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Towards Sustainable Content Delivery with Peer-Assisted CDN

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SUMMARY Users are watching increasing amounts of video over the Internet, for which ISPs must be prepared. Of course, ISPs want to minimize the cost of delivering content to users. Due to the business and technical complexity of content delivery networks (CDNs), CDN managed ISP/Telco and the initiatives for CDN interconnection are soared in the recent years. On the other hand, the deployment of FTTx and xDSL is rising, increasing the technical opportunity for truly broadly distributed servers. We propose a network model of a peer-assisted CDN that involves cooperation between an ISP/Telco that manages its own CDN and its customers/users where the peer-assisted application is run on top of the customer's home gateway. We use a simple stochastic fluid model (stationary and stationary with churn) that seeks the different between ISP/Telco that using CDN only and ISP/Telco that using peer-assisted CDN in delivering video stream. We propose different admission policy by CDN for peers to join peer-assisted swarms. We give the results of a simple techno-economic analysis based on ISP game strategies.

Our simple approach correctly models the ratio of leechers to seeders based on the upload rate of seeders for stationary and for stationary with churn. We found that the upload rate of seeders has a big impact on the systems. Bigger upload means, ISP CDN can minimize cost of delivery to users. Upload rate of seeders has bigger impact compare to discount price
key words: *P2P, CDN, ISP, Game Strategy*

1. Introduction

Streaming content, especially video, represents a significant fraction of the traffic volume on the Internet, and it has become a standard practice to deliver this type of content using Content Delivery Networks (CDNs) such as Akamai and Limelight for better scaling and quality of experience for the end users. For example, Youtube uses Google cache and MTV uses Akamai in their operations.

With the spread of broadband Internet access at a reasonable flat monthly rate, users are connected to the Internet 24 hours a day and they can download and share multimedia content. P2P (peer to peer) applications are also widely deployed. In China, P2P is very popular; we see many P2P applications from China such as PPLive, PPStream, UUSe, Xunlei, etc. Some news broadcasters also rely on P2P technology to deliver popular live events. For example, CNN uses the Octoshape solution that enables their broadcast to scale and offer good video quality as the number of users increases.

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From the Internet provider point of view, the presence of so many always-on users suggests that it is possible to delegate a portion of computing, storage and networking tasks to the users, thus creating P2P networks where users can share files and multimedia content. Starting from file sharing protocols, P2P architectures have evolved toward video on demand and support for live events.

A P2P based architecture usually requires a sufficient number of nodes supplying the data (seeders) to start the distribution process among the joining peers. A peer usually offers a low outbound streaming rate due to the traditional asymmetrical DSL home connectivity and hence multiple peers must jointly stream contents to a requesting peer (leecher). The decentralized, uncoordinated operation implies that scaling to high number of peers comes with side effects. Typical problems of a P2P streaming architecture are low stream quality with undesirable disruptions, resource unfairness due to heterogeneous peer resources, and high startup delay. Moreover, current P2P applications are not aware of the underlying network and may conflict with the ISP routing policies and business model.

A number of P2P streaming applications have been designed, analyzed and deployed, attracting a significant number of users. Research studies and deployment experiences have both demonstrated that P2P is a promising solution in terms of scalability and deployment costs. On the other hand, the heterogeneous nature and unstable behavior of the peers contributing bandwidth and computational resources, along with the networking issues, affect the user experience and limit the commercial success of P2P video streaming applications. Alternatively, video contents can be efficiently distributed on services offered by managed network architectures and CDN companies. The major issues of CDN are high deployment cost and good but not unlimited scalability in the long term. Given the complementary features of P2P and CDN, in recent years some hybrid solutions have been proposed [1–3] to take the best of both approaches.

Broadband network access helps P2P applications to perform better. xDSL networks are deployed worldwide, and in some countries, such as Japan, even higher bandwidth fiber to the home (FTTH) already exceeds DSL in market penetration. In the coming years, FTTH will be massively deployed by network operators throughout the world. As access bandwidth increases, P2P systems may become more efficient since a peer can contribute much more.

P2P architecture offers great potential for content providers to cost effectively distribute content by capitalizing on the network resources already deployed for end users. It is economically superior to the traditional client-server architecture and it has been demonstrated by lots of academic work and successful commercial systems [3]. We believe more content providers will adopt P2P technology in the future.

