

# **CSCI 15: AN INTRODUCTION TO THE MODERN INTERNET**

Lecture 3: Internet Service  
Providers

# INTERNET SERVICE PROVIDER

- Comcast, AT&T, Spectrum, Williams
- Provides access to the entire internet to consumers
  
- Just a heads up: we're ignoring cell phones for today (but same ideas apply)



Comcast network. Source: [business.comcast.com](http://business.comcast.com)

- Network (or networks) controlled by one entity

AUTONOMOUS SYSTEM

# TODAY

- How do you transmit information from one AS to another?
- Who pays for all of this?
- What does this mean for us?

# PAID TRANSIT

- An ISP might buy access from another, larger ISP
- Example: Williams probably does this
  - Williams' network probably does not extend to (say) Europe

# PEERING

- Two ISPs may agree to exchange traffic for free
- When are they likely to agree to this?

# TIERS OF ISP

- Tier 1: Never buys traffic. Can reach the entire internet through peering or its own infrastructure
  - AT&T, Sprint, Tata, Telia, Level3 (now part of CenturyLink)
- Tier 2/3: Has to pay other providers for access to some parts of the internet
  - Williams, Comcast (barely), small cable companies

# THIS IS TO SAY

- The “internet backbone” is the conglomeration of many AS’s
- They work out mutual agreements for who can use each others infrastructure



# The AT&T Global Network —

Advanced and Powerful Network Carries More Than 8.52 Petabytes of Data Traffic\* on Average Business Day

- Multiprotocol Label Switching (MPLS)-based services\*\* available to 137 countries over 1,600+ nodes.
- 130,000 MPLS customer ports.
- 32 Internet data centers across the globe.
- 535,000 fiber route miles.



Simplified map: not all nodes/links/routes shown

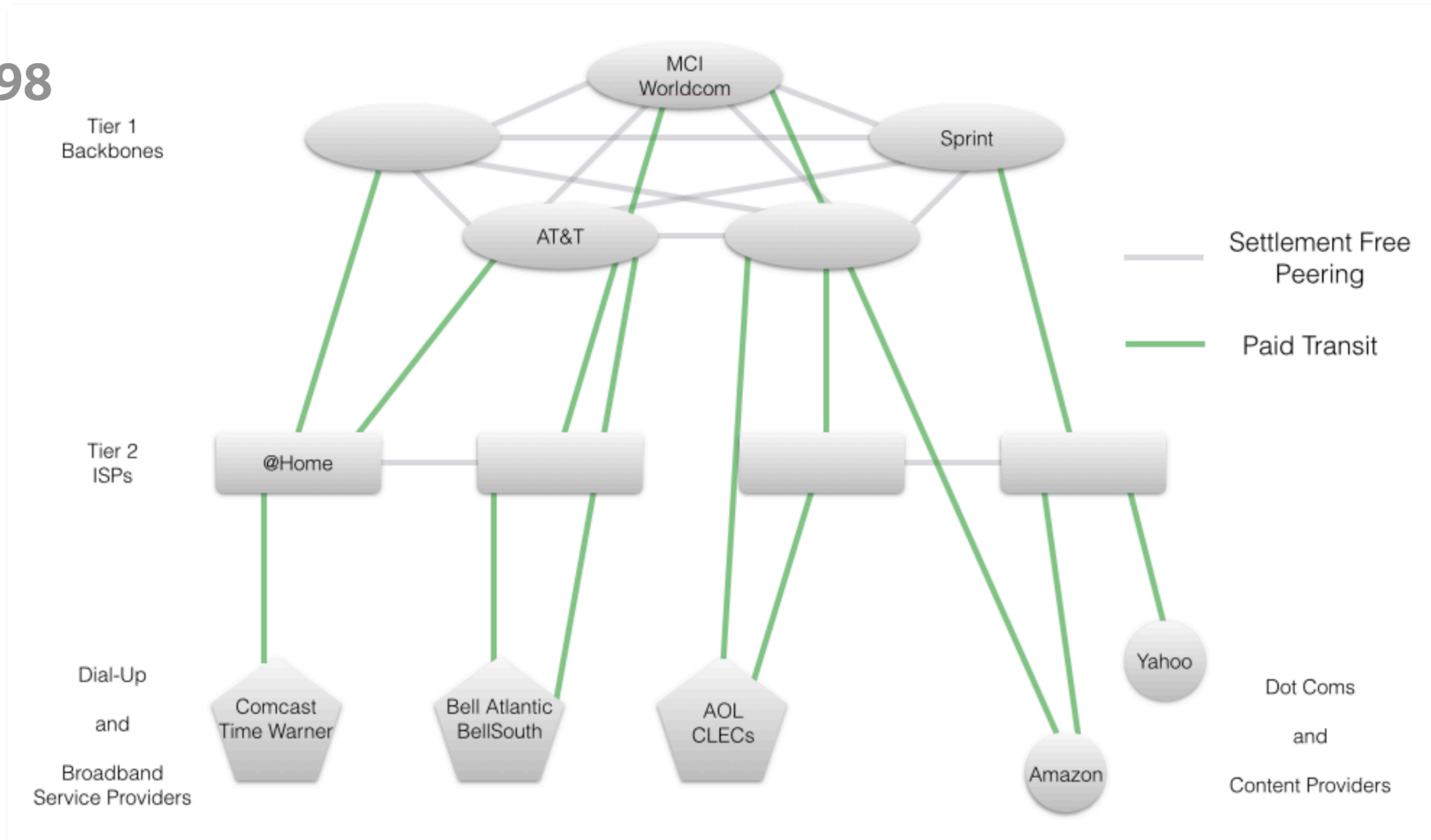
\* Enough data to transmit the digitized contents of the Library of Congress more than 400 times every day.

