Internet Video: Implications for Architecture, Interconnection, and Network Management

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Part I: Future of video

I have the most compelling and unique video you will see this week

Not shot through a lens

Not recorded with a camera

Not generated with computer graphics

Play: http://etherpad.com/ep/pad/slider/13sentences

A 'recording' of Paul Graham (a venture capitalist and writer) writing an essay

A fascinating perspective into the craft of writing

Recorded and played back with Javascript

What is video is **not** determined by the recording device, the transmission medium, or the playback device

Rather it's defining characteristic is that it shows something evolving over time with a fluid presentation

Today we experience largely fixed 'snapshots' of most things that intersect our lives
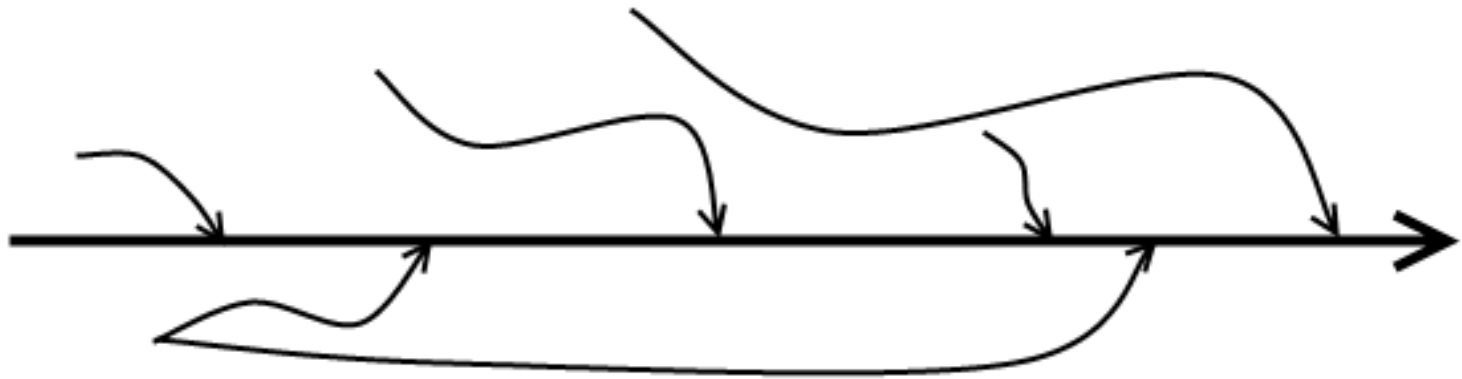
We will increasingly have more views into these other timelines
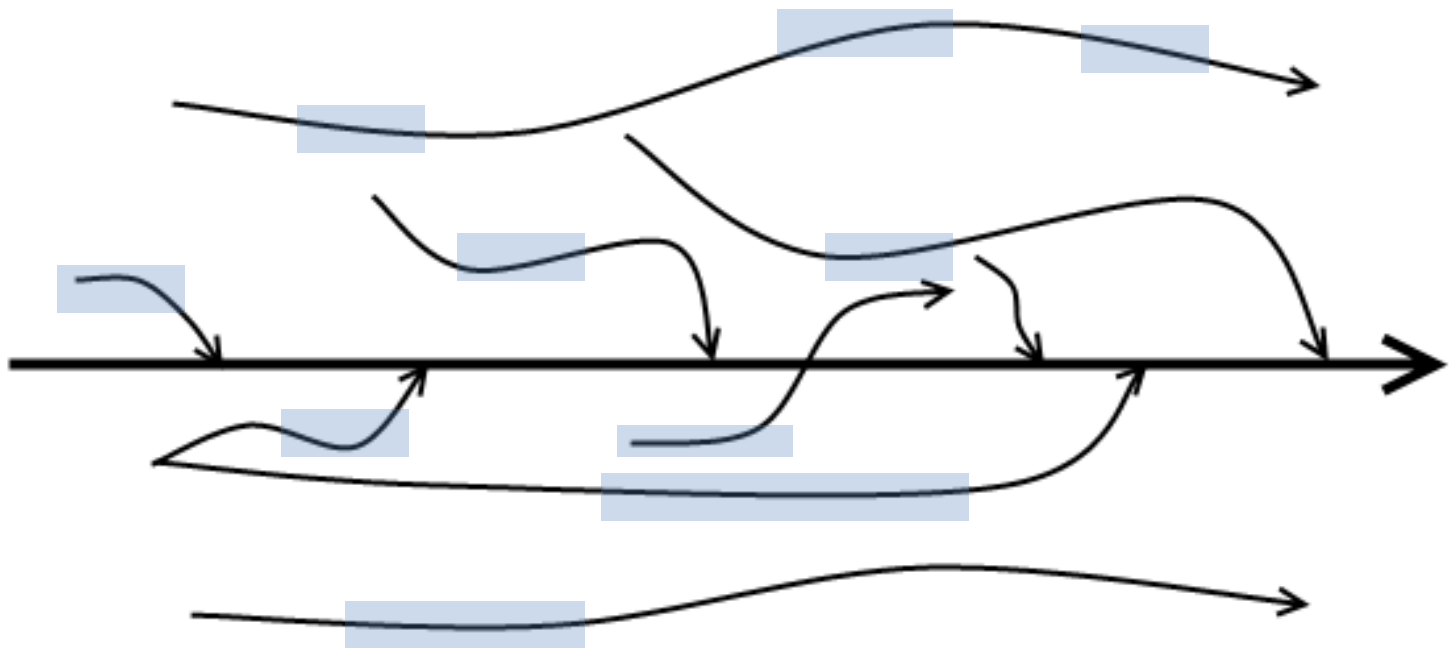
…experienced often as video.

