



Trends in Internet Traffic Patterns

Darren Anstee,
EMEA Solutions Architect

This Talk

- **The End of the Internet as we Know it**
- **We present the largest study of Internet traffic every conducted**
 - Peer-reviewed at a networking research conference
- **What is really changing in the Internet**
 - And how this impacts carriers, enterprise, consumers and basically everything

S. Iekel-Johnson, D. McPherson
Arbor Networks, Inc.

J. Oberheide, F. Jahanian
University of Michigan



The Internet.....

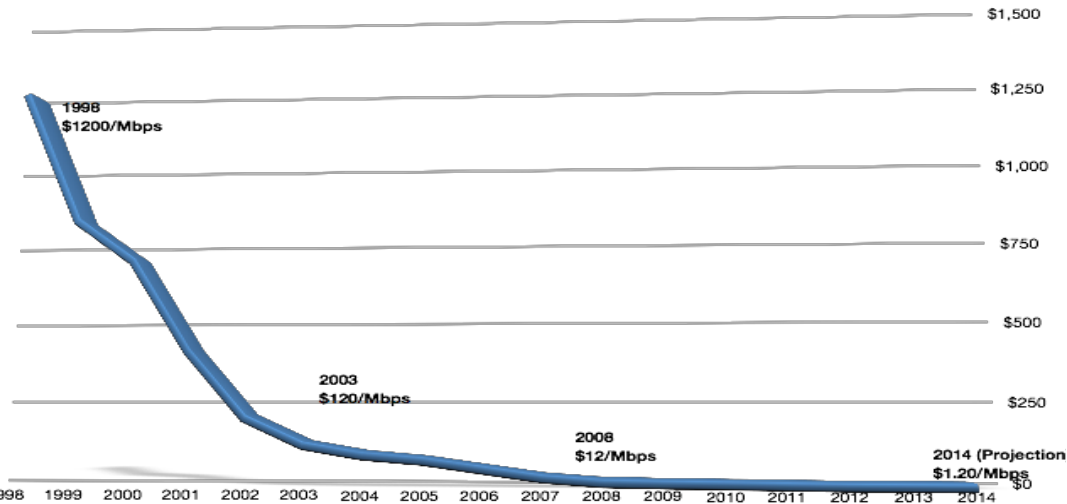
...is changing dramatically

- Social networking, Cloud, etc



- **But this is not the whole story...**
- **Even more significant changes in**
 - Internet / carrier economics
 - And fundamental end-to-end design principals
 - With dramatic impact on security and future networks

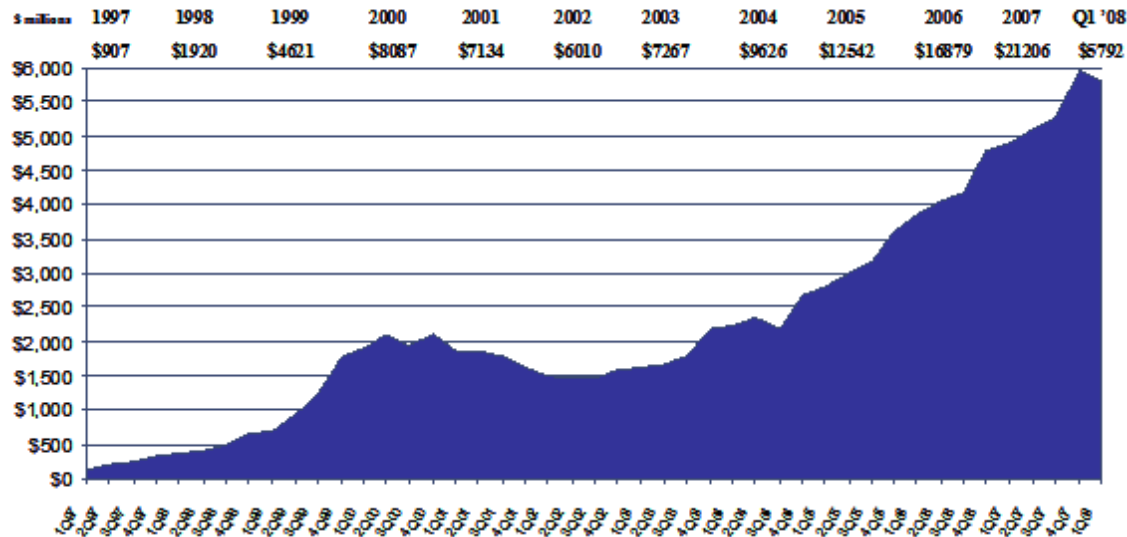
Specific Market Forces



Revenue from Internet Transit

Source: Dr. Peering, Bill Norton

Quarterly Internet Ad Revenues



Revenue from Internet Advertisement

Source: Interactive Advertising Bureau

Means ISP / Content Strategies Changing

- **Commoditization of IP and Hosting / CDN**
 - Drop price of wholesale transit
 - Drop price of video / CDN
 - Economics and scale drive enterprise to “cloud”
- **Consolidation**
 - Bigger get bigger (economies of scale)
 - e.g., Google, Yahoo, MSFT acquisitions
- **Success of bundling / Higher Value Services**
 - Triple and quad play, etc.
- **New economic models**
 - Paid content (ESPN 360), paid peering, etc.
 - Difficult to quantify due to NDA / commercial privacy
- **Disintermediation**
 - Direct interconnection of content and consumer
 - Driven by both cost and increasingly performance



Industry Speculation

- **No shortage of speculation about about these ongoing large Internet changes (e.g. Wired, Wall Street Journal)**
- **But very, very, little hard data...**
 - None really
- **Not surprising since providers do not like to share traffic information**
- **So really no good data since 1995**

