This Green Revolution
Improving the yield of your network investment

Internet Reloaded
March 2009

Eric Klinker
eklinker@bittorrent.com
What We Do

“we make the Internet more efficient”

For Consumers: Efficient access to content

For Publishers: Lower delivery costs, less infrastructure

For Operators: More efficient use of the network

Core Technology to organize User-Contributed Bandwidth into a Viable Resource
**BitTorrent Consumer Clients**

**Consumer BitTorrent freeware:**
- The world’s 2 most popular BitTorrent clients:
  - >200m downloads to date
  - >40m active clients monthly
  - High performance
  - Minimal resource utilization
Publishers will soon be pushing traffic that rivals P2P usage today

1: Source: Cisco Systems, Approaching the Zettabyte Era, Whitepaper June 2008
So what is an Exabyte?

- Roughly = 1 thousand PetaBytes = 1 million TeraBytes
  = 1 billion GigaBytes = 1 trillion MegaBytes

<table>
<thead>
<tr>
<th></th>
<th>Exabyte equivalent</th>
</tr>
</thead>
<tbody>
<tr>
<td>3,507,000</td>
<td>months of TV (stream encoded at 1 Mbps) (292,000 years)</td>
</tr>
<tr>
<td>64,944</td>
<td>months of Blu-Ray DVD (max std 54Mbps) (5,412 years)</td>
</tr>
<tr>
<td>20</td>
<td>months of 2007 YouTube traffic (1.7 years)</td>
</tr>
<tr>
<td>1</td>
<td>months of BitTorrent traffic</td>
</tr>
</tbody>
</table>

1. Assumes 50% network utilization
How to Deliver an ExaByte

Content Delivery – Past
- Content delivered directly from company server
- Delivery time slow, often interrupted and expensive

CDNs – Present
- CDNs provide global network of servers delivering files from the edge of the network
- Faster, more reliable delivery times; still significant costs

<table>
<thead>
<tr>
<th>1</th>
<th>Exabyte/month</th>
</tr>
</thead>
<tbody>
<tr>
<td>~70,000</td>
<td>Servers</td>
</tr>
<tr>
<td>~1.2</td>
<td>KWatt/ server (power + HVAC)</td>
</tr>
<tr>
<td>84</td>
<td>MWatts</td>
</tr>
</tbody>
</table>

Roughly equal to all revenues of CDN market leader Akamai

8% of the capacity of a large modern nuclear power plant (e.g. Japan’s 1100 MW Higashidōri)

~7,000 Gbps capacity
~$10 Price Per Mbps
$70M Monthly
Market Coverage – Big CDN

Market Saturation

Low 100 10k 1M >10M

High

Publishers
Improving Efficiency for Operators

- Policy and Routing
- Congestion Control
Policy

- Applications make ultimate peer selection based on peer performance
  - This does not consider potential efficiencies of
    - Capacity
    - Cost
    - Traffic Engineering
- Policy gives operators a say in these decisions
  - More effective traffic engineering
  - Help guide applications in the overall use of the network
- Can you approach Multicast efficiencies in network utilization?
Solutions to the Policy Problem

- “P4P” working group
  - Research sponsored by Yale University
  - Promising results from limited trials
  - However, the architecture is not suited for consumer BitTorrent
    - Trackers in this ecosystem are generally uncooperative
    - Clients learn about peers using decentralized means
      - DHT
      - PEX

- ALTO working group in the IETF
  - Recently chartered, first meeting in Minneapolis Dec ’08
  - Envisions something closer to a centralized policy service
Goals:
- Reduce Operator expense
- Improve the manageability of the network

1. Peer list xchg
2. PSS discovery and policy exchange
3. Connect to preferred peers
4. P2P download from cache (preferred peer)
5. P2P download/upload

Operators

Subscribers using P2P

Metro-core & Backbone

IP/MPLS Backbone

Peering/Transit Backbone

Internet P2P end-points

P2P Tracker

P2P Client

P2P Cache

P2P Client

Network topology data

Policy Svc

Operators

Internet
An Example Policy Format

cidr:10/8:10
asn:0:5
cidr:10.1/16:20
cidr:10.2/16:-10
cidr:[de:ad:be:ef:fe:ed]/48:20

- Positive weights are “Preferred”
- Negative weights are “To be avoided”
- Zero weight (or IPs not covered) are the default set
- The greater the weight, the greater the preference
We Need a New Congestion Control Protocol

- Replace TCP for P2P transfers
- Design Goals for this new protocol:
  - Keep the bottleneck full (maximize throughput)
  - Keep the delay lower than the unloaded delay + $e$
  - Yield to TCP on the forward path
  - Separate reverse path congestion
  - React in 1 RTT
- Congestion control approach:
  - Continuously estimate one-way delay
  - Separate queuing delay from propagation delay
  - Target a small value for queuing delay

We call this new transport “uTP”
Impact of uTP with target of 100ms

- **25-50ms**: Extreme gamers start to notice problems
- **50-100ms**: Gaming impact apparent
- **100-150ms**: Real-time gaming degraded
- **200ms**: VoIP stops working
- **250ms**: Games become unplayable
  - Interactive apps seriously degraded
- **400-500ms**: Web browsing seriously degraded

**Operators**
Implications for Network Operators

- uTP creates a “Scavenger Service”
  - Only idle capacity is utilized
  - Other applications have priority
- Networks can run “hotter” (with revised cap planning)
- Networks can now use capacity previously reserved
  - VPNs and MPLS
  - Operators enjoy improved profitability or reduced capex
- User complaints from P2P greatly diminish
- No ability for P2P from one user to harm another user

Potential for greater and more efficient use of the network
Status of uTP

- Implemented inside the ‘DNA’ commercial client
- Instrumented to minimize queuing delay
- Extensively tested in the lab
- Tested on the Internet in over 14M DNA clients worldwide
- Works as designed
- LEDBAT working group formed in the IETF
- Currently in testing with 400k beta consumer clients
- Planned implementation in over 40M active consumer clients.
What about Users??

- Users will have to “opt-in” to policy usage
  - ISPs can’t implement policies that hurt users
  - ISPs should provide an incentive to users
    - E.g. local, “on-net” bytes are free or don’t count against a cap
    - “Performance benefits” alone are likely insufficient

- Better congestion control improves the user experience
  - Eliminates common local congestion effect on the home network
  - Equivalent to automatic bandwidth management settings
  - ISP offered incentives for users work here as well
A Fork in the Road Ahead

Scavenger transport is a failure
Voracious clients emerge that break from the friendly posture
A return to the zero sum game of measure and countermeasure
The tragedy of the commons is confirmed

Scavenger transport is successful
Shaping/Blocking becomes an anachronism
Networks enjoy a period of profitable growth
The myth of the tragedy of the commons is confirmed
Thank you