\*\* MPLS technology enables high-quality delivery of multiple services over a single IP network infrastructure.



# HOW DOES TRAFFIC WORK?

c. 1998



From “How the Net Works: !A Brief History of Internet Interconnection” by Bret Swanson

# INTERNET EXCHANGE POINT

- What if two Tier 2 ISPs can help each other out?
- Cut out the expensive Tier 1 middleman
- Tier 2s can come to peering agreements to exchange traffic
  - To their customers
  - Transit

# INTERNET EXCHANGE POINT

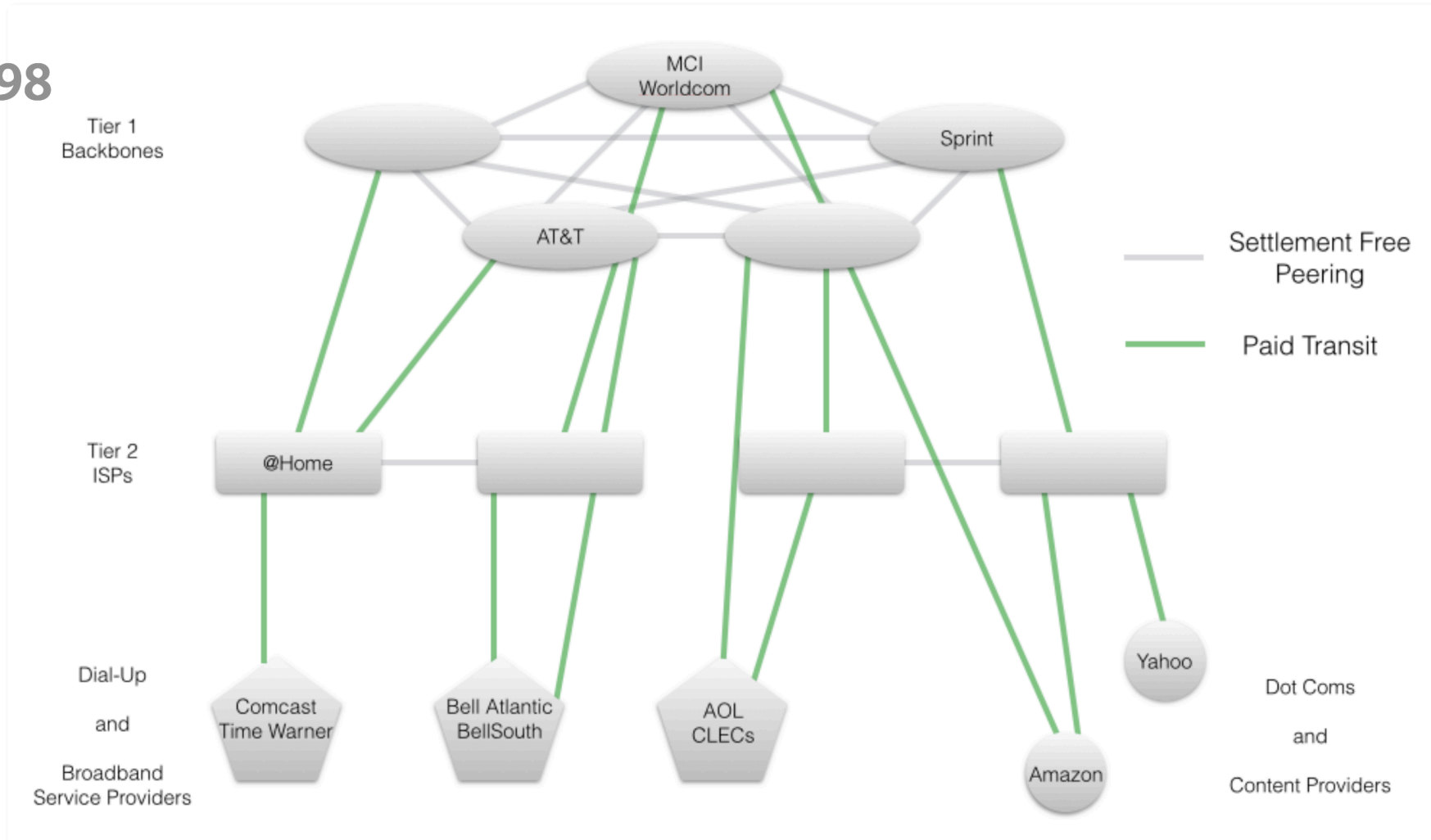
- Place where ISPs can exchange traffic
- Many of these now!
- <https://www.internetexchangemap.com/>
- Pretty big
  - One in Marseilles, France handles 1.7 TB per second

