IPTV Bandwidth Demands in Metropolitan Area Networks

LANMAN 2007

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Introduction

- **Shift towards IPTV**
  - Converged voice, video, data networks
  - Unified management: OPEX savings
  - Emerging services: VoD (20% of users that have access to VoD use it daily), Gaming, Interactivity?
- **VoD is a bandwidth driver in MAN: Ability to generate multiple 100 Gb/s**
  - Amount of generated bandwidth depends on where VoD servers are located and caching of content
- **Large fraction of future traffic VoD: up to 90%**
  - Implications for network: QoS, unidirectional traffic patterns, large packets
- **This work:**
  - IPTV/VoD delivery in service provider network
    - Not Internet content delivery (YouTube, MovieLink, etc..)
    - Service provider determines caching locations
    - Centralized architecture (not peer-to-peer (P2P))
  - How much traffic on MAN network?
  - What is effect of caching content and delivering from an aggregation node?
  - What fraction of future traffic will be VoD?

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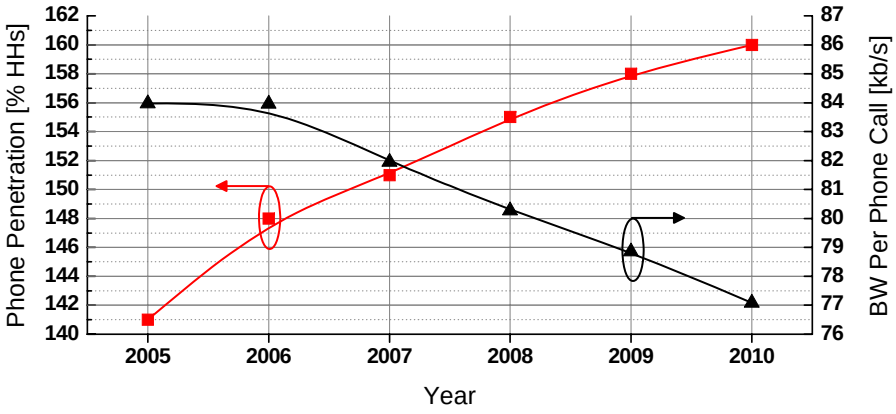
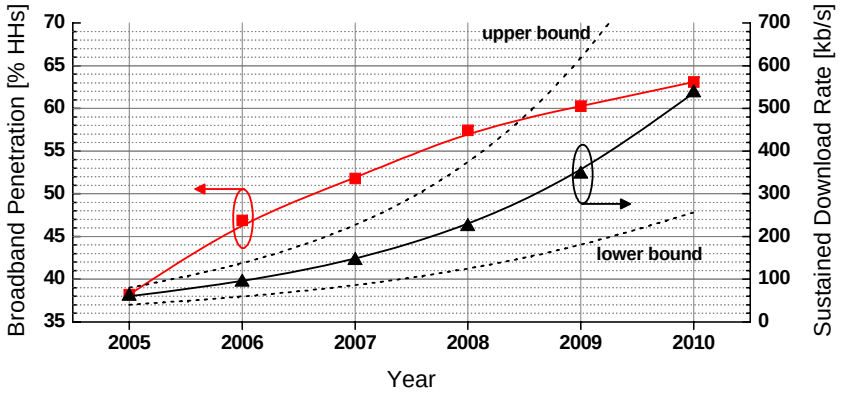
Traffic Breakdown: Voice, Data, Video

Voice



Data



- **Voice**
  - Traffic bandwidth usage predicted to remain nearly flat over the next 5 years:
    ~30 Gb/s in 2005-2010 for MAN with 1M households
- **Data (including P2P)**
  - Average sustained download rate of 41 kb/s (over 24 h per broadband user, 2005)
  - From peak-to-average bandwidth ratio of 1.44, obtain 60 kb/s per user in evening hours
  - Market study forecast of 55% growth/year → 340 Gb/s in 2010
    - Lower bound: 45% growth/year gives 160 Gb/s
    - Upper bound: 65% growth/year gives 620 Gb/s
- **Video**
  - Broadcast: 50 HD channels (8 Mb/s for HD) and 200 SD channels (2.3 Mb/s for SD) use only 0.9 Gb/s of BW in MAN
  - VoD: Potential for large amounts of bandwidth usage