Typically, each end user device is involved directly in the P2P swarm, both to receive the benefits of P2P and to serve others. In such cases, the installation of P2P software in every end device is necessary and the user is directly involved in the content's swarm. Under such conditions, the disposition of peers may result in unstable behavior and the swarm can be affected by the rapid and frequent disconnections that are common for mobile devices. Furthermore, users' devices usually can contribute to the swarm only with limited upload bandwidth. In addition, techniques developed to select P2P neighboring peers are often unfriendly toward the ISP's routing policies.

Different topologies have been proposed in the literature, such as those where the collaborative mechanism for content distribution is created among more stable devices such as residential gateways. The residential gateway (i.e., a home gateway placed in at the user's premises, serving several terminals within the home network but directly managed by ISP) is considered the central entity for a managed P2P infrastructure [4, 5]. Running on more stable and powerful devices, each gateway peer can contribute more bandwidth to the content swarm compared to the traditional end-user P2P systems. Peer selection procedures can be managed directly by the ISP, with the goal of avoiding the traversal of multiple nodes across ISP boundaries. Since P2P traffic is now decreasing and moving to the cloud [6], there is plenty of headroom for the ISP to use the gateway in a peer-assisted CDN, and the always-on nature of the gateway makes it the perfect device to run peer-assisted applications. ISPs may even be willing to give rebates to users who allow their gateways to be used, since the ISP benefits from incorporating the gateway into their CDN. With the growing interest to interconnect CDNs [7, 8], this architecture can benefit the ISP.

In this paper, we study the incentive for adopting peer assisted CDN for streaming and show its advantages.

2. System Description

Figure 2 shows our system architecture model, consisting of a two-level CDN (Level-1 and Level-0), and a P2P network. This two-level CDN follows the hierarchical model in Mathieu et al., [11], with some modifications. The Level-1 CDN consists of high capacity servers strategically placed to increase network backbone capacity. The Level-1 CDN is similar to current CDN networks, where CDN nodes can communicate with each other by using a common interconnect interface even though the CDN nodes are owned by different companies or different ISPs [7]. The Level-0 CDN consists of CDN proxies owned or managed by an ISP and placed close to end users. The CDN proxies join the P2P network along with other nodes owned by the end users.

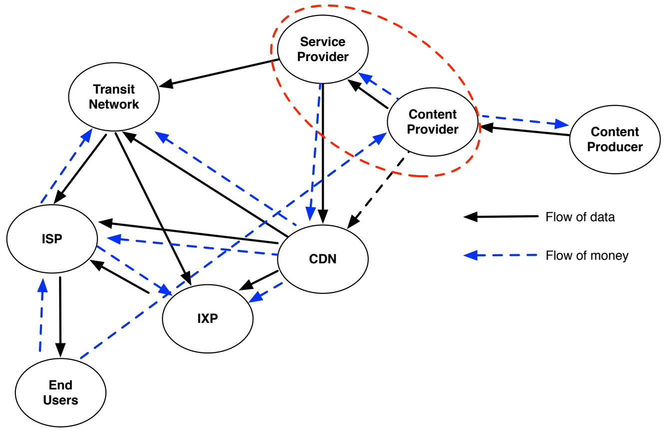

Fig. 1: Complex relationship of entities in Internet. The data flow from content producer to content provider. Content producer such as movies companies send their movies to content provider for example: Netflix and Hulu. Content providers then deliver the movies using CDN or they also can use their upstream provider. Depends on routing and peering policy, data from CDN can flow directly to ISP or flow to ISP via IXP (Internet Exchange) or via transit network. Flow of data noted by straight arrow and flow of money noted by dash arrow line. In current modern Internet topology, content provider and service provider can be merged in on entity, for example: Google. Labovitz et al., [6] mentioned that the hyper-giant entities such as Google doing massive peering to IXP in order to be closed to ISP. Although CDN is placed close to ISP network, it does not guarantee end-users can get good quality video stream [9]. Other than technical complexity as mentioned before, CDN also faces economic complexity [10]. Therefore, the future of CDN business is likely to live deeper into ISP networks, more integrated into and interleaved with ISP infrastructures.