Amazon orders today

Track your package

Date	Time	Location	Event Details
March 26, 2010	02:53:00 PM	Belmont MA US	Delivered
March 26, 2010	08:31:00 AM	Needham MA US	Out for delivery
March 26, 2010	07:49:00 AM	Needham MA US	Arrival Scan
March 25, 2010	07:50:00 PM	East Boston MA US	Arrival Scan
March 25, 2010	04:32:00 PM	Memphis TN US	Departure Scan
March 24, 2010	11:39:00 PM	Memphis TN US	Arrival Scan
March 24, 2010	06:51:00 PM	Parsons KS US	Departure Scan
March 24, 2010	10:00:00 AM	Parsons KS US	Shipment received by carrier
March 24, 2010	07:09:57 PM	---	Shipment has left seller facility and is in transit

Amazon orders in the future
(Amazon Patent 7,689,465)

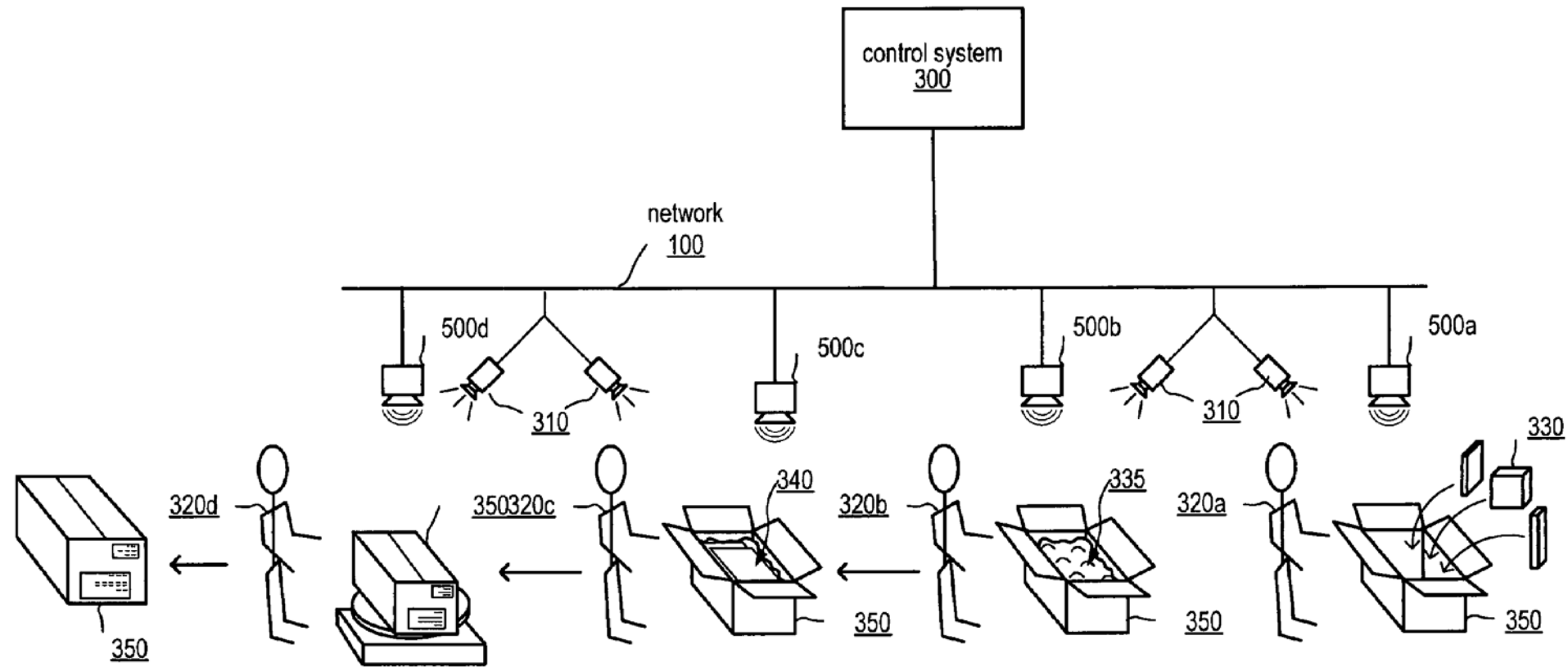**FIG. 3B**

Hollywood recognized the value and interest in the back story long ago and provided DVD extras

Additional Scenes
Alternate Ending
Alternate Opening
Alternate Scenes/Takes
Animated Short
Anniversary Edition
Artist Profile
Audio Commentary
    Actor/Cast Commentary
    Cinematographer Commentary
    Composer Commentary
    Costume Designer Commentary
    Director Commentary
    Editor Commentary
    Historian/Expert Commentary
    Producer Commentary
    Production Designer Commentary
    TV Showrunner/Creator Commentary
    Visual Effects/Special Effects Commentary
    Writer Commentary

Behind The Scenes -Making of - Featurettes
    Acting
    Casting
    Cinematography
    Costume Design
    Editing
    Film Scoring
    Locations
    Make-Up
    Production Design
    Rehearsal Footage
    Screen Tests/Auditions
    Screenwriting
    Sound Design
    Special Effects
    Storyboard/Previs/Animatics
    Stunts
    Topical Docu Featurette
    Visual Effects