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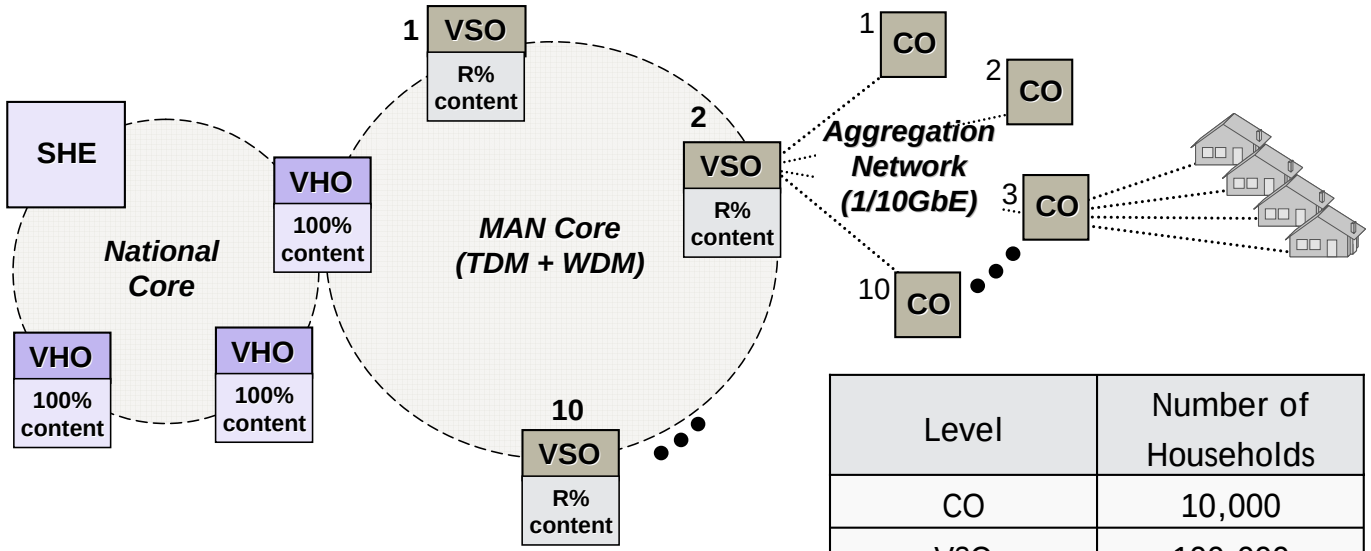
VoD Network Architecture



Level	Number of Households
CO	10,000
VSO	100,000
VHO	1,000,000

SHE: Super Headend
VHO: Video Hub Office
VSO: Video Source Office
CO: Central Office

- Based on service provider network architectures:
  → Layer of aggregation, optical MAN core w/ TDM and WDM
- VHO contain VoD servers that contain 100% of video content
- VSOs contain VoD servers with more popular content closer to users
- Unique HD stream sent to each user from VHO and VSO offices (assume HD, 8 Mb/s per stream)

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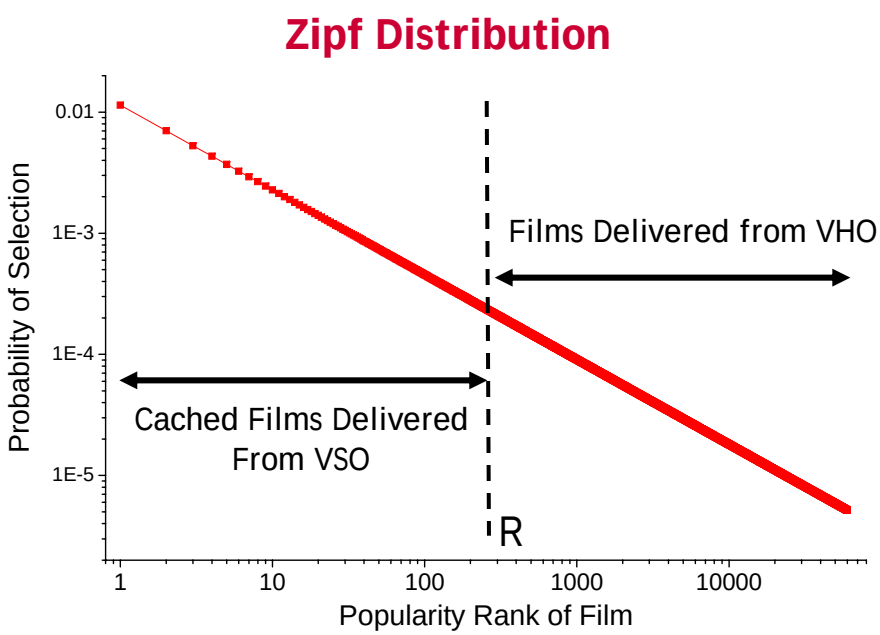
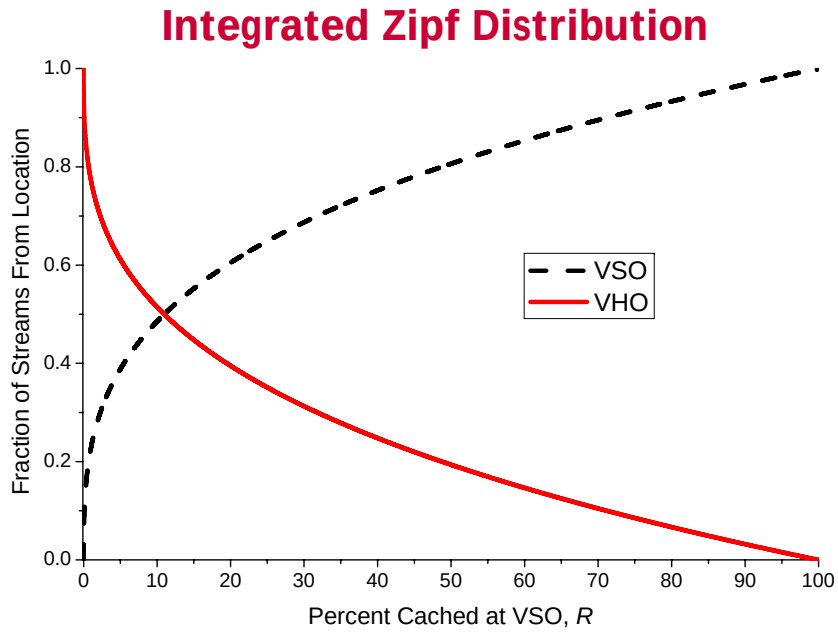
Content Popularity





