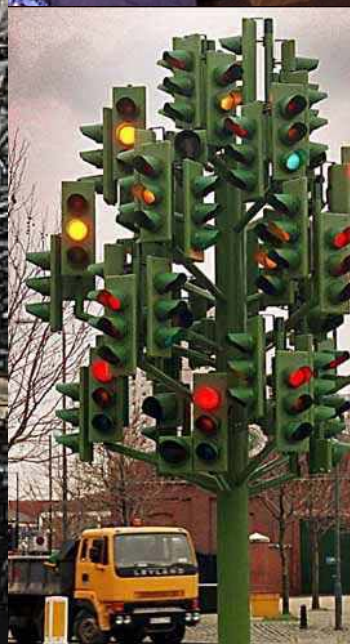
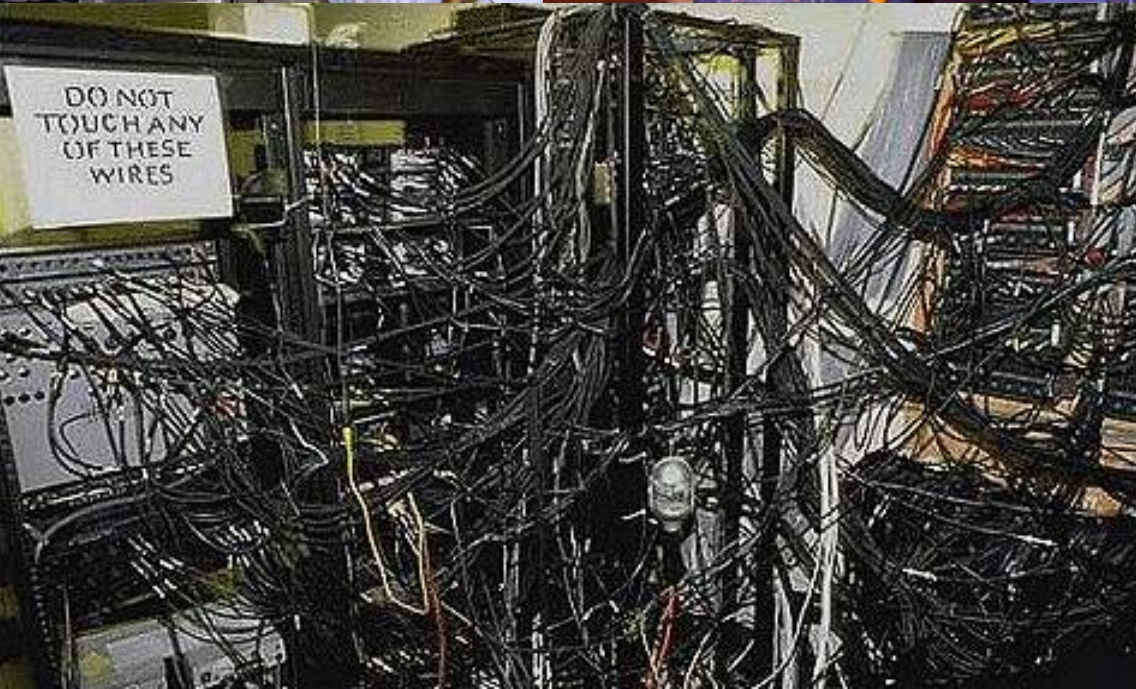


The Evolution of the U.S. Internet Peering Ecosystem

William B. Norton
Co-Founder and Chief Technical Liaison
Equinix, Inc.



INTERNET OPERATIONS RESEARCH

5 YR MISSION

W/PEERING COORDINATORS

90% EXTERNALLY FOCUSED

CORRECT LACK OF OPERATIONS

DOCUMENTATION ON PEERING PRACTICES

DOCUMENT INTERNET OPERATIONS FINDINGS IN
PUBLICLY AVAILABLE WHITE PAPERS...

NETWORK OPERATIONS DOCUMENT

1. Find Operations Area
2. Experts-White Paper v0.1
3. Community Walk Through
4. Revise White Paper
5. Present White Paper at conferences
6. Solicit comments over lunches and dinners

Public Network Operations Documents

Interconnection Strategies for ISPs

Internet Service Providers and Peering

A Business Case for Peering

The Art of Peering: The Peering Playbook

The Peering Simulation Game

Do ATM based Internet Exchanges Make Sense?

Evolution of the U.S. Peering Ecosystem

Asia Pacific Peering Guidebook

Email to wbn@equinix.com for any of these

The Evolution of the U.S. Peering Ecosystem

150 Peering Coordinators:

How has Peering changed since Telecom Crash?

