The Business Case for Multicast

Marshall Eubanks

Thanks

- Thanks to
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  - Gurvinder Singh, Cisco Systems
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  - John Kristoff and Tim Ward, Northwestern U.
  - Dave Schroeder and David Devereaux-Weber, U. Wisconsin - Madison
  - Brandon Butterworth, BBC.
  - And my apologies to anyone I missed.

Agenda

- ## What is Multicast ?
  - – A (brief) guide for the perplexed
    - • Including the history of multicast !
- ## Multicast Business Models
  - – The timely distribution of data
    - • Financial Services
  - – Video Distribution and the "Triple Play"
- ## The Walled Garden and how to break it.
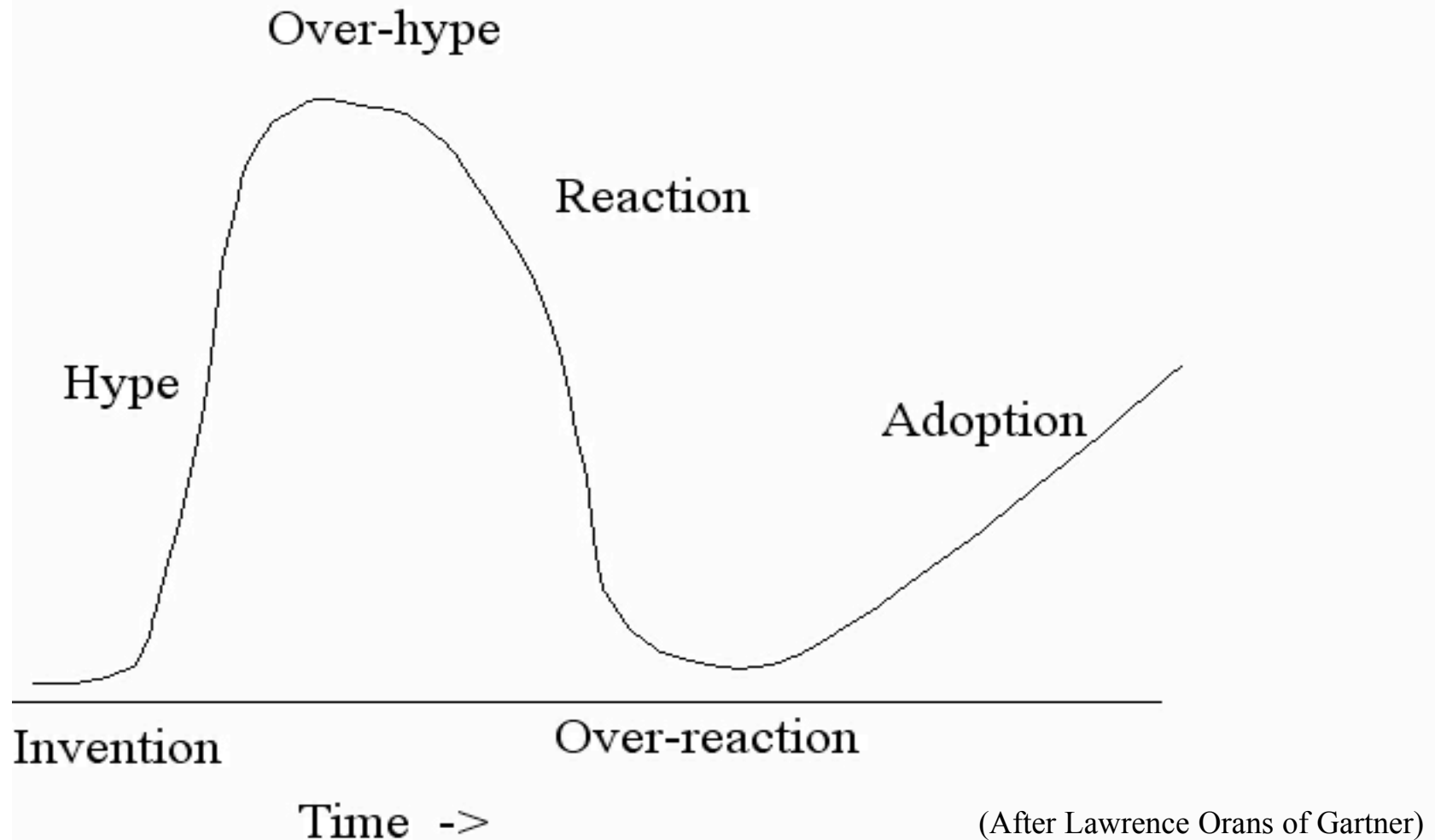
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A Brief History of Multicast

- My first rule of technology is that really good engineering only comes after the first iteration.
  - By that criteria, Multicast should be good indeed…

- My second rule of technology is that anything that takes too long will be superceded, no matter how cool it is.
  - Has multicast escaped this trap ?

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What Happened to Multicast?

- By 1995, multicast seemed well on its way to universal adoption.
  - The MBone (Multicast backBone) had been set up and was growing.
  - Audiocasts and Videocasts of meetings, seminars, etc., were fairly routine.
  - Serious interest was coming from industry.
- So why isn't it ubiquitous now ?
  - The hype got ahead of the technology!
  - The original technology was not suitable for adoption throughout the Internet. Basic parts had to be re-engineered on the basis of experience (see the first rule).
  - This took from ~ 1997 to early 2001.

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The Life Cycle of New Technologies in General

(After Lawrence Orans of Gartner)