Bloopers
Booklet
Collector's Edition
Conceptual Art
Criterion Collection
Deleted Scenes/Outtakes
Deluxe Edition
Digital Copy
Director's Cut
DVD Easter Egg
Extended Cut/Version/Edition
Extended Scenes
Final Cut
Gag Reel
Graphic Novel/Comics Included
Interviews/Conversations
Isolated Music Score
Limited Edition
Live Action Short Film
Multi-Angle
Music Video
Never-Before-Seen Footage
Photo/Poster Gallery
Production Notes
Screenplay/Articles
Special Edition
Trailers
TV Shows
Ultimate Edition
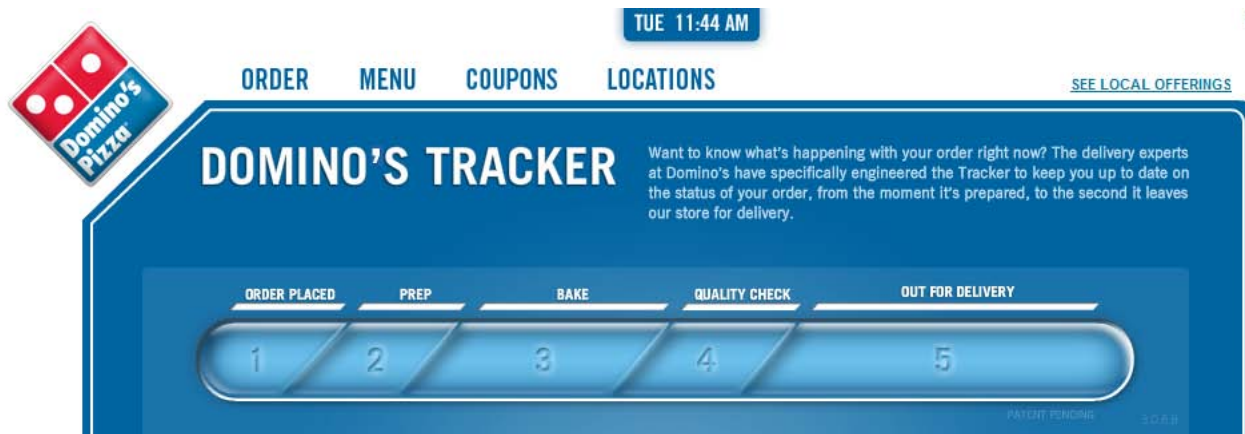Uncategorized
Uncut Edition/Version
Unrated Edition
Video Diary
Video Introductions

From: http://dvdspecialfeatures.net/

Where else are we going to see video showing views into these other timelines?
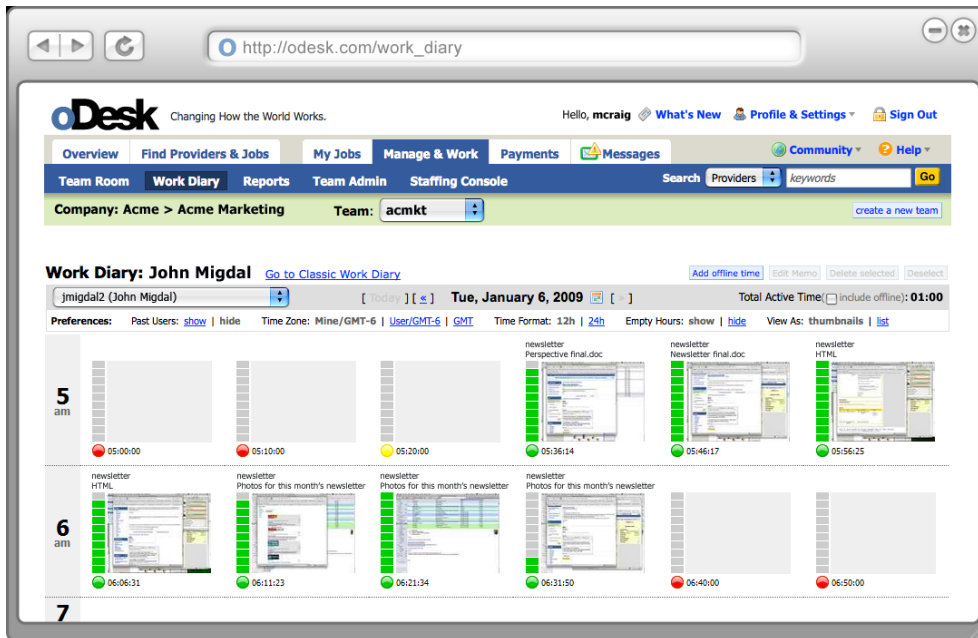
Video of pizza being made?

Watch a video of the car you are considering purchased being assembled?

Watch a video of your car being repaired?

Odesk Work Diary (software development outsourcing)

- Keystroke volume
- Screenshots of a provider's computer taken at roughly 10-minute intervals,
- **Already has optional webcam shots of the provider at his or her desk**

An increasingly blurry distinction between sensor information and video

Static electric bill

Realtime electrical usage

General point is that…

Context, process, history, whatever you want to call it, will increasingly

Matter

Be interesting to others

Be seen(surprisingly at times) as entertaining

Have value

Be a business differentiator (for awhile) for those than can capture and expose it

Why are these (potential) trends important?

Everything that will be experienced as video will not require high bandwidth

Don't miss the 'low-bandwidth' things that can increasingly be turned into compelling video experiences

Recognize the importance of video throughout different value chains

Video is not just about consumer entertainment or personal and business communication

Disclaimer: predicting the future of video is hard

The often cited home security video scenarios may be like the historical predictions that computers would be used to organize receipts in the kitchen

One of the few things many people **don't** use computers for today

Part II:
Implications for Architecture, Interconnection, and Network Management

Obvious challenges and implications

- Significantly more bandwidth required
- Large capital investments must be made both in capacity and supporting video infrastructure
- Over-the-top video vs. provider video
- Encoding, storage, processing, administration costs of video
- Delivering video in mobile contexts
- Navigating the video standards battles
    - Flash/HTML5
    - VP8/H.264/Theora

What do we need so that is possible for every pizza shop in the country to **deliver both pizza and the video of it being made**?

Not just higher speed connections
- Upgrading the business DSL line that connects many shops is only a part of the challenge

Challenge is to make it easy, reliable, and cost effective to integrate video into evolving business systems

Receiving new pizza orders is more important than delivering the pizza-prep video (i.e. network management will be important in some scenarios.)

Economic value of broadband

Where would the "value" of seeing a video of your pizza being made show up?

- Consumer satisfaction?
- Cheaper management costs because monitoring is more efficient?
- Increased pizza consumption?
- Willingness to pay higher prices?

