New user applications and broadband access – challenges for the network

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- Traffic on the Internet today
- Requirements for high quality audio and video
- Video service types
- Architectures for content distribution
- Traffic issues in content distribution networks
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Emerging New Network Applications

high-speed (xDSL) access is a disruptive technology
Disruptive technology

- Incremental technological advances are introduced by equipment vendors and service providers to improve the way we do things ...
- … but they often have the side effect of allowing us to start doing something we were not doing before
- Technological progress produces positive and creative discontinuities in user applications
- We want to plan ahead for the positive disruptions caused by high-speed access
- Network strategy must stay ahead and predict the changes
xDSDL as disruptive technology

- One discontinuity has been known for a while: xDSL is Always On
  - but so far there has been little application adaptation to this capability
- The innovation will probably come from the increased bandwidth initially and exploit Always On later
More bandwidth does not mean more of the same!

- **28.8kb/s:** Audio streaming
- **56kb/s:** Music and low quality video streaming
- **14.4kb/s:** Gopher ➔ Web graphics
- **ADSL:** A few 100 kb/s upstream, a few Mb/s downstream, high quality video?
Influence of “broadband” on streaming technology

- Streaming technology affects Internet components:

  Initial Focus of streaming technology (incl. Video codecs)

  HTTP servers can no longer cope with the load

  Content Distribution Networks: dedicated networks pushing content to the edge

  Content publishers learn the do’s and don’t’s of low bandwidth streaming

  - New roles are defined
  - Media companies incorporate the Internet distribution channel in business models

  - Fuels the development of streaming technology deployment
  - Starts the loop again
New applications and the home network

- The PC, as the multi-application platform, has been adopted by all categories of users: home, SOHO, SME and Corporate.

- With the PC being in the middle of networking and applications, applications are being networked, e.g.:
  - online games
  - picture and home movie exchange
  - pull communication: personal web sites.
The PC is no longer king of the Internet
New network appliances

- Putting more and more applications on the PC and making it simpler is a losing game
  - going beyond the community of fault-tolerant technophiles will require robust systems
- An important page is being turned – we’re moving towards application specific devices, used in homes, SOHOs and enterprises
  - network-aware PDAs
  - network-aware cameras and camcorders
  - network-aware music devices
  - network-aware televisions
  - multiple network-aware telephones
  - network-aware positioning devices
Traffic on current IP networks

Which traffic is on the network nowadays?
Elastic versus streaming applications

- **Elastic applications** (most of the time TCP-controlled)
  - if resources are available, they will try to consume them
  - if resources are temporarily unavailable, they will wait without being severely affected
  - examples: www, email, ftp, news, ...

- **Streaming applications** (most of the time over UDP/RTP)
  - once the first packet is played, there is a “deadline” for all others
  - for “interactive” applications this deadline is tight
  - a minimum amount of resources is required
    - only if this minimum amount is available, the application works well
  - examples: VoIP, streaming video, ...
## Applications and protocol stacks

<table>
<thead>
<tr>
<th>Application</th>
<th>Protocol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voice over IP</td>
<td>UDP</td>
</tr>
<tr>
<td>Video over IP</td>
<td>TCP</td>
</tr>
<tr>
<td>DNS</td>
<td>TCP</td>
</tr>
<tr>
<td>Real-time games</td>
<td>TCP</td>
</tr>
<tr>
<td>SNMP</td>
<td>TCP</td>
</tr>
</tbody>
</table>

## Protocol Stacks

- **UDP**
  - Voice over IP
  - Video over IP
  - DNS
  - Real-time games
  - SNMP

- **TCP**
  - HTTP (www)
  - telnet
  - FTP (file transfer)
  - SMTP (mail)
  - POP3, IMAP
  - NNTP (news)
  - IRC (chat)

- **IP**
  - Ethernet, ATM, PPP, ...

- **Ethernet, ATM, PPP, ...**
Current traffic mix

Traffic Mix February 2000 (percentage of bytes)

source: http://www.caida.org/outreach/papers/AIX0005/
Current traffic mix (cont’d)

Detailed Traffic Mix February 2000 (percentage of bytes)

Source: http://www.caida.org/outreach/papers/AIX0005/
Trends in the traffic mix

Source: http://www.caida.org/outreach/papers/AIX0005/

- Most traffic is still TCP-controlled
  - mainly web-related traffic
- There was not yet a lot of UDP traffic on the Internet (in February 2000)
- UDP traffic is growing
  - due to gaming traffic (1%) and
  - due to a limited, but growing, amount (1%) of streaming traffic (audio and video)
- Napster traffic has grown to about 1%
The Streaming Multimedia Scene

from narrowband to broadband:
from hype to critical analysis
Streaming media
some history