Foreign Tier 1 ISP enters U.S. and expects peering with all the Tier 1 ISPs

-> explain / document motivations of NO

Explain Peering Motivations and Behavior, particularly across Internet Regions

THE U.S. PEERING ECOSYSTEM

INTERNET REGIONS

Definition: Global Internet Peering Ecosystem consists of many Autonomous but interconnected Internet Regions (Countries)

Each Internet Region has roughly three classes of organism each with their own position, motivations → predict peering behavior:

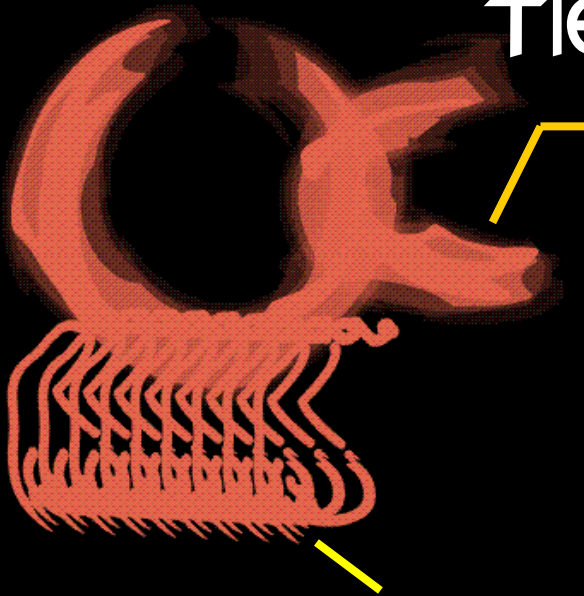
1. Tier 1 ISPs
2. Tier 2 ISPs
3. Content Players

NOTE: RECLAIMING DEFINITIONS HERE

TIER 1 ISP

PEERING LINKS

DEF: AN ISP THAT HAS ACCESS TO THE ENTIRE INTERNET REGION ROUTING TABLE, SOLELY THROUGH PEERING RELATIONSHIPS.

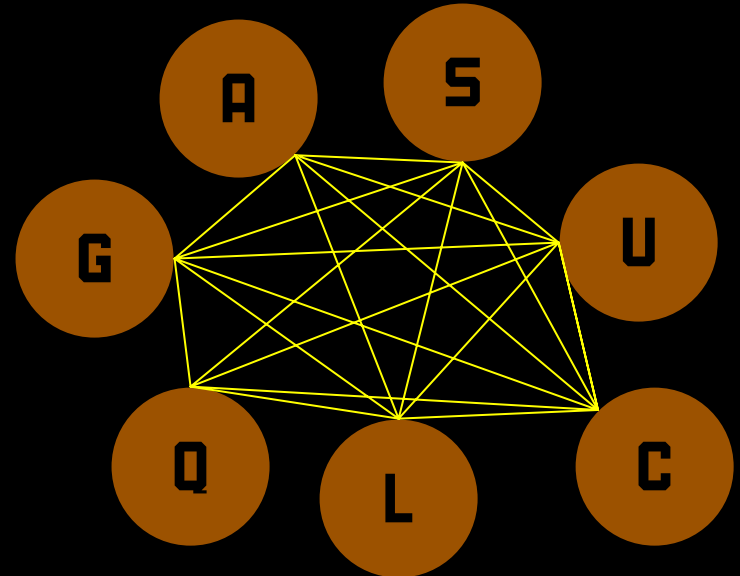


TRANSIT (DOWNSTREAM) LINKS

PEERING BEHAVIOR

MOTIVATION: "WE DON'T NEED ANY MORE PEERING."

INCLINATION: RESTRICTIVE



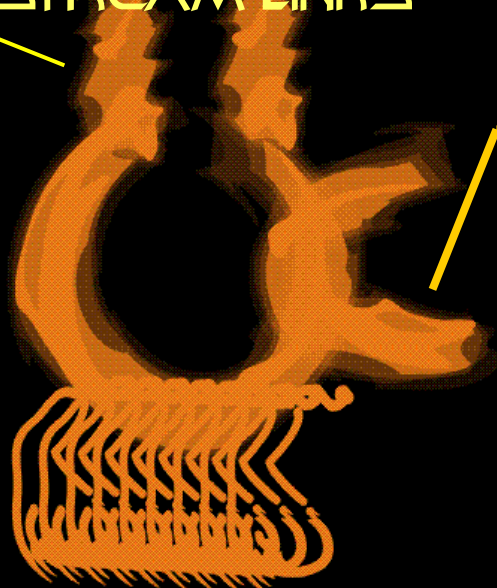
UPSTREAM LINKS

TIER 2 ISP

PEERING LINKS

DEF: ALL NON-TIER 1 ISPS
(MUST BUY TRANSIT)

