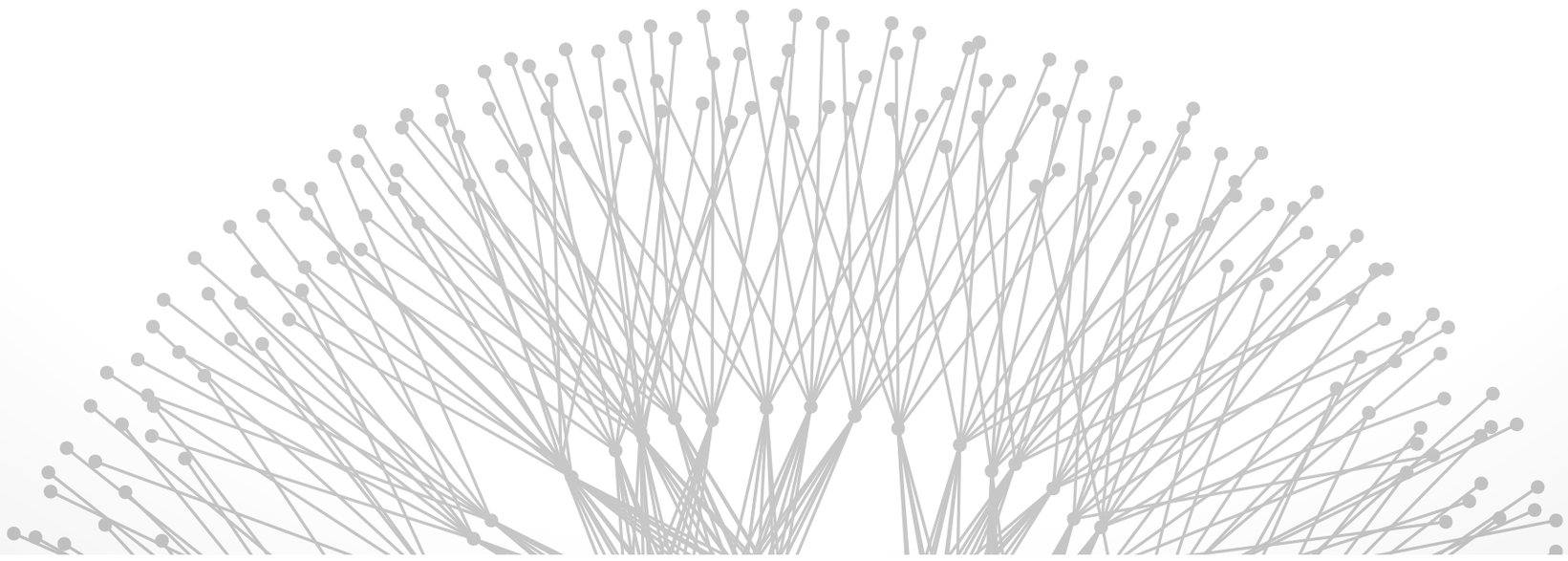
Networking Review & Grand Challenges

Brighten Godfrey

CS 538 January 23 2017



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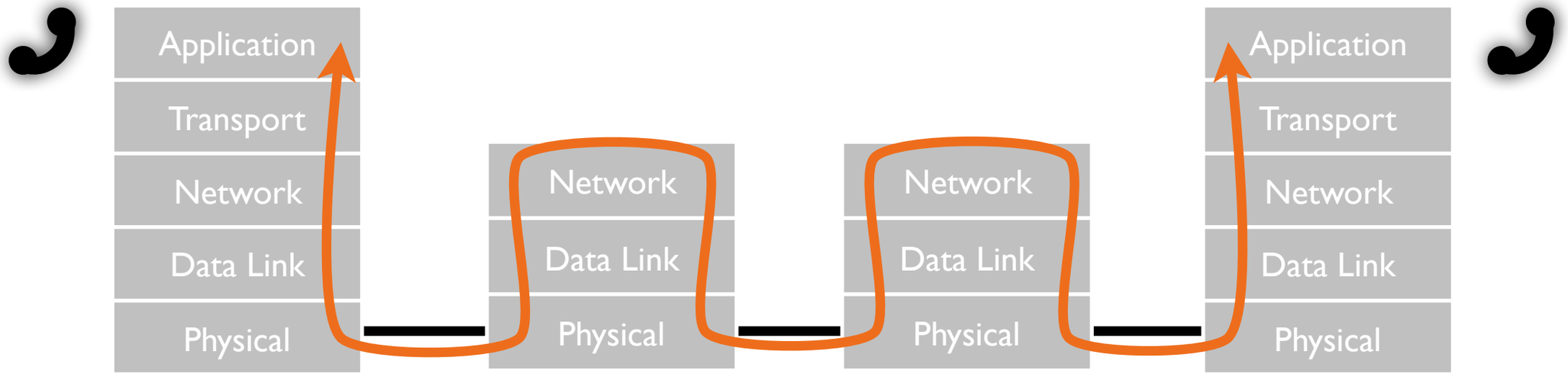
Undergraduate Networking in Three Slides

(including this one)

