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研究課題名(和文) Design and Implementation of Caching and Premium Peering Mechanisms for Internet Services Providers
研究課題名(英文) Design and Implementation of Caching and Premium Peering Mechanisms for Internet Services Providers
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研究成果の概要(和文)：ネットワーク帯域幅とキャッシュの価格設定は、インターネットサービスプロバイダー(ISP)のシステムリソースを収益化する上で重要な役割を果たし、特に情報中心ネットワーク(ICN)などの将来のインターネットアーキテクチャにおいて、ユーザーに対してサービスの品質(QoS)を提供するインセンティブを与えます。このプロジェクトの研究成果は2つあります。1) ISPがキャッシュをより効果的に収益化および管理できる実用的な契約を設計しました。2) ISPがCPの支払いに基づいて帯域幅を割り当てるプレミアムピアリングを開発しました。これらの研究成果について、いくつかの学術論文が発表されています。

研究成果の学術的意義や社会的意義

The findings of this research project offer practical solutions for improving the monetization and management of network resources, while also fostering a more efficient and user-oriented internet service ecosystem. They could also influence both academic research and industry practices.

研究成果の概要(英文)：The pricing of network bandwidth and caches plays important roles in monetizing system resources of Internet service providers (ISPs), and thus incentivizes them to provide quality of service (QoS) for users, especially for the future Internet architectures such as information-centric networks (ICN). The research results of this project are two folds: 1) We have designed practical contract under which ISPs can better monetize and manage caches, and 2) We have developed the premium peering between ISP and CP, under which ISP allocates bandwidth based on CP's payment. The time-based caching contracts and the corresponding pricing schemes for ICN has been studied, and the premium peering mechanisms between multiple competing ISPs and CPs where ISPs set price have been studied for allocating bandwidth to achieve QoS. Several academic papers have been published.

研究分野：Network, Network economics

キーワード：ISP CP pricing caching utility time-to-live game theory ICN

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1 . 研究開始当初の背景

According to Cisco Systems' report , nearly two-thirds of the global population will have Internet access by 2023. There will be about 5.3 billion total Internet users by 2023, up from 3.9 billion in 2018. Internet users are accessing the contents distributed globally through various kinds of devices such as Tablets, smartphone, TVs, Internet of Things (IoT) devices, and traditional personal computers. As content distribution over the Internet become more and more popular and important, future Internet architecture requires highly scalable infrastructures to distribute content efficiently. Information-centric networks (ICN) was proposed as a kind of important future Internet architecture to facilitate the contents distribution.

The pricing of network bandwidth and caches plays important roles in monetizing system resources of Internet service providers, and thus incentivizes them to provide quality of service (QoS) for users, especially for the future Internet architectures such as information-centric networks (ICN). Traditional caching policies such as least recently used (LRU) or most recently used (MRU) make caching decisions based on content popularity and therefore, do not help ISPs monetize their cache resources; and the best-effort Internet services provided by Internet service providers do not guarantee QoS.

2 . 研究の目的

In this research, we research on 1) practical contract designs under which Internet service providers can better monetize and manage caches, and 2) the premium peering between Internet service providers and content provider (CP), under which Internet service providers allocates bandwidth based on CP's payment. The purposes of this research are to propose time-based caching contracts and the corresponding pricing schemes for ICN, and to study premium peering mechanisms between multiple competing Internet service providers and CPs where Internet service providers set price for allocating bandwidth to achieve QoS. As an important and promising future Internet architecture, ICN has been promoted both by academia and industry. While most research has concentrated on the technical aspect of ICN, we will focus on the important economic aspect of ICN and provide the viability of future ICN architectures.

3 . 研究の方法

ICN uses content name as the routing locator has been proposed for efficient contents distribution. In ICN, content is dynamically cached in routers, which is different from traditional content distribution networks that still use IP address as routing locator and cache content at distributed servers, and caching has been identified as a critical component for ICN. We proposed a time-based caching mechanism for service providers (SPs) to monetize caching. The SPs cache contents of contents providers for a certain amount of time, depending on the payment from CPs (see Fig.1).

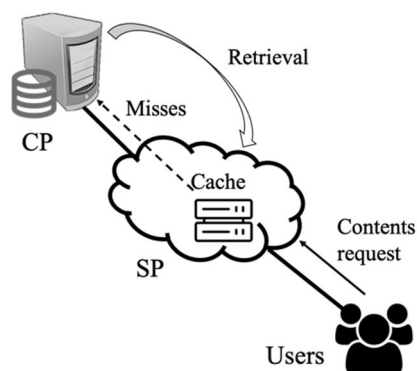


Fig.1 Cache retrieval model.

As shown in Fig. 2, a time-to-live (TTL) base cache replacement mechanism with nonlinear pricing is proposed. Different from traditional LRU cache replace mechanism, in TTL based cache mechanism, a timer is attached to each content in cache, and the content will be evicted if time set in the timer is out. The contents' TTL is determined by the payment from CP to SP. Therefore, SP has the incentives to deploy caches in its networks, while CP can control the contents' access performance for users. The analytical results for occupancy rate, CP's payment and utility are obtained.

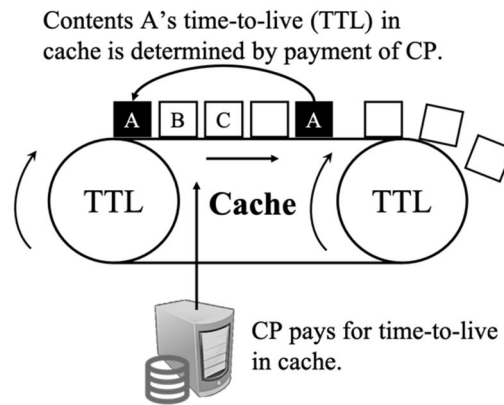


Fig. 2. Time-to-live caching: contents' time in cache is determined by the payment from CP.

4 . 研究成果

The research results of this project are two folds: 1) We have designed practical contract under which ISPs can better monetize and manage caches, and 2) We have developed the premium peering between ISP and CP, under which ISP allocates bandwidth based on CP's payment. The time-based caching contracts and the corresponding pricing schemes for ICN has been studied, and the premium peering mechanisms between multiple competing ISPs and CPs where ISPs set price have been studied for allocating bandwidth to achieve QoS. Several academic papers have been published.

5. 主な発表論文等

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2. 論文標題 Budget Allocation for Incentivizing Mobile Users for Crowdsensing Platform	5. 発行年 2022年
3. 雑誌名 IEICE Transactions on Communications	6. 最初と最後の頁 1342 ~ 1352
掲載論文のDOI（デジタルオブジェクト識別子） 10.1587/transcom.2021TMP0014	査読の有無 有
オープンアクセス オープンアクセスではない、又はオープンアクセスが困難	国際共著 -

〔学会発表〕 計4件（うち招待講演 0件 / うち国際学会 4件）

1. 発表者名 Cheng Zhang
2. 発表標題 Time Based Concave Cache Pricing for Information-centric Networks
3. 学会等名 Asia-Pacific Network Operations and Management Symposium (APNOMS) (国際学会)
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〔図書〕 計0件

〔産業財産権〕

〔その他〕

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6. 研究組織

氏名 (ローマ字氏名) (研究者番号)	所属研究機関・部局・職 (機関番号)	備考
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7. 科研費を使用して開催した国際研究集会

〔国際研究集会〕 計0件

8. 本研究に関連して実施した国際共同研究の実施状況

共同研究相手国	相手方研究機関
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