Connecting to the Cloud

"Tomorrow is Now: What we are Connecting to the Cloud"

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Content we are connecting?

- Data storage and retrieval (incl. HTTP, Social) enjoy consistent global popularity, highest frequency
- Video taking bandwidth lead in NA away from file sharing. Following but still advancing in both EU and Asia
- NA mobile content profile lags fixed line, but trending upwards
- Constraints:
 - Device type & network connection (i.e. I/O)
 - Processing less so...for major providers (Amazon, Google, Microsoft)

	Upstream		Downstream		Aggregate	
Rank	Application	Share	Application	Share	Application	Share
1	BitTorrent	36.35%	Netflix	31.62%	Netflix	28.18%
2	НТТР	6.03%	YouTube	18.69%	YouTube	16.78%
3	SSL	5.87%	НТТР	9.74%	НТТР	9.26%
4	Netflix	4.44%	BitTorrent	4.05%	BitTorrent	7.39%
5	YouTube	3.63%	iTunes	3.27%	iTunes	2.91%
6	Skype	2.76%	MPEG - Other	2.60%	SSL	2.54%
7	QVoD	2.55%	SSL	2.05%	MPEG - Other	2.32%
8	Facebook	1.54%	Amazon Video	1.61%	Amazon Video	1.48%
9	FaceTime	1.44%	Facebook	1.31%	Facebook	1.34%
10	Dropbox	1.39%	Hulu	1.29%	Hulu	1.15%
		66.00%		76.23%		73.35%
		Fi	ixed line: 2	013	Sai	dvine

	Upstream		Downstream		Aggregate	
Rank	Application	Share	Application	Share	Application	Share
1	Facebook	20.62%	YouTube	17.69%	YouTube	16.65%
2	YouTube	13.20%	Facebook	15.44%	Facebook	16.62%
3	НТТР	12.64%	HTTP	14.07%	HTTP	13.74%
4	SSL	11.11%	MPEG - Other	7.92%	SSL	8.59%
5	Pandora Radio	5.19%	SSL	7.84%	MPEG - Other	7.27%
6	MPEG - Other	5.11%	Google Market	5.99%	Google Market	5.75%
7	Google Market	4.95%	Pandora Radio	5.03%	Pandora Radio	5.07%
8	Instagram	3.52%	Netflix	5.01%	Netflix	4.36%
9	Netflix	2.19%	Instagram	3.53%	Instagram	3.53%
10	iTunes	1.59%	iTunes	3.16%	iTunes	2.80%
		80.12%		85.68%		84.40%
Mobile: 2013 🛛 🕅 sandvine						

Sandvine

Devices we are connecting?

- Mobile (smartphones, tablets, 2.5G+) set to globally overtake fixed broadband access to the Internet.
 - Estimates range: 2014 2017
 - In some markets already has, especially in developing countries, leaping past fixed line
 - Penetration higher, data consumption lower (up to 10x)

New content maps to mobility:

- NA: YouTube leads, but nearly equal to Social
- Streaming music is popular worldwide
- In some markets streaming music is 80% of digital sales

Connectivity fueled by 4G, LTE growth and less by WiFi

Apple1984: a personal computer company

Global fixed broadband and mobile Internet penetration (%) 2008-2017





Apple 2014: a mobile device company

Example

Netflix Cloud:

- Streaming subscriber base grew from <1MM in 2007 to nearly 30MM+ in 2013
- Overall growth driven by streaming content and availability in gaming consoles (PlayStation #1) and CE devices
- Netflix video streaming is the single largest source of peak downstream Internet traffic in US
- Mobile largest source of new growth
- Use of buffering aligns with content & infrastructure
- Built largely in the public cloud with OSS

NETFLIX





(Source: Netflix & HBO public data & filings)

So what's next?

- Further increases in mobile cloud access (WiFi, 4G, LTE, LTE A)
- GPU oriented clouds:
 - Amazon EC2 (Tesla onwards)
 - Nvidia GRID
- Bi-directional "interactive clouds"
 - Gaming: PlayStation's streaming game service
 - Visualization: Animation, Simulation
 - Beyond "responsive design" -> Real time custom interfaces
- Dramatic fidelity increases (as infrastructure permits!)
 - File: Varied (+ assisted, i.e. Aspera) -> Near seamless interaction
 - Video: 720p HD -> 4K (today some Full HD: PlayStation and Apple @ bitrate 50%+)
 - Audio: <=320 kbps -> 1411 kbps (~CD @ 44Khz 16bit)







(Source: Autodesk Naiad

What's next is already here



Supported by continuous WiFi/HotSpot improvements (802.11a - 802.11ac)

Market Availability	2003	2006	2009	2011	2016+
Avg. Down	200 kbps	1 Mbps	2-10 Mbps	5 – 20 Mbps	~30 – 90 Mbps
Avg. Up	64 kbps	500 kbps	0.5 - 4 Mbps	3-10 Mbps	~10-60 Mbps
Max Peak	384 kbps	7 Mbps	42 Mbps	~150 Mbps	~1 Gbps

Increasing Back-end Investment:



Infrastructure Commercialization:







Available LTE A in Korea (SKT, U+, etc.)

(Images: SK Telecom, Google, Verizon)

Consumer advantages

- Instant access
- Broad content offerings
 - Open content distribution (for a while...)
 - Catalog offerings
 - "Long-tail" finally realized?
- Ubiquity and portability...
 - ...over years (Netflix 5+, Hulu 4+, Dropbox 3+)
- Flexible, "unbundled" pricing
 - A dream?...unlikely
 - Time will become the new currency
- Long-term: "seamless" computing power on thin clients
- Today's youngest consumers will only know cloud!

Content companies

Economic opportunity drives progress:

- Demand (Netflix, YouTube, Facebook, Amazon, Spotify, etc.)
- Competitive pressure
- Potential verticalization, channel control

Build, buy or ?

- Can be capital intensive
- Rent, lease, option, partner

Keys to scaling:

- Matching utilization
- Leveraging the consumer
- Flexibility

Really difficult:

• Why few "content companies" are <u>directly</u> cloud engaged...



But it's not easy....



But it's not easy...

- Bandwidth caps
- Inconsistent infrastructure roll-out:
 - How to productize?
 - How to market?
- Buffering won't always work
- Bi-directional clouds <u>require</u> low-latency networks
 - ("Akamai" revisited, i.e. game streaming services)
- Capital intensive (terabits+, beyond CDN scale)
- Complexity and inter-reliance of cloud players
- "Last 10 feet", WiFi challenges:
 - · Obstructions, air availability
 - · Avg. vs consistent throughput and latency



(Source: Akhshabi, et al, An Experimental Evaluation of Rate-Adaption Algorithms in Adaptive Streaming over HTTP, 2011, Georgia Institute of Technology. Republished by ACM, Microsoft)



Looking to the future

- Mobile utilization continues to climb
- Increased GPU based cloud solutions
 - Video gaming
 - Rendering and visualization
 - Manufacturing & more...

Industry consolidation and cooperation

- Hybrid, federated and burst clouds
- Formalized "Intercloud" relationships
- Brokers, cloud markets
- · Companies who can scale lead the way
- WiFi:
 - QoS improvements (WiFi Multimedia, 802.11e)
 - Beamforming

Content will drive consumption!







Thank You!

Q&A?

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