The proxies communicate with each other to serve content requests from the users, serving the contents from their caches if the content is available or retrieving it from the Level-1 CDN servers otherwise. Some end user nodes assist the proxies to serve content requests by uploading the contents in their caches to other end user nodes, and a user node may either receive content exclusively from the proxies or from both the proxies and other user nodes, hence creating a P2P swarm. The user nodes are configured to not communicate with nodes outside the ISP's network, limiting the P2P swarm to a single ISP (or an administrative domain).

In this P2P network, the proxies can be considered to be super nodes, or super seeders, which serve all contents that cannot be served by other nodes. The proxies also coordinate the user nodes, whether they act as seeders or leechers. The proxies should satisfy all users while minimizing their resource usage, e.g., bandwidth and cache capacity, by optimizing the utilization of seeders in the P2P swarm. In the case of file sharing, the proxies may not need to serve contents to the seeders if the upload rate from the user nodes in the P2P swarm is enough to satisfy all users. In the case of streaming content, the proxies serve the contents at the full streaming rate to the seeders; the leechers do not need to receive the full rate from the proxies as they also receive some content from the seeders. Also in this case, even though the upload rate from the user nodes in the P2P swarm is enough, relying only on user nodes may cause some nodes to experience high latency, hence the proxies should have a good coordination strategy to satisfy the latency requirements.

The aim in introducing this system is cost reduction for the ISP, by reducing its core network needs and data volume with its own upstream provider, and its costs when providing its own CDN. Thus, the ISP may offer incentives, e.g., a subscription fee discount, to its users in order to get them to participate in the P2P swarm. It should also devise a strategy for its offers in order to achieve its commercial objectives, including customer satisfaction. The next section analyzes this system and the strategies of an ISP in introducing this system.

3. System Model and Analysis

We present a model for the interaction between P2P and CDN using a simple, single bitrate for video streaming as shown in Fig.3. The model is a stochastic fluid model similar to [12]. While the authors in [12] focus on the probability of degraded service on small and large systems, our work focuses on finding the minimum capacity for a CDN proxy to support the system. Minimum capacity is very important for capacity planning. In the next subsection we also present a simple game theory model to describe the interaction between the ISP who operates the P2P-CDN and the users. We aim to find out the indifferent utility function between ISP and users.

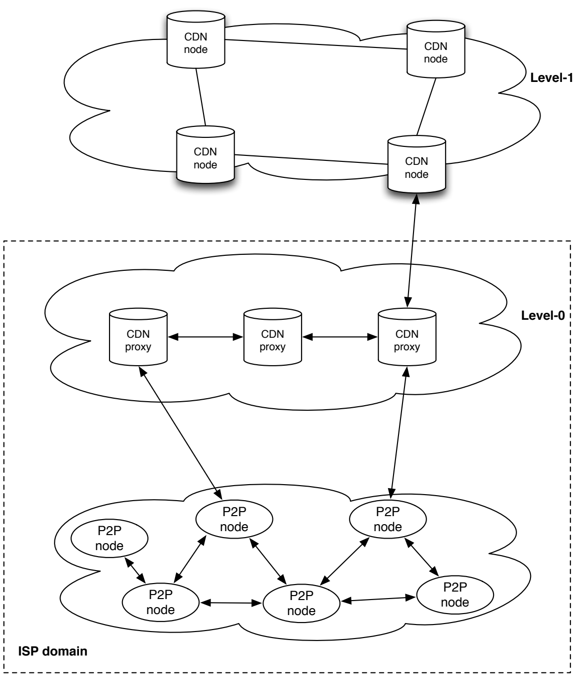

Fig. 2: Two tier CDN-P2P topology. The CDN proxy maintained by ISP. ISP also has CDN node. CDN node can exchange contents with other CDN node owned by other CDN companies.P2P nodes are ISP's customers that run P2P software.