# INTERNET EXCHANGE POINTS

- Side note: who controls these??
- Many owned by Packet Clearing House
- (Also controls DNS)
- International nonprofit
- European Internet Exchange Association
- Private companies also own them (often internet

# HOW DOES TRAFFIC WORK?

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**HOW HAS THE INTERNET CHANGED SINCE 1998?**

# CONTENT DELIVERY NETWORKS

- Companies like Netflix don't just upload from one server to some ISP--- why?
- Congestion
- Significant lag

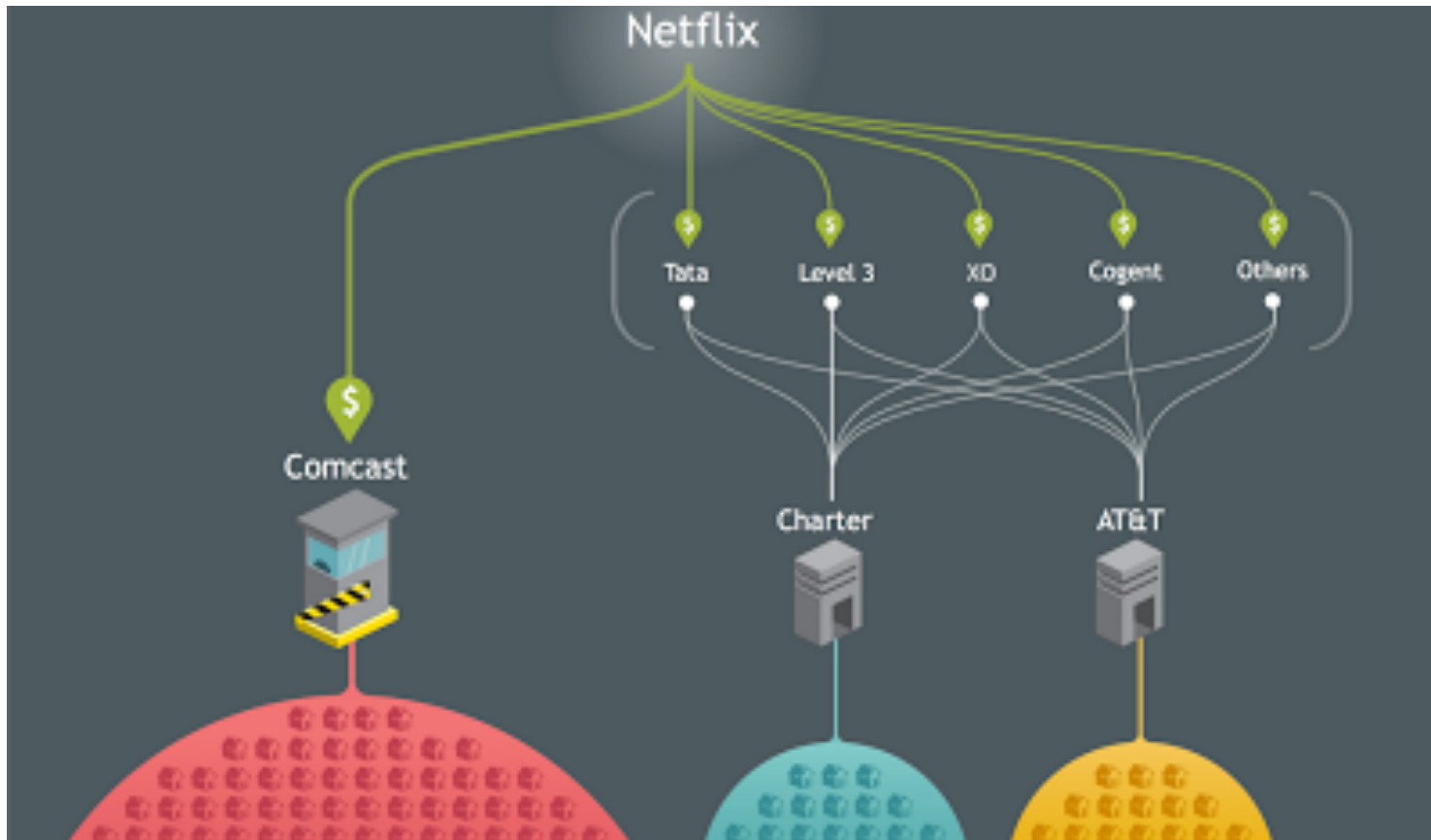


# CONTENT DELIVERY NETWORKS

- Want: this data is available everywhere quickly and effectively
- Copy server to multiple locations
- CDN companies (Amazon, HP, Akamai)
- Build your own (Netflix)
- BIG.

# PEERING WITH CDNS

- How does this change peering and traffic?
  - More
  - Localized
  - Asymmetrical



## PEERING WITH CDNS

- How does this change what each company can offer?
- Before: a high-tier AS offers infrastructure
- Now:
  - Fast access to popular sites like Netflix
  - Fast access to millions of customers (no other option!)

# EXAMPLE: COMCAST DISPUTES

- In mid 2010s, Comcast wanted to renegotiate their peering agreements

# COMCAST'S ARGUMENT

- Comcast receives far more information from Netflix than it transmits to it
- Comcast's main routes were completely congested
- So, Netflix (or the CDN hosting Netflix) should pay more

## LEVEL 3 AND NETFLIX'S ARGUMENT

- Comcast is holding their customers hostage
- “In countries or markets where consumers have multiple broadband choices (like the UK) there are no congested peers”
- Who gets hurt if a person can't access Netflix?