Layering

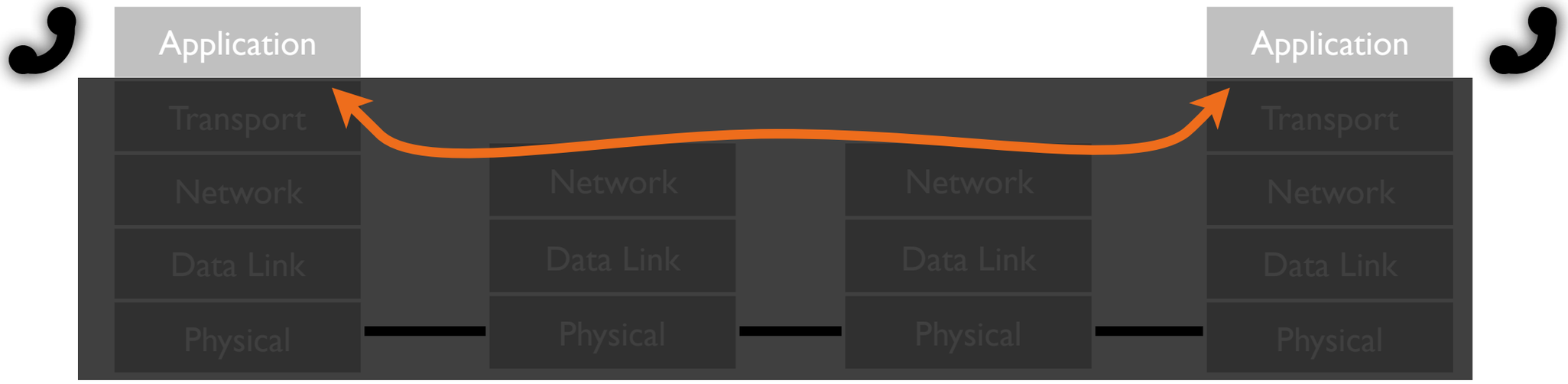


A kind of modularity

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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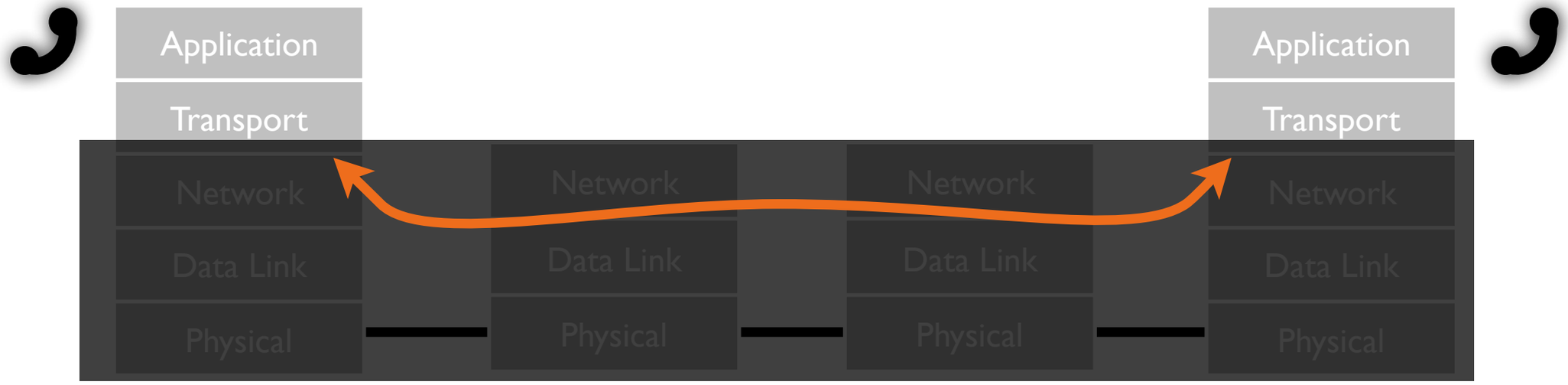

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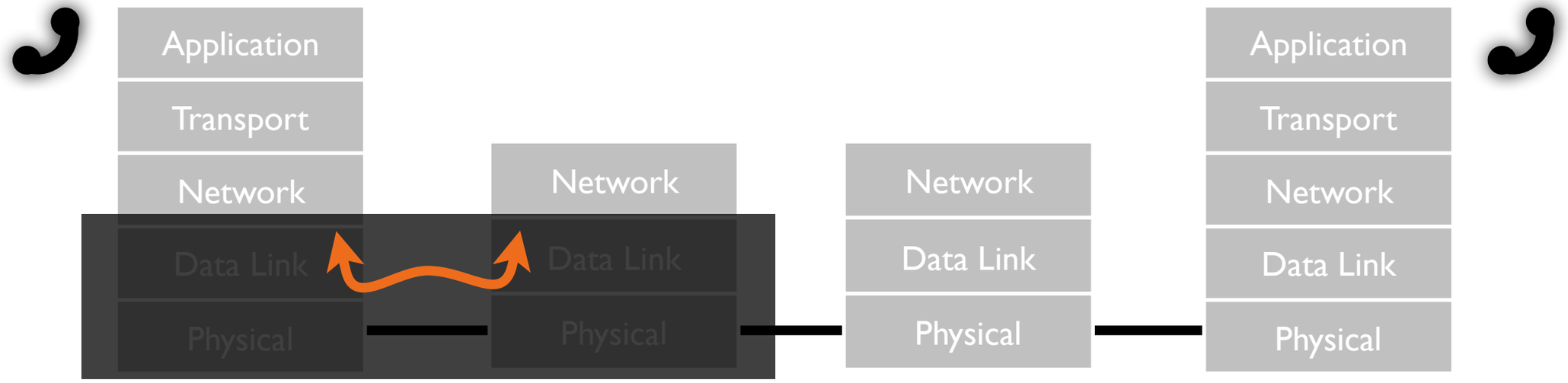

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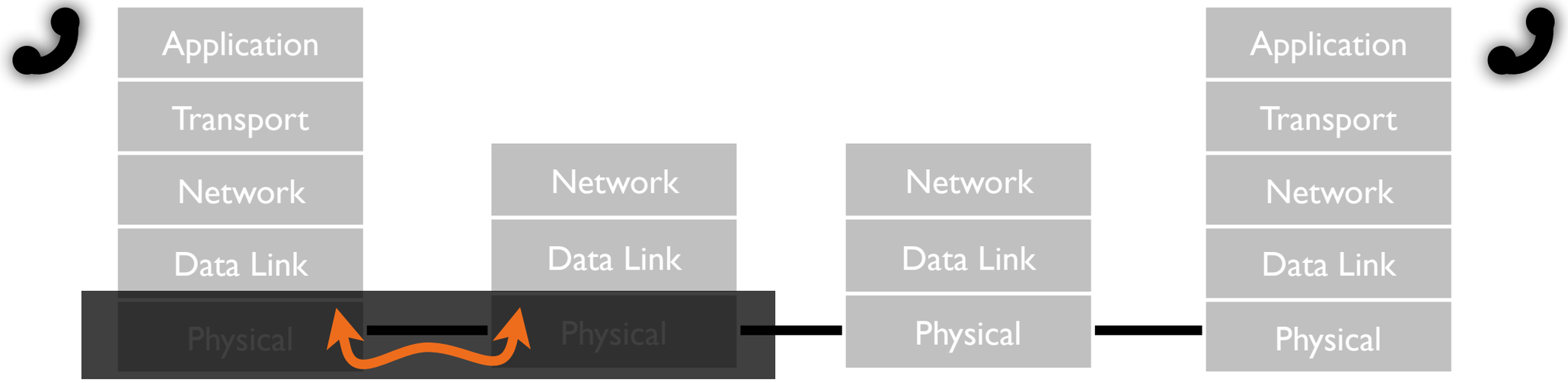

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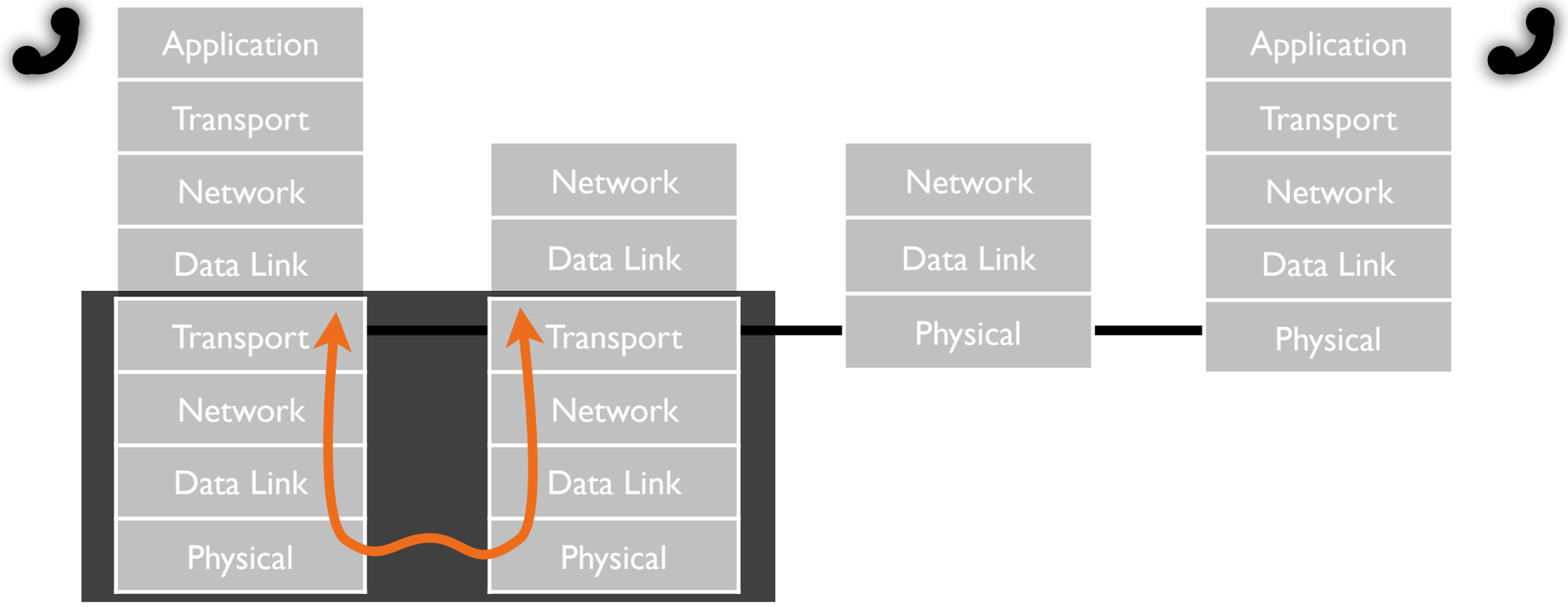