TRANSIT (DOWNSTREAM) LINKS



1998

Tier 1 ISP

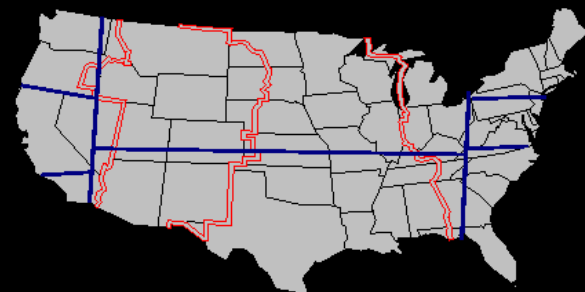
Tier 2 ISP

Content

PEERING BEHAVIOR

MOTIVATION: PEER TO
REDUCE TRANSIT FEES,
PERFORMANCE

INCLINATION: OPEN → SELECTIVE



Sparse Peering

UPSTREAM LINKS

CONTENT PROVIDER

1998

Tier 1 ISP
Tier 2 ISP

Content



DEF: PROVIDES CONTENT,
DOES NOT PEER,
DOES NOT SELL TRANSIT,
MOSTLY OUTBOUND
TRAFFIC

PEERING BEHAVIOR

MOTIVATION: FOCUS ON
END-USER EXPERIENCE:
GENERALLY FEW NETSTAFF

INCLINATION: NO PEERING



THE INTERNET PEERING ECOSYSTEM

A decorative graphic consisting of several horizontal lines. A thick yellow line is at the top, followed by a thin black line, a thin orange line, and another thin black line. Below these, a yellow line curves down from the left side to meet a diagonal orange line that extends to the right edge of the slide.