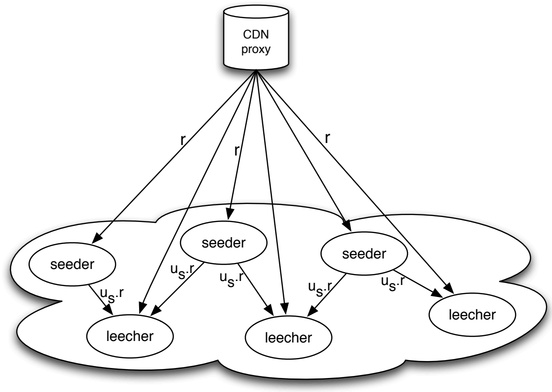

Fig. 3: System architecture on Level-0. P2P nodes that run on user home gateway communicates to CDN proxy. Let the upload capacity of each seeder as u_s and we normalize u_s to $r = 1$, then $0 \leq u_s \leq 1$.

3.1 System in Stationary State

Let the number of leechers and the number of seeders in the P2P swarm, not including the CDN proxy, be n_l and n_s, and the bitrate r. In order to satisfy the users' requests for streaming content, the minimum total upload bitrate to the P2P swarm is $(n_s + n_l)r$. Let the upload capacity of each seeder be $u_s r$, $0 \leq u_s \leq 1$, therefore the minimum CDN proxy capacity to support the system is:

$$U_p = n_s.r + n_l.r - min(n_s.u_s.r, n_l.r). \tag{1}$$

Note that if $n_l r$ is less than the upload capacity of the seeders, the proxy does not need to serve the leechers. Also note that if the system is for file sharing, then the CDN proxy does not need to serve the seeders. From the above equation, we define $X = \frac{n_l}{n_s}$, which is the ratio of the number of leechers to the number of seeders, and we normalize $r = 1$, hence:

$$\frac{U_p}{n_s} = (1 + X - min(u_s, X)), \tag{2}$$

which means that the upload capacity requirement of the CDN proxy relative to the number of seeders will be higher as X increases beyond $X = u_s$.

Figure 4 shows the system at equilibrium. For $u_s = 1.5$, the minimum required capacity CDN proxy relative to the number of seeders to support the system can be achieved if the ratio of leechers to seeders is less than 1.5. We see that the CDN proxy prefers a higher u_s in the system. A special case is $u_s = 0$, which is equivalent to no P2P swarm. It is also clear that as X increases, the CDN proxy must add capacity, thus adding the cost for the ISP.

3.2 System with Churn

In this analysis, we assume peers (user nodes) join at random times, stay in the system for random periods of time,

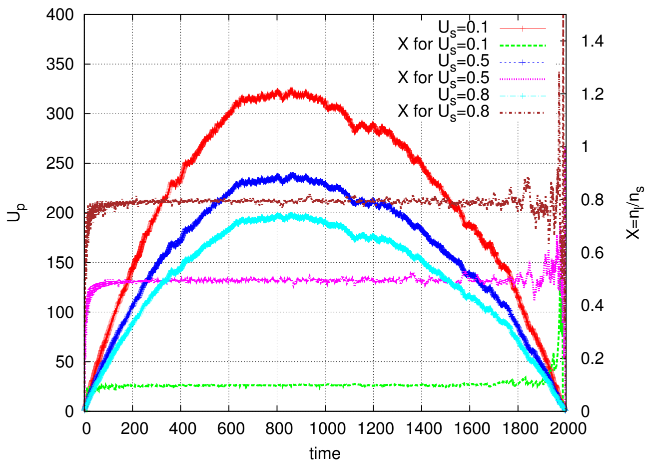

Fig. 5: U_p for $N = 1000$ for admission policy 1.

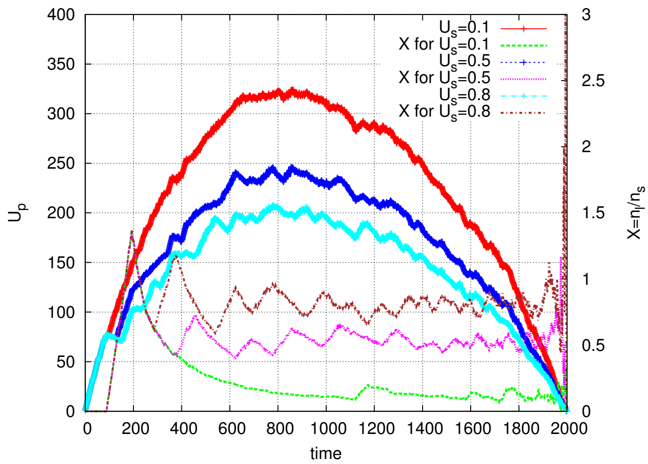

Fig. 6: U_p for $N = 1000$ for admission policy 2.