But maybe it is actually really hard still to quantify the value of broadband?

Video is a key driver for usage noted in the national broadband plan

Exhibit 3-C:
Actual Download Speeds Necessary to Run Concurrent Applications (Mbps)

Legend:
- = Non-real-time
- = Near-real-time
- = Real-time

Chart values by type of user:
- Utility: 0.5 (E-mail, Browsing)
- Multimedia: 1.0 (E-mail, Browsing, YouTube video)
- Full media + Latency: 4.0 (E-mail, Browsing, Streamed SD classroom lecture)
- Advanced + Upload, Latency, Jitter, etc.: 7.0 (E-mail, Browsing, 2-way video teleconference)

Types of Users
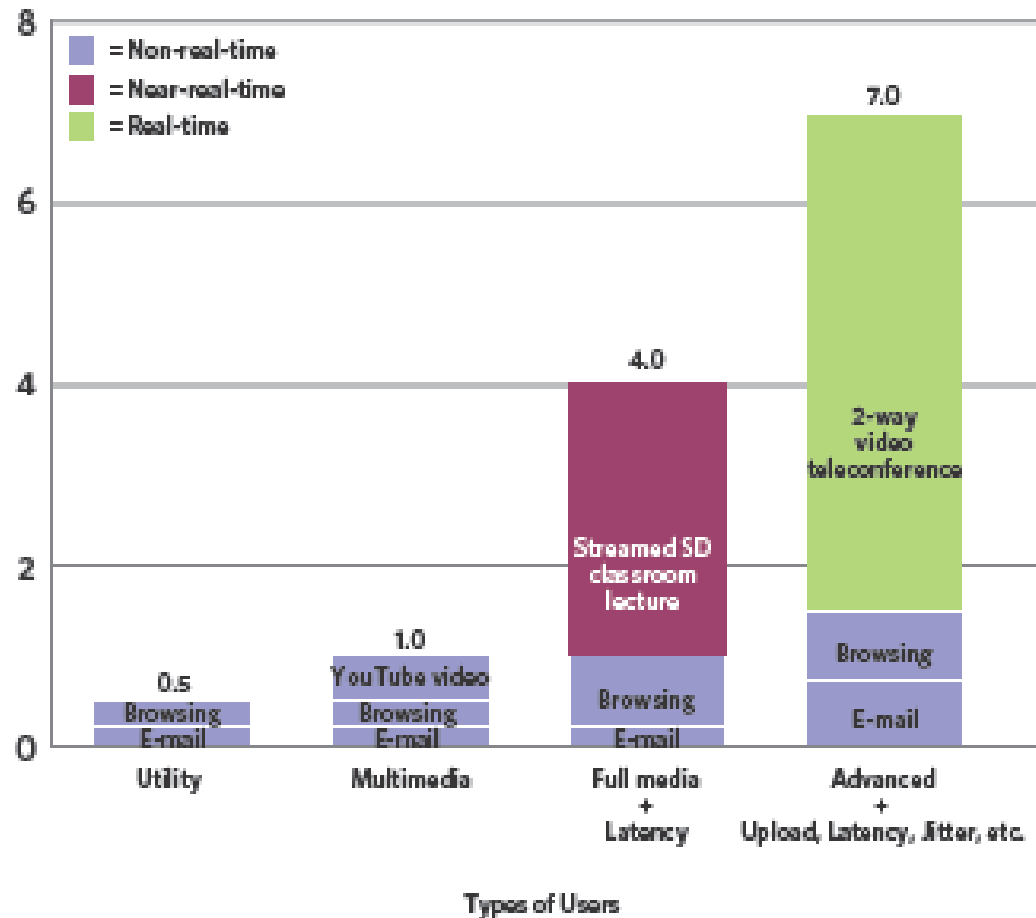
Figure 5.1 Overall satisfaction with broadband service
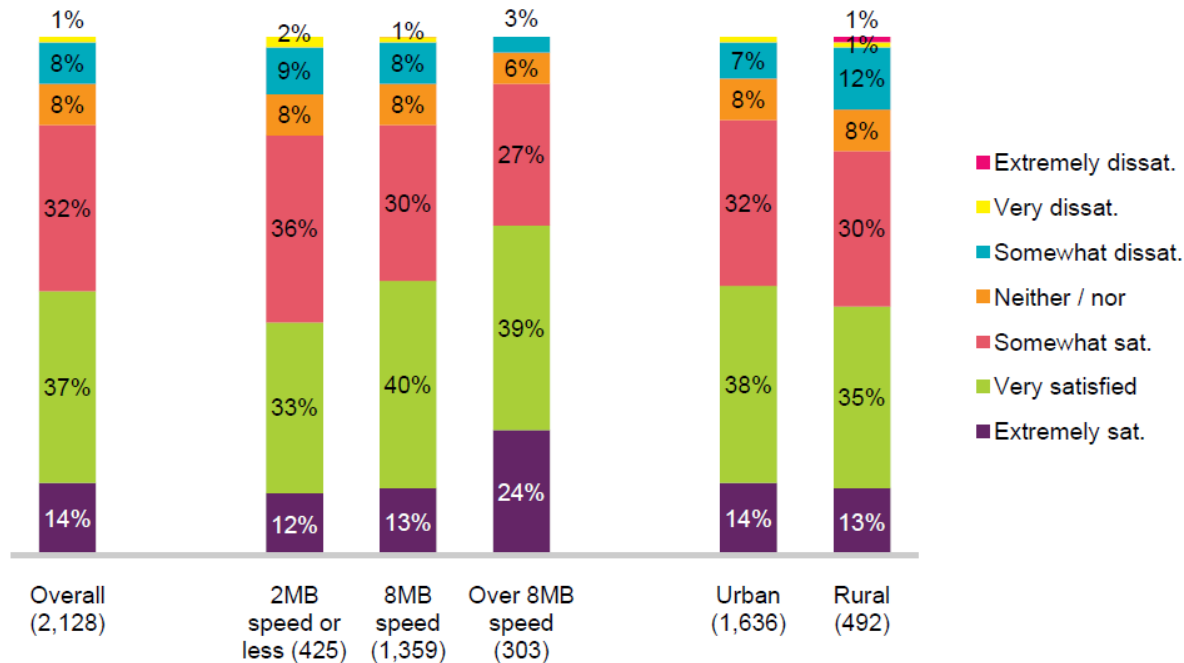
Q7: Overall, how satisfied are you with your current broadband service?