PRE-CRASH: 1998

U.S. INTERNET REGION

1998

Tier 1 ISP
Tier 2 ISP
Content

In-group
Peering

Transit

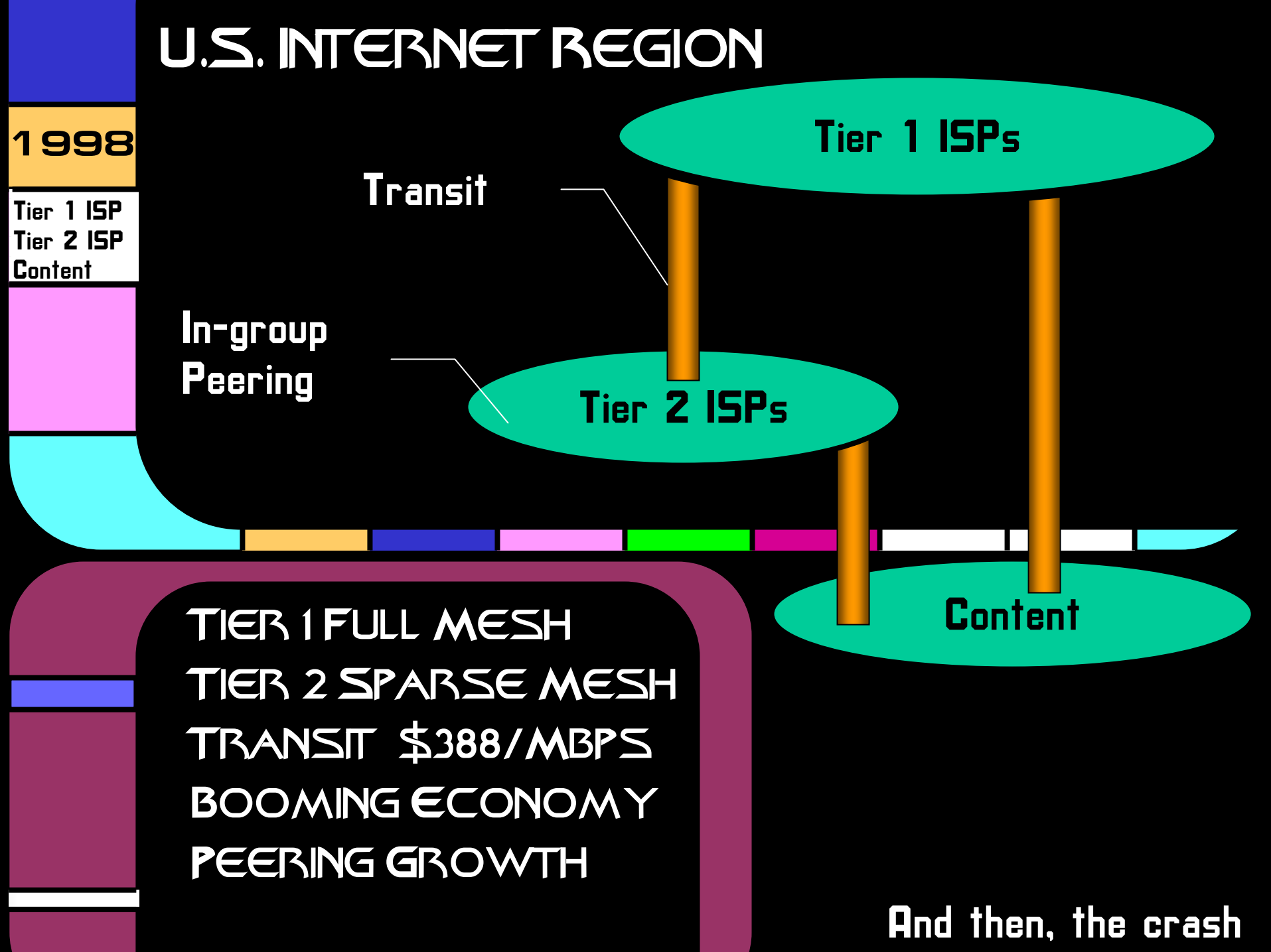
Tier 1 ISPs

Tier 2 ISPs

Content

TIER 1 FULL MESH
TIER 2 SPARSE MESH
TRANSIT \$388/MBPS
BOOMING ECONOMY
PEERING GROWTH

And then, the crash



Windows

A fatal exception 0E has occurred at 0020:C0011E36 in UXD UMM(01) + 00010E36. The current application will be terminated.

- * Press any key to terminate the current application.
- * Press CTRL+ALT+DEL again to restart your computer. You will lose any unsaved information in all applications.

Press any key to continue _

NO, NOT THAT TYPE OF CRASH...

A decorative graphic consisting of several horizontal bars. At the top is a thin yellow line. Below it is a thicker yellow line. Then a thin black line. Then a thin orange line. Then a thick orange line. Finally, a thick yellow line at the bottom. The bars are contained within a yellow outline that has rounded corners on the left side and a diagonal cutout on the right side.

THE TELECOM INDUSTRY CRASH

CRASH: '99-'01

Five key events led to a drastic disruption in the U.S. Peering Ecosystem:

CRASH: '99-'01

- 1) TIER 1 ISP BANKRUPTCIES
- 2) THE GROWTH OF THE USED EQUIPMENT MARKET
- 3) THE UPSTREAM PROVIDER FOR THE CABLE COMPANIES (@HOME) WENT BANKRUPT
- 4) PEER-TO-PEER FILE SHARING SYSTEMS (LIKE KAZAA) GROW IN POPULARITY, TRAFFIC GROWS EXPONENTIALLY BETWEEN ACCESS PROVIDERS (1.5MB MP3 → 700MB AVI FILES)
- 5) TRANSIT PRICES DROP, TRANSPORT PRICES DROP

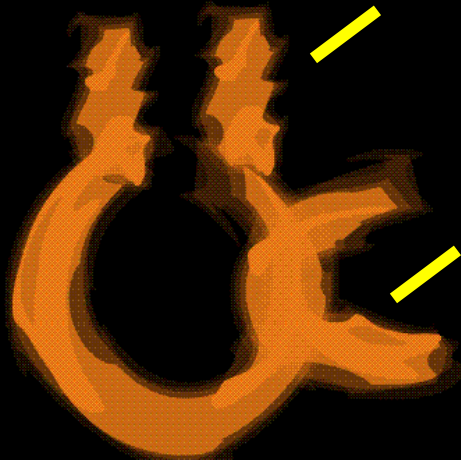
Led to 3 major evolutions → A new Organism

TRANSIT (UPSTREAM) LINKS

CABLE COMPANY

2002

Tier 1 ISP
Tier 2 ISP
Content
Cable Co.