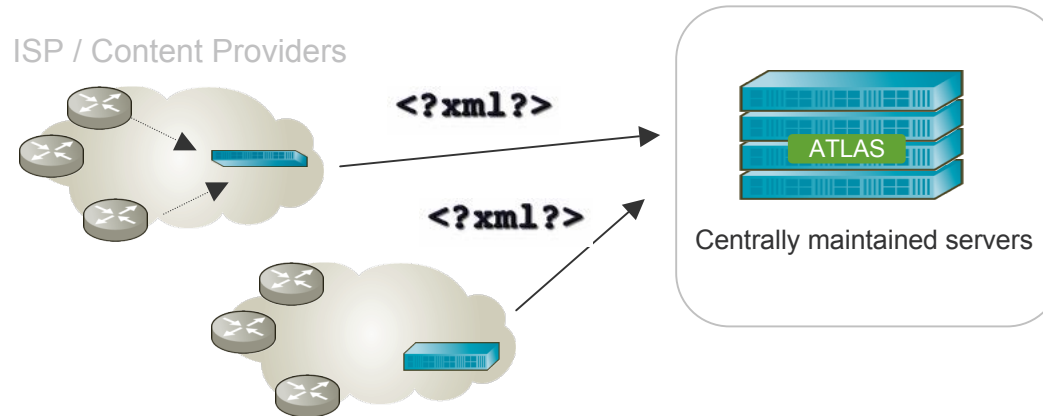
This Talk



Graphic not an accurate representation of current ATLAS deployments

- **Largest study of Internet traffic ever conducted**
- **Leverage large, widely deployed commercial Internet monitoring infrastructure**
- **Global deployment across 110+ ISPs / Content Providers**
 - Near real-time traffic and routing statistics (14 Tbps)
 - Participation voluntary and all data sources are anonymous

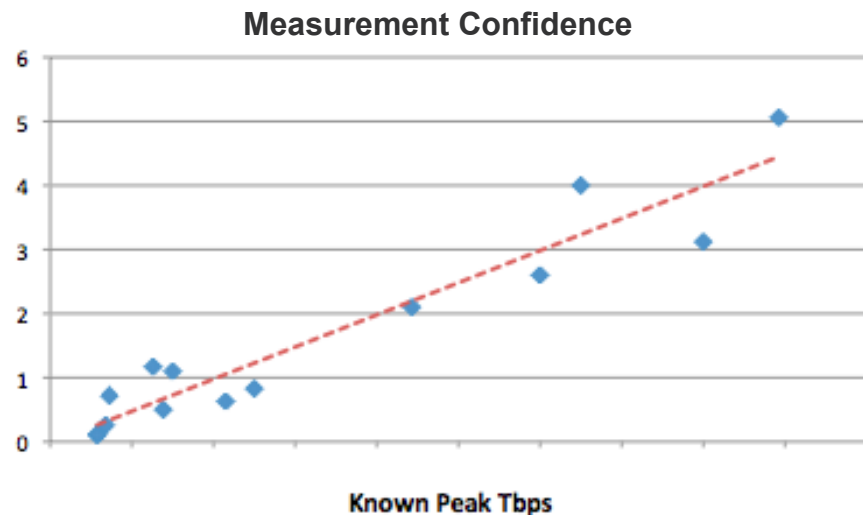
Internet Observatory, Data Details



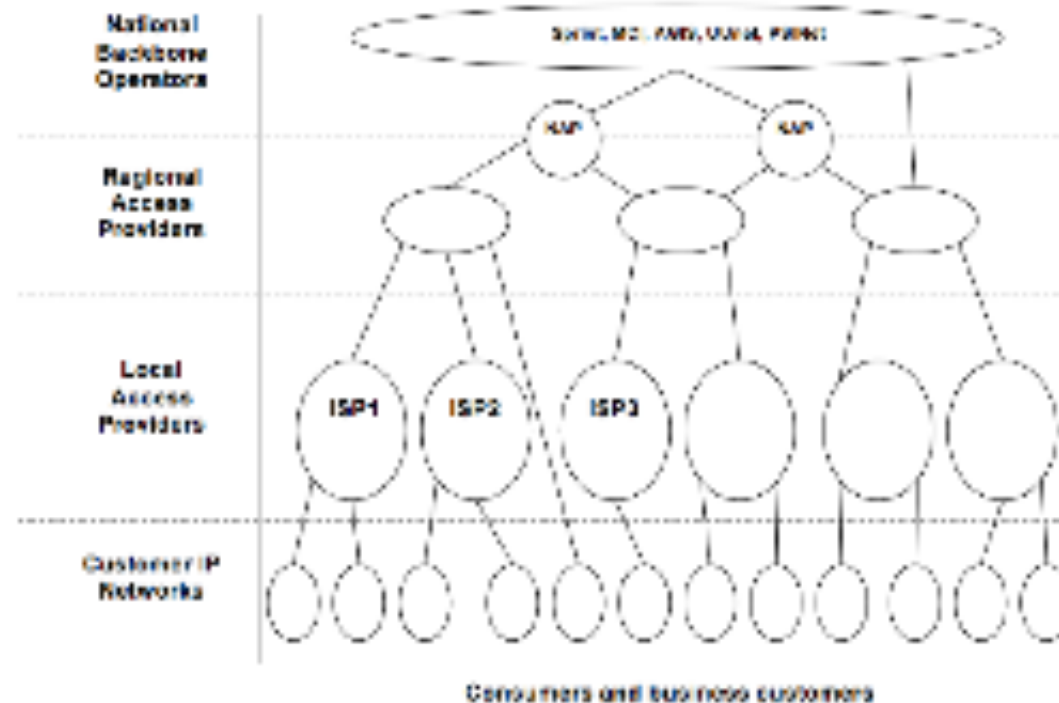
- **Within a given ISP, commercial probe infrastructure**
 - Monitors “flow” and routing across possible hundreds of routers
 - Probes topology aware of ISP, backbone and customer boundaries
 - Routers typically include most of peering / transit edge
 - Some deployments include portspan / inline appliances
- **Deployments send anonymous XML file to central servers**
 - Includes self-categorization of primary geographic region and type
- **Data includes coarse grain anonymized traffic engineering statistics**