Base: All UK broadband decision makers

Overall satisfaction with broadband services was high (83% satisfied, just 9% dissatisfied)

Would bet that those that were dissatisfied were ones often frustrated with watching video

Speed and reliability are the top two reasons for dissatisfaction

Figure 5.2   Main reason for dissatisfaction with ISP
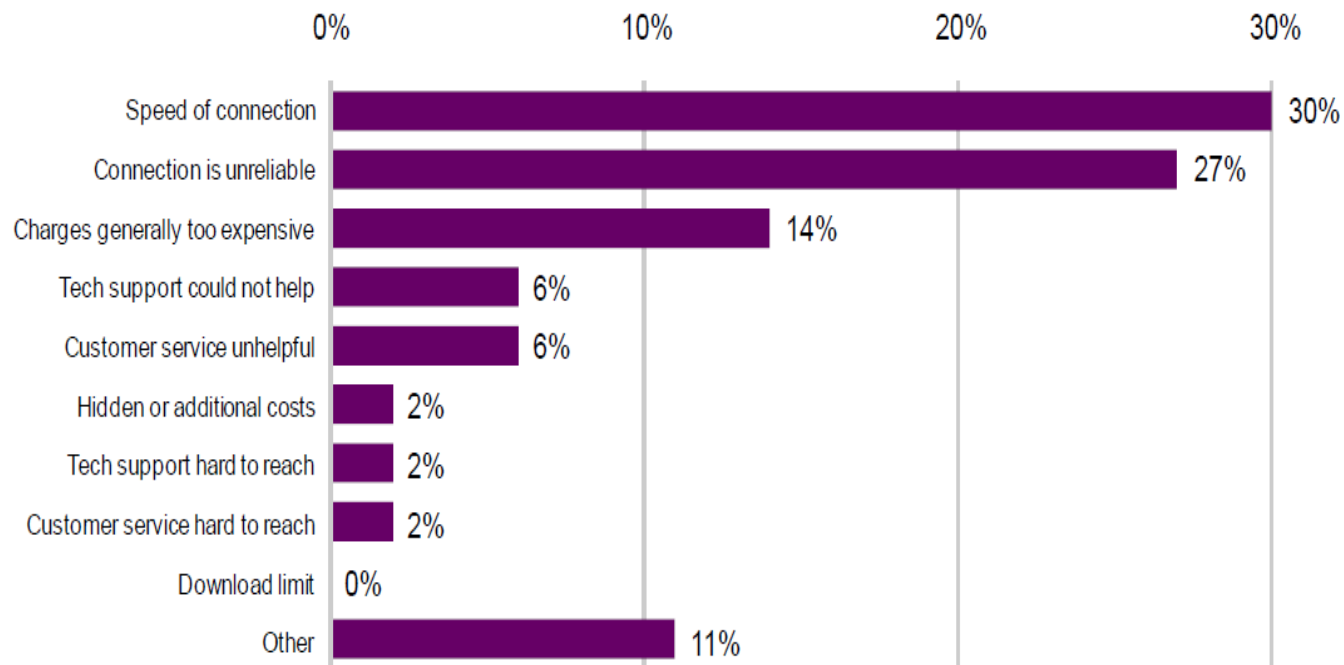
Q11: What is the MAIN reason you are dissatisfied with your Internet provider?
Base: All dissatisfied UK broadband decision makers (205)
Source: GfK broadband speeds survey among 2,128 online panel respondents who are broadband decision makers, September-October 2008

So how will speed and reliability be measured and monitored?

Speed

Lots of different methodologies

Lots of different definitions of "speed"

Producing conflicting results

Some systematically biased

Reliability

A community problem… not something one can always diagnosis accurately from the edge

Even for experts it can be hard

Reliability of network will be increasingly important with video as problems are more noticeable and frustrating

Average reported US download speeds

Reporting	Download speed	
Speedtest.net	7.71 mbps	http://speedtest.net/global.php (accessed 3/16/2010)
Comscore	3 – 4 mbps	http://www.starbulletin.com/news/20100313_fcc_effort_to_widen_internet_access_sets_off_battle.html
Akamai	3.9 mbps	http://www.cnn.com/2010/TECH/03/15/fcc.broadband.plan/index.html
Youtube	3.83 mbps	http://youtube.com/my_speed (accessed 3/16/2010)

Reported speeds for individual providers in Boston area

Download speed	Comcast	Verizon
Speedtest.net	15.03 mbps	13.31 mbps
Youtube	5.87 mbps	6.56 mbps

Results download on March 16, 2010 by computers in the Boston area from

1. http://speedtest.net/global.php#0,1,1,26
2. http://youtube.com/my_speed

Eight sequential tests on broadband.gov

M-lab based NDT tests

1

Download Speed:	**2622** kbps
Upload Speed:	**2802** kbps
Latency:	**177** ms
Jitter:	**226** ms

3

Download Speed:	**14347** kbps
Upload Speed:	**2802** kbps
Latency:	**159** ms
Jitter:	**326** ms

5

Download Speed:	**2636** kbps
Upload Speed:	**2829** kbps
Latency:	**178** ms
Jitter:	**226** ms

7

Download Speed:	**11443** kbps
Upload Speed:	**2830** kbps
Latency:	**173** ms
Jitter:	**226** ms