then leave. We assume the peer arrivals follow a Poisson process with rate λ, and peers staying in the system follow a general probability distribution with mean $\frac{1}{\gamma}$. Let $N(t)$ be the number of peers in the system at time t, i.e., the number of nodes in a $M/G/\infty$ queue. We can denote U_p as a function of time t

$$U_p(t) = N(t)r - min(n_s(t)u_sr, (N(t) - n_s(t))r), \qquad (3)$$

where $N(t) = n_s(t) + n_l(t)$, and $n_s(t)$ is determined by the system's admission policy.

We now compare two admission policies: 1. The system starts admitting new arrivals as seeders until $(n_su_s > n_l)$, then each arrival is admitted as a seeder or a leecher according to the equation. 2. The system admits arrivals every d time interval. If $(n_su_s > n_l)$ at the beginning of a time interval, all arrivals within the time interval are admitted as leechers, otherwise as seeders.

Figure 5 shows the U_p values during simulation with $N = 1000, \lambda = 2, \mu = 2, u_s = \{0.1, 0.5, 0.8\}$, and we use the first admission policy in this simulation. We also plot ratio values X using the scale on the right. Figure 6 shows the U_p values during simulation using the second admission policy with $delta_t = 1.0$ and other parameters kept unchanged. From both figures, we can see that the first admission policy can stabilize the value X in order to keep the CDN proxy capacity high enough to supply the system. In the second admission policy, the CDN proxy decides the same role for all peers arriving in a time interval. Figure 7 shows the CDF of X for $U_s = 0.1, U_s = 0.5$, and $U_s = 0.8$ for both admission policies. We can see that the second admission policy gives a higher variance, while the first admission policy can keep the ratio ideal. Finally, we can see that seeder upload makes a good contribution to this system. The next section discusses how to give incentives to the peers in this system.

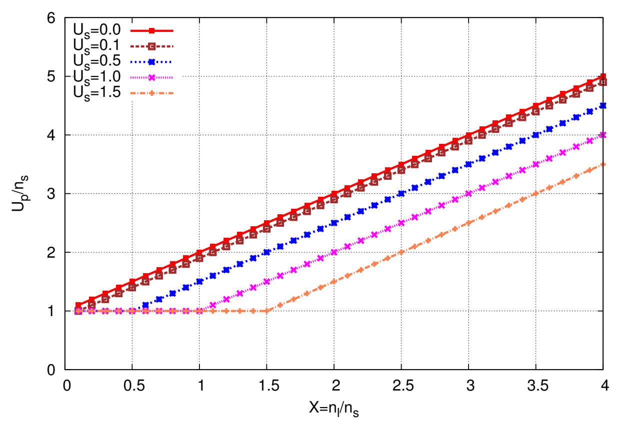

Fig. 4: Steady-state requirement for upload capacity relative to the number of seeders.

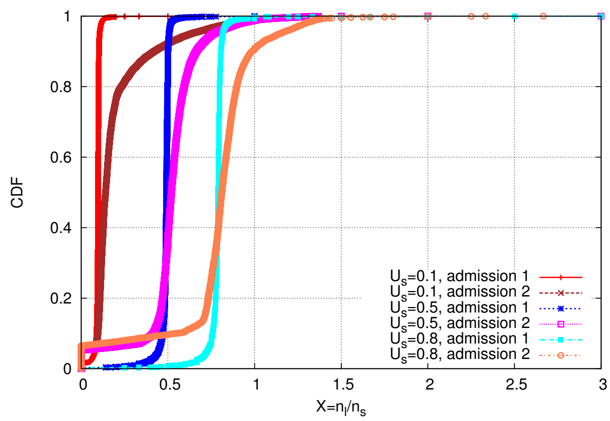

Fig. 7: CDF of n_l/n_s. We can see that the variance is higher for admission policy 2 compared to the admission policy 1.