Study Accuracy (why we think we got it right)

- We guess we're directly monitoring around 25% all inter-domain traffic
- And then we obtained "ground-truth" numbers from 12 ISPs
- And compared our predictions
- We got it right



Original Internet (1995 – 2007)



Settlement Free

Pay for BW

Pay for access BW

- Textbook diagram (still taught today)
- Hierarchical, relatively sparsely inter-connected Internet
- All money flows uphill

Largest Carriers: Then and Now

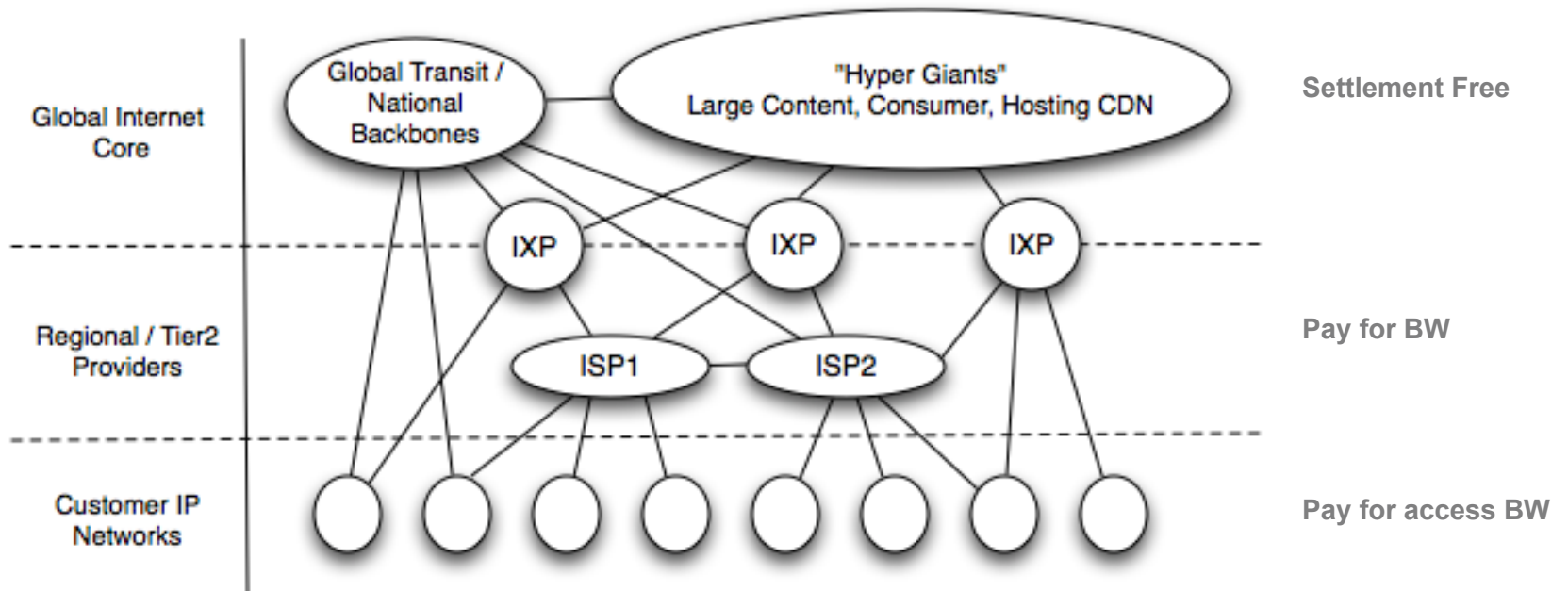
Rank	2007 Top Ten	%
1	ISP A	5.77
2	ISP B	4.55
3	ISP C	3.35
4	ISP D	3.2
5	ISP E	2.77
6	ISP F	2.6
7	ISP G	2.24
8	ISP H	1.82
9	ISP I	1.35
10	ISP J	1.23

Rank	2009 Top Ten	%
1	ISP A	9.41
2	ISP B	5.7
3	Google	5.2
4	-	
5	-	
6	Comcast	3.12
7	-	
8	-	
9	-	
10	-	

Based on analysis of anonymous ASN (origin/transit) data (as a weighted average % of all Internet Traffic). Top ten has NO direct relationship to study participation.