- Real Networks streaming client software
  - 1995: Introduction of RealAudio Software
  - 1997: First release of RealVideo
  - Today: >20 million RealPlayer clients installed

- Streaming media web sites (source: Multimedia Research Group)
  - 1998: 36,000
  - 1999: 108,000
  - 2000: 250,000
Lots of dotcoms focus on Internet video
“MP3 today - video tomorrow”
Telco - Cable operator competition

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**We want Video!**

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**Broadband Service Set**

- VoD - Interactive TV
- Broadcast TV
- High-Speed Internet
- Telephony
2001
back on the ground

- Fall 2000: dotcom bubble bursts - content sites disappear
  - DEN, FastTV, Pseudo, iCast, POP, ...
  - ad revenues cannot support broadband sites
  - content owners are cautious - copyright issues remain a challenge

- Telecom Providers still want video services, but ...
  - critical analysis of business models
  - efficient use of network resources
  - ONE video service will not be the killer application
Requirements

Which bit rates are needed for streaming applications?
Current quality is low

- Offered streaming content is of low quality due to bit rate restrictions
  - audio
    - music stations, radio news
    - 8 kb/s - 64 kb/s
  - video
    - news shows (CNN.com, abcNews.com), movie trailers (screening room)
    - 1 to 10 frames per sec
    - small image size (e.g. 144x180)
    - 16 kb/s to 128 kb/s
“High” quality audio and video

- TV quality video (currently) requires about 4 Mb/s (MPEG 2)
  - over a “good” ADSL link it is possible to stream one video channel in downstream direction
  - 1 movies lasting about 1.5 hour (say 5000 sec) takes about 2.5GB of disk space
- CD quality stereo audio (currently) requires 128 kb/s (MP3)
  - over an ADSL link it is possible to stream CD quality audio in up- and downstream direction
  - 1 song lasting about 3 min (180 sec) takes about 3MB of disk space
  \[⇒ \text{napster, gnutella happen!}\]
- Codec technology is still evolving
Video Service Types
Classification of video service types

- **Streaming**
  - **Broadcast**
  - **Near VOD**
  - **Video On Demand**

- **Download**
  - **Broadcast + Personal Video Rec.**
  - **Progressive Download**
  - **Pre-Download Video on Demand**

**Push** vs. **Pull**
Example service 1

**High Quality Video on Demand**

<table>
<thead>
<tr>
<th>Terminal</th>
<th>TV (high-end)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Video Quality</td>
<td>DVD - digital TV</td>
</tr>
<tr>
<td>Audio Quality</td>
<td>CD</td>
</tr>
<tr>
<td>Service</td>
<td>-VCR-like control</td>
</tr>
<tr>
<td></td>
<td>-EPG, T-commerce</td>
</tr>
<tr>
<td>Content</td>
<td>-movies</td>
</tr>
<tr>
<td></td>
<td>-documentaries - special events</td>
</tr>
</tbody>
</table>
## Example service 2

### Pre-Download Video on Demand

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Terminal</td>
<td>TV + Set-Top Box with storage</td>
</tr>
<tr>
<td>Video Quality</td>
<td>DVD - digital TV</td>
</tr>
<tr>
<td>Audio Quality</td>
<td>CD</td>
</tr>
<tr>
<td>Service</td>
<td>EPG, subtitling, ...</td>
</tr>
<tr>
<td>Content</td>
<td>-movies, documentaries, ...</td>
</tr>
<tr>
<td></td>
<td>-recent TV broadcast content</td>
</tr>
</tbody>
</table>
Architectures for Video Services Distribution & Delivery
Today’s basic webcasting model

- Simple client-server architecture
- Global scale
- User communicate
  - with content provider, or
  - with other users
- Integrated with web browsing
The Internet: no bandwidth, no multicast

- The current Internet can not support broadband streaming
  - “trickling media” instead of streaming media
- No multicast support
  - thousands of concurrent unicast sessions generate high server and network load
- Bandwidth scarcity
  - media quality is limited to bottleneck bandwidth between streaming client and server
Video services architecture

- Trying to solve the Internet’s problems: a two-step approach
Content distribution networks

- Dedicated (virtual) network that pre-positions content on the edge of the network, in surrogate servers
- Redirection mechanisms guide the client to the optimal surrogate server to answer the request
- Originally used for heavy components in webpages (jpeg's)
- Specialized companies offer content distribution services (Akamai, iBeam, Cidera, Digital Island, ...)
- Used for web casting (live) and video on demand
A content distribution network in action

User 1

User 2

User 3
Video Delivery (xDSL based)

- Live TV Content
- Recorded Content
- Satellite TV Content
- Video Server (VOD)
- DSLAM
- Modem / IAD
- STB

Supporting Services (Electronic Program Guide, Security, Authentication, Charging, ...)