- 60,000 films – More than today's VoD offerings, similar to Netflix
- Cache the more popular content at the VSO (closer to the end user)
- Zipf distribution: $P = M/k^a$, k is popularity rank, a = 0.7 for VoD content
- Integrated Zipf distribution shows fraction of streams from VSO and VHO as function of R

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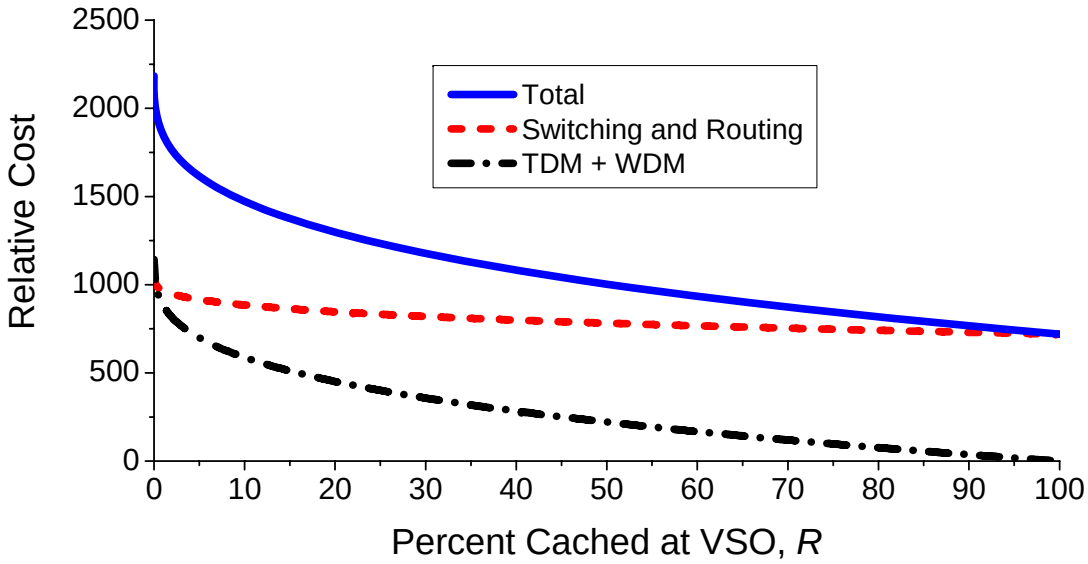
Cost for Switching, Routing, and Transport



- Routing & Switching
  - Cost for the router cards with Ethernet interfaces and the number of routing hops traversed
  - Some streams served from VSO, some from VHO (cost never goes to zero)
- TDM and WDM Transport & Switching
  - Assume MAN core is TDM circuits connected with WDM transport system with optical bypass
  - Only the traffic served from VHO incurs TDM and WDM cost
- VoD server cost
  - Include film storage cost and cost per VoD stream
  - Film storage cost increases with more content cached at VSOs