3.3 ISP Strategies: Game Theory Approach

In this section, we present simple game theory approach for analysis of ISP strategies. Game theory as described in [13]

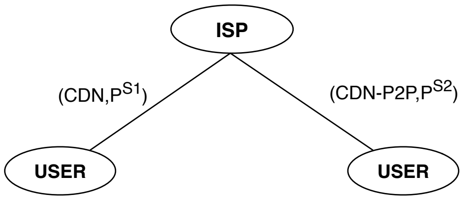

Fig. 8: Extensive form of game between ISP's strategies

is a mathematical framework to study and analysis of situation where decisions made by a set of two or more rational players. Basic element of game are: rational players, strategies, and payoff or utility. Rational players choose a strategy for maximizing its payoff or utility. Extensive-form game is representation of corresponding decision nodes in a directed tree. Later, we will use extensive-form game to represent our game. In our model, ISP has already attempted to implement solution for peer-assisted CDN. Moreover, it is reasonable to assume that ISP is naturally initiators. Stackelberg game also known as a leader-follower game is a class of game that concerns with situation where one player, the leader, initiates the decision making and where the second player, the follower, responds to the actions by the leader. Moreover in our model, ISP can be modeled as leader who decided to implement peer-assisted or not according to their expected payoff, while users can be modeled as followers that evaluate the decision of the ISP and responds according to their available actions and payoffs. In this section, we will focus on ISP side.

Definition 1 (ISP Strategies): We define the pure strategy space S_{isp} to include two strategies combination choice $s \in \{CDN, CDN-P2P\}$ and corresponding subscription free P^s. Futhermore, we denote the strategies as:

- $s_1 = (CDN, P^{s_1})$: the ISP decides to use CDN only and thus keeps charging the initial subscription free P^{s_1}.
- $s_2 = (CDN - P2P, P^{s_2})$: the ISP decides recommends peer-assisted and offers a subscription fee $P^{s_2} \leq P^{s_1}$.

Where the ISP strategy space $S_{isp} = \{s_1, s_2\}$.

3.3.1 ISP Payoff

We now describe the payoff function for ISP in our model. We assume a profit maximizing ISP that gains higher utility in proportion to the increasing profit, which is only determined by the revenue from users and the bandwidth cost to reach the users.

For the revenue model, we assume that the ISP collects revenue solely by charging an initial flat rate subscription fee $P^{(s_1)}$ to its N number of users who purchase internet access with equal and fixed quality of service. ISPs are often price discriminatory towards its customers and thus operate with different price levels for different bandwidth or QoS. ISPs are often get revenue from other businesses such as email hosting, web hosting, etc. In our model, we do not include such revenue, and we found it reasonable only to focus on users that buy the same internet access product. Given the above simplifications, the ISP collects a total revenue (when deciding on a strategy s) of $R = NP^{(s)}$. The analysis focuses on the ISP side only, and we are very interested to see the difference (δ) between payoff of strategy s_1 and strategy s_2. For strategy s_1, the payoff for the ISP is:

$$\pi^{(s_1)}_{(N)} = NP^{(s_1)} - NTP_t \tag{4}$$

$$\tag{5}$$

For strategy s_2, ISP has payoff:

$$\begin{aligned} \pi^{(s_2)}_{(N)} &= \pi^{(s_2)}_{(n_l)} + \pi^{(s_2)}_{(n_s)} & (6)\\ &= n_l p^{(s_1)} - n_l TP_t + min(n_s u_s, n_l)TP_t \\ &+ n_s P^{(s_2)} - n_s TP_t & (7) \end{aligned}$$

In $n_l p^{(s_1)}$ we use $p^{(s_1)}$ because leechers are not join to peer-assisted mode offer by ISP thus the price is without discount. We also note that $N = n_l + n_s$. Therefore payoff difference between strategy s_2 and s_1 is:

$$\begin{aligned} \delta &= n_l P^{(s_1)} + min(n_s u_s, n_l)TP_t & (8)\\ &+ n_s P^{(s_2)} - NTPt - NP^{(s_1)} + NTPt & (9)\\ &= n_s(P^{(s_2)} - P^{(s_1)}) + min(n_s u_s, N - n_s)TP_t & (10) \end{aligned}$$

Description of notation as follows:

- n_s is number of seeders.
- n_l is number of leechers.
- $P^{(s_1)}$ is subscription fee for strategy s_1
- $P^{(s_2)}$ is subscription fee for strategy s_2 where it is discount price.
- T is video traffic bitrate.
- P_t is transport cost.
- U_s is upload rate of seeders.