# LEVEL 3 AND NETFLIX'S ARGUMENT

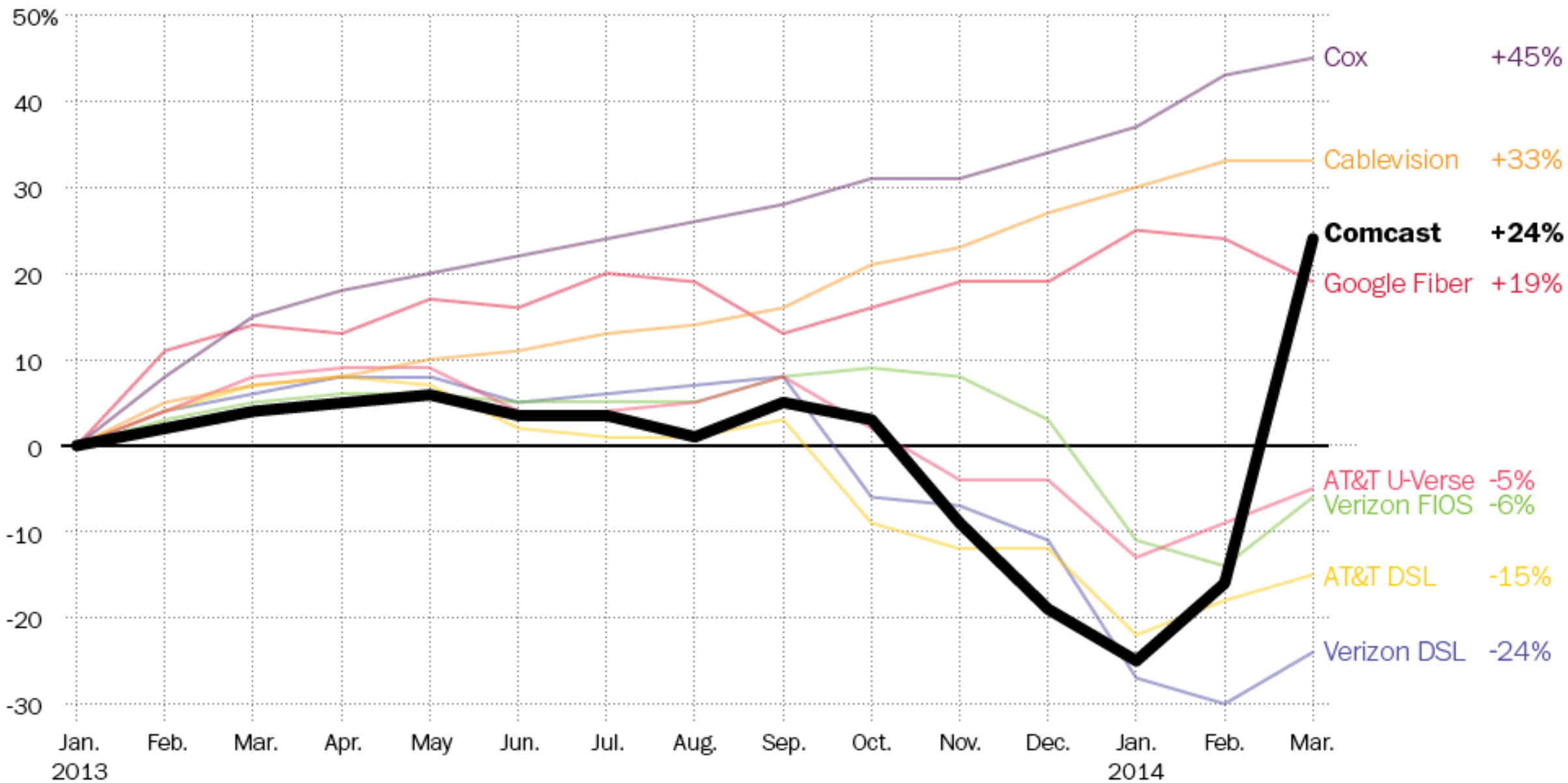
- Also pointed out that Comcast is not a Tier 1 network
- “paying an ISP like Comcast for interconnection is not the same as paying for Internet transit. Transit networks like Level3, XO, Cogent and Tata perform two important services: (1) they carry traffic over long distances and (2) they provide access to every network on the global Internet. When Netflix connects directly to the Comcast network, Comcast is not providing either of the services typically provided by transit networks.”

# WHAT HAPPENED?

- Netflix now has its own CDN
- Does pay Verizon and Comcast
- Also publishes ISP ranking
  - <https://ispspeedindex.netflix.com>
- These disputes are a bit less common
- Companies like Netflix have an interest in anti-trust issues