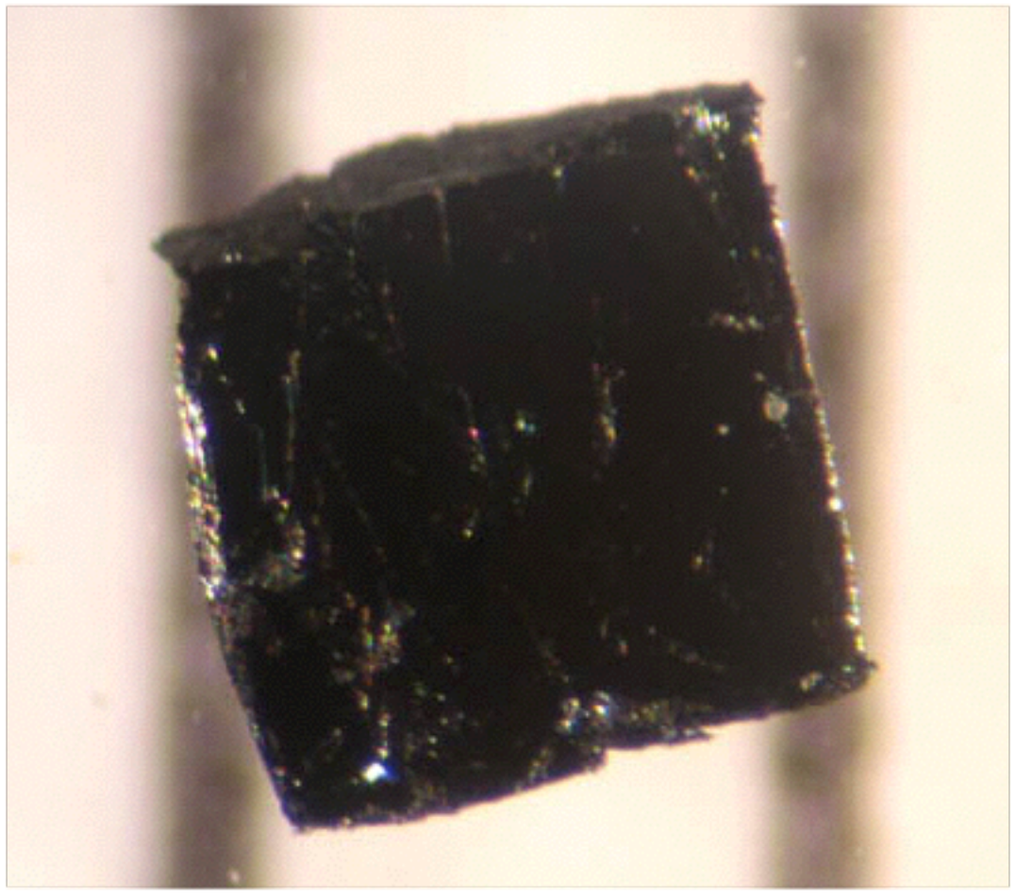
Tunnel

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, analog-to-digital

Grand Challenges

Bismuth strontium calcium copper oxide (BSCCO)



[Photo: James Slezak via Wikimedia]

Superconducts up to about -168°C (-271 °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?

GC's in networking

An Informal Survey

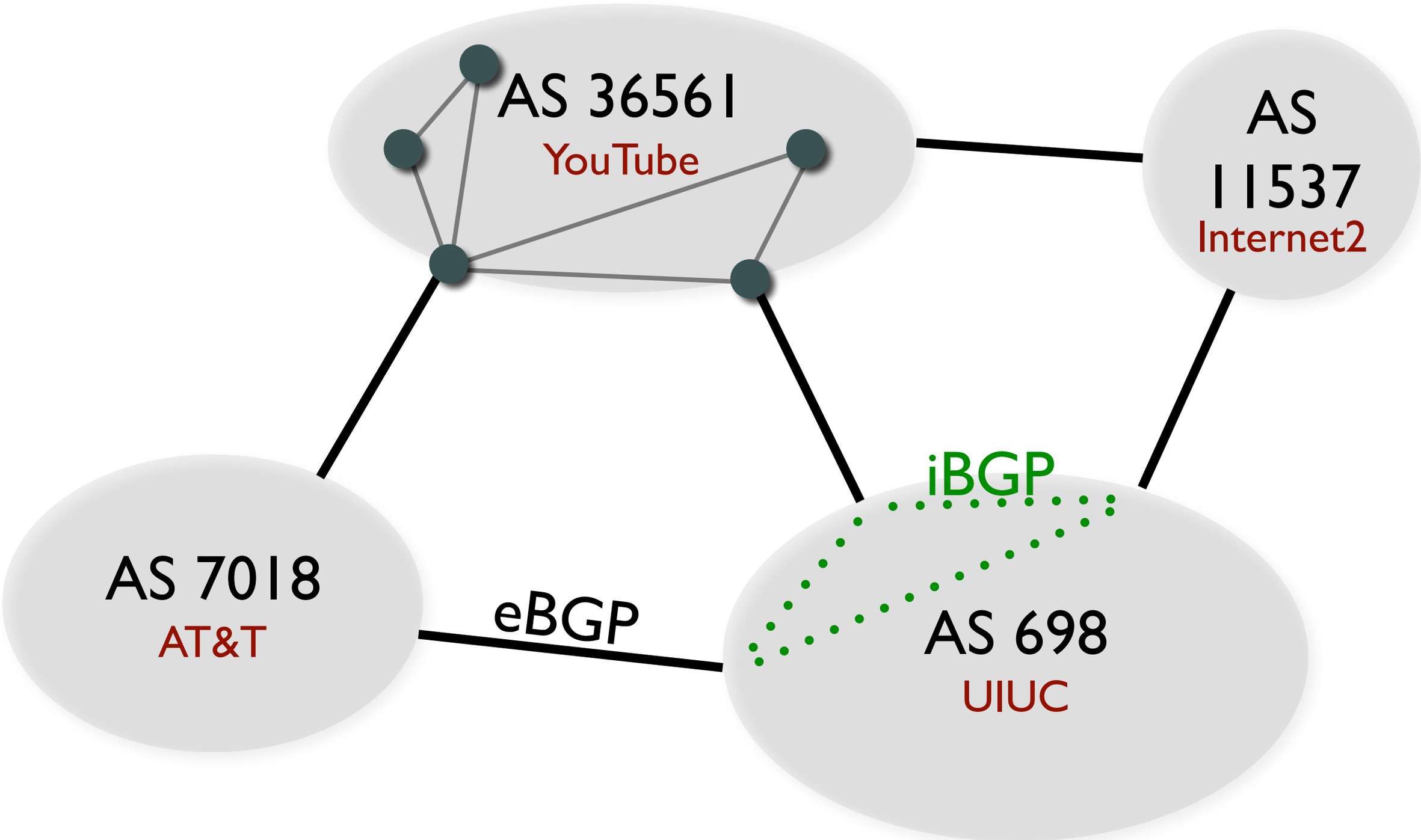
1. "What I'm working on!"
2. High level objectives