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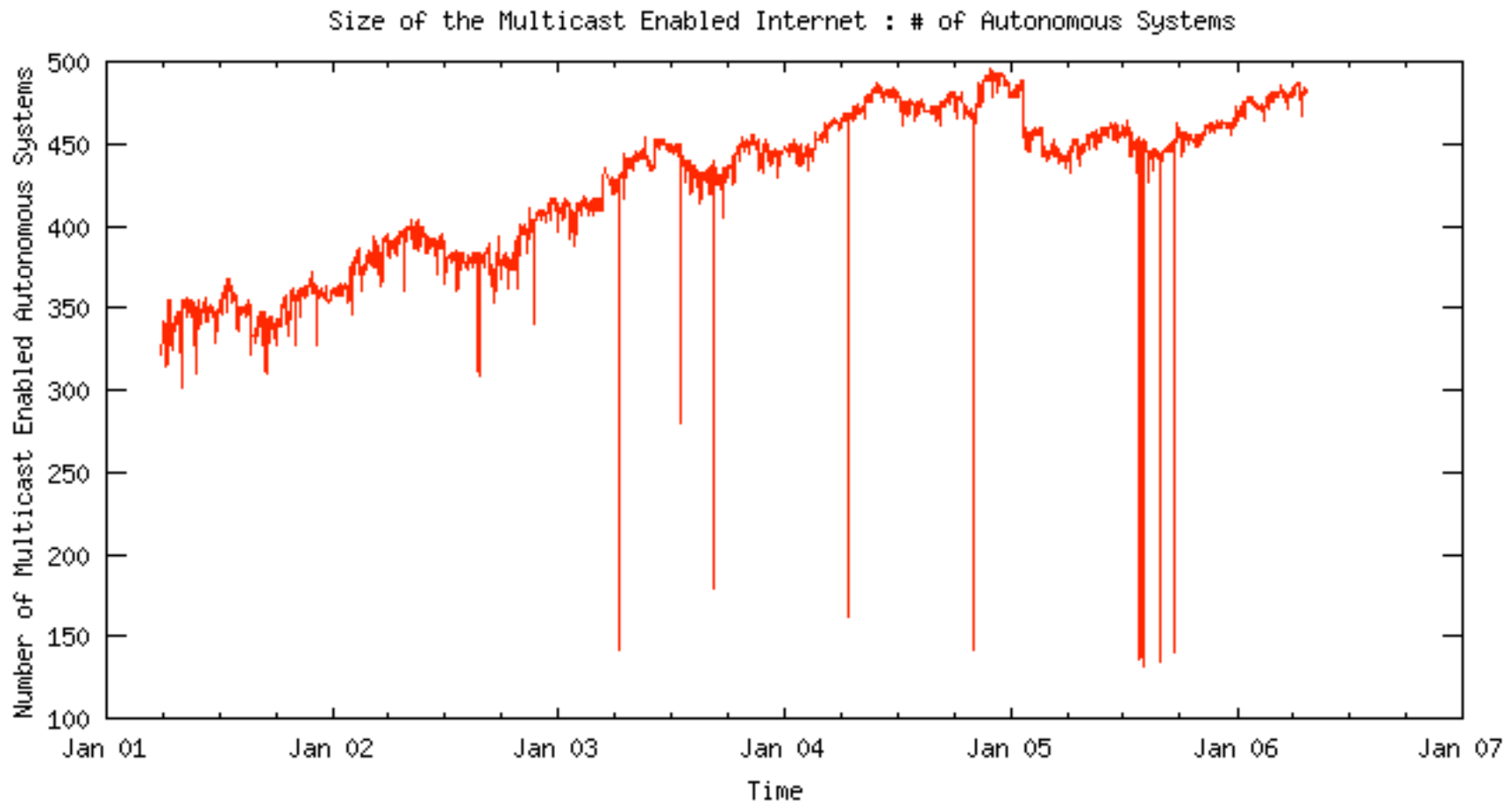
The Life Cycle of Multicast in Particular
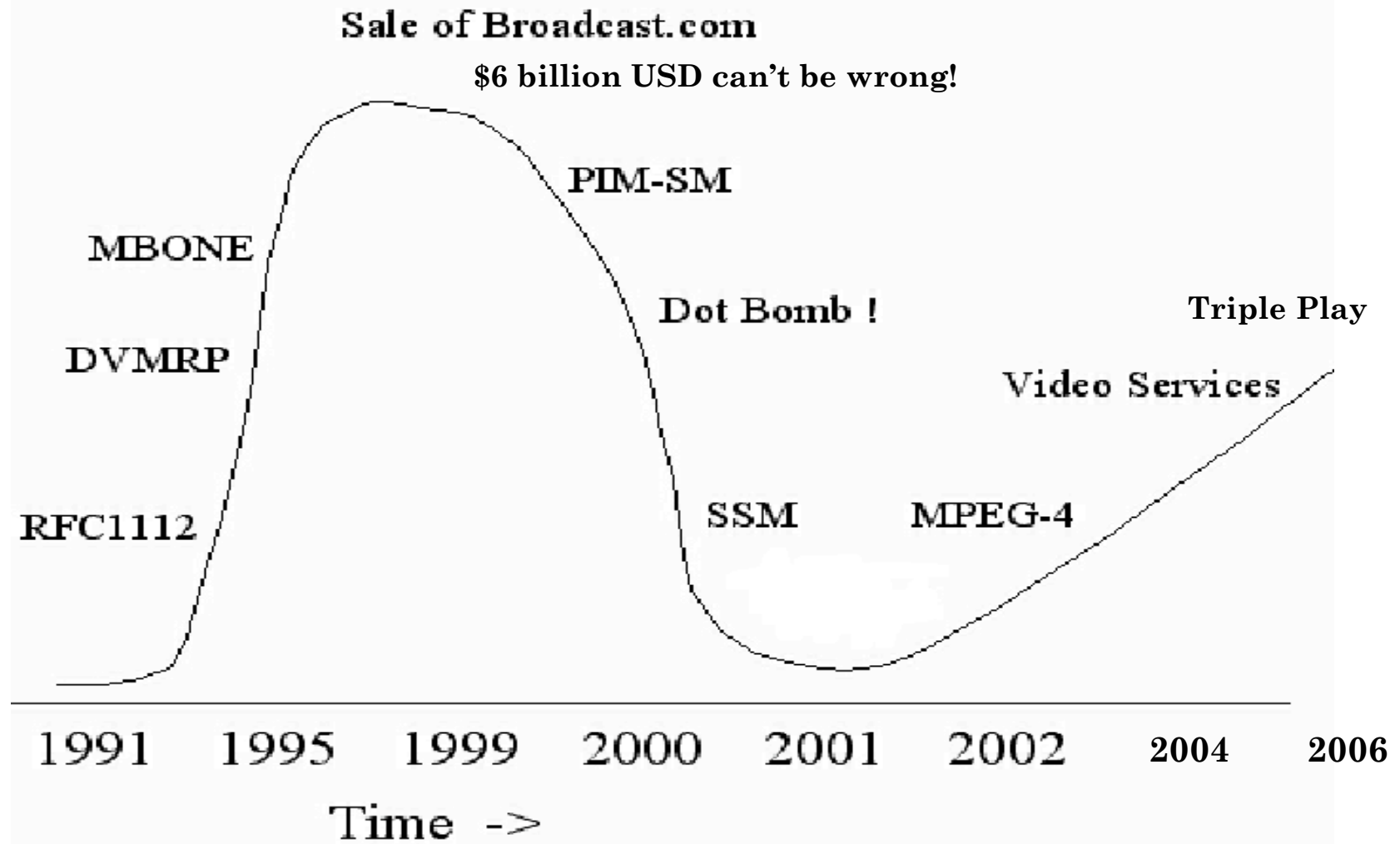
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Multicast Grows Up

- Since 2000, the building blocks for a multicast-enabled Internet have been put into place.
  - Protocol Independent Multicast – Sparse Mode (PIM-SM) was developed and deployed.
  - Multiprotocol BGP (MBGP) multicast peering was developed and deployed.
  - The service model was split into:
    - a many-to-many part (e.g., for videoconferencing): Any-Source Multicast (ASM), and
    - a one-to-many (or "broadcast") part: Source-Specific Multicast (SSM).
- By 2006, with the use of Multicast accelerating, "Triple Play" became the buzzword of the moment - Voice, data and (Multicast) video, all on the same network.

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"Global" Multicast Deployment is lagging...

Size of the Multicast Enabled Internet : # of Autonomous Systems

http://www.multicasttech.com/status

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… but still growing…

Size of the Multicast Enabled Internet : MBGP

http://www.multicasttech.com/status

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...while Multicast is suddenly "hot"

- By 2006, with the use of Multicast accelerating, "Triple Play" became the buzzword of the moment - Voice, data and (Multicast) video, all on the same network.
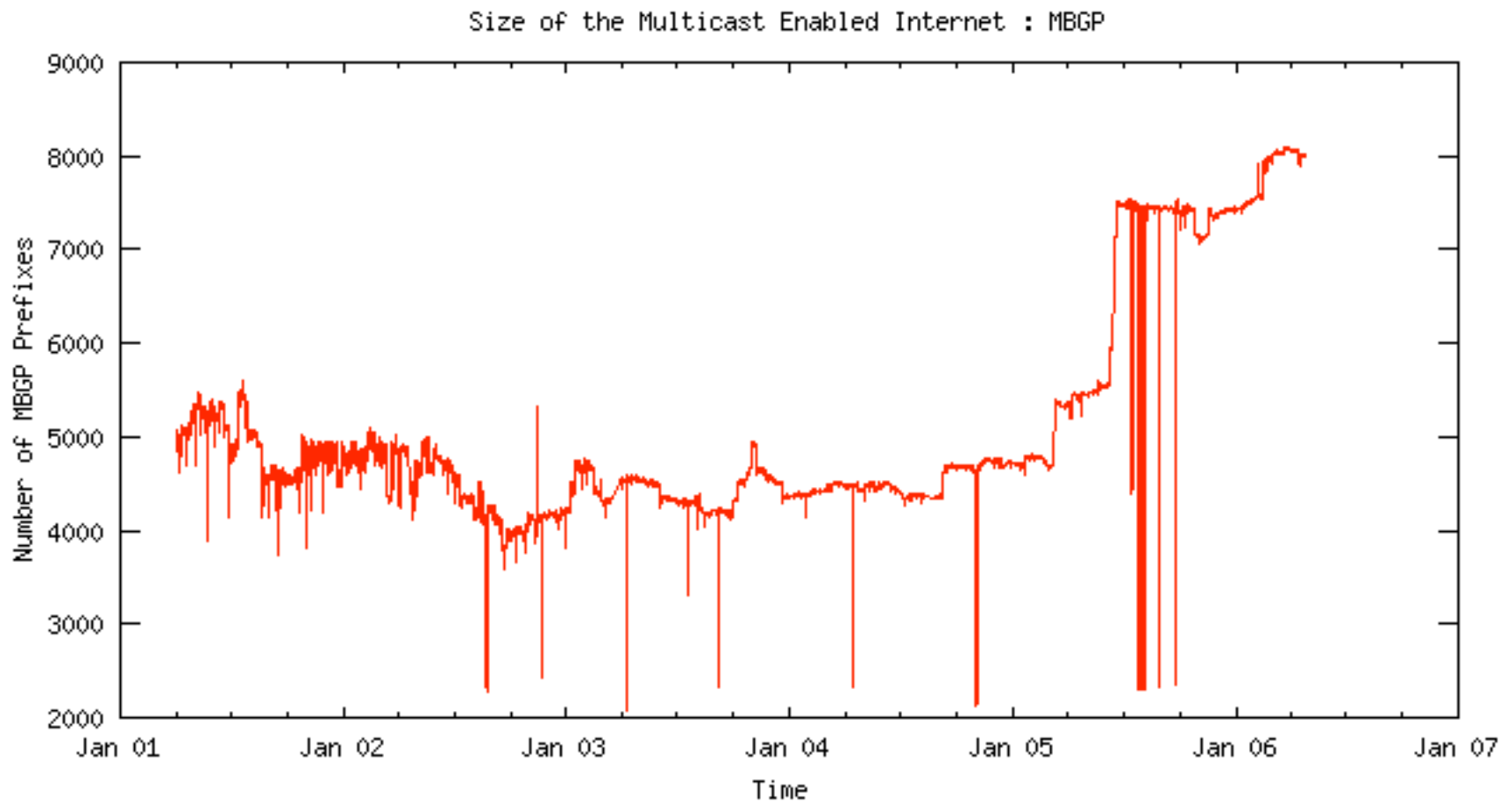 - 16,700 hits for "Triple Play" this morning on Google™ **News**
  - 1800 hits for "IPTV" this morning on Google™ **News**
- Multicast is BCP for Triple Play / IPTV video
  - Generally ASM with IGMPv2
- 3G Wireless has adopted IP Multicast in the 3GPP MBMS and 3GPP2 BCMCS services
  - This includes multicast at the RF link layer.
  - 1130 hits for "3G Video this morning on Google™ **News**
- L3VPN Multicast is a hot topic in the IETF
  - Doesn't get in the news that often...