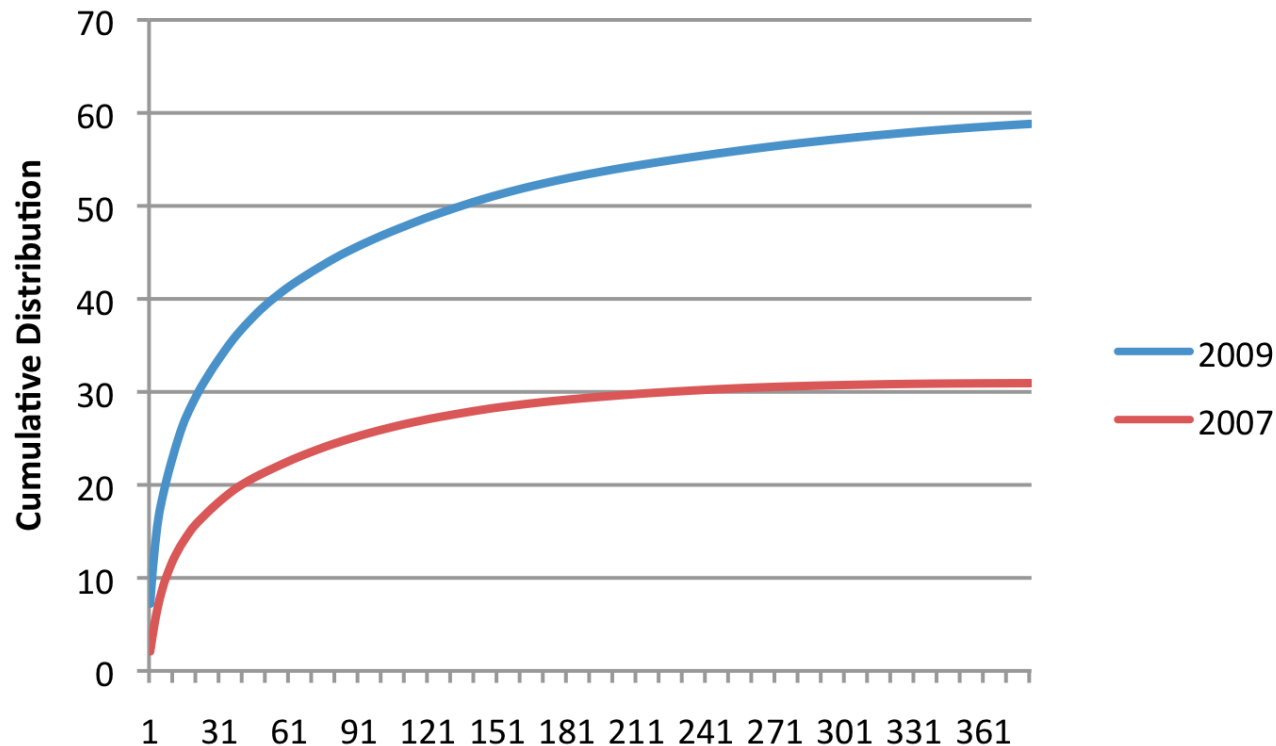
- In 2007, top ten match “tier-1” ISPs (e.g., Wikipedia)
- In 2009, global transit carry significant traffic volumes
 - But Google and Comcast join the list
 - And a significant percentage of ISP A traffic is Google transit

The New Internet



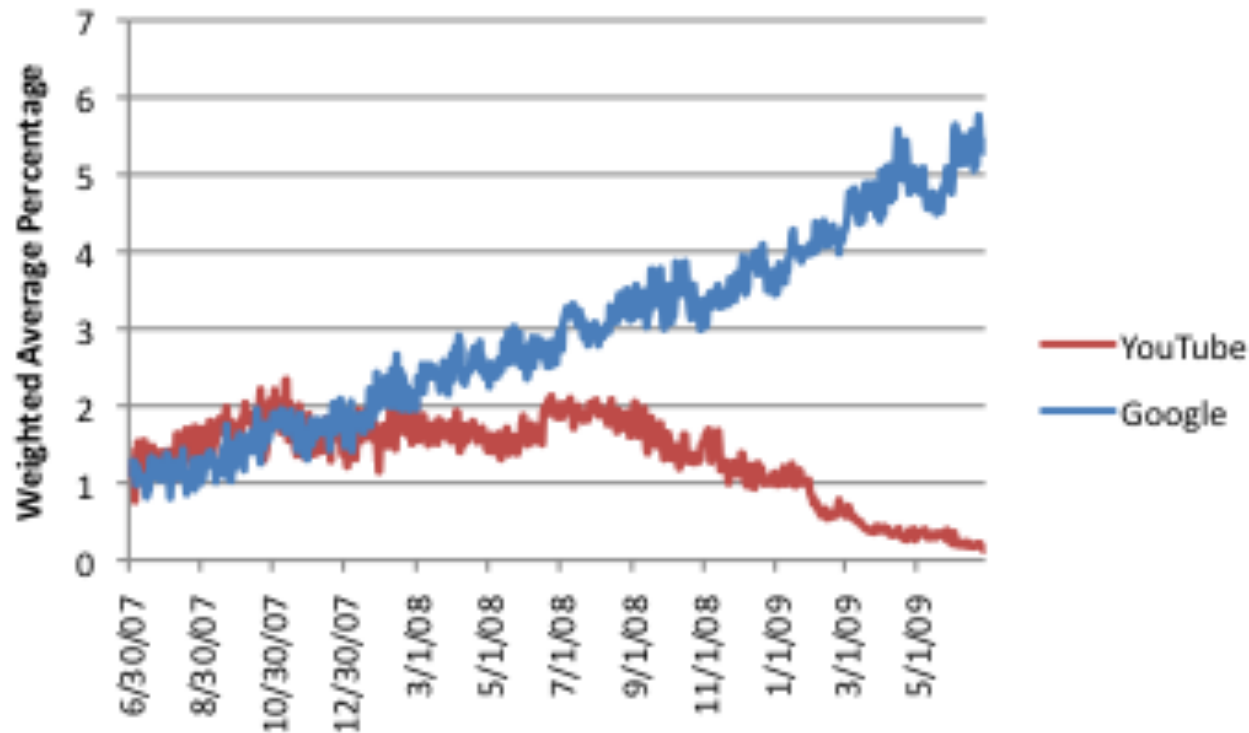
- Flatter and much more densely interconnected Internet
 - Significant routing, traffic, security, economic, implications
- Disintermediation between content and eyeball networks
- New commercial models between content, consumer and transit