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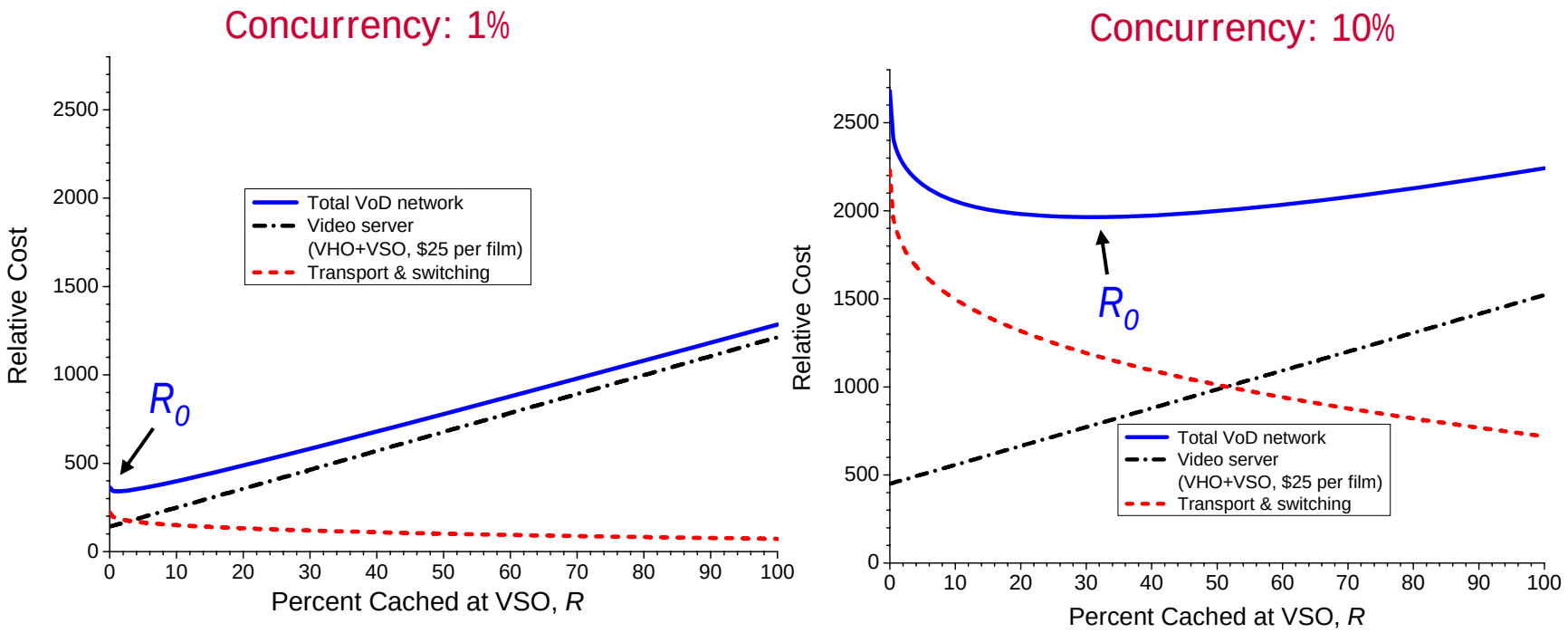
Optimum Amount of Caching



- Optimum amount of caching (R_0) found at minimum total network cost
- R_0 becomes higher as the concurrency increases
  - At high VoD usage, more content should be delivered close to the end user

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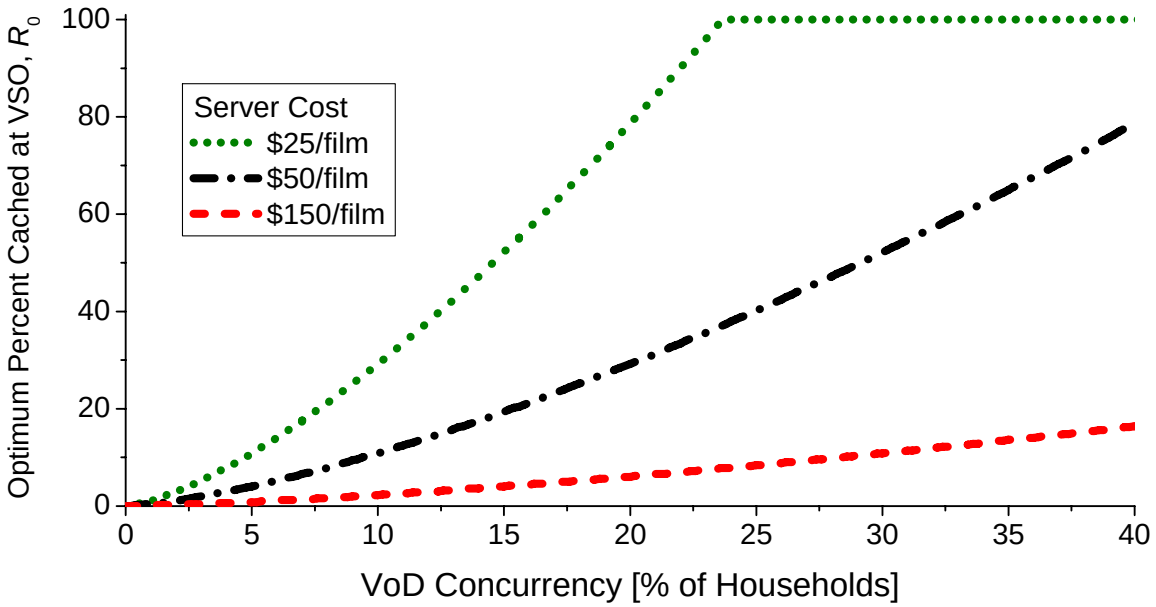
Optimum Caching Level