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What Multicast areas are actually seeing activity ?

- I looked at references to Multicast as seen by my news filters from March 22 to April 22, 2006
  - I try to decide what area they are in and filter out duplicates (this is not a perfect process…)

- 3GPP MBMS & BCMCS   : 17 press references
- IPTV   : 16 press mentions
- Monitoring / Control   : 3 press mentions
- General products   : 3 press mentions
- Applications (zero conf)   : 3 press mentions
- DSL   : 2 press mentions
- IP Core   : 1 press mentions
- Other   : 8 press mentions

This works out to about 1.7 press releases / day

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The First Multicast "Killer App" : Distribution of Financial Data

- Many stock exchanges use multicast to "push" financial information and stock quotes to traders and analysts
  - Very tight requirements on simultaneity of data delivery
  - Absolutely mission critical application
  - Common to use middleware to obtain reliable multicast
    - Tibco / Talarian PGM is common
- Exchanges include
  - Nasdaq
  - New York Stock Exchange
  - Nikkei
  - FTSE
  - Bombay Stock Exchange (using DVMRP)

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Commercial Multicast
Video Distribution

- Multicast is becoming the preferred means of distribution for video (TV) to Set Top Boxes (STB) over IP Networks (i.e. IPTV).

- Why ?

  It saves money.

  It uses the IP Infrastructure

- The Buzzword of the day is "Triple Play" - Data, VOIP, and Video on the same network

  - And this requires Multicast Video

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Multicast Video Today

- I will cover 4 test cases :
  - Northwestern University (NUTV)
    http://www.i2-multicast.northwestern.edu/
  - University of Wisconsin (DATN)
    http://datn.wisc.edu/about/
  - Hong Kong Broadband Networks (HKBN)
    http://www.cisco.com/application/pdf/en/us/guest/netsol/ns610/c647/cdccont_0900aecd80375b69.pdf
  - MTN Triple Play Network
    http://www.netinsight.net/pdf/040616_Case_study_MWT.pdf
    (this is actually Layer 2 multicast)

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Northwestern's Experience

- Effectively, Northwestern University is running a medium sized "cable" company, except entirely through IP Multicast.

- Northwestern uses video broadcast solutions from Video Furnace, Inc.
  - http://www.videofurnace.com/

  - "The Video Furnace solution handles all the heavy tasks of capturing and encoding live video to standards based MPEG streams with quality from VHS to full D1 broadcast, while seamlessly managing the distribution of client viewers to your Windows, Mac and Linux users."

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What Has Been Deployed?

- 20 channels of entertainment television
  - Combination of off-air and CATV channels
- Multicasted to all undergraduate dormitories (4350 unique locations)
- MPEG2 encoding, 29.97 FPS, ~2Mbps per stream (128Kbps mono audio)

Courtesy Northwestern University   RIPE-52 April 2006

Why Deploy This Type of System?

- No CATV in student dormitory rooms
  - Only in common areas/lounges
- Over 60 residence halls
  - Cost to wire with coax very high ($2-$5 Million)
  - Estimated time of completion: ~4 years
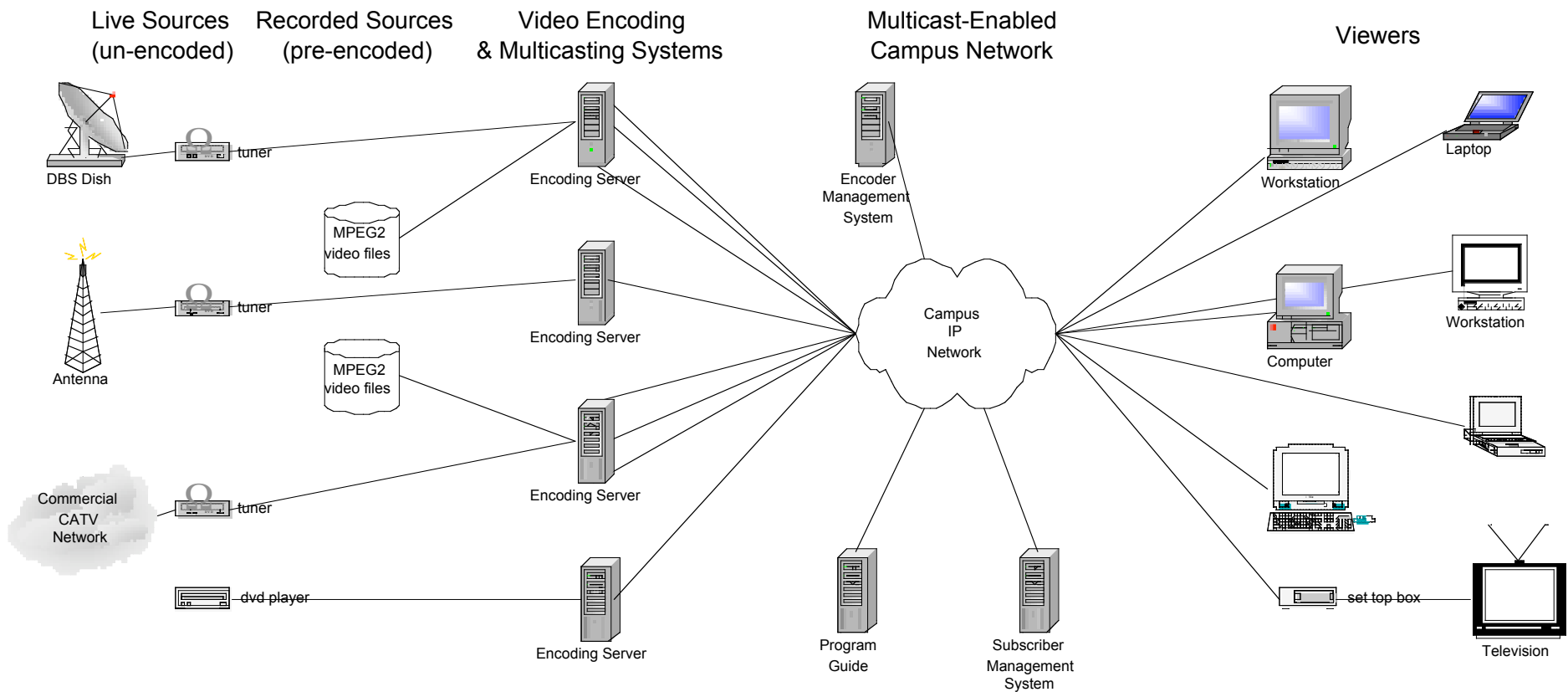- CATV major issue for the student population

