Improving Deployability of Peer-assisted CDN Platform with Incentive

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Background

- The great popularity of large-scale video services on the Internet; e.g., YouTube

Managing ultimately huge video traffic is an important and challenge task

Cisco Systems, Visual Networking Index Forecast and Methodology, 2008-2013
Existing approach -- Peer-assisted CDN

- **Key idea:**
  - Make use of resources of participating peers
    - 100,000 users x 10GB / 10 % of CPU → 100TB of storage capacity, 10,000 CPU power
  - Distribute the workload on several peers/locations → good scalability and robustness

- **Effective to the large-scale video sharing services:**
  - YouTube [imc07]
  - MSN Video [sigcomm06]

- **Already deployed in the real world**
  - Joost, BBC iPlayer, P2P-next
Drawback of Peer-assisted CDN

- Random peer selection
  - It does not consider underlying network topology
  - Traffic can be unnecessarily scattered
  - Increase cross-domain traffic, which in general requires cost to deliver
Existing approach
- Managed Peer-assisted CDN (MP-CDN)

- The idea:
  - Make use of “Oracle” to avoid inefficient peer selection
  - “optimize” traffic based on the knowledge collected by Oracle

- Extensively studied in the past year
  - P4P: SIGCOMM 2008
  - Taming the Torrent: SIGCOMM 2008
  - IETF ALTO WG
Open issue of MP-CDN

- MP-CDN works gracefully in theory or in a controlled environment
- There have been no general studies that address how peers can be incentivized in MP-CDN

**Question:**
- What is the motivation for peer nodes to participate in the system and contribute their resources?
Our solution: a new business model

- ISP manages Oracle (PM server) and provides users with explicit incentive if they are cooperative to the system
  - Incentive can be virtual currency or some “points” that can be used in the system
  - Incentive can be fixed charge or calculated charge
- ISP provides CDN platform and Content provider and end-users use it
- **Principle:** End-users would prefer candy (incentive) rather than whip (bandwidth cap)
Key Idea of our business model

Sell electricity back

Why not using this model in the network context?
Model of MP-CDN in an ISP

ISP

PM Server

Original Server

direct download

peer-assisted download

End-hosts
Analysis of the model

• Show the intrinsic trade-off between cache performance and cost for incentive
  • Increasing incentive
    → increase in the # of participating users
    → improve the cache performance → save the traffic cost
  BUT...
    → increase the cost for incentive as well

• Study how external factors such as #of users, #of files, and storage capacity of each user, affect the cache performance.

• Goal: To obtain design implications
Simulation setup

- Nodes are identical
- Content requests arrive with the Poisson process
- Nodes keep content files with LFU cache algorithm
- The nodes and content files are fixed (no churn)
- There are no resource constraints on bandwidth and CPU of nodes
File access pattern

- Stretched Exponential Distribution (Discrete Weibull)
- Realistic model of modern web workload

\[
p_i = \frac{y_i}{\sum_i y_i},
\]

\[
y_i = (-a \log(i) + b)^{1/c}
\]

\[
a = x_0^c, \text{ and } b = y_1^c
\]
Acceptance of Incentive

- Logit model
- Given incentive of $x$, a node becomes cooperative with the probability:

$$p(x) = \frac{1}{1 + e^{-(\beta_1 + \beta_2 x)}}$$
Simulation Setup cont’

- 10 independent experiments for each parameter setting
- N: # of end-hosts
- m: # of content files
- S: cache capacity of each node (# of files)
- Simulation time $T = 10000$
  - Corresponds to a month in real time
Role of incentive in the system

Cost factor
= Cost for incentive
- $\theta$ Cost of saved traffic

N=100, m=1000
T=10000
The effect of # of nodes (N)

Incentive x = 10
Other external factors
Design implications

- There exists *optimal* amount of incentive (should be designed carefully)
- It is better to keep # of nodes in a P2P NW small
- It is better to keep # of distinct content files small
- User storage capacity can be fairly small
Conclusion and future work

- A new business model - selling bandwidth back to ISP
  - Solve the incentive problem
- Design implications through the simulation analysis
- Studying more realistic model, e.g., heterogeneous setting is for our future work
Roles of PM (peer mgmt) server

• Acts as “virtual cache server”
  • Keeps the list of peer nodes and their files
  • Storage space is given by peer nodes

• Acts as “Oracle”
  • Select peers according to the underlay network information

• Provides “AAA” functions
  • Accounting, authentication, and authorization
Business model

- User
  - Service, Ad.
  - Payment for content
  - Incentive (discounting)

- ISP
  - Sell
    - Machine Resources
    - Bandwidth
  - Service Agreement
  - Cheap, ISP-oriented service

- Content Provider
  - Service Agreement
    - Cheap, ISP-oriented service

Can establish “Win-win-win” situation
Other issues:

- **Scalability**
  - Avoid making PM server be a single point of failure

- **Underlying network structure**
  - Upload bandwidth bottleneck (CATV)

- **Privacy**
  - Introduce some randomness in the peer selection

- **More efficient content delivery**
  - Introduce the pipelining model like BitTorrent, i.e., files are chopped into pieces and transferred simultaneously