PEERING LINKS

@HOME HANDLED INTERNET

30-60 DAYS NOTICE

→ TIER 1 TRANSIT

40% TRAFFIC KAZAA

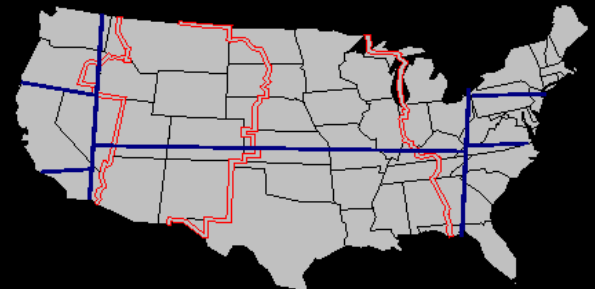
3-5 GBPS OF TRANSIT

→ UP TO 2GBPS OF PEERING TRAFFIC!

PEERING BEHAVIOR

MOTIVATION: PEER TO SAVE MONEY, IMPROVE PERFORMANCE

INCLINATION: OPEN-SELECTIVE

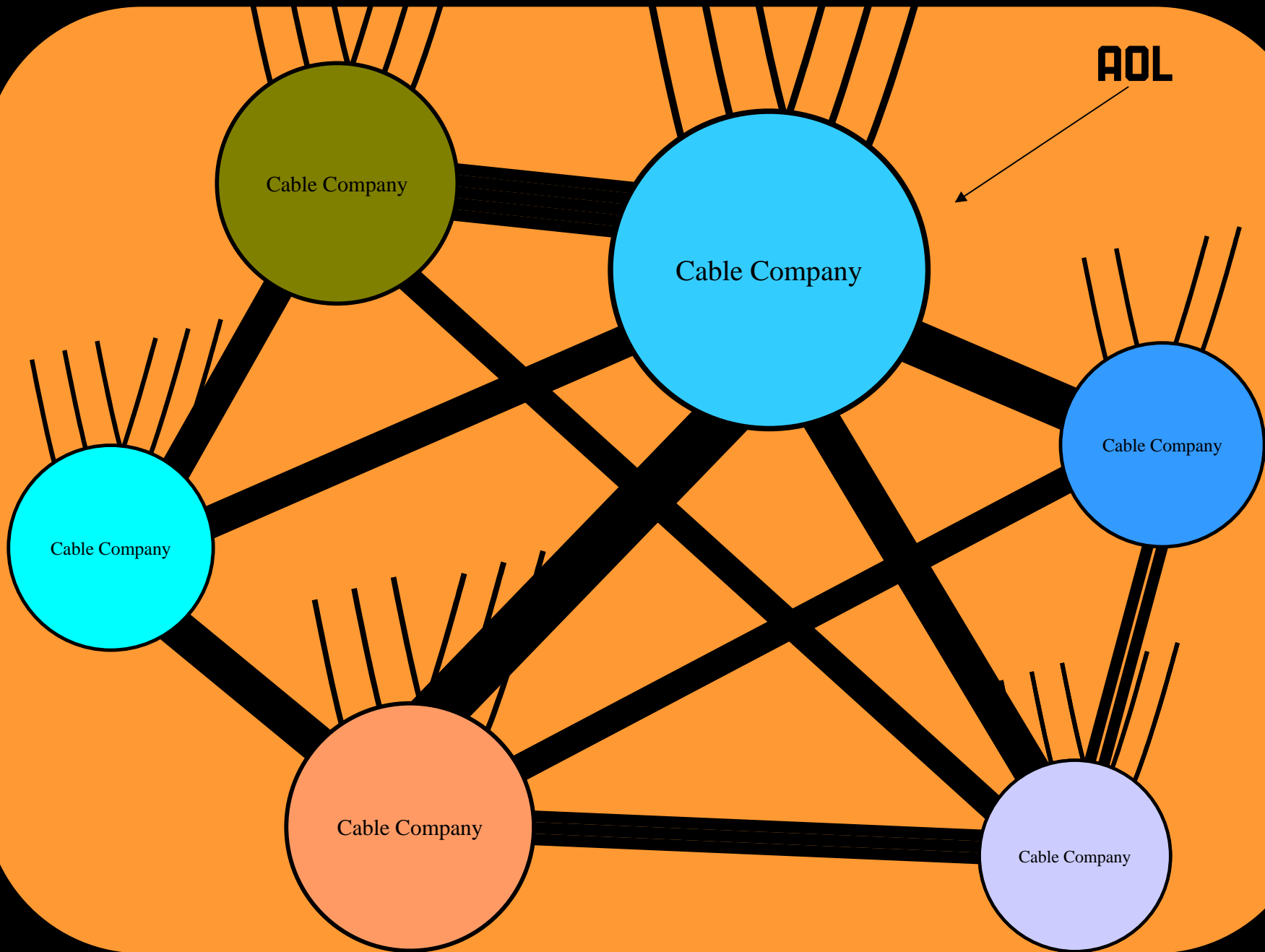


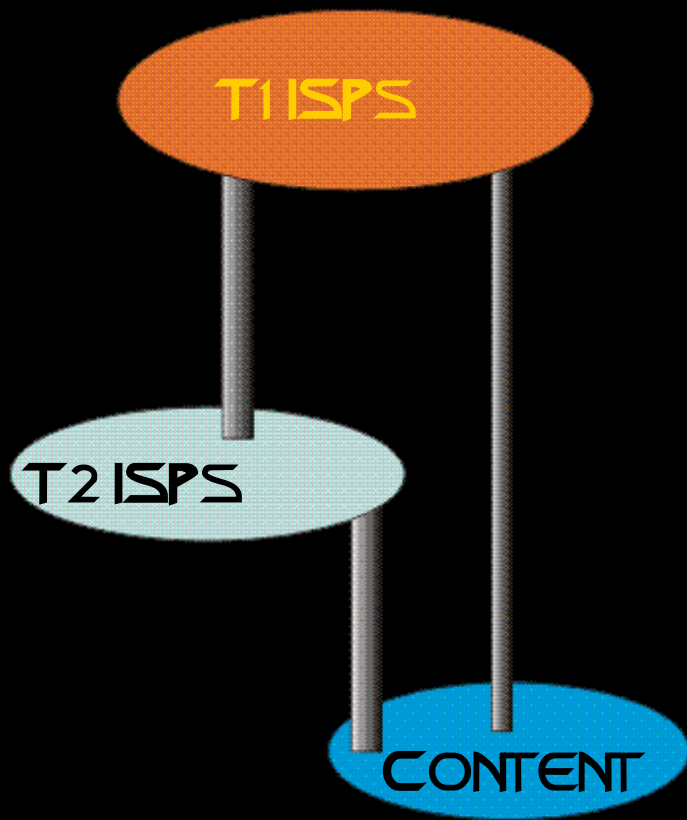
Sparse (Regional) Peering

U.S. Cable Companies Eyeballs

MSO	Country	YE02	Change in 02
Comcast	USA	3,620,300	1,199,100
Time Warner	USA	2,613,000	1,027,000
Cox	USA	1,407,900	524,400
Charter	USA	1,180,000	572,300
CableVision	USA	770,100	263,500
Shaw (Big Pipe)	Canada	750,000	?
Rogers	Canada	650,000	?
Adelphia	USA	610,000	305,900
Bright House	USA	490,000	159,000
Mediacom	USA	191,000	76,000
RCN	USA	160,400	49,800
Insight	USA	144,800	56,700
Cable One	USA	78,100	45,200
Total		12,665,600	4,278,900

AOL is the 800 Pound Gorilla





Evolution #1

Cable Companies Peer

SIGNIFICANT EVOLUTION...