Ookla-based tests

2

Download Speed:	**16806** kbps
Upload Speed:	**2852** kbps
Latency:	**19** ms
Jitter:	**3** ms

4

Download Speed:	**16901** kbps
Upload Speed:	**2907** kbps
Latency:	**36** ms
Jitter:	**41** ms

6

Download Speed:	**16745** kbps
Upload Speed:	**2870** kbps
Latency:	**17** ms
Jitter:	**2** ms

8

Download Speed:	**16825** kbps
Upload Speed:	**2837** kbps
Latency:	**19** ms
Jitter:	**6** ms

FCC M-lab NDT tests from Boston based computer were to server in Amsterdam

⬇ Download Speed:	**2625**	kbps
⬆ Upload Speed:	**2798**	kbps
📊 Latency:	**179**	ms
〰 Jitter:	**238**	ms

⬇ Download Speed:	**13973**	kbps
⬆ Upload Speed:	**2824**	kbps
📊 Latency:	**172**	ms
〰 Jitter:	**232**	ms
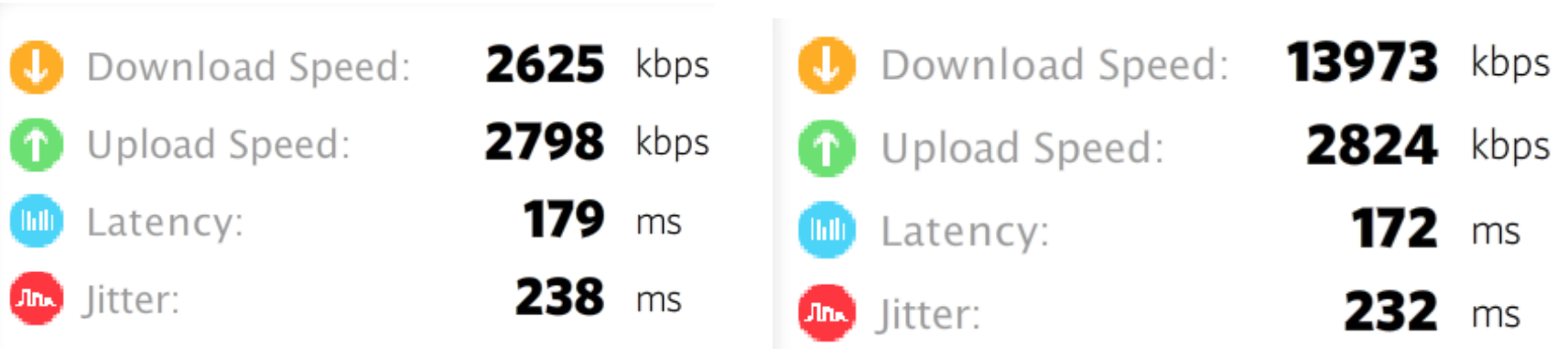
```
traceroute to 72.26.217.103 (72.26.217.103), 30 hops max, 60 byte packets
 1  legacy26-0.default.csail.mit.edu  (18.26.0.1) 3.646 ms  3.704 ms  3.750 ms
 2  kalgan.trantor.csail.mit.edu (128.30.0.245) 0.292 ms  0.367 ms  0.428 ms
 3  B24-RTR-2-CSAIL.MIT.EDU (18.4.7.1) 17.836 ms  17.913 ms  17.967 ms
 4  EXTERNAL-RTR-1-BACKBONE.MIT.EDU (18.168.0.18) 0.501 ms  0.565 ms  0.678 ms
 5  EXTERNAL-RTR-3-BACKBONE.MIT.EDU (18.168.0.50) 0.593 ms  0.639 ms  0.671 ms
 6  nox1sumgw1-Vl-530.nox.org (207.210.142.233) 0.599 ms  0.626 ms  0.592 ms
 7  nox300gw1-Vl-111-NoX-INTERNET2.nox.org (207.210.142.1) 0.810 ms  0.734 ms  0.780 ms
 8  nox300gw1-PEER-NoX-INTERNET2-207-210-142-2.nox.org (207.210.142.2) 5.365 ms  5.293 ms  5.306 ms
 9  paix-ny-peer.lga5.us.voxel.net (198.32.118.47) 5.793 ms  5.881 ms  5.935 ms
10  0.te1-2.tsr1.ams1.nl.voxel.net (208.122.44.94) 82.311 ms  82.202 ms  82.215 ms
11  (72.26.217.103) 82.201 ms  82.294 ms  82.234 ms
```
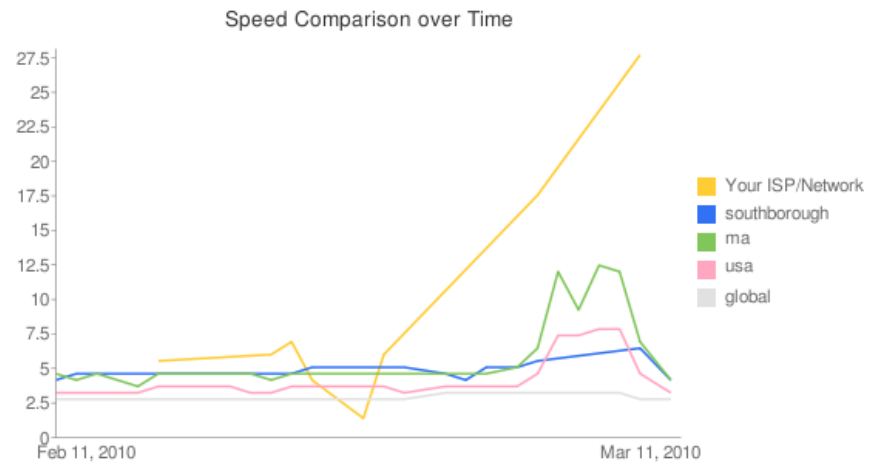
Recent Youtube speed results:

Two computers on the same floor at MIT on the same day

128.30.93.224   **18.26.0.106**
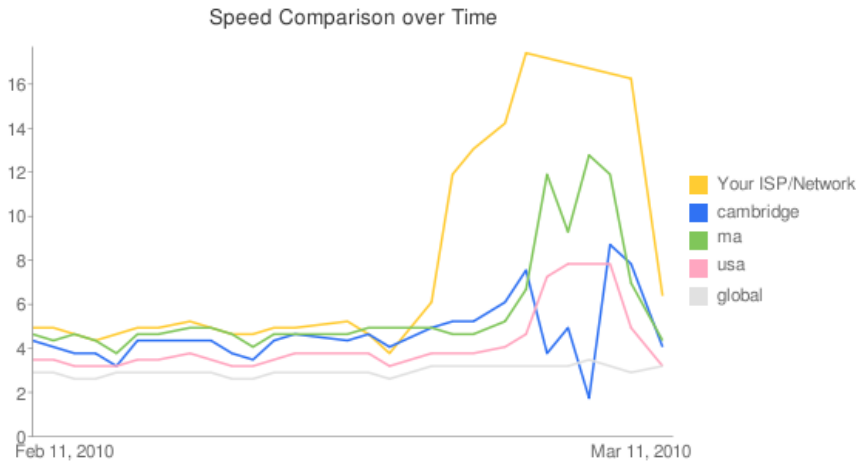
Topology of the Internet is changing
Interconnection between large content providers and large access providers

A comment on peering in general, but equally applies to this situation:

"In many ways, the outcome of these discussions can be likened to two animals meeting in the jungle at night. Each animal sees only the eyes of the other, and from this limited input, the two animals must determine which animal should attempt to eat the other!"

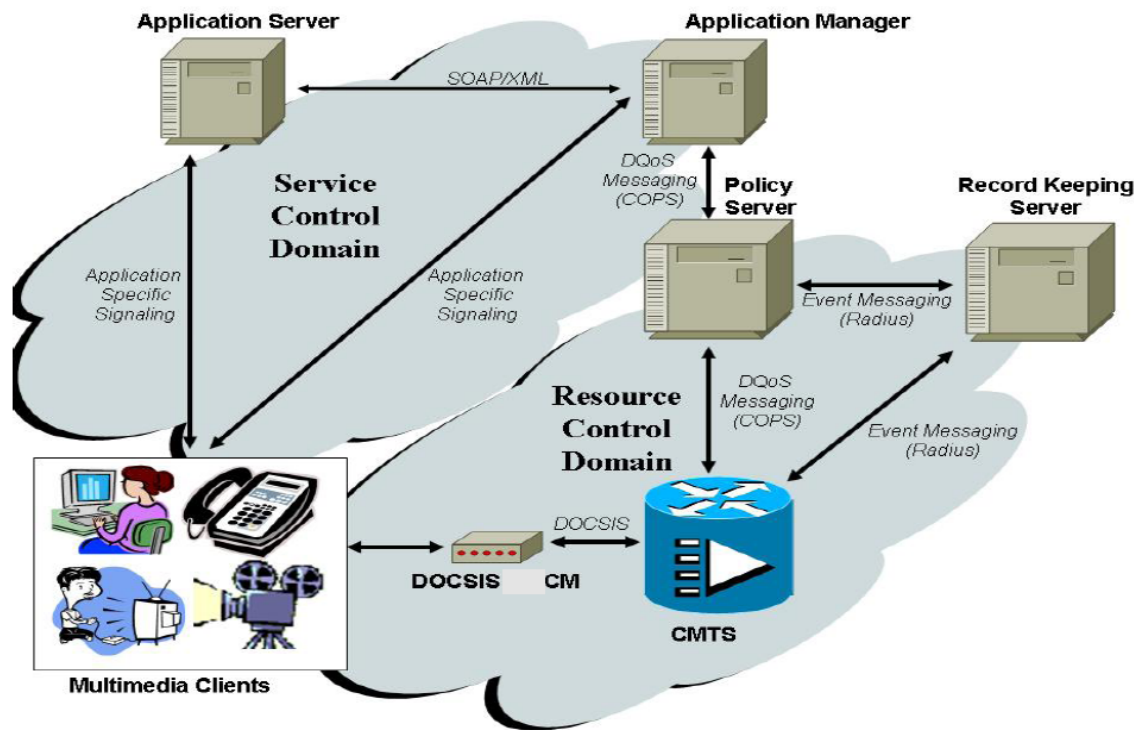- Geoff Huston

From: Interconnection, Peering and Settlements
http://www.cisco.com/web/about/ac123/ac147/ac174/ac200/about_cisco_ipj_archive_article09186a00800c8900.html