Distribution

Delivery
Service Components for Video

- **A video operation: a lot more than media transport!**
  - Electronic program guides (EPG)
    - Personalised program guides and streaming portals direct the user to content in line with his personal taste
  - Video search engines
  - User authentication and authorization
  - On-line payment mechanisms
  - Digital Rights Management (copyright protection)
Traffic Issues
Traffic issues for streaming video

- Traffic characteristics of video
  - TV quality video needs a lot of resources
    - video streams are big streams (a few Mb/s)
    - video files to download are big files (a few GB)
    - how far can the evolving codec technology bring these requirements down?
  - burstiness of video depends on tolerable delay
    - zapping response of streaming applications
    - streaming versus download

- Is layered coding useful?
- Are adaptive applications useful?
  - TCP-friendly streaming sources
Traffic issues for streaming video (cont’d)

◆ Content distribution from the content provider to the edge
  ◦ streaming “live content” to the edge
    • how many bursty sources can be multiplexed in the core network?
    • acceptance control for UDP traffic of amount of UDP traffic grows
  ◦ copying “recorded content” to the edge
    • when to distribute the content?
    • to how many points?
◆ Streaming the content from the edge to the user
  ◦ how close to the user should the multicasting point be positioned?
  ◦ how many video streams can an xDSL link carry simultaneously?
Conclusions
Conclusions

- xDSL has the potential of being a disruptive technology
  - due to its very high capacity
  - due to its “always on” feature
- Internet traffic is mostly TCP-controlled nowadays
  - there is shift towards UDP traffic
  - there is nowadays a limited amount of streaming traffic (of low quality)
- Technology is ready for streaming video at high quality
- Content distribution networks, i.e. core network to distribute the content from the provider to the edge combined with multicasting network from the edge to the user, pose
  - new architectural issues
  - new traffic management issues
Backup slides
Crystal gazing:

What will the users do with their high-speed access?
The Future

- Video services must use the Internet experience model:
  - easy integration of applications
  - inherent interactivity
  - global reach

- The killer application will not be a single video service, but the bundle of broadband multimedia services:
  - on-demand, broadcast, download
  - conferencing applications

- PC is no longer king of the Internet:
  - Internet appliances used in home networks and on the road

- Digital Rights Management will remain a hot topic

- Content distribution is an example of application layer networking
Fetch bigger files

- The web content today is mostly static
- The increased capacity of ADSL, and the flat tariff, will initially encourage users to do a lot more of what they used to do with dial-up networks, i.e., download more/bigger files
- Big files means mostly video clips
- The amount of server based video content, and its variety, is very limited
- There is no real business model which would encourage this type of application to spread
Exchange bigger files

- Peer-to-Peer music exchange has already created a solid example of how and why this can work.
- Hardware at reasonable price now exists for home users to create, transform and capture video content.
- Unlike server-based commercial and archived content, p2p video exchange represent an unlimited potential content.
- The network traffic created can be huge – but avoids the problems of clustering characteristics of server file exchange.
Music exchange over the net has shown both the possibilities and dangers of exchanging existing commercial content.

The problem of content ownership for music and commercial films is going to continue.

We are still in the early days of user-network relationship. Users see themselves as primarily consumers of content.

Ultimately the users are going to move towards a more active and creative relationship, in which they both consume and create content.
See more of the world

- Combine a relatively large bandwidth and «Always On» and what have you got?
  Permanent windows to the outside world.
- Fifty years ago Isaac Asimov wrote that in future people will keep in touch with their friends and family by having large, high definition virtual windows into each other’s homes.
- Always-On High-Speed access is making this possible.
Innovation spreading backwards

Example

- Increased bandwidth makes it worthwhile to create a new application
- Large scale adoption of the new application creates a market and business support for improving codecs
- The improved codecs can now be used on the lower bandwidth access interfaces
- Example: Net Music
  - The 56K modems opened the door for AM Quality music
  - Large scale adoption of net-music created competition between the two Player Software providers
  - The codecs continuously improved to the point that now AM Quality music is possible at half the original rate