- Security & privacy
- Reliability
- Usability

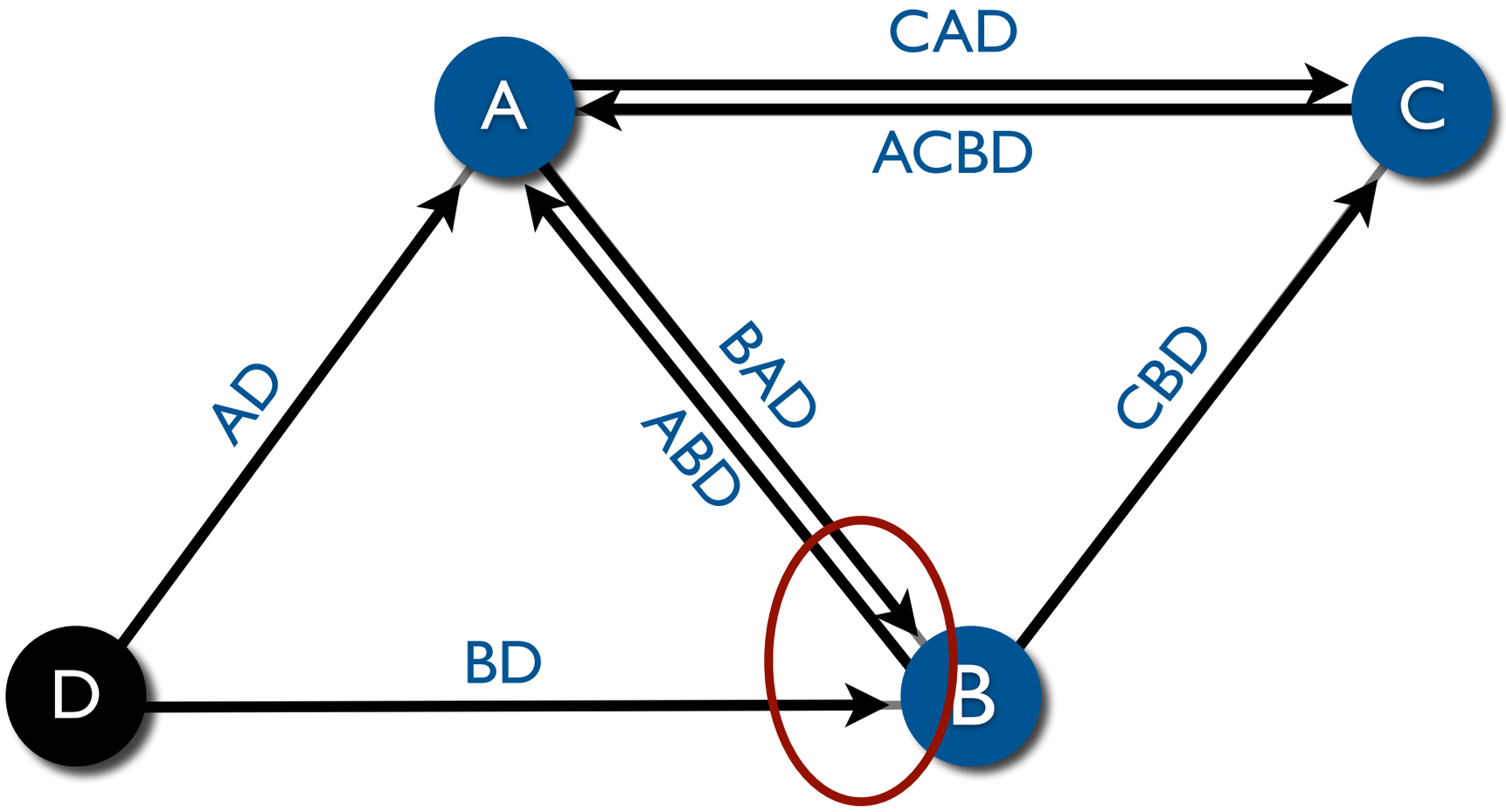
- Different than P vs. NP: hard to even define "security"; objectives involve tradeoffs