Courtesy Northwestern University

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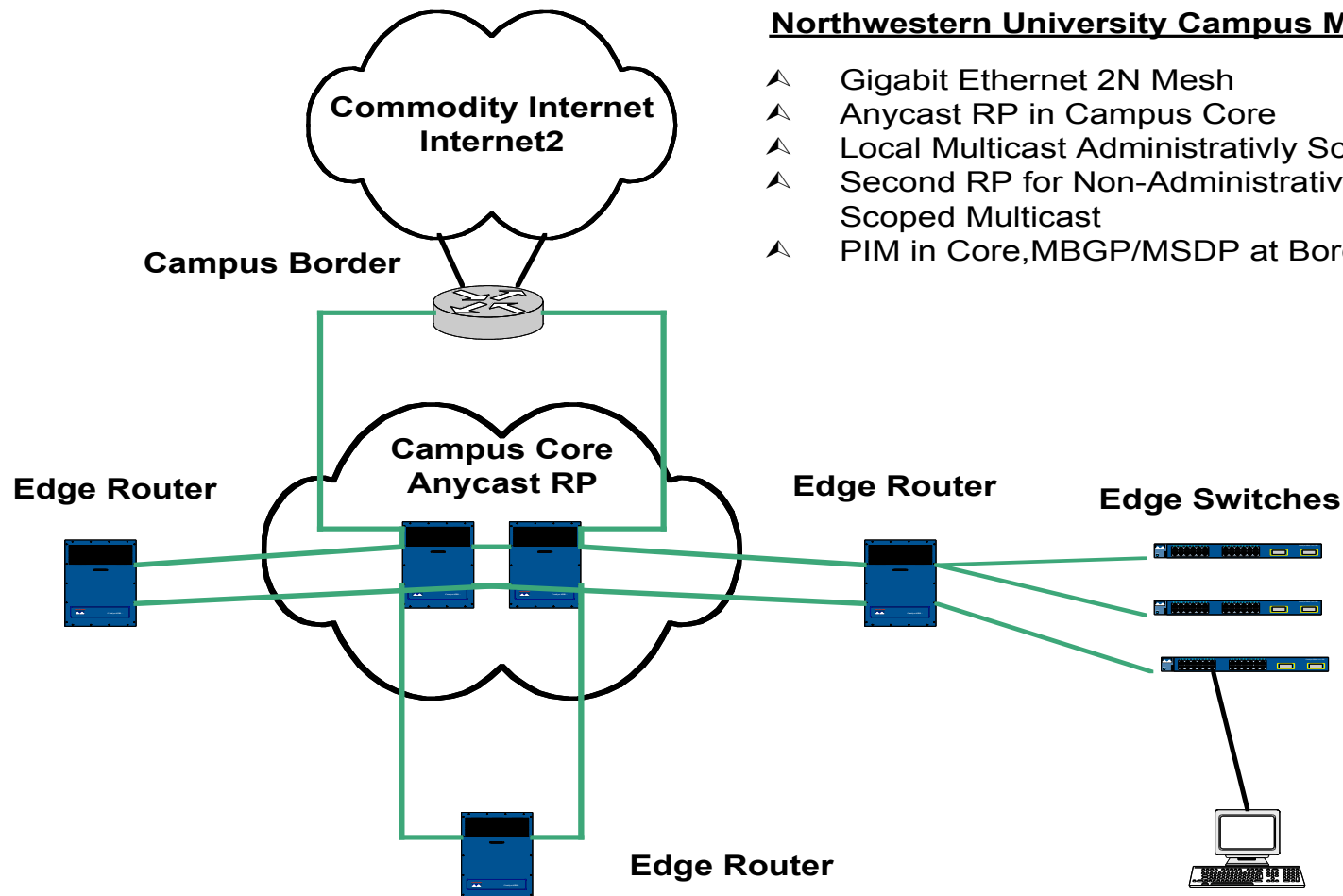
Northwestern University Campus Multicast

- Gigabit Ethernet 2N Mesh
- Anycast RP in Campus Core
- Local Multicast Administrativly Scoped
- Second RP for Non-Administratively Scoped Multicast
- PIM in Core,MBGP/MSDP at Border

Commodity Internet
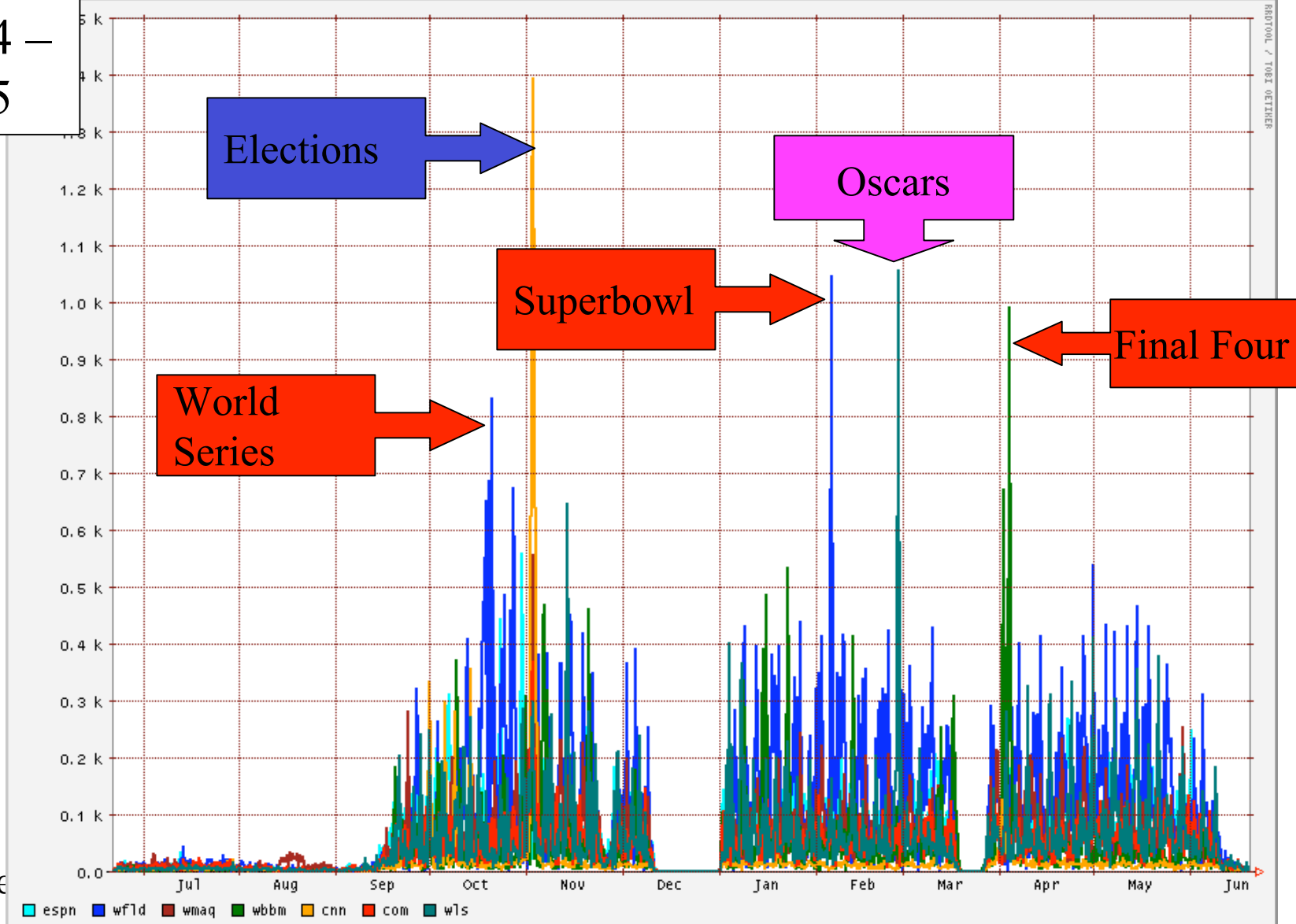Internet2

Campus Border

Campus Core
Anycast RP

Edge Router

Edge Router

Edge Switches

Edge Router

Courtesy Northwestern University

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System Components

Live Sources
(un-encoded)

Recorded Sources
(pre-encoded)