- At high VoD usage, more content should be delivered close to the end user
- When is all content delivered from VSO?
  - \$25/film: R_0 reaches 100% at low concurrency, 24%
  - \$50/film: R_0 reaches 100% at higher concurrency, 48%
  - \$150/film: some content always delivered from VHO
- Include OPEX overhead in cost

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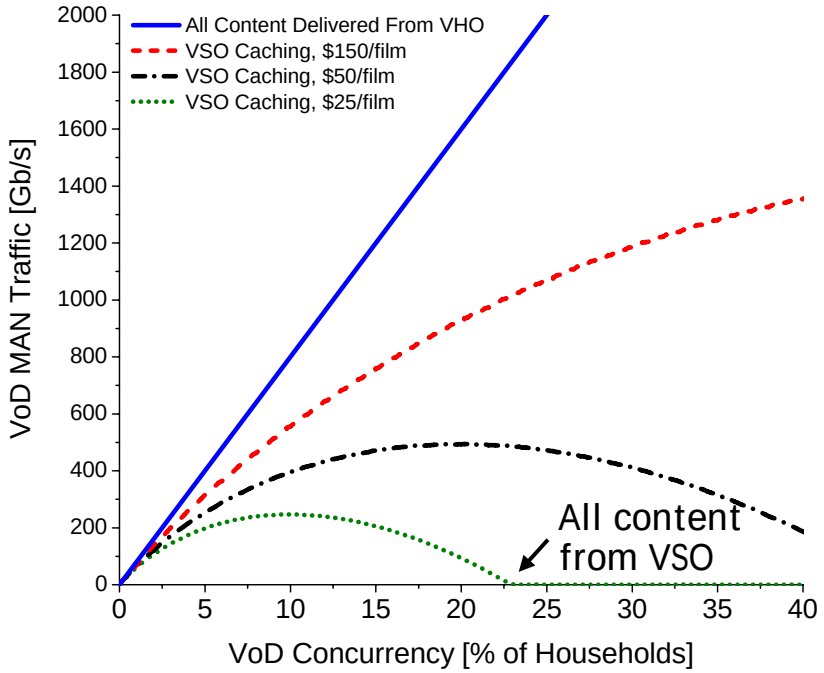
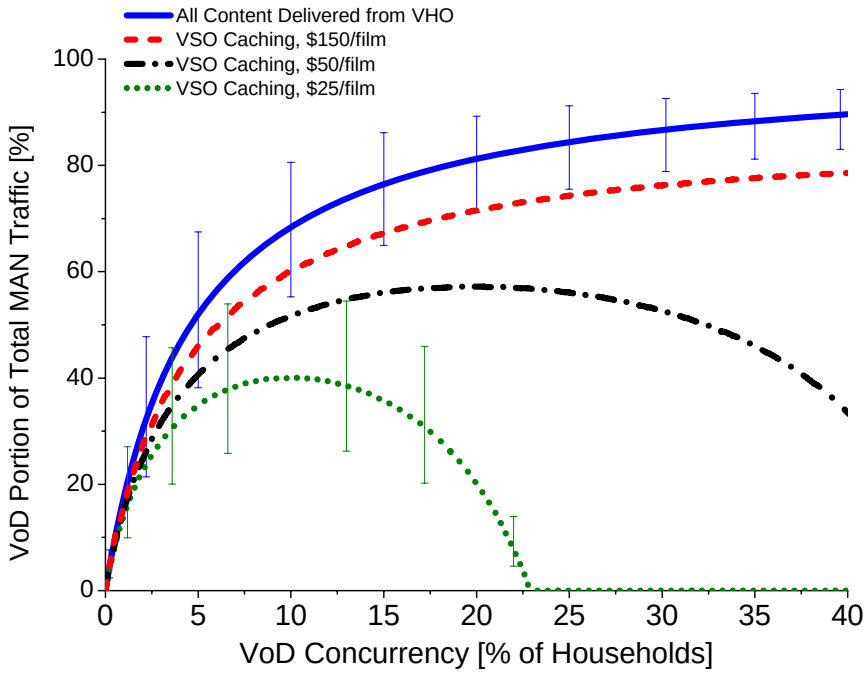
VoD Traffic in the MAN