Unreliability: One Example

Internet Routing

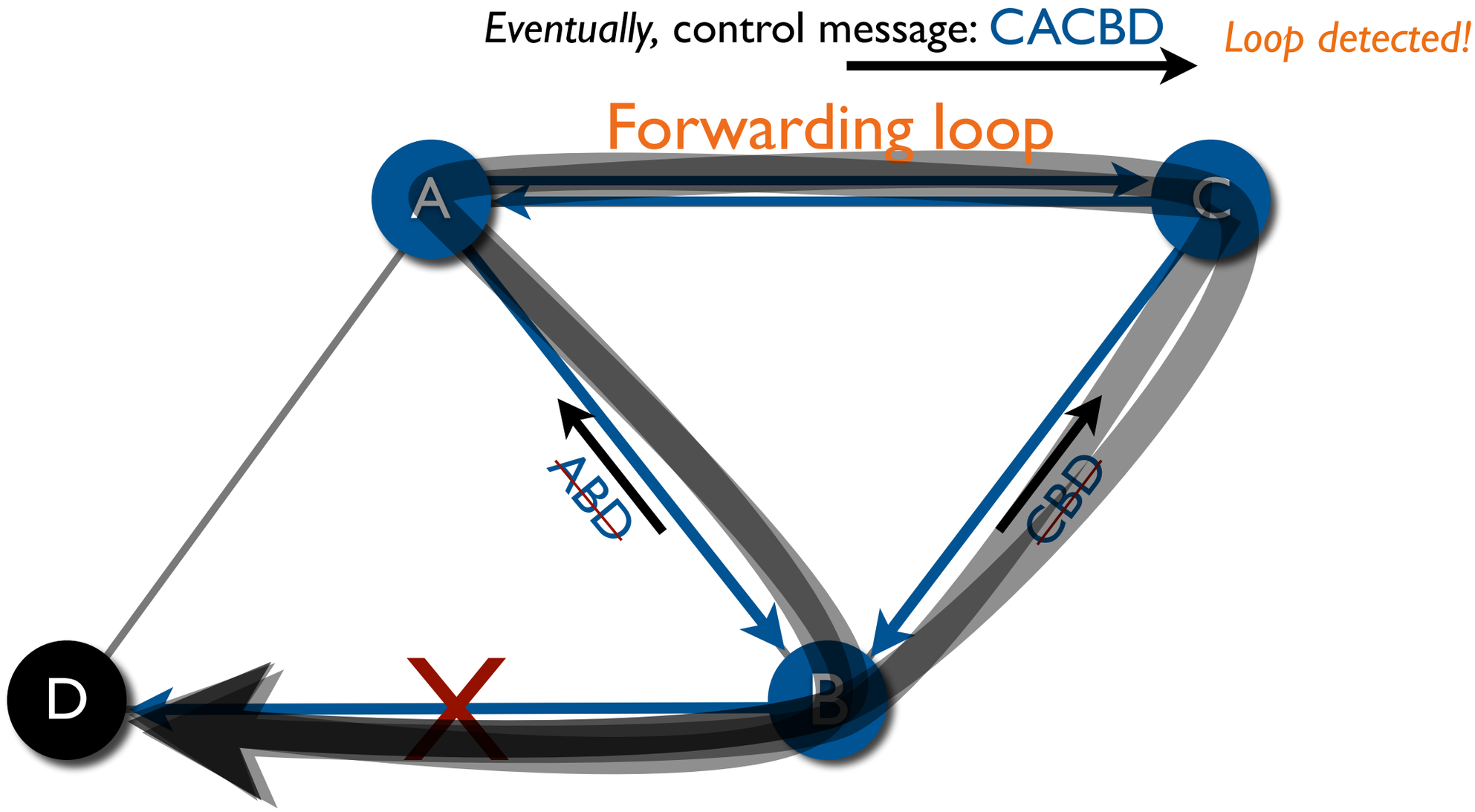


Border Gateway Protocol



route selection

Instability causes outages



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

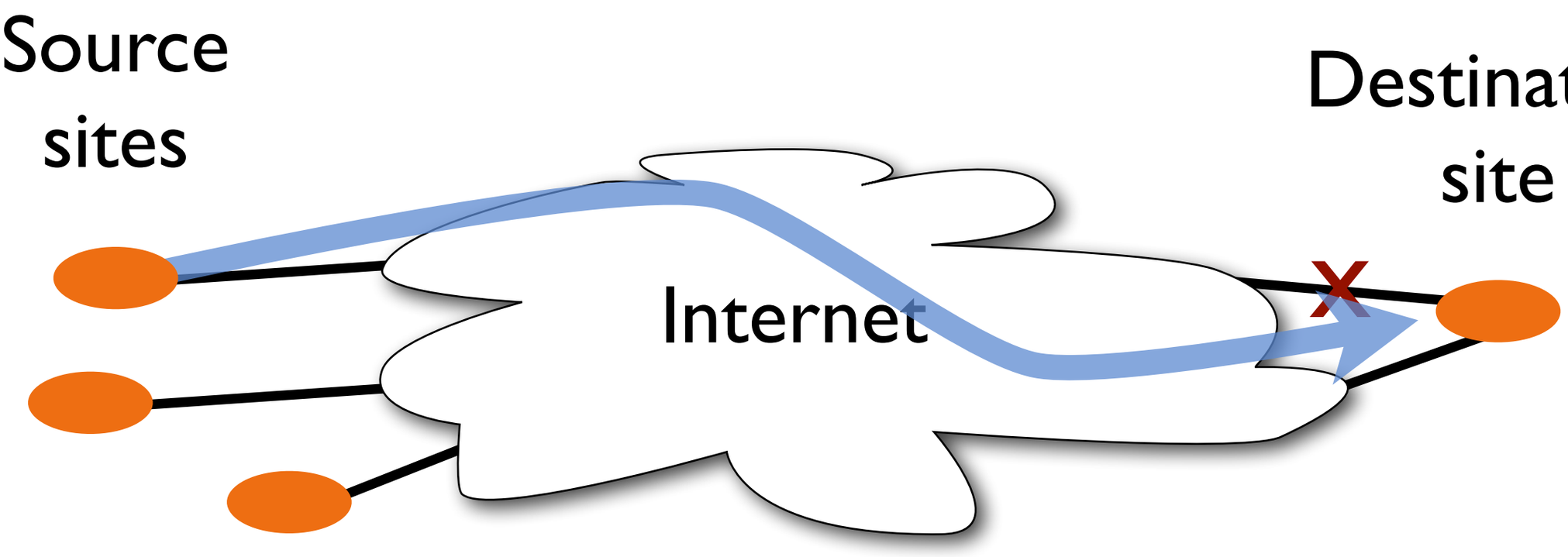
⟹

- Loops
- Detection delay
- Black holes

⟹ FAIL

Instability causes outages

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



Instability causes outages

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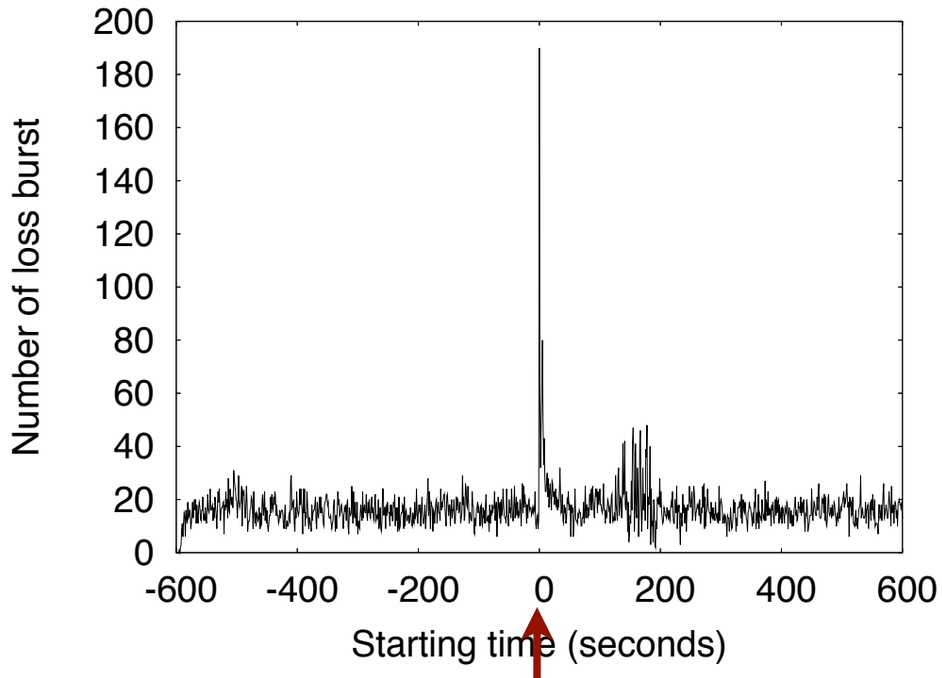
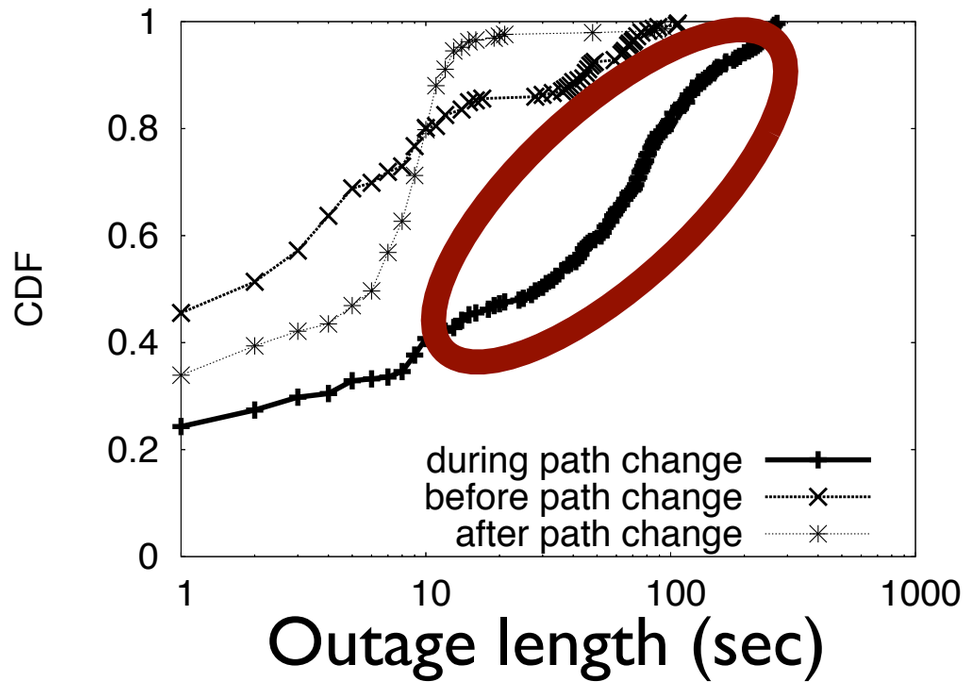
More outages