Architecturally possible for 3rd parties to reserve capacity in next generation architectures
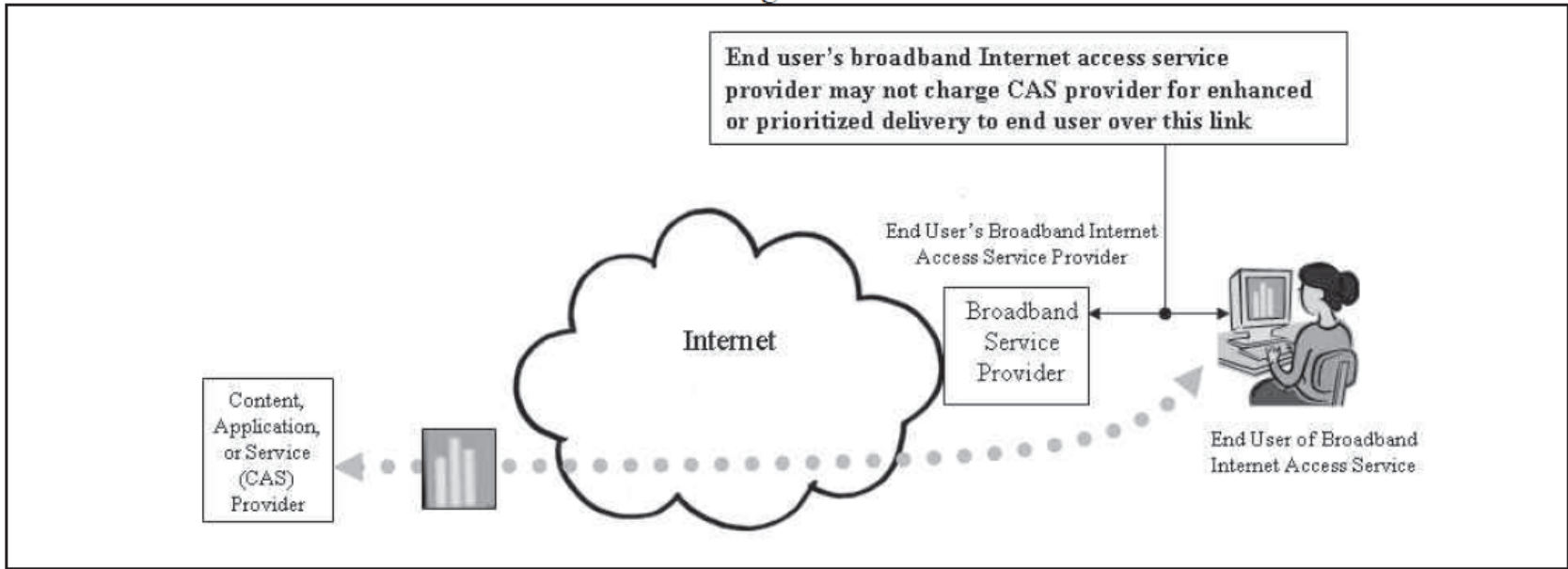

PCMM Architecture

Whether that happens in the marketplace (or is necessary) is an open question

Policy implications of the flattening Internet topology

Diagram 2

End user's broadband Internet access service provider may not charge CAS provider for enhanced or prioritized delivery to end user over this link

End User's Broadband Internet Access Service Provider

Internet

Broadband Service Provider

End User of Broadband Internet Access Service

Content, Application, or Service (CAS) Provider

Submitted comment to FCC urging they reconsider this proposed rule

Possible for data (and over-the-top video) to share capacity with provider's video in the DOCSIS 3.0 architecture
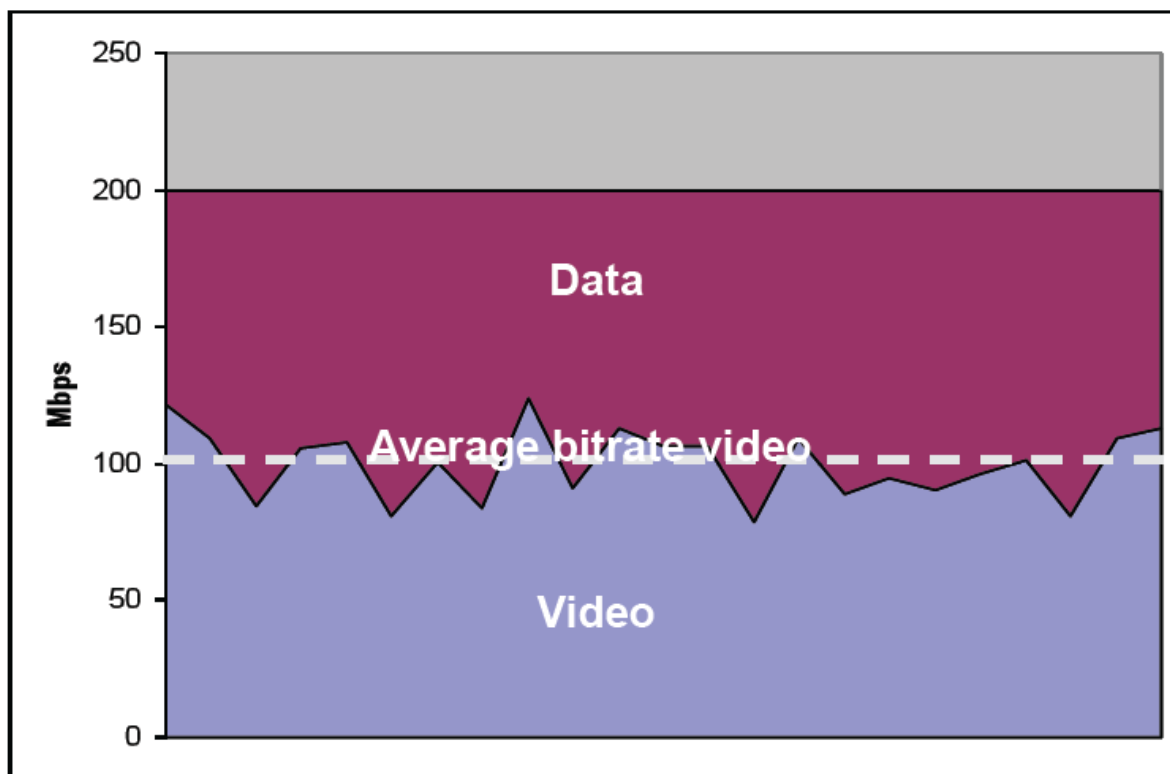
Significant because the "winding dirt road" isn't the right analogy in this architecture.

The right analogy would be general Internet traffic can get forced to the side (or one lane) of a bigger shared road by the semi trucks of provider video traffic

Maybe not as problematic from a policy standpoint?

Conclusion

Video shows something evolving over time with a fluid presentation

Video is not just about consumer entertainment or personal and business communication

Video traffic will be a key driver of architectural, interconnection, and network management changes

Interesting policy challenges ahead

What we measure and monitor to understand these changes will be evolving

- MITAS (http://mitas.csail.mit.edu)