Video Encoding
& Multicasting Systems

Multicast-Enabled
Campus Network

Viewers

DBS Dish

tuner

Encoding Server

MPEG2
video files

Encoder
Management
System

Antenna

tuner

Encoding Server

MPEG2
video files

Campus
IP
Network

Commercial
CATV
Network

tuner

Encoding Server

dvd player

Encoding Server

Program
Guide

Subscriber
Management
System

Workstation

Laptop

Computer

Workstation

set top box

Television

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Courtesy Northwestern University

June 2004 – June 2005

Elections

Oscars

Superbowl

World Series

Final Four

Courte...

espn   wfld   wmaq   wbbm   cnn   com   wls

Department of Information Technology

3400 viewers

3200 Total

Thu. Oct. 28 – Wed. Nov. 3, 2004

College F'ball

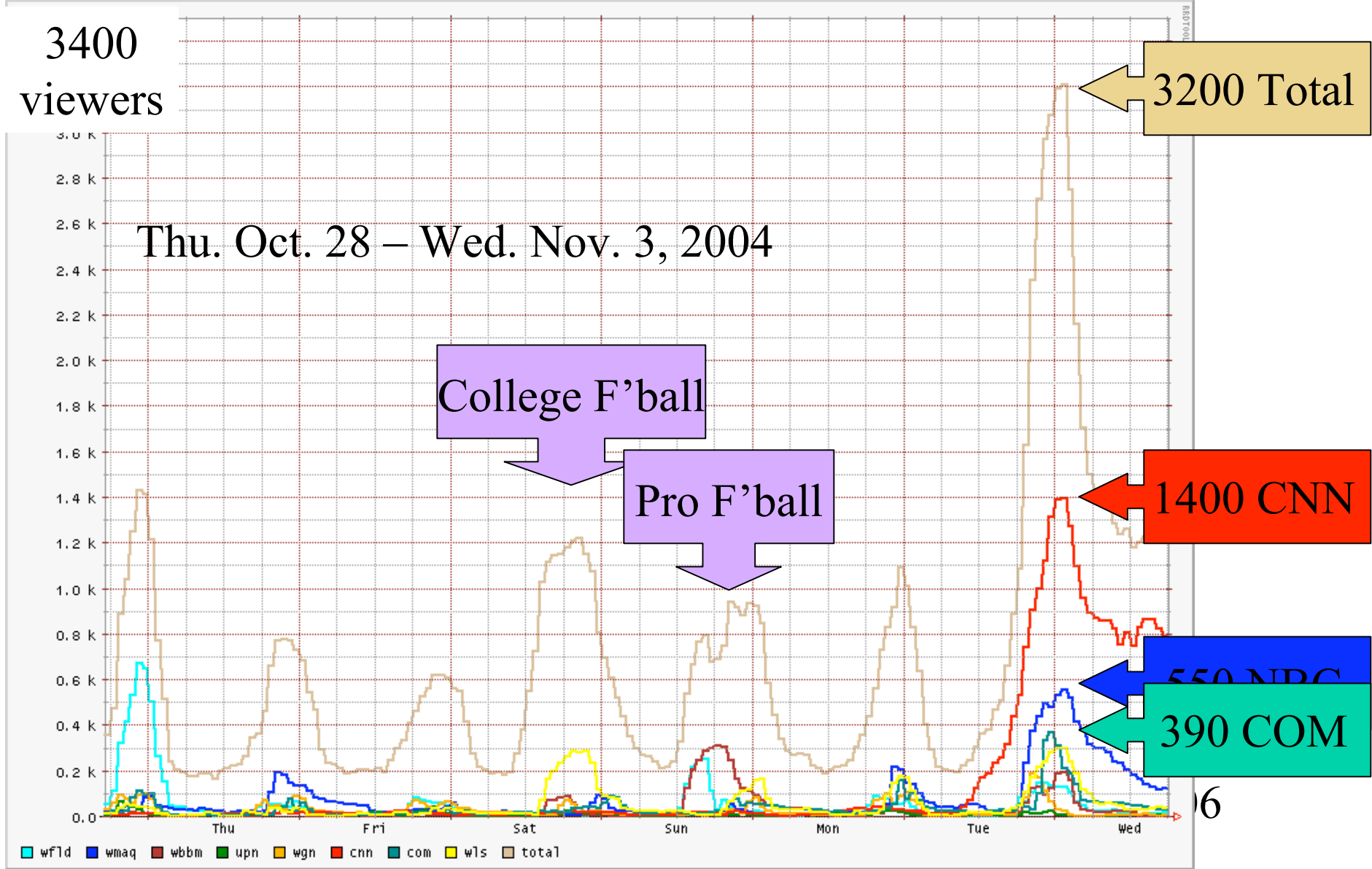Pro F'ball

1400 CNN

550 NBC

390 COM

wfld wmaq wbbm upn wgn cnn com wls total
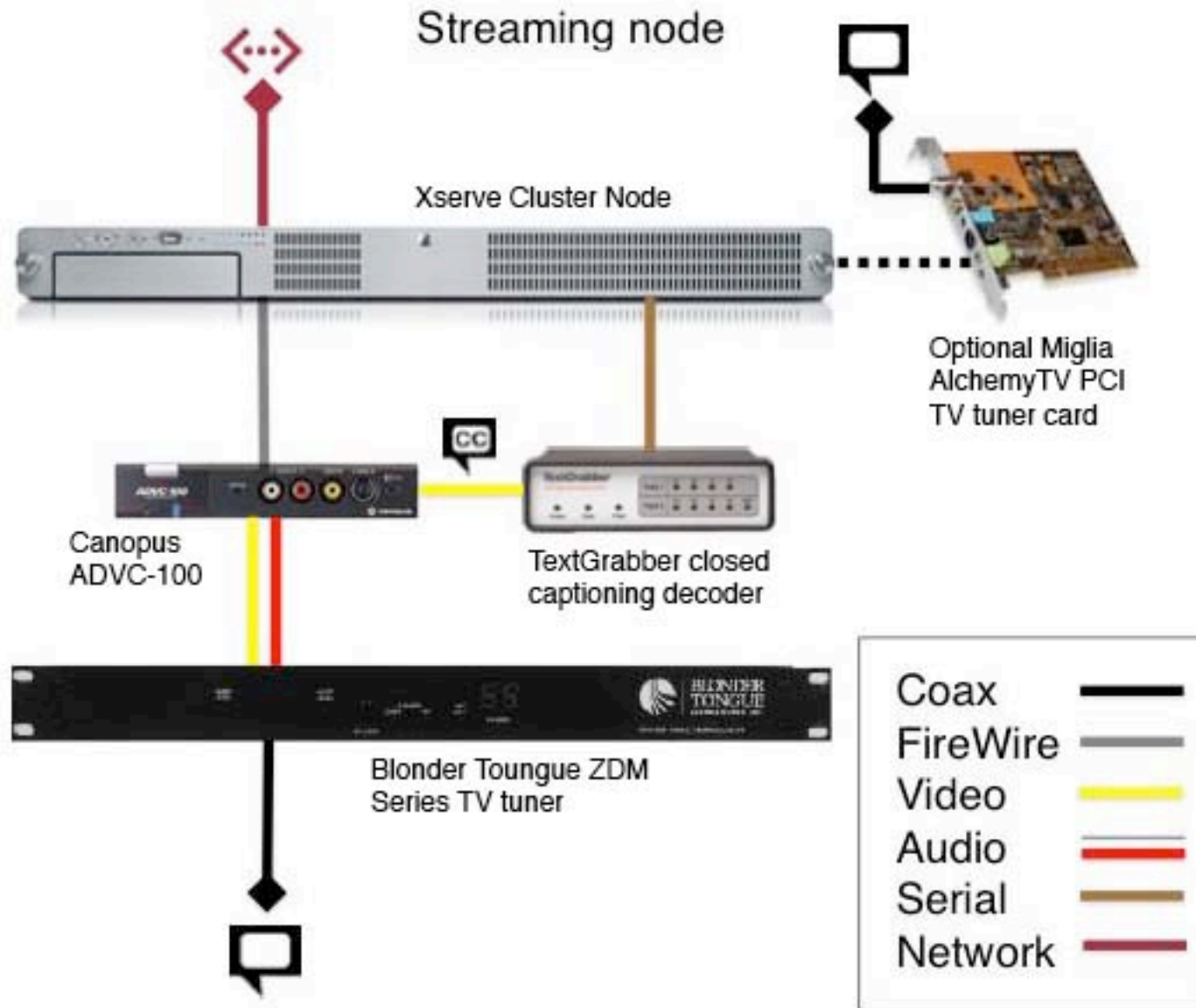
Wisconsin DATN