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!

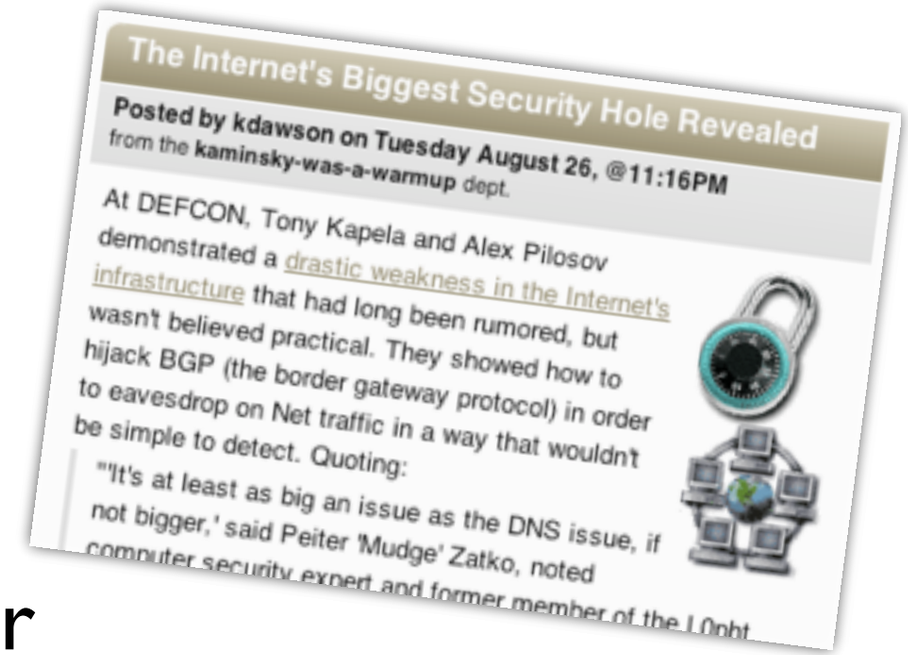
How can hijacker get the advertised routes to actually be used by other ASes?

- 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

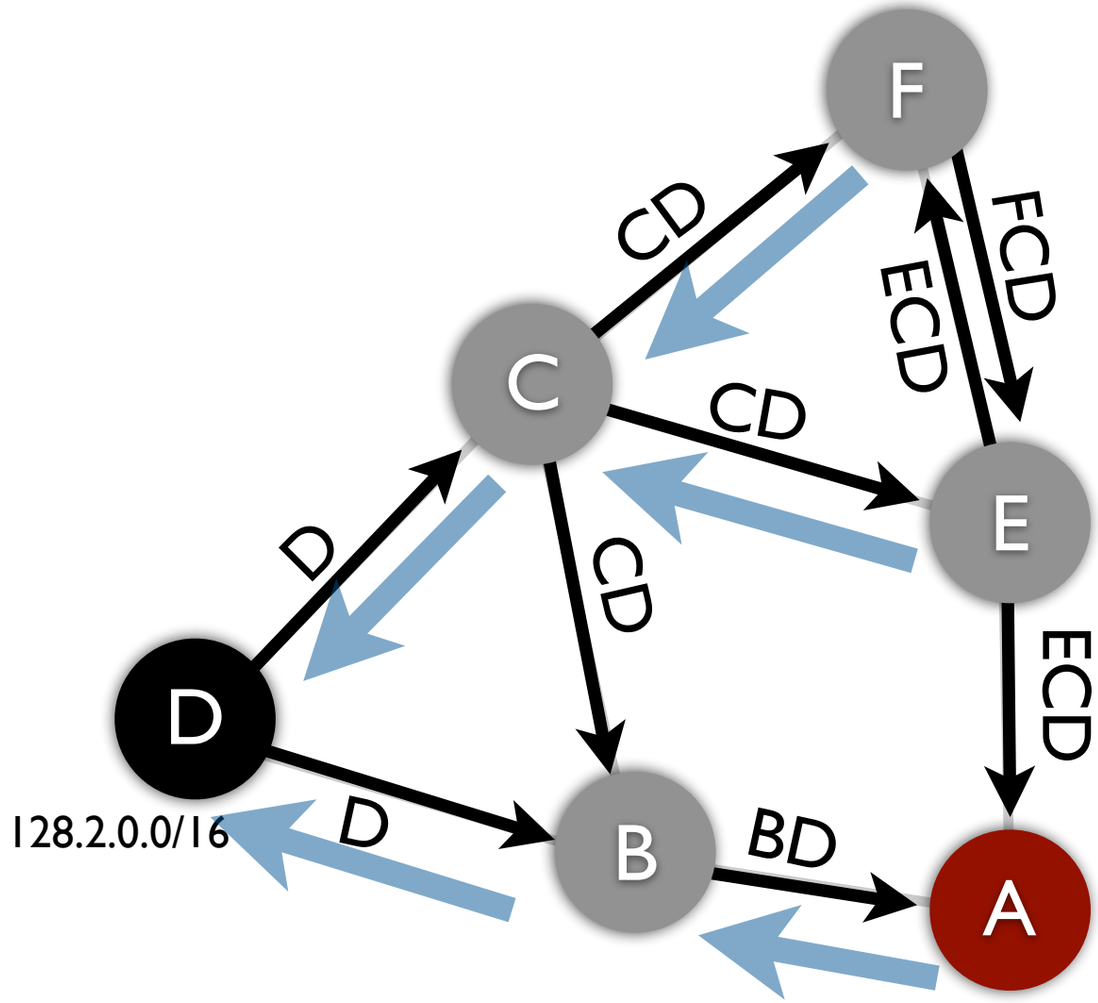
- Traffic to a destination redirected (not blackholed) through an attacker
- Attacker can watch everything you do without you noticing