Consolidation of Content (*Grouped Origin ASN*)



- In 2007, thousands of ASNs contributed 50% of content
- In 2009, 150 ASNs contribute 50% of all Internet traffic
- Approximates a power law distribution

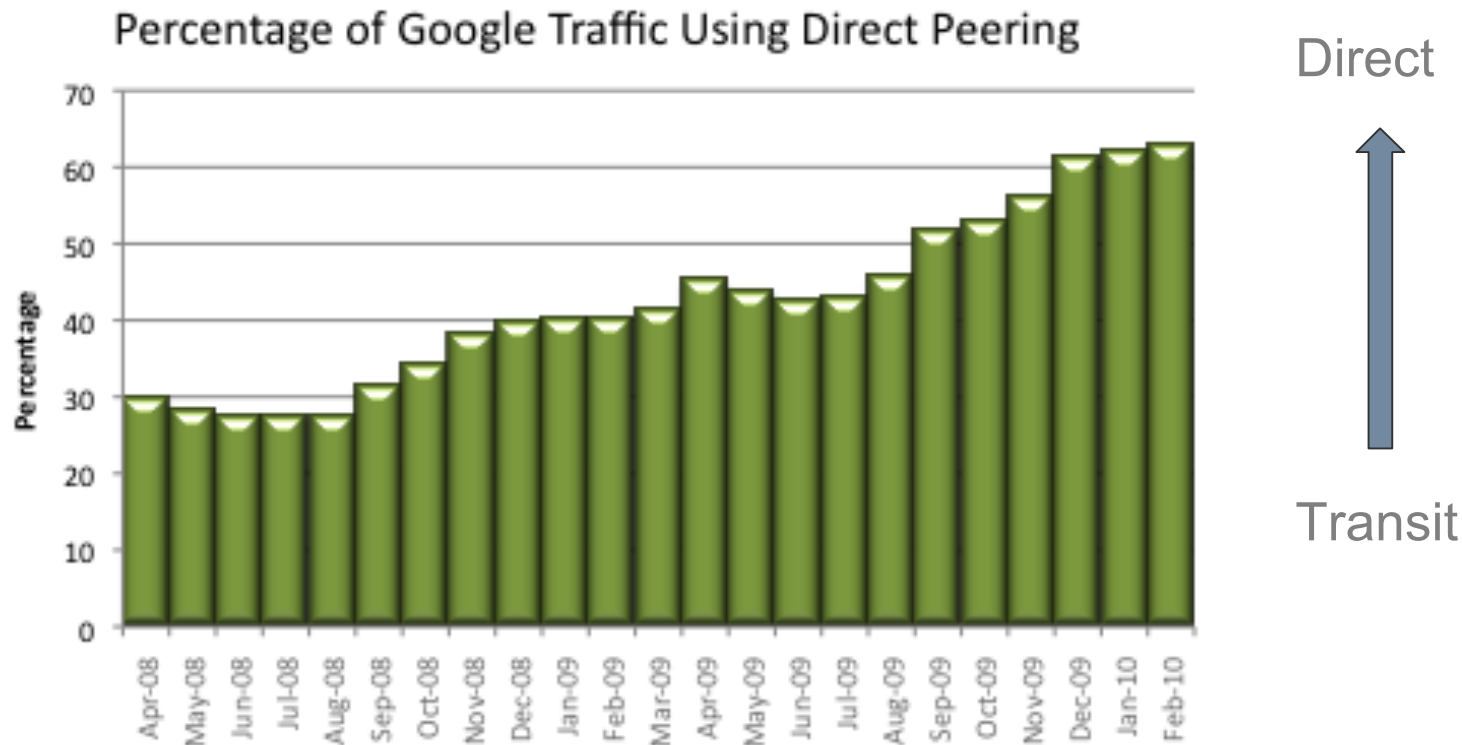
Case Study: Google



Graph of weighted averaged grouped ASNs

- Over time Google absorbs YouTube traffic
- As of July 2009, Google accounts for 6% of all Internet inter-domain traffic
- Google the fastest growing ASN group

Google Dense Interconnection



- Over time, Google increasingly using direct peering with tier 2/3 and eyeball networks
- As of February 2010, more than 60% of Google traffic does not use transit
 - Remainder largely global transit carriers
- These numbers do not include GGC



Applications

- **Beyond traffic levels between ISPs**
- **Massive changes in the way Internet is used**
 - Video
 - Web becomes new “IP”
 - And, the end of end-to-end
- **This is important, because “end-to-end” is the fundamental design principal of the Internet**
 - What makes the Internet different from telephony
 - What made the Internet great
 - And what is now quickly disappearing...

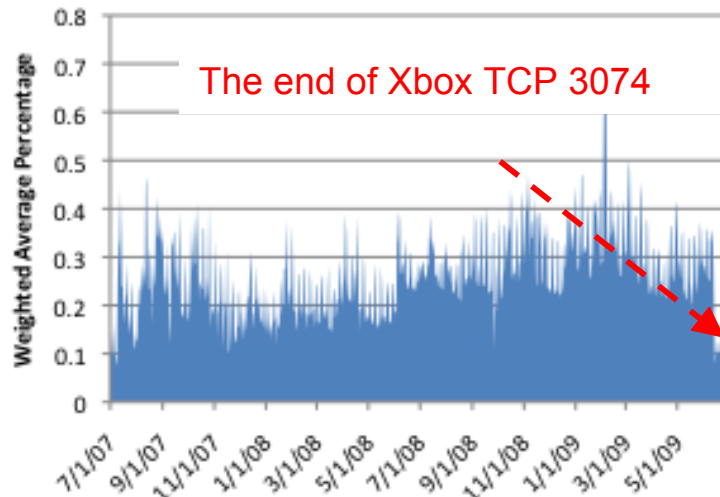
Global Application Trends

Rank	Application	2007	2009	Change
1	Web	41.68%	52.00%	24.76%
2	Video	1.58%	2.64%	67.09%
3	VPN	1.04%	1.41%	35.58%
4	Email	1.41%	1.38%	-2.13%
5	News	1.75%	0.97%	-44.57%
6	P2P (*)	2.96%	0.85%	-71.28%
7	Games	0.38%	0.49%	28.95%
8	SSH	0.19%	0.28%	47.37%
9	DNS	0.20%	0.17%	-15.00%
10	FTP	0.21%	0.14%	-33.33%
	Other	2.56%	2.67%	4.30%
	Unclassified	46.03%	37.00%	-19.62%