- Wisconsin has chosen a more open system.
  - Digital Academic Television Network or DATN
  - At University of Wisconsin - Madison
  - Based on Apple Quicktime
    - Quicktime 7 or VLC is the player
    - Server is Apple Xserve (1 per channel)
      - Mac OS X Server
      - QuickTime Broadcaster
      - QuickTime Streaming Server
      - Apache
      - Tongue ZDM Series (TV tuner)
      - TextGrabber GP500 closed captioning decoder
      - Canopus ADVC-100 analog to FireWire AV converter

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DATN Channel Architecture

Streaming node

Xserve Cluster Node

Optional Miglia
AlchemyTV PCI
TV tuner card

CC

Canopus
ADVC-100

TextGrabber closed
captioning decoder

Blonder Toungue ZDM
Series TV tuner

Coax	━━━
FireWire	━━━
Video	━━━
Audio	━━━
Serial	━━━
Network	━━━

DATN Video

- DATN
  - Streams 78 channels of live local television
  - via multicast over a 10-GigE backbone network
  - to a 65000-person research campus.
  - No DRM (Digital Rights Management)
    - They don't want it
  - No EPG (Electronic Program Guide)
    - This is an issue with Multicast Video
    - A standard is needed

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DATN Video : Why Quicktime

- Why did DATN pick Apple Quicktime and QTB and QTSS ?
  - Support of open standards
    - MPEG-4 and H.264 (MPEG-4 version 10)
  - Support of common OS's
  - Cost
    - Quicktime is free
    - Quicktime Streaming Server is free
    - Quicktime Broadcaster is free

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DATN Video : More about why QT

- QuickTime capabilities :
  - QuickTime Text Track allows DATN to stream closed captioning content independent of video
  - QuickTime Skins allows DATN to use flexible approaches for the display of video on the client end
  - Because of the granularity of the system, other uses of the content can be explored
    - Closed captioning search database
    - Video archival
    - Custom players and other applications
    - Computer "set top box" configurations
    - See http://datn.wisc.edu/about/DATN_WWDC_2005.pdf for more details

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What DATN Looks Like :

- DATN Developed its own player skin

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Other Educational Multicast Video

- Northwestern University and UW-Madison are hardly alone
  - Many schools are running trials or initial deployments of multicast video
  - Dartmouth announced it will use Video Furnace equipment on May 18th, 2005
    - 62 channels and wireless. -
  - Cornell University is rolling out service "soon."
    - They have lots of Cat-3 wiring, unfortunately.
  - AHECTA - American Higher Education Cable TV Association - is interested
- Then there is also the Open Student Television Network (OSTN.tv)
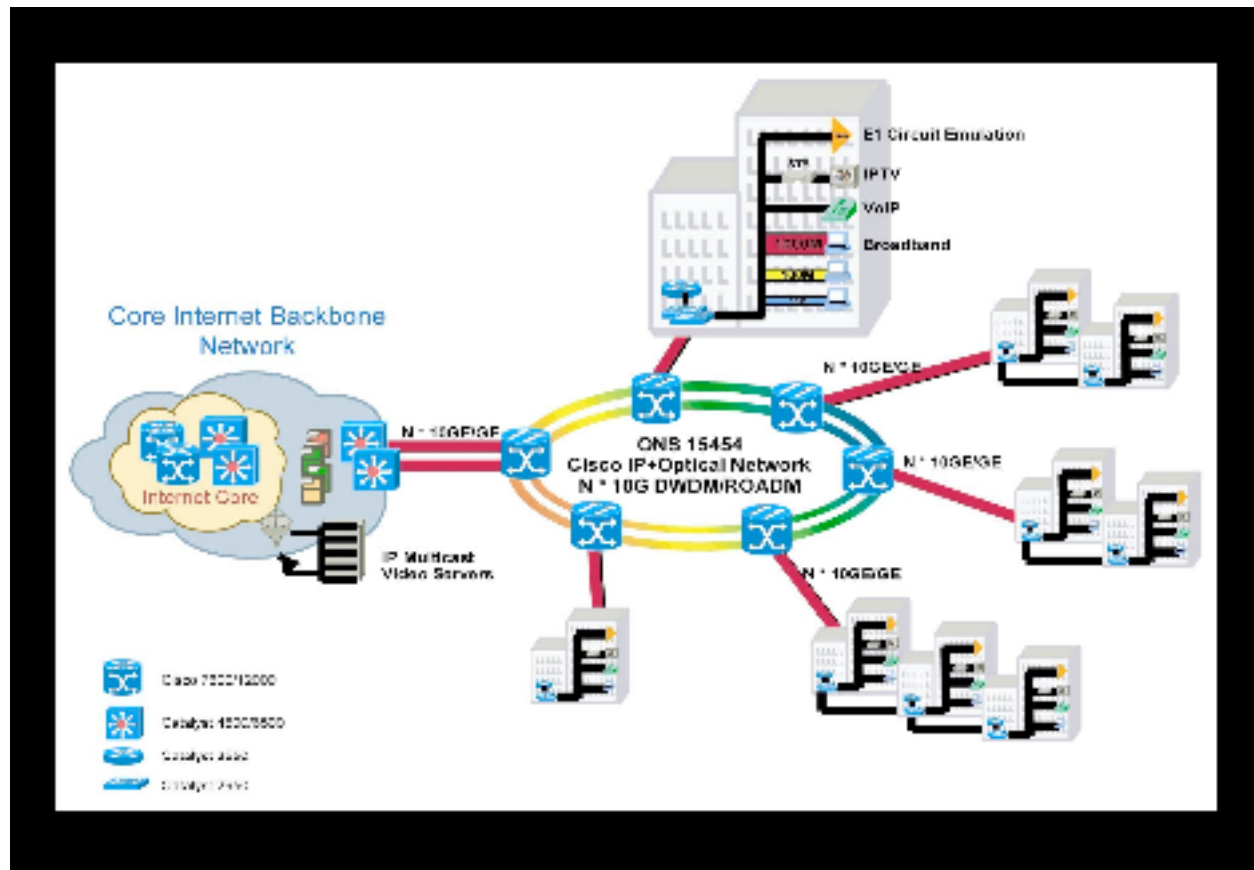 - Focused on student produced content

Hong Kong Broadband Networks LTD.

- A commercial video deployment
  - All Cisco based solution
- They want to compete with DSL by using Ethernet deployments
- Customer Charges :
  - 10 BaseT is "below dialup" cost
  - 100 BaseT is $ 27 USD / month
  - 1 GigE is $ 172 USD / month

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HKBN Business Model

- HKBN offers (to subscribers)
  - VOIP at $ 6 / month flat rate
  - 60+ channels of IPTV
    - In 10 / 2005 :
    - HKBN has 120,000 subscribers @ $ 16 USD / month
    - Their conventional competitor, HK Cable, has 685,000 subscribers @ $ 39 USD / month
  - Ethernet Cost is 130 USD / residence passed
    - Hong Kong is a population dense urban environment
    - 2 year amortization is ~ 6.00 USD / month.