VoD MAN Traffic



Video Fraction of MAN Traffic



- Multiple 100 Gb/s generated in MAN
  - MAN traffic peaks for low film caching cost as more content delivered from VSO
  - Argument for 100 GbE in the MAN network
- VoD portion of MAN traffic can range up to 90% for no caching, and up to 40% for low storage cost
  - VoD portion of MAN traffic given as fraction of total (voice + data + video)
  - Voice and data are projections for 2010 (30 Gb/s voice and 340 Gb/s data)

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Conclusions

- VoD delivery has the capability to generate multiple 100 Gb/s of traffic in MAN
  - Driver for 100 GbE
- Large percentage of MAN traffic may be VoD traffic – up to 90%
- Local caching closer to the user reduces MAN traffic
  - For a large number of titles (e.g. 60,000) fraction of VoD traffic in the MAN can still reach 40% with low caching costs
- Implications for the network
  - Video sensitivity to loss
  - Low packet burstiness for smooth streams from server
  - Many large packets
  - Unidirectional
- Network can be optimized for VoD delivery
  - Asymmetric delivery with high bandwidth density

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THANK YOU

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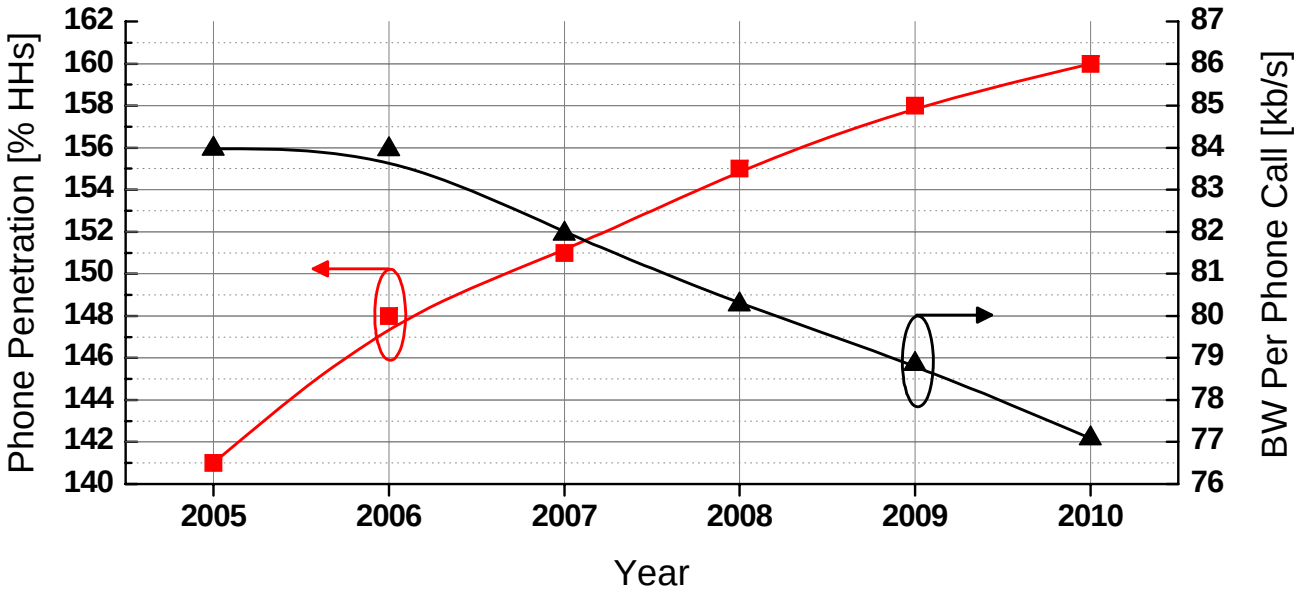
MAN Voice Traffic



- Voice traffic bandwidth usage predected to remain nearly flat over the next 5 years: 30 Gb/s in 2005, 31 Gb/s in 2010 for MAN with 1 M households
- Surveyed: Market studies forecasting subscription rate of mobile phones, fixed land lines, and VoIP lines
- Predict decline of PSTN lines but overall increase in phone connections due to growth in mobile and VoIP
- Growth in phone connections offset by decline in bandwidth per call due to PSTN replacement with more efficient VoIP and mobile lines