- 1) VOLUME OF TRAFFIC IS HUGE
- 2) CABLE COS OPEN PEERING
- 3) "KAZAA EFFECT" AMPLIFIES PEERING BENEFITS

TRANSIT (UPSTREAM) LINKS

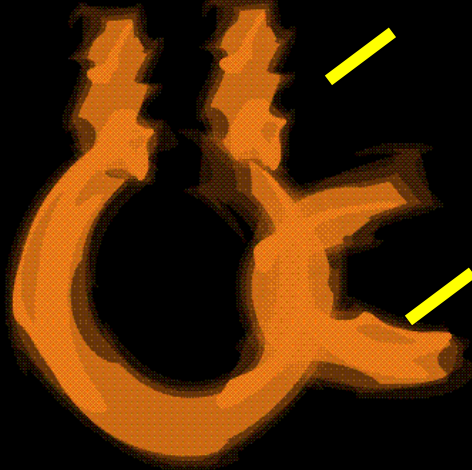
LARGE SCALE

NETWORK SAVVY

CONTENT PROVIDERS

2002

Tier 1 ISP
Tier 2 ISP
Content
Cable Co.
LSNSCP

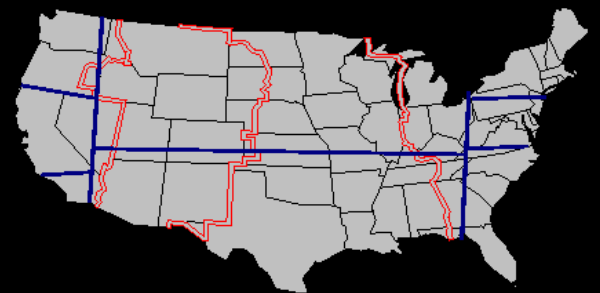


PEERING
LINKS

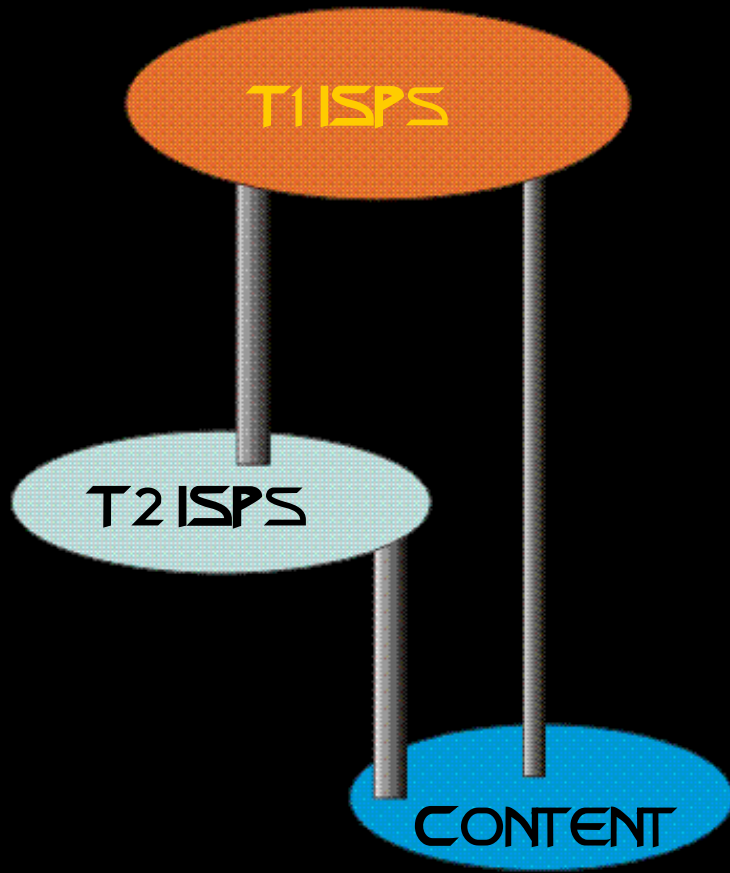
PEERING BEHAVIOR

MOTIVATION: PEER TO SAVE
MONEY, IMPROVE
PERFORMANCE

INCLINATION: OPEN



Sparse (Regional) Peering



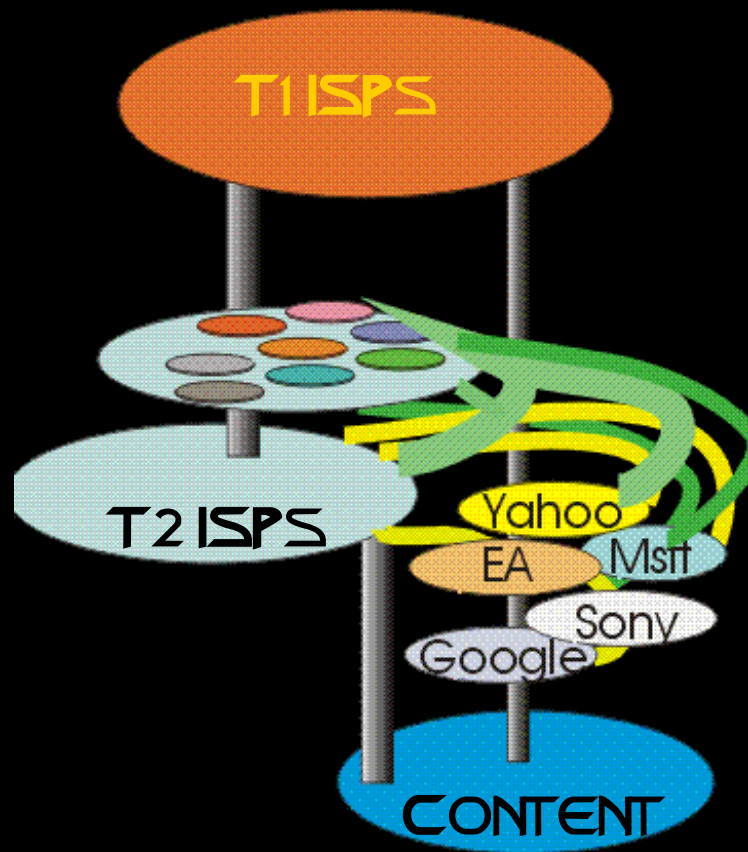
Evolution #2

Large Scale Content Players Peer

SIGNIFICANT EVOLUTION...