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HKBN Network Topology

HKBN Network Architecture

- Multiple 10 Gig DWDM rings
  - Cisco 12000 and 7600's
- 10 GigE to the Internet and video servers
- 10 GigE to Multi Tenet Units (MTU's)
  - Catalyst 4500's switch at the "miniPOP's"
  - Catalyst 3450's at the MTU's
- Convert to Copper and put on risers
  - Catalyst 2950 switch to users at the subscribed rate.
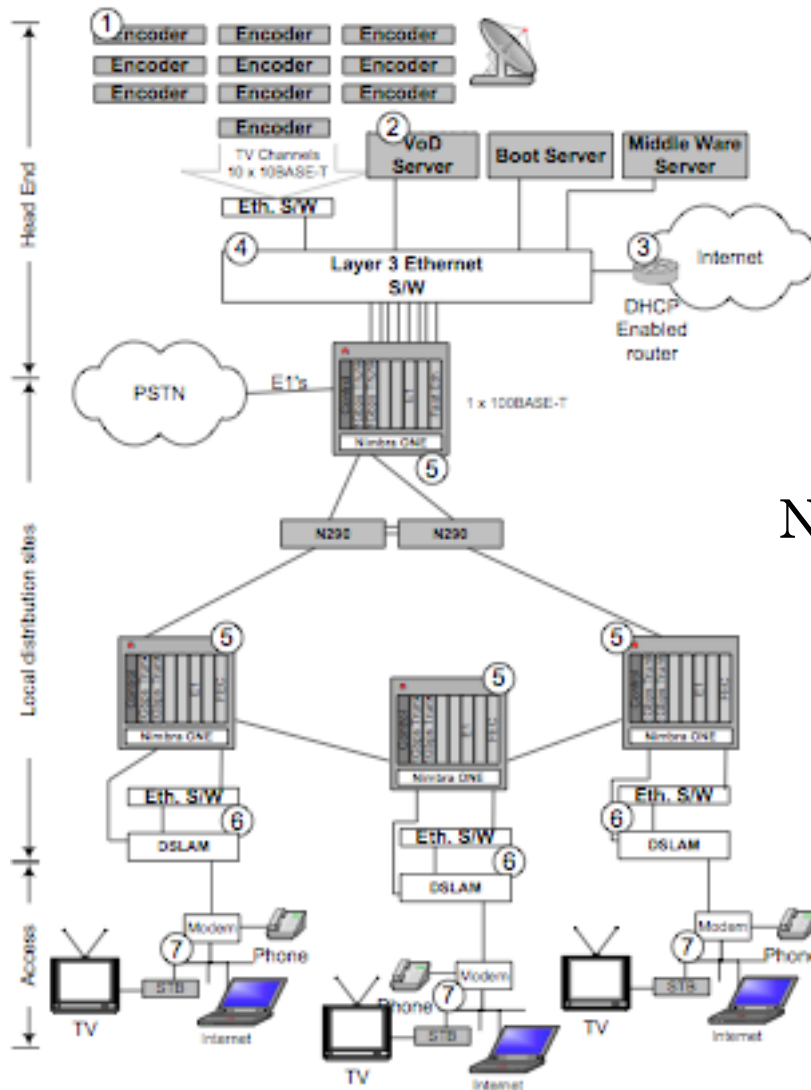
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Midwest Tel Net Triple Play Network

- Midwest Tel Net (MTN) is a small IOC network in Wisconsin
- MWT's triple play network is
  - A Multi-vendor solution
  - ADSL to the customer
  - Fiber based Ethernet backbone
  - 100+ channels of Television
  - Plus data and voice
  - To 22,000+ homes
- Video Setup Cost is $ 30 to $ 80 / subscriber
  - Depending on the take up rate.

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MWT Video Distribution

- Minvera encoders take video from satellite feeds and convert it to 3.5 Mbps MPEG-2 streams.
  - These are multicast onto the Ethernet backbone.
  - At the edge
    - Net Insight's Nimbra One
    - ATI Rapier 24i Ethernet switch/router
    - Allied Telesyn DSLAM 7000 Series
      - Puts the data onto DSL copper
  - At the customer premises, a Set Top Box (STB) is connected by Ethernet to the ADSL router/gateway.
    - Two channels can be viewed simultaneously

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MWT Physical Architecture

Nimbra One 100 Base T
Switched Network

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Other Commercial Multicast Video Deployments

- Time Warner is undergoing trials of Multicast Video in San Diego
  - Using Real Networks for back office, encoders, DRM, etc.
  - The encode rate in demonstrations was 700kbps, but is adjustable.
  - DRM is being used, but not clear if this is for multicast or unicast content.
- Comcast is in the process of converting to a multicast enabled national backbone.
- Fox Cable, with TVN Entertainment, is using multicast to pre-cache Video on Demand (VOD).
- There is my very own AmericaFree.TV
  - This is a unicast / multicast source
  - 500 Kbps H.264 encoding (multicast & unicast)
  - Actively seeking access to Set Top Boxes

BBC Multicast

- The BBC has been multicasting for a long time.
  - Licensing issues limit much of their content to the UK
    - ISP's tend to follow national boundaries
      - Being an island has some advantages
  - September 1, 2005, they announced that "our multicast trial […] received approval today to use most BBC channels."
    - So far,multicasts are for the UK only.
  - http://support.bbc.co.uk/multicast/
  - http://news.bbc.co.uk/1/hi/entertainment/tv_and_radio/4187036.stm
- Brandon Butterworth is the technical lead on this.

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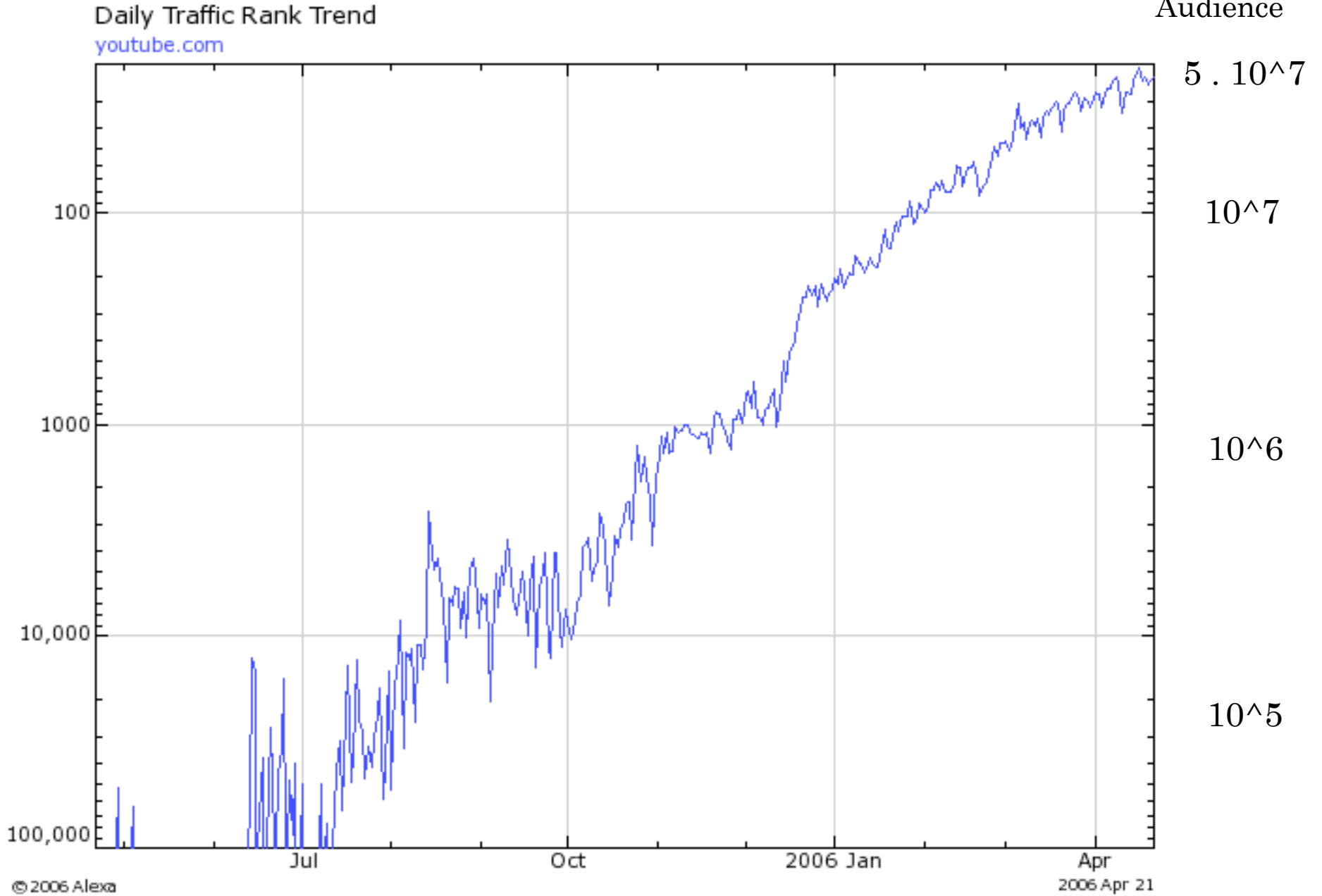# Multicast Streaming : Walled Garden or Global Utility

- Most current plans for multicast streaming is entirely behind the scenes.
  - The "walled garden" approach.
    - Video packets and user packets never touch
- The real question is whether Zipf's Law will allow the walls to stand.
  - As you will see, statistical models predict 10,000's to 100,000's of channels in the USA alone.
  - It's hard to see how the walled garden can be extended to encompass this
  - 100,000 channels is thousands of servers
    - The content providers should buy these, not the ISP.