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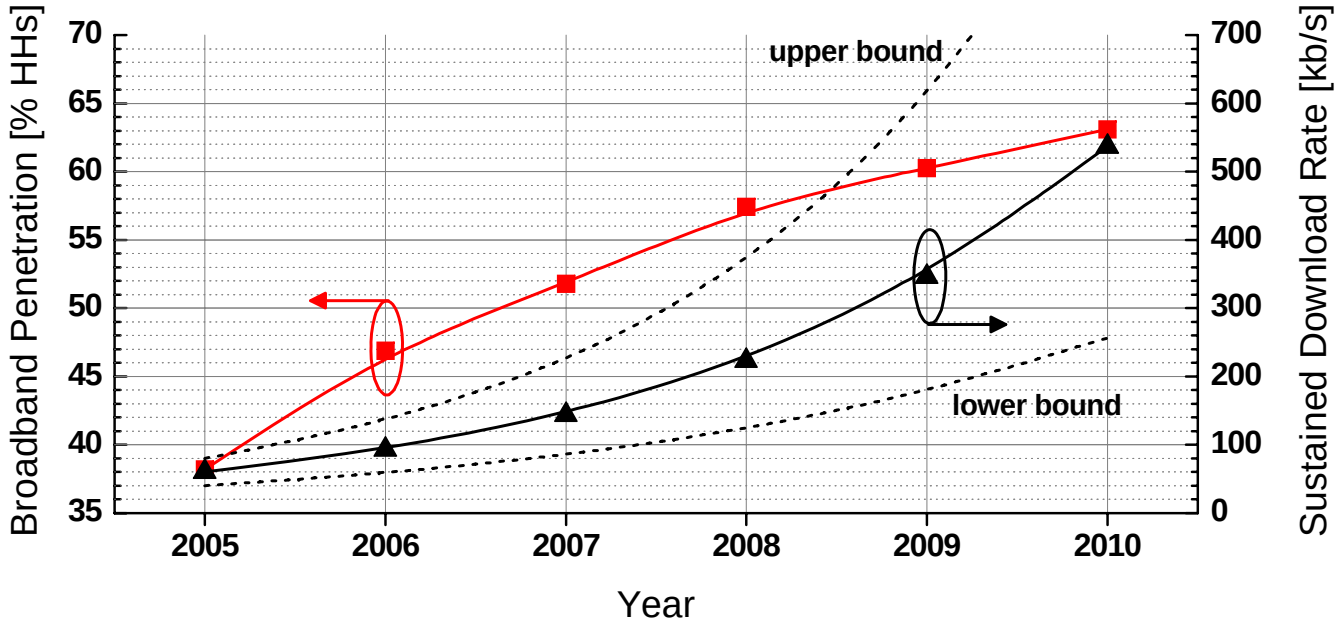
MAN Data Traffic



- From 2005 Japanese broadband access study, obtain average sustained download rate of 41 kb/s over 24 h per broadband user
- From peak-to-average bandwidth ratio of 1.44, obtain 60 kb/s per user in evening hours
- Market study forecast of 55% growth/year results in 540 kb/s in 2010
  - Lower bound: 45% growth/year gives 260 kb/s
  - Upper bound: 65% growth/year gives 980 kb/s
- Broadband penetration: 70%, Concurrency: 90%
- Ranges: 160 Gb/s → 340 Gb/s → 620 Gb/s in 2010