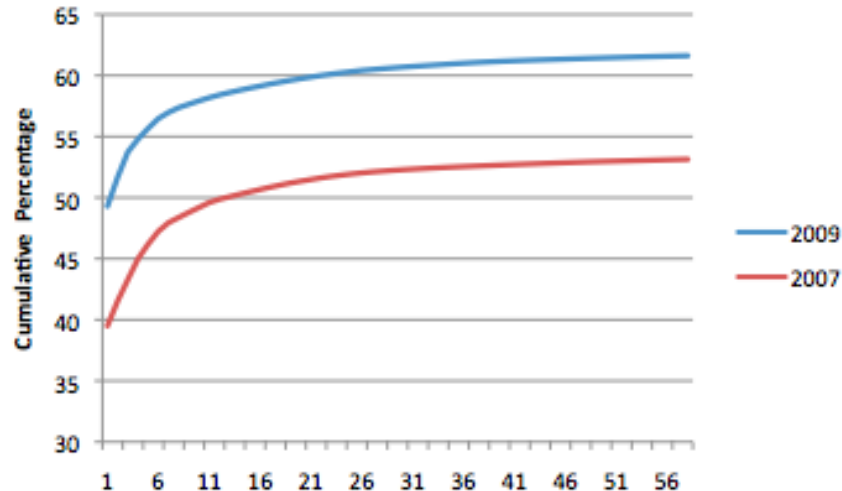
(*) 2009 P2P Value based on 18% Payload Inspection
Weighted average percentage of all Internet traffic using well-known ports

- **Growing volume of Internet traffic uses port 80 / 443**
 - Includes significant video component and source of most growth
- **Unclassified includes P2P and video**
 - Payload matching suggests P2P at 18%
 - P2P is fastest declining

The End of End-to-End?



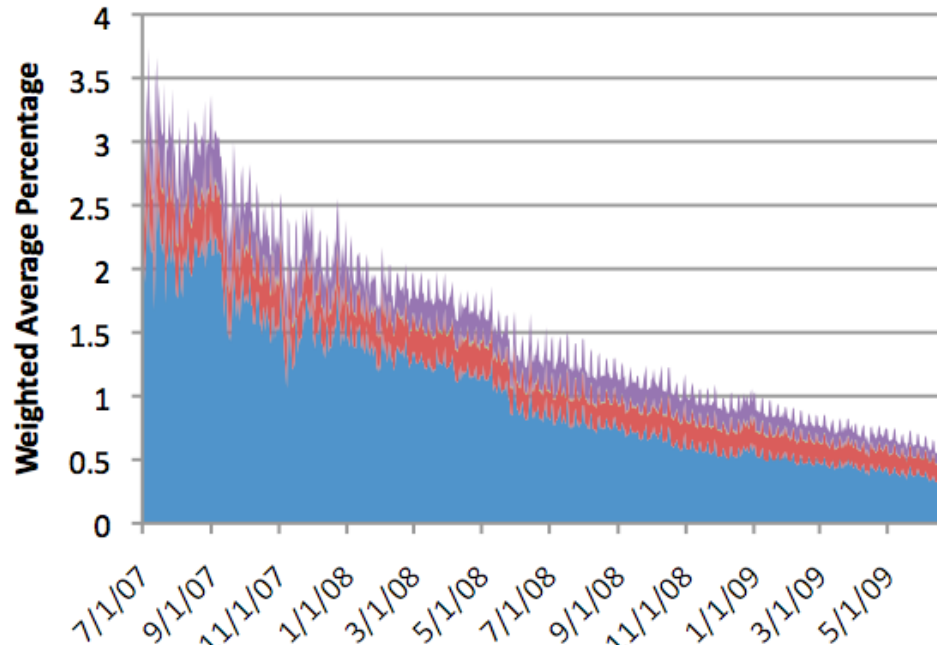
Weighted average percentage of Xbox Internet traffic



Cumulative Distribution of Traffic to TCP / UDP Ports

- Growing dominance of web as application front-end
- Plus burden of ubiquitous network layer security policies
- Results in growing concentration of application traffic over a decreasing number of TCP / UDP ports
 - Especially port 80
 - Especially video