# % change in Netflix download speed since Jan. 2013, by I.S.P.

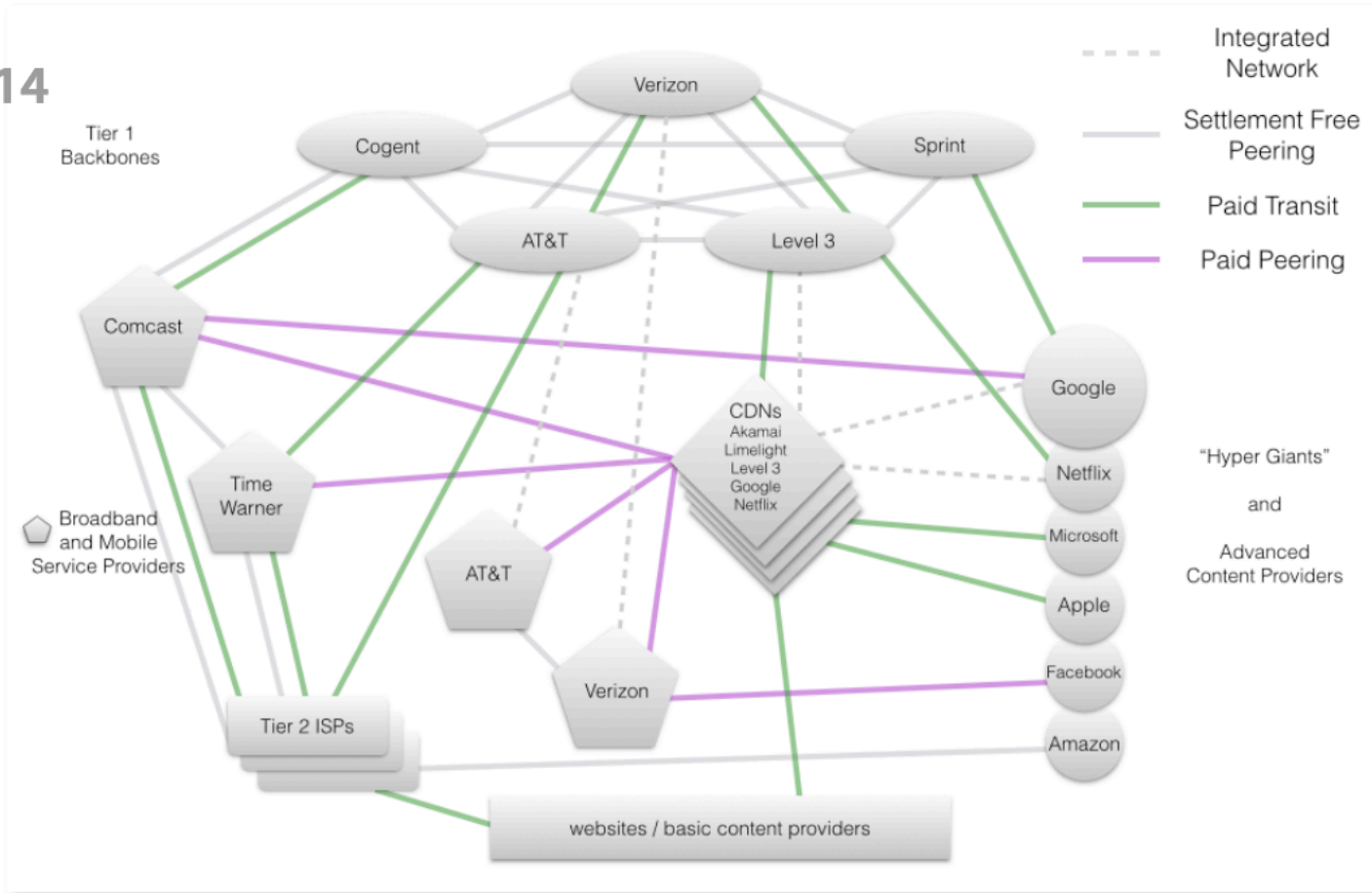


SOURCE: Netflix

GRAPHIC: The Washington Post. Published April 24, 2014

# WHAT DOES THE INTERNET LOOK LIKE NOW?

c. 2014



From "How the Net Works: !A Brief History of Internet Interconnection" by Bret Swanson

# ROUTING

- How can you find a way from A to B within an AS?
- How can you find a way from A to B if B is in another AS? Or requires traversing multiple?
- How does this affect peering?

# BORDER GATEWAY PROTOCOL (BGP)

- Protocol to trade information between autonomous systems

# NET NEUTRALITY

- All traffic must be treated equally
- An ISP gets some traffic – what does it know?
  - Source
  - Destination
  - Contents (type)
  - (maybe) equipment, profile of who sent

# NET NEUTRALITY

- How can an ISP change how it “treats” traffic?