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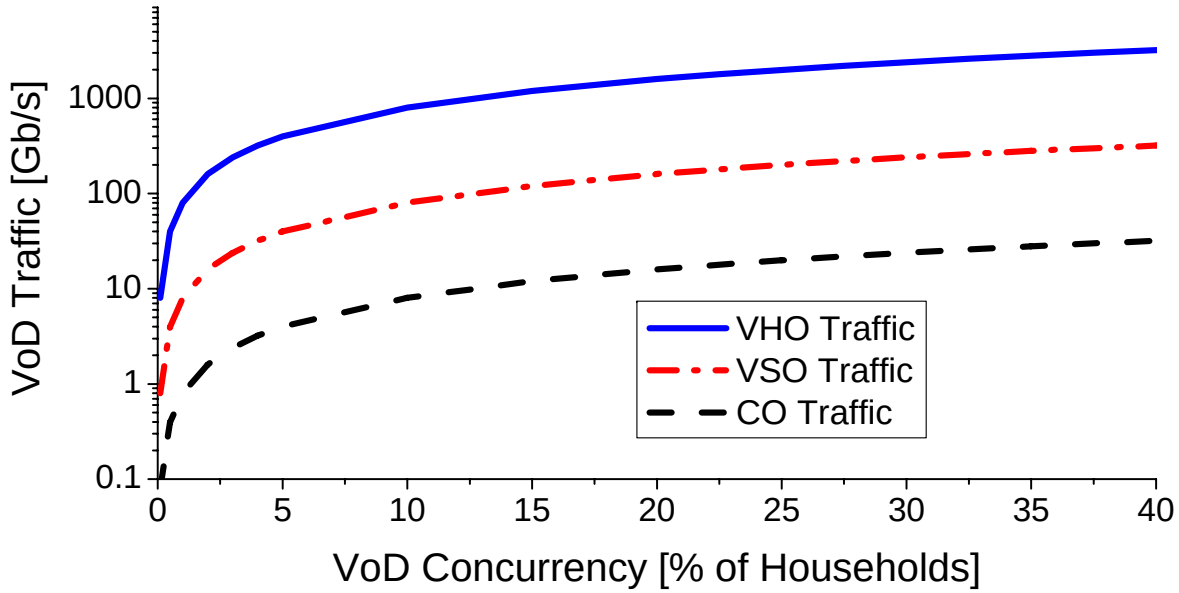
VoD Traffic, No Caching Limits



- Amount of traffic delivered from a single CO, VSO, and VHO assuming all content stored and streamed from that location (assume 8 Mb/s per stream)
  - CO traffic: below 10 Gb/s
  - VSO traffic: reaches 100 Gb/s
  - VHO traffic: multiple 100 Gb/s
- How does caching at the VSO reduce the VHO traffic?

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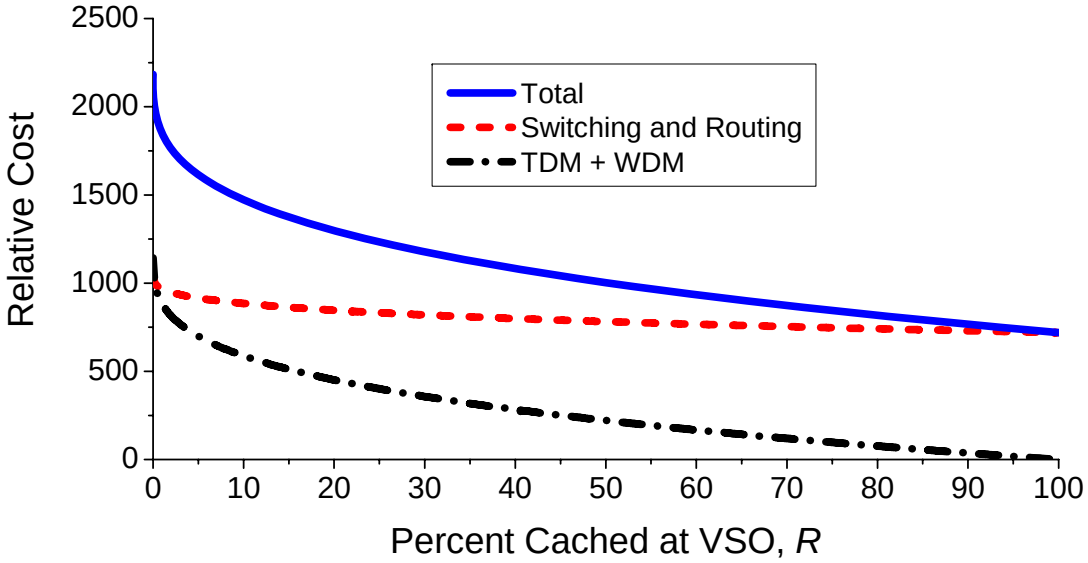
Cost for Switching, Routing, and Transport



- Routing and Switching: $C_{RS} = C_{EIF}\ (B_{VHO} * H_{VHO} + B_{total} * H_{total})$
  - C_{EIF}: Cost for Ethernet interface, B_{VHO}: BW delivered from VHO, H_{VHO}: Number of routing hops this traffic undergoes
- MAN core consists of TDM switching nodes connected with WDM transport links with optical bypass for through traffic: $C_{TDM+WDM} = B_{VHO}(C_{TDM} + C_{WDM})$
  - C_{TDM}: Cost for TDM interface, C_{WDM}: Cost for WDM interface
- VoD server cost: $C_{Server} = C_{Storage}(R*N_{VSO} + F) + C_{stream}*N_{Sessions}$
  - $C_{Storage}$: cost/film for disk storage and management, N_{VSO}: Number of VSO nodes, F: total number of films offered, C_{stream}: cost per VoD stream, $N_{Sessions}$: number of simultaneous VoD sessions

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