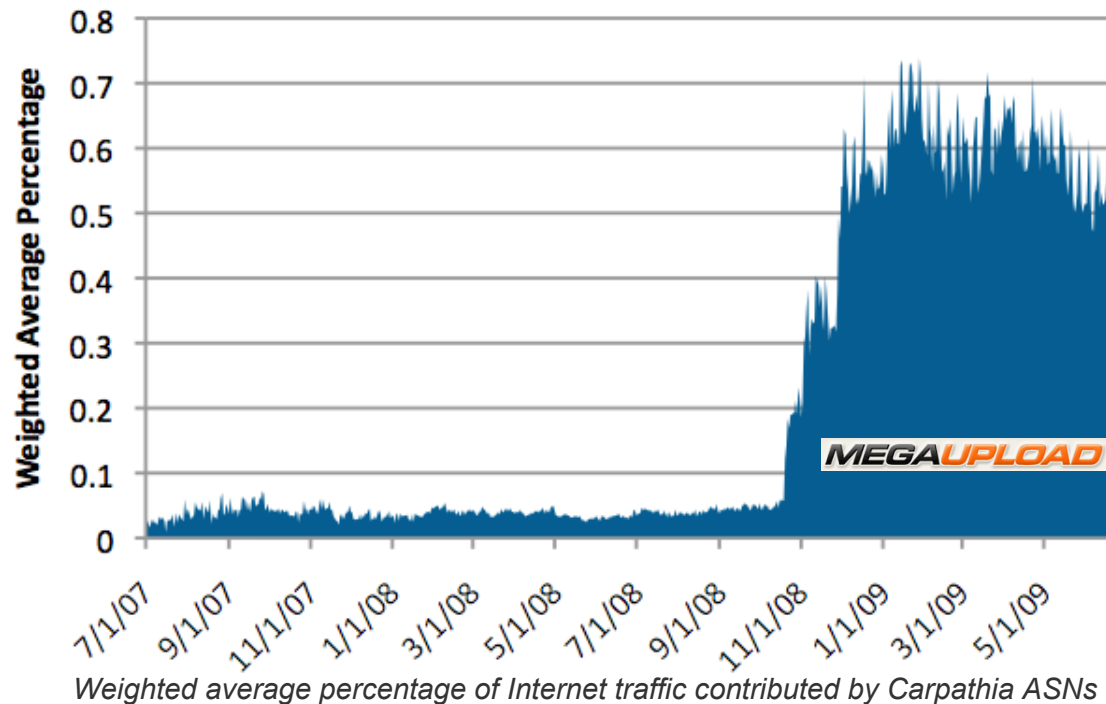
P2P Trends



Graph of weighted average traffic using well-known P2P ports

- **In 2006, P2P one of largest threats facing carriers**
 - Significant protocol, engineering and regulatory effort / debate
- **In 2010, P2P fastest declining application group**
 - Trend in both well-known ports and payload based analysis
 - Still significant volumes
 - Slight differences in rate of decline by region (i.e. Asia is slower)

P2P Surpassed by Direct Download



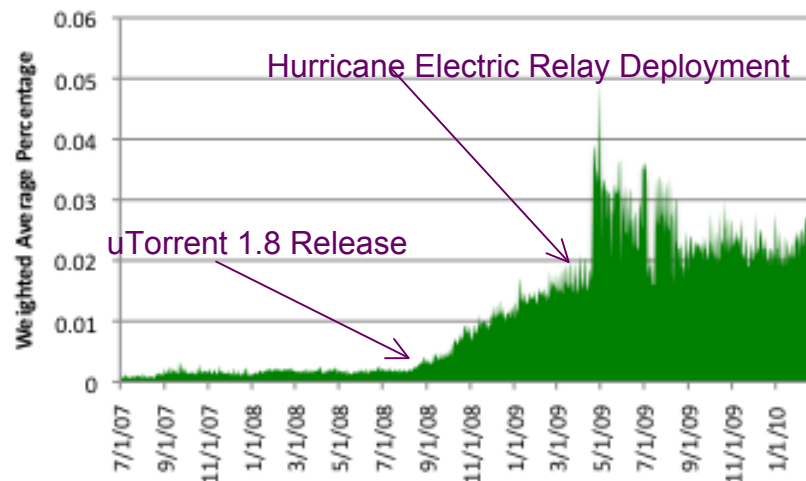
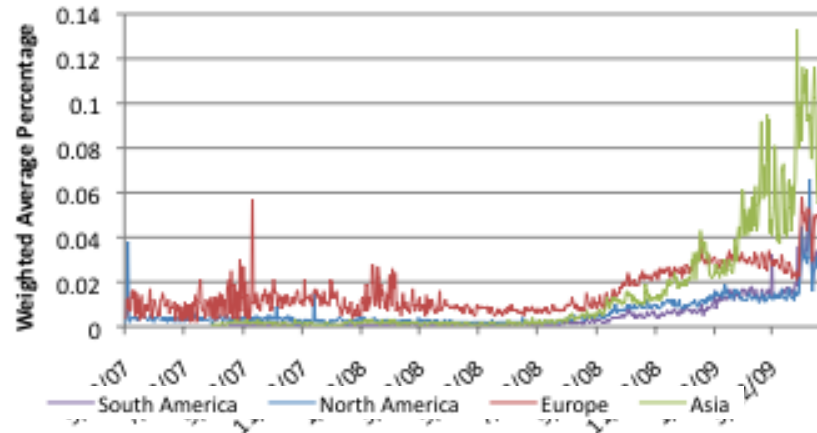
- **Normally study lacks visibility into hosting customers**
- **Mega [Upload|Video|Erotic] is an exception**
 - Carpathia small hosting company by traffic volume in Fall 2008
 - Mega becomes Carpathia customer in November 2008
 - Carpathia Hosting grows overnight to more than 0.5% of all traffic

Applications Trends in Region

Class of applications	Change over 6 months
WEB (dl)	-3,56%
VIDEO (dl)	+5,19%
EMAIL (total)	-22,72%
NEWS (dl)	-5,12%
P2P (total)	+0,98%
GAMES (dl)	+21%

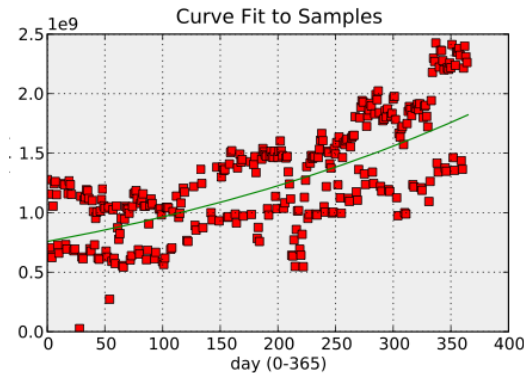
- **Percentage describes change over % of total traffic in a period of 6 months**
- **Trend is different – why?**
 - Shorter time period?
 - More Local content?
 - Web content caching?
 - Decrease in SPAM?
 - Slower adoption of content download from the Web?
 - DPI traffic control?

