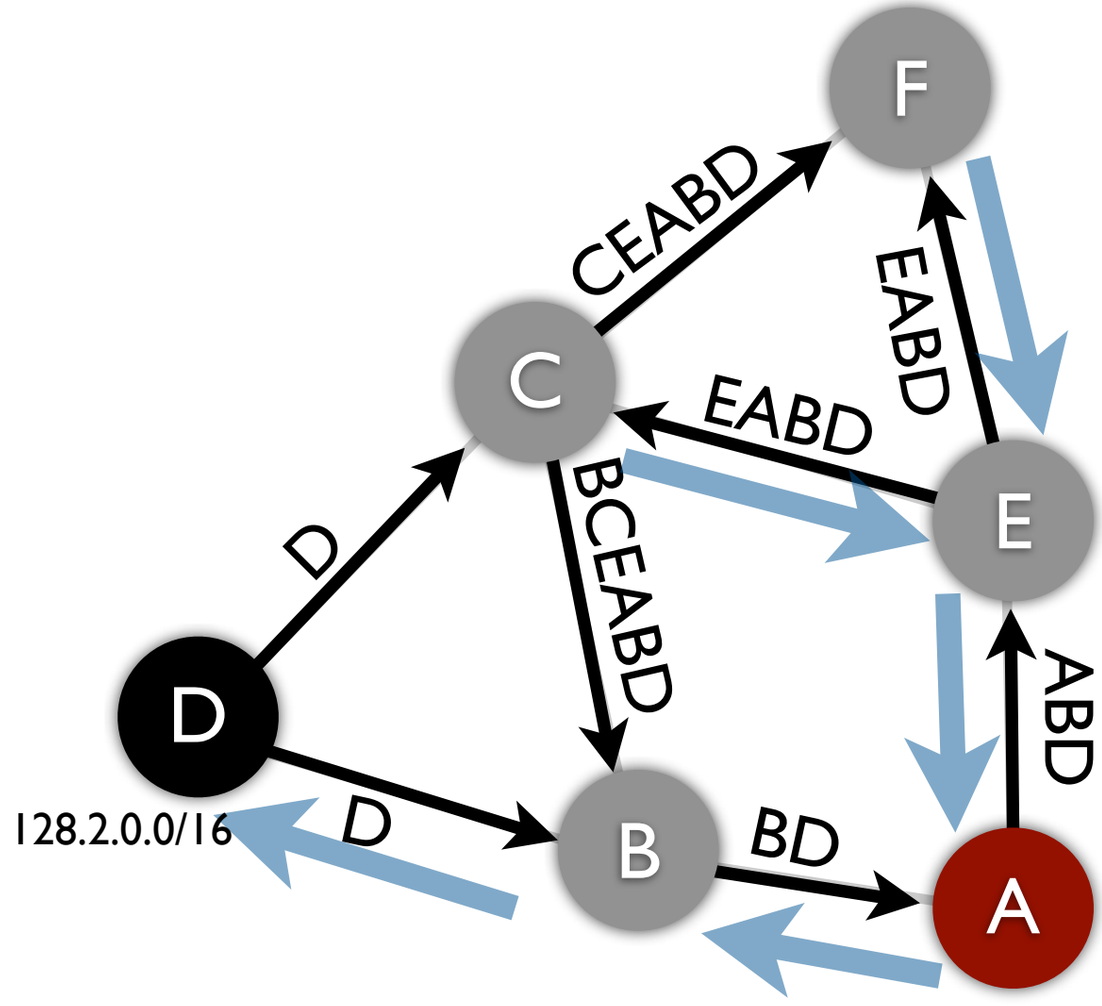
Hijacking + eavesdropping

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



Hijacking + eavesdropping

Kapela & Pilosov also described how to spoof traceroute information to be even more undetectable.



BGP Announcements

Selected routes & flow of data

Grand Challenges in networking

An Informal Survey

1. "What I'm working on!"

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

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

Grand Challenges in networking

Meta-challenge:

How do we make the Internet evolvable?

Announcements

Reviews due by 11:59 pm Monday:

- A protocol for packet network intercommunication (Cerf and Kahn, 1974)
- The Design Philosophy of the DARPA Internet Protocols (Clark, 1988)