Explanation of notation as follows: $NP^{(s_1)}$ is revenue in strategy s_1. NTP_t is cost to deliver content to users in strategy s_1. $n_l p^{(s_1)}$ and $n_s P^{(s_2)}$ is revenue in strategy s_2. $n_l TP_t + min(n_s u_s, n_l)TP_t$ and $n_s TP_t$ is cost to deliver content to users in strategy s_2. We also noted that $P^{(s_2)}$ is price that ISP give in strategy s_2. $P^{(s_2)}$ is discount price because users accept strategy s_2 to join peer-assisted CDN. We can get discount price by indifference payoff between strategy s_1 and s_2 with total peer N:

$$\begin{aligned} \pi^{(s_1)}_{(N)} &= \pi^{(s_2)}_{(N)} & (11)\\ N.P^{(s_1)} - \tau^{(s_1)} &= N.P^{(s_2)} - \tau^{(s_2)} & (12)\\ P^{(s_2)} &= P^{(s_1)} - \frac{1}{N}(\tau^{(s_1)} - \tau^{(s_2)}) & (13) \end{aligned}$$

Where $\tau^{(s_2)}$ is traffic cost for strategy s_2 and $\tau^{(s_2)}$ is traffic cost for strategy s_1. Factor $\frac{1}{N}(\tau^{(s_1)} - \tau^{(s_2)})$ is discount factor. We can define discount factor as $\frac{\gamma}{N}(\tau^{(s_1)} - \tau^{(s_2)})$. Maximum discount that ISP can give to user when $\gamma = 1$ and minimum discount that ISP can give to user when $\gamma = 0$. We can also say that γ is a ratio that express how much of the ISP

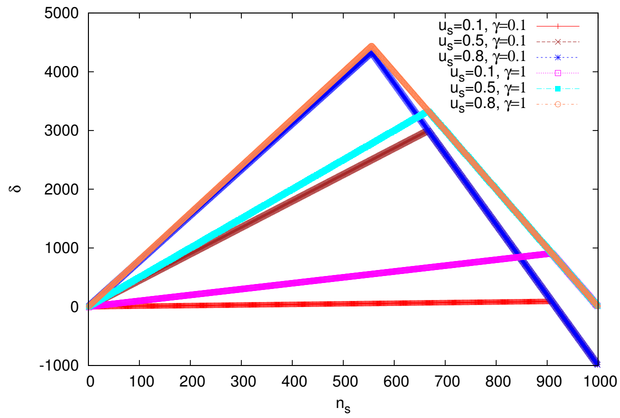

Fig. 9: δ between strategy s_1 and s_2 with U_s variation and γ variation. The peak of graph is the ISP maximum payoff with maximum number of seeders. The left side before peak is the region where ISP can add more seeders. The right side before peak is the region where ISP can not add seeder because the payoff is decreasing.

expected utility increase it wants to share with its users.

3.3.2 Numerical Result

In this subsection we do numerical evaluation the ISP strategy. The assumptions that we use for this numerical simulation:

- We assume that traffic is generated by video traffic and the traffic.
- We assume that user utilize 100% of their internet connection capacity.
- We assume users never turn off their home gateway so ISP do not need to give penalty to users.
- We assume there is no investment cost though ISP may need to give different firmware software to run peer-assisted application inside users home gateway. We assume that cost is very small thus we assume investment cost is zero.

Parameters value that we use in this numerical simulation as follows:

Table 1: Parameters values for simulation

u_s	$\{0.1, 0.5, 0.8\}$
N	1000
T	1Mbps
P_t	10USD
$P^{(s_1)}$	50USD
γ	$\{0.1, 1.0\}$

Figure 9 shows difference payoff between strategy s_1 and s_2. It shows clearly the inflection point where ISP get maximum payoff with maximum seeders. Thus the left side of line is the region where ISP still can add more seeders and the right side of line is the region where ISP can not add more seeders because the payoff is decreasing. We summarize the numerical results in table 2. It is clear that contribution of γ to ISP is very small. On the other side, contribution of seeder upload rate u_s to ISP payoff is big.