- 1) VOLUME OF TRAFFIC IS HUGE
- 2) CONTENT IS OPEN PEERING
- 3) IMPROVES END-USER EXPERIENCE
- 4) LEADING PLAYERS ARE PAVING THE WAY

...NEED TO MOVE OUT OF
BANKRUPT COLO ANYWAY...



Evolution #3

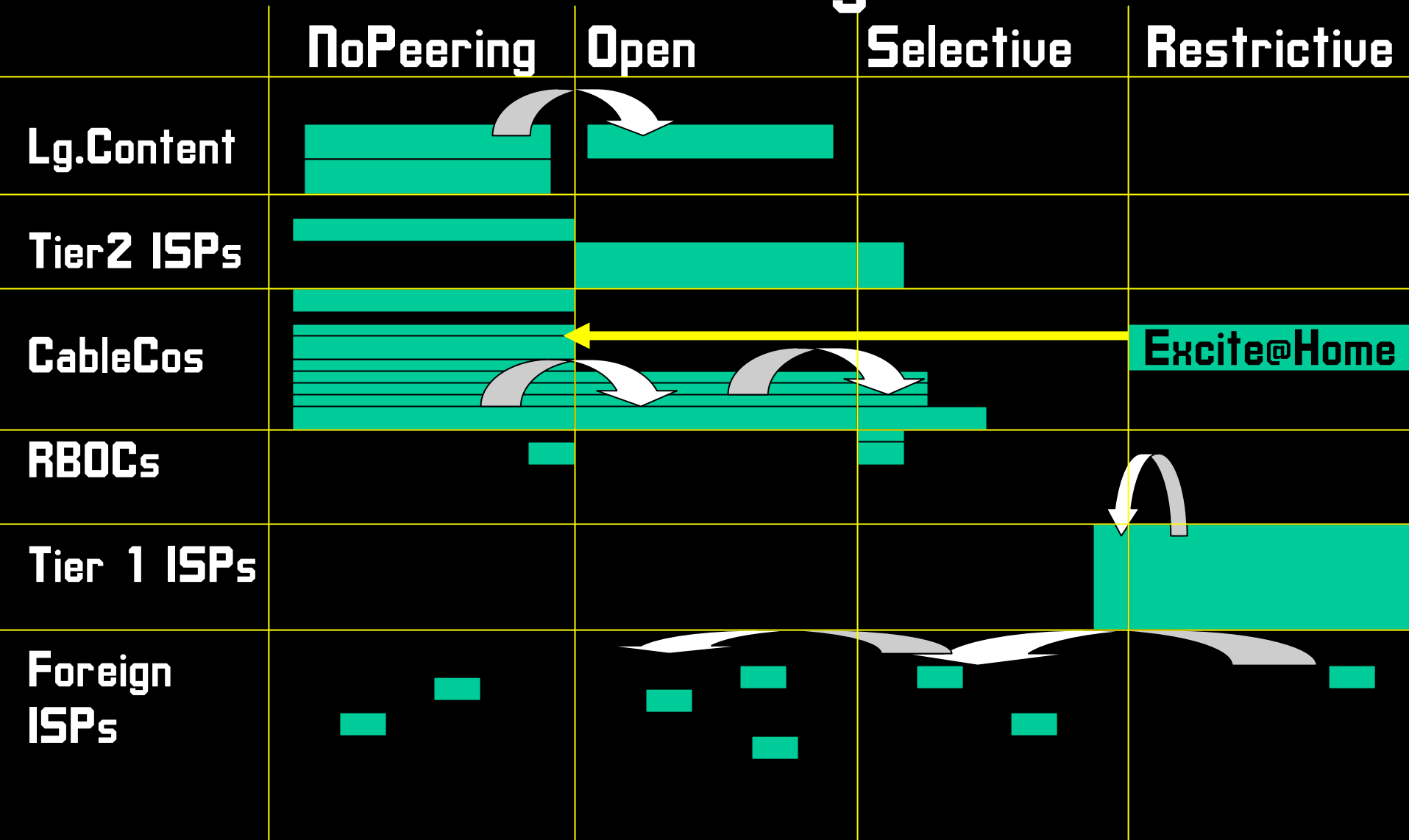
**Cable Cos Peer w/Large
Scale Content Players**

SIGNIFICANT EVOLUTION...

- 1) Volume of traffic pulled away from T1s is huge**
- 2) Reduces perceived need for T1s (for local delivery anyway)**
- 3) T1s still needed for distance**

**→ Content Literally right on the
Cable Company Network**

Peering Ecosystem Evolution Summary



Questions?

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