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Why Walled Gardens Won't Last

- Both the (potential) demand and the (potential) supply of Video Appear to be nearly boundless
- To Understand this it will be necessary to look a little into Zipf's Law, Pareto distributions and the "Long Tail"
- But first, a new company called YouTube.Com
  - YouTube simply provides a means for people to host video content they source themselves
  - The vast majority of the content is amateur video straight from the camera
  - They are making a lot of money from the Long Tail

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The Growth of YouTube.com (from Alexa)

~ Monthly
Audience

Daily Traffic Rank Trend
youtube.com

$5 \cdot 10^{7}$

100

10^{7}

1000

10^{6}

10,000

10^{5}

100,000

Jul   Oct   2006 Jan   Apr

© 2006 Alexa   2006 Apr 21

Zipf's Law

- Zipf's Law has been found in virtually every case of (not artificially limited) content selection.
- Zipf's law postulates a power law relation between the frequency of selection of options by humans and the rank order of the option, expressed mathematically by Zipf's equation :

$$P \sim R^{Z-1}$$

- where R is the rank order, Z is the Zipf exponent, and P is the frequency of selection.
  - In video rentals, $Z \sim 0.27$.
  - For Amazon.com Book sales, $Z \sim 0.13$
  - For Web Site Usage, I found $Z \sim 0.15$

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The "80-20" rule

- A common, heuristic, version of Zipf's Law
  - 80 percent of the business comes from the top 20% of the content.
  - The observed Zipf's Law in Video Rentals says that the top 20% of the titles generates 62% of the rentals.
    - Not bad for a heuristic.
- Zipf's law probably arises from similar distributions in social networks
  - I think that "6 degrees of separation" and the Pareto distributions have the same root cause.

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Zipf's Law in Web Site Usage

Alexa Rank versus Reach
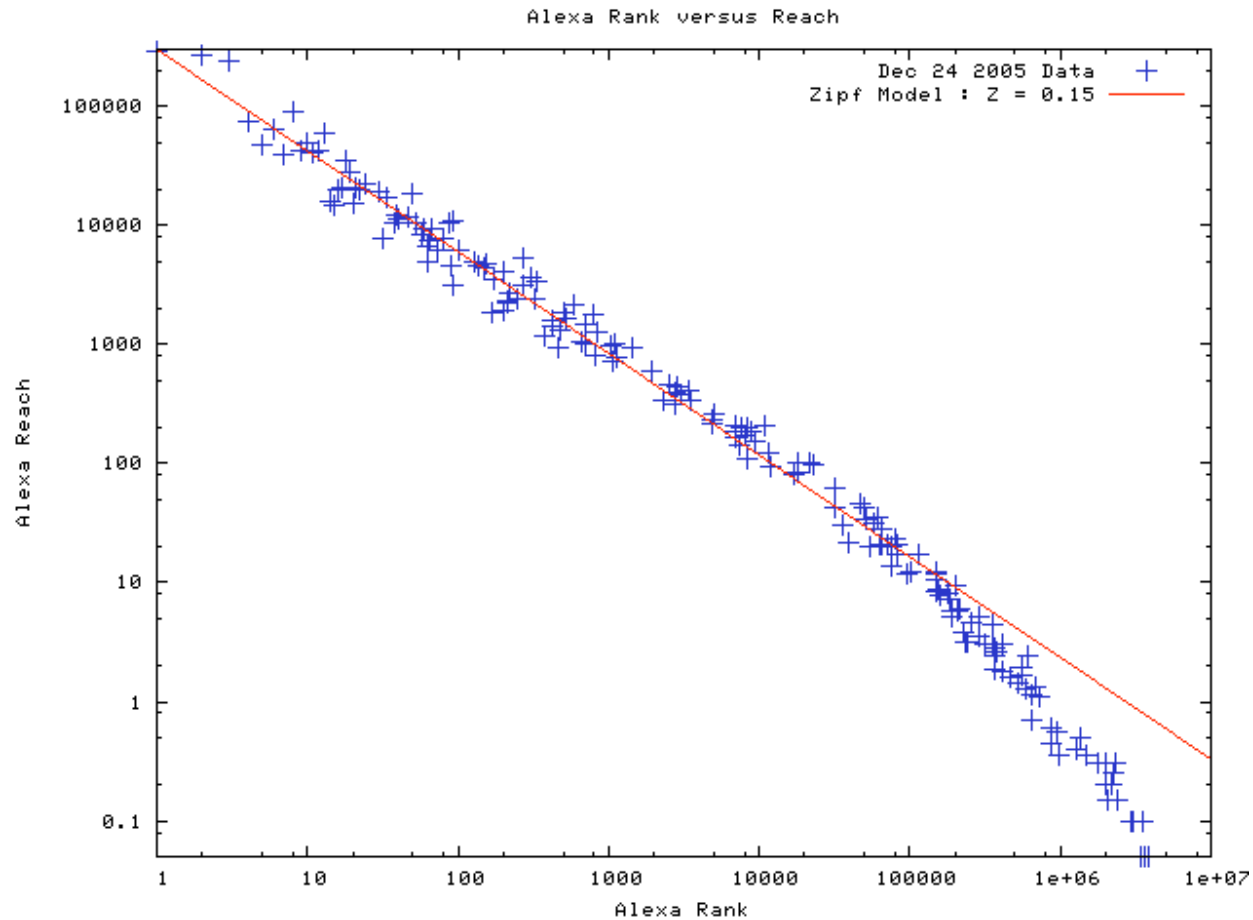
Reach is the proportion of all Internet users who visit a given site, expressed per million users.

It is thus a measure of audience size, with an empirical calibration being monthly audience ~ reach * 2000

Data from Alexa : http://www.alexa.com/data/details

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Well, what can you do with this ?

- You can estimate the total video audience distribution
  - Need to know
    - Z (I assume 0 to 0.27)
    - Video audience (I assume 100 million)
    - Minimum channel audience size (I assume 1000)
    - Have to estimate a scale factor (audience for some rank) to provide the proper audience for a given cutoff .

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The Z's the thing

Z	Mininimum Channel Size	Total # Channels	50% Channel Rank
0.27	1000	28,700	2668
0.0	1000	10,210	~ 100
0.27	100	275,000	~ 25,000

50% Channel Rank : 50% of the Audience is at ranks above (or below) this point.

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Zipf's Law and the Video Universe

- With our assumptions, the world can support a lot of video channels !
  - 100's of thousands of profitable channels does not seem outrageous world-wide.
  - The long tail in video content will be long indeed.
- Although the appropriate Z exponent for video channels is unknown, and although there may be other limits to the expansion of the video universe (e.g., cost and availability of content), it seems clear that the video universe is set for rapid expansion.

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Why Does this Break the Walled Garden ?

- People will want to see this video on their screens.
- The Walled Garden does not scale.
- How can you support 100,000 channels ?
  - Interdomain Multicast using SSM can do it
  - Fortunately, the Triple Play development is creating the infrastructure that can support this.

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What Needs to be Done ?

- This will need standards :
  - Video Encoding
  - Video bit rate, frame rate, aspect ratio, etc.
  - Metadata
    - For electronic program guides
    - For content filtering and selection
- This is not (or not entirely) a job for the IETF
  - One of the many industry forums needs to do this, or a new one needs to be created.

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Conclusions

- I have tried to give some flavor of the solutions in place today using Multicast
  - People do make money from Multicast
  - Multicast is becoming widely used behind the scenes
  - The Question is, will it ever come back out into the open ?
- Multicast research and development continues, and there are new applications on the horizon that I didn't have time to cover.
  - Multicast VPN's and the use of Multicast with MPLS are good examples.

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Information Online

- http://multicast.internet2.edu
  especially the tutorial-style paper at
  http://multicast.internet2.edu/almeroth.pdf

- http://dast.nlanr.net/Projects/Beacon/

- www.multicasttech.com/faq/multicast_faq.html
  and
  www.multicasttech.com/status/

- Greg Shepherd's multicast site: www.shepfarm.com/multicast/

- http://www.cisco.com/en/US/tech/tk828/tsd_technology_support_protocol_home.html and
  ftp://ftpeng.cisco.com/ipmulticast.html

- www.sprint.net/multicast/faq.html

- http://www.juniper.net/techpubs/software/junos/junos72/swconfig72-multicast/html/ip-multicast-overview.html

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