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

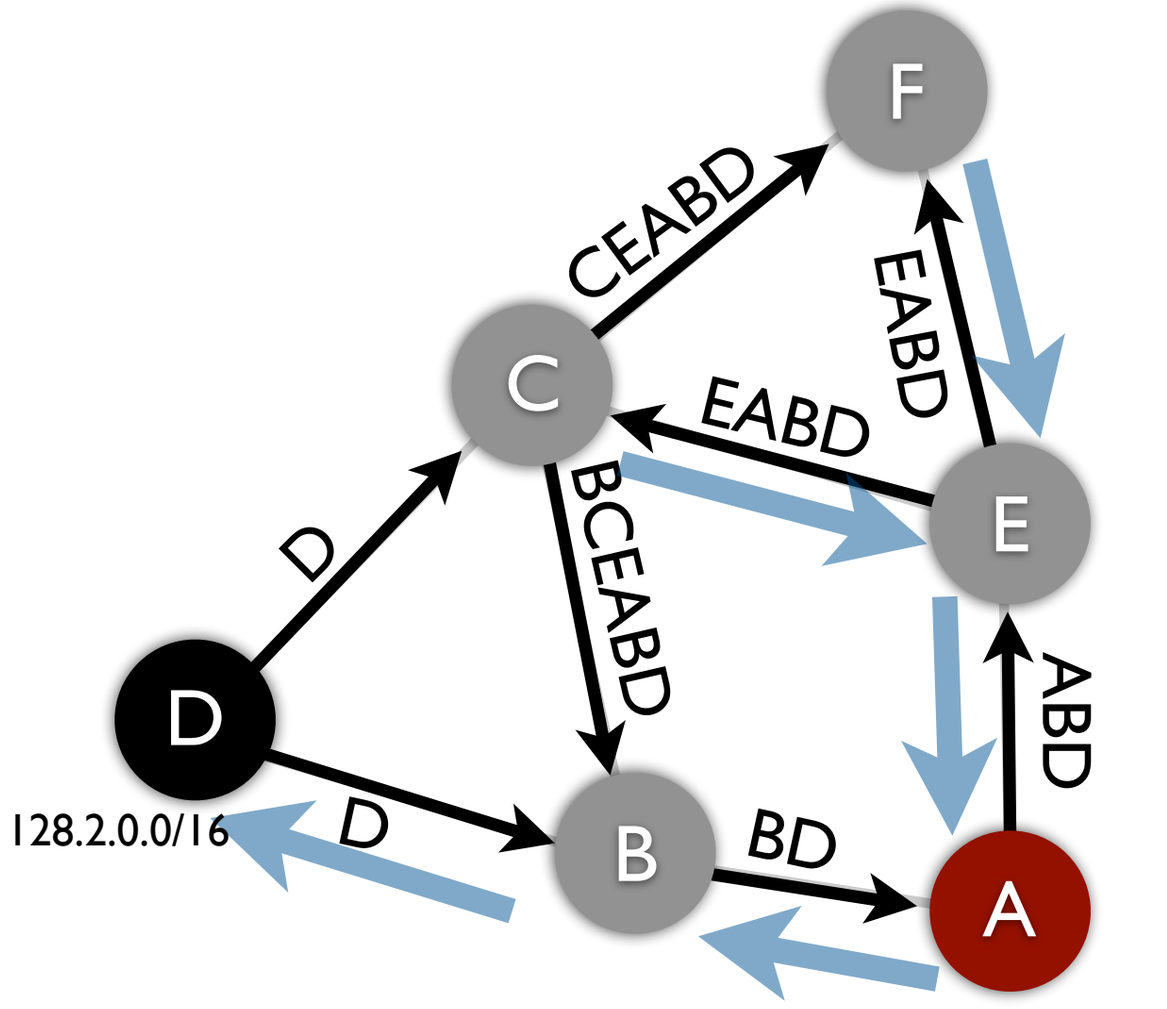


BGP Announcements

Selected routes & flow of data

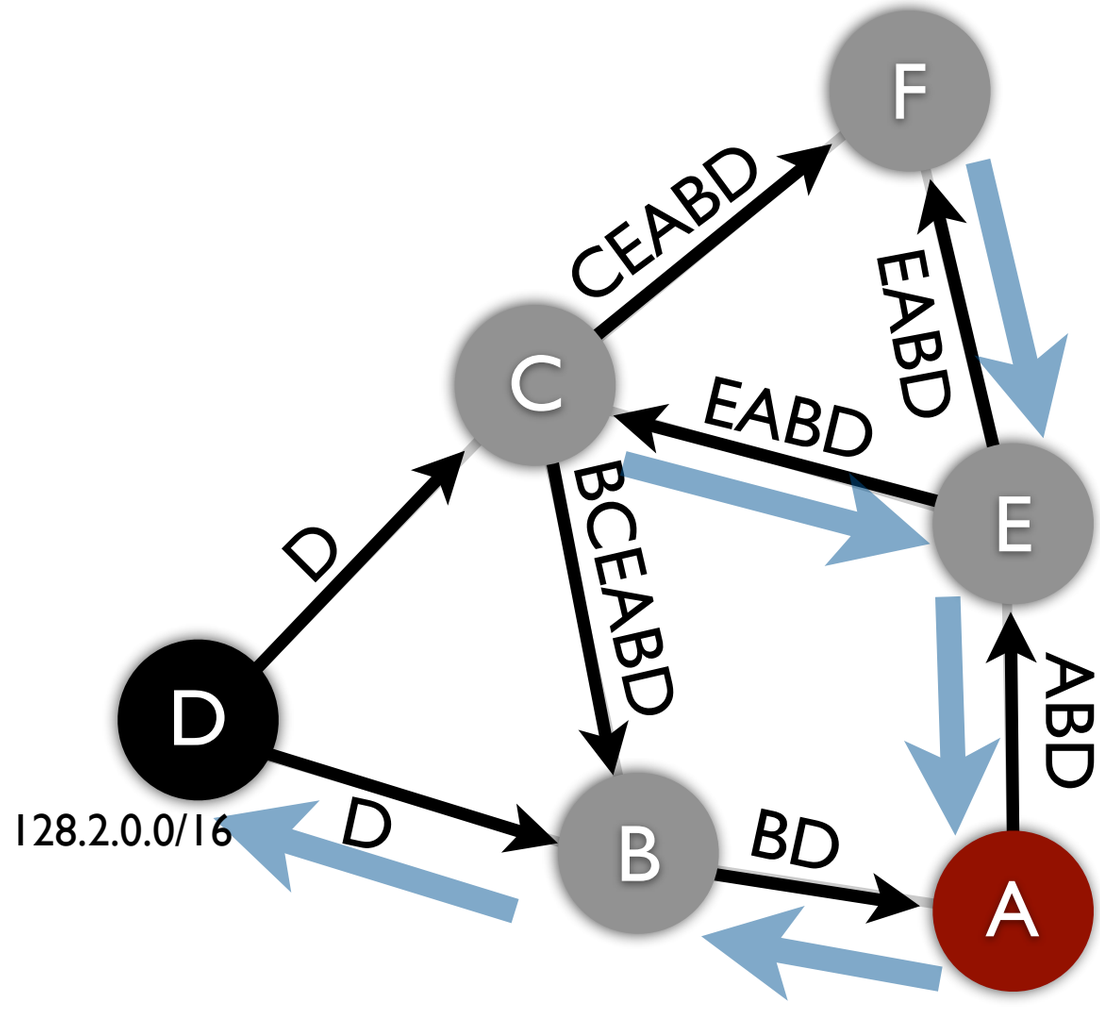
Hijacking + eavesdropping

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

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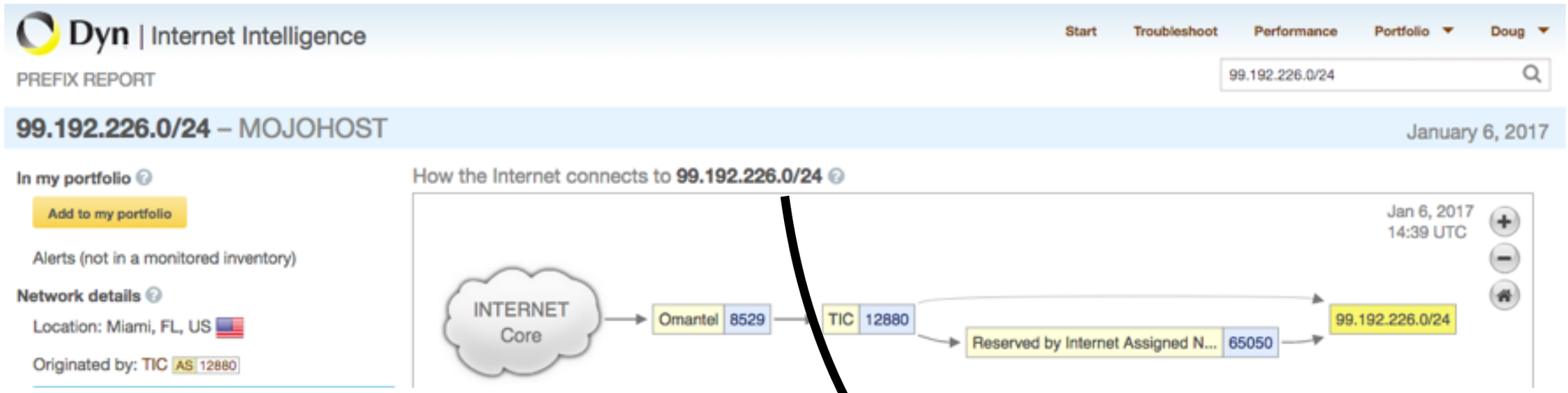
January 5, 2017 incident

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



Iranian state ISP

January 5, 2017 incident

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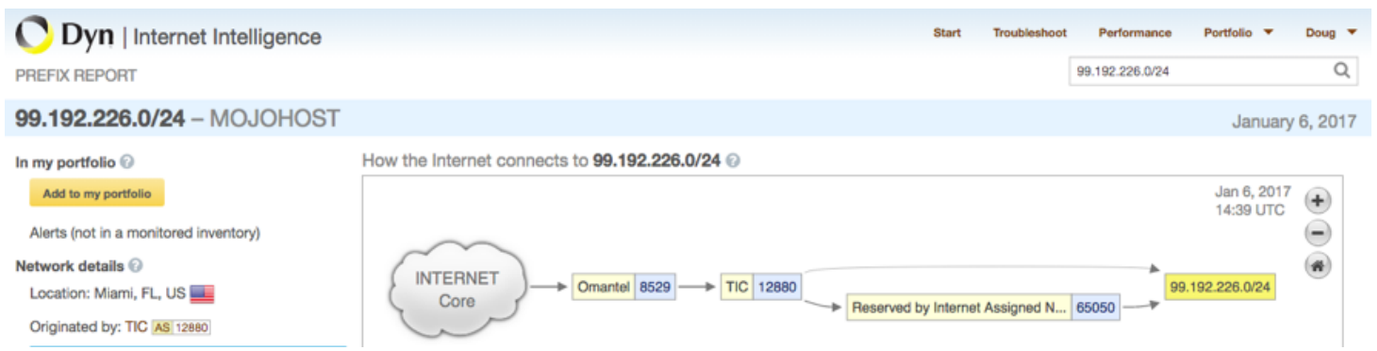