4. Related Work

Content Distribution Networks with peer-assisted have been successfully deployed on the Internet, such as Akamai [1] and LiveSky [14]. The Authors of [1] conclude from two real world traces that hybrid CDN-P2P can significantly reduce the cost of content distribution and can scale to cope with exponential growth of Internet video content. Yin et al., [14] described commercial operation of CDN with peer-assisted in China. LiveSky solved several challenges in the system design such as dynamic resource scaling of P2P, low startup latency, ease of P2P integration with the existing CDN infrastructure, and network friendliness and upload fairness in the P2P operation. Xu et al., [15] using game theory shows that right cooperative profit distribution of P2P can help ISP to maximize the utility. Their model can easily implemented to current Internet economic settlement. Misra et al., [4] also mentioned the importance of P2P architecture to support content delivery networks. The author uses cooperative game theory to formulate simple compensation rules for users who run P2P to support content delivery networks.

The idea of telco or ISP managed CDN has been proposed in recent years. The complexity of CDN business makes telco and ISP want to managed their own CDN. It has been shown that it is cost effective [16] [17]. Kamiyama et al., [18] proposed optimally ISP operated CDN. Kamiyama et al., mentioned that to deliver large and rich Internet content to users, ISP needs to put their CDN in data center. The locations are limited while the storage is large, makes this solution become effective, using optimum placement algorithm based on real ISP network topologies. The authors found that inserting CDN to ISP's ladder-type networks is effective to reduce the hops length thus reduce total link cost. On the other hand, an effort for telco or ISP managed CDN to be connected each other has been also initiated by Cisco to form CDN federation [16] using open standard [7]. They argue that the current CDN architecture is not close enough to the users and ISP can fill this position.

The idea to utilize user's computation power to support ISP operation is not new. The Figaro project [19] proposed residential gateway as an integrator of different networks and services and become Internet-wide distributed content management for future Internet architecture [19]. Cha, et al., [5] performed trace analysis and found that IPTV architecture powered by P2P can handle much larger num-

Table 2: Numerical Simulation Result

u_s	γ	n_s
0.1	0.1	909
0.1	1	910
0.5	0.1	666
0.5	1	667
0.8	0.1	555
0.8	1	556

ber of channels with limited demand for infrastructure compare to IP multicast. Jiang et al., [20] proposed scalable and adaptive for content replication and request routing for CDN servers that located in users home gateway. Maki et al., [21] propose traffic engineering for peer-assisted CDN to control the behavior of clients and presents a solution for optimizing the selection of content files. Mathieu et al., [11] mentioned that in France telecom network, peer assisted delivery give great benefit. 5% population of FTTH with 60% upload rate can serve all networks for 600Kbps video stream. A work by Mathieu et al., [11] is the most relevant with our works. Our work is same in system model architecture which uses different level of topologies (Level-0 and Level-1), where in Mathieu et al., [11] the authors use different names, which are regional and national. We emphasize that compare to Mathieu et al., [11] our work provides completely different approach. Mathieu et al., [11] mostly based on empirical data from France telecom company thus the authors can directly calculate network load caused by video traffic and calculate network load saving if peer-assisted CDN is employed, while our study focus on mathematical model of different admission policies for peers to join peer-assisted CDN and ISP payoff can get from employing peer-assisted CDN.

5. Conclusion and Future Work

This paper presents scheme for peer-assisted ISP managed CDN model that estimate lower bound of peers based on stochastic fluid model and estimate the economic incentive for ISP based on game theory. We have same observation with Mathieu et al., [11]. Compare to discount price, We found that upload rate seeder has big influence to the system. Finally, our numerical result shows that peer-assisted CDN managed by ISP or telco is feasible to deploy and does not harm to ISP business. Some areas of improvement that we have identified for future are: more work on stochastic fluid model to include multiple video streaming bitrate and downtime effect of user home gateway and penalty to ISP payoff. We also very interested to include energy trade off this peer-assisted CDN architecture in order to know how much energy saving by ISP and how much increase of energy at users home gateway side in this architecture.

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