Global IPv6 Trends

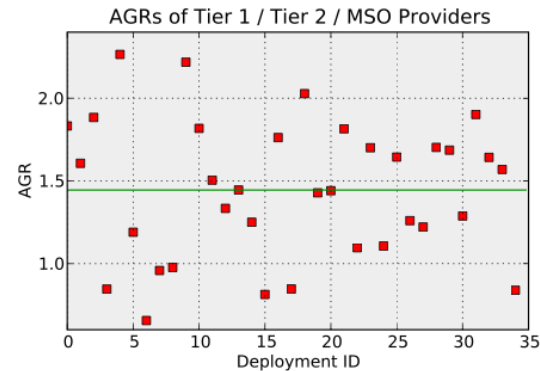


- IPv6 miniscule percentage of Internet traffic (.04 %)
- Still relatively little native IPv6 peering between large carriers
- Few carriers with v6 traffic visibility (i.e. flow)
- Tunneled IPv6 shows growth since IPv6
 - Due to uTorrent
 - And Hurricane Electric global Teredo deployment (see blog)

Internet Size / Growth



(a) Example AGR Calculation



(b) Per-deployment AGRs

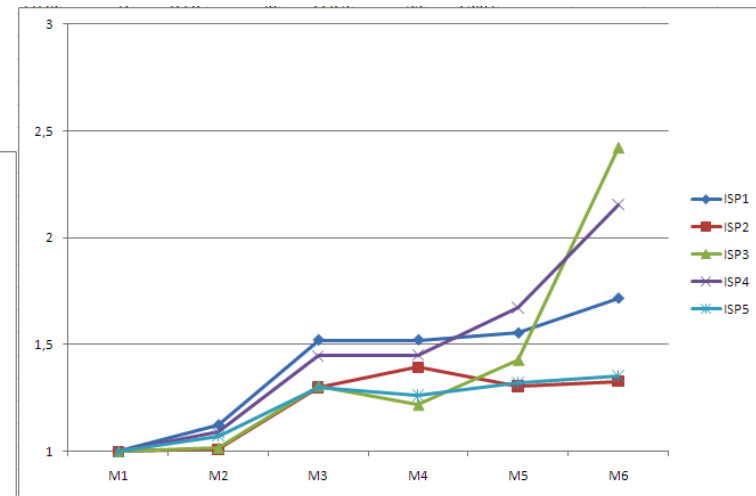
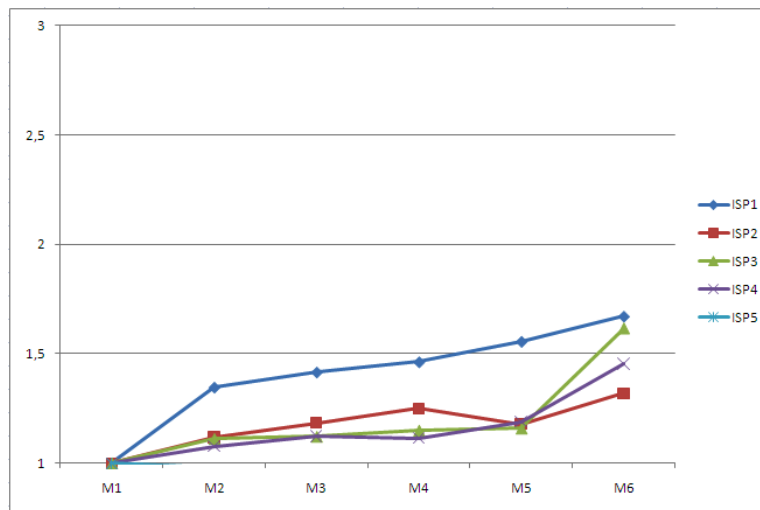
Estimate	Observatory	ISP Survey	Cisco	MINTS
Traffic Volume Per Month	9 exabytes	N/A	9 exabytes	5-8 exabytes
Traffic Annual Growth Rate	44.5%	35-45%	50%	50-60%

- **In 2009, Internet (inter-domain) roughly ~45 Tbs**
 - And growing at 45% per year
- **Significant, but no “Exaflood”**
 - Followed MINTS methodology for AGR
 - Used 10 known ISP totals (MRTG / Flow based) to extrapolate Internet total

Regional Internet Growth

- **Data from 5 ISPs in the region, over 6 months:**

- Monthly average (left)
- Monthly peak (right)



- **Shows growth is much faster in region (6 months):**

- Average growth : 41%
- Peak Growth : 80%

- **Not long enough sample period**

Discussion

- **Significant changes in Internet traffic**
- **A shift from connectivity to content**
 - Aggregation of content / traffic sources
 - Shift from transit to direct interconnection
 - Most significant growth in ~150 large content ASN
- **And concurrent shift in applications to port 80**
 - i.e. the web may represent the new end-to-end
- **Implications on engineering and research**
 - ACL / port based security model
 - Fault tolerance
 - Routing, traffic engineering, network design
 - Rapid growth of non-interactive traffic demands (i.e. DC)