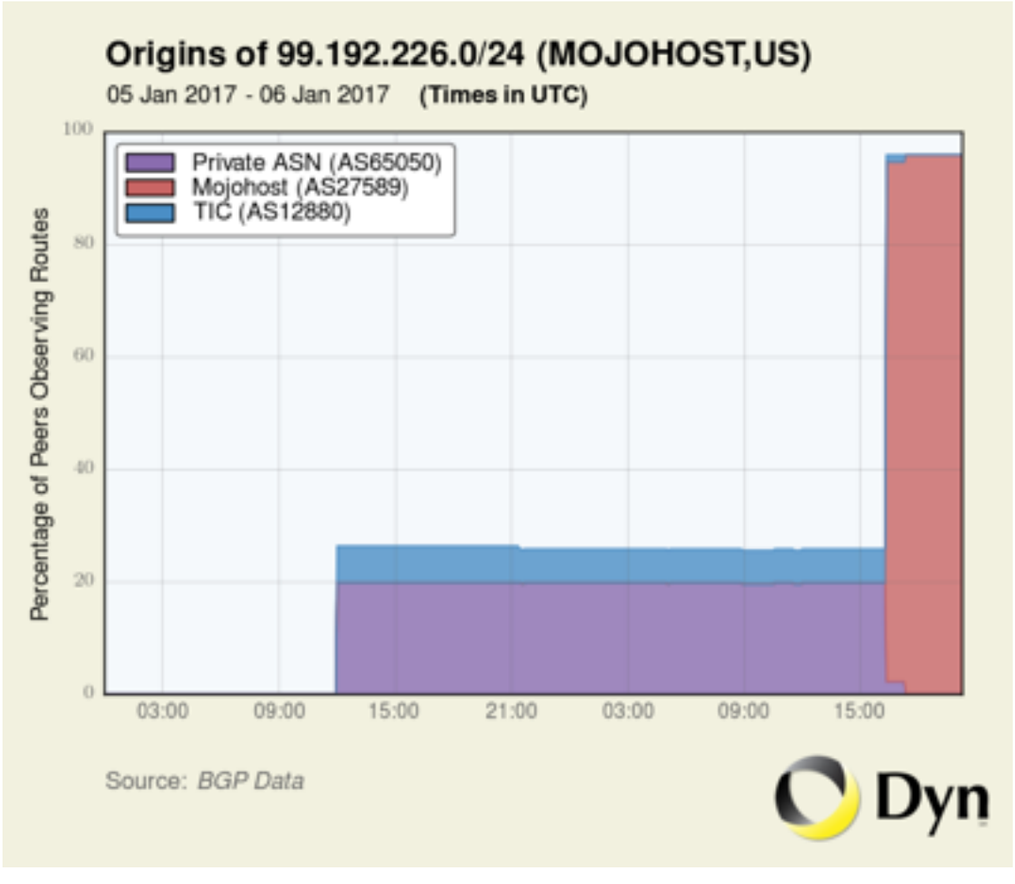


Recovery after owner finds out and takes action



Source:
http://dyn.com/blog/iran-leaks-censorship-via-bgp-hijacks/

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

Grand Challenges in networking

Meta-challenge:

How do we make the Internet evolvable?

Announcements

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)

Micro-presentations

For those of you looking for project teams, tell us

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

[moved to next time]