A New Cooperative Caching Mechanism in Distributed Social Wireless Networks

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Abstract

This paper mainly introduces very new cooperative caching policies to minimize electronic content provisioning cost in Social Wireless Networks (SWNT). SWNTs are the devices that are mainly formed by integrated collection of several mobile devices, such as data enabled phones, E-Book readers and a lot more, sharing all the common interests in the form of electronic content, and physically gathering all together in public places. The proposed new method of object caching in SWNTs are shown to be able to reduce the content provisioning cost. In this paper, we mainly proposed a new caching technique with cooperative mode practically deals with network, service, and pricing models which are then used for creating two object caching strategies for minimizing content provisioning costs in networks with homogenous and heterogeneous object demands. Finally at the end of our research, we construct theoretical and practical simulation models for analyzing the proposed caching strategies in the presence of selfish users along with several end consumers that deviate from network-wide cost-optimal policies.

Keywords

Cooperative Caching, Content Provisioning, Social Networks

1. Introduction

A wireless network consists of wirelessly interconnected, that can also interact with their surrounding environment by controlling and sensing ‘‘physical’’ parameters. Wireless Sensor Networks [1], [2] have rapidly increased its attention from many users during the last decade due to the advances in low-power hardware and the development of appropriate software. These networks have covered maximum with a huge number of applications, such as environment control and machine surveillance, target tracking in battlefields, and so on. In today’s mobile ecosystems, there was a huge demand with the emergence of these data enabled mobile devices and wireless-enabled based data applications. A list of such new mobile devices includes Apple’s iPhone, Google’s Android, Amazon’s Kindle, and electronic book readers from several other vendors.

By using conventional download model for downloading content by any mobile vendor , a user who wish to download the data, download’s contents directly from a Content Provider’s (CPS)

Server over a wide Communication Service Provider's (CSP) network. For the first time, CSP will involve a very initial action for the first time data download by taking a small amount of cost for each and every download. This amount may be collected either from the end users directly who wish for that data to be downloaded or sometimes it may charge by content providers who need that initial data from CSP's. To find out this research problem and to find how it works with CSP, we adopted Amazon Kindle E-Book delivery business model in which the Content Provider like (Amazon, Apple), pays to Sprint, who is the CSP, for the cost of network usage based on the downloaded content size each and every Kindle users who wish to download the E-Books for the first time.

Social Wireless Networks (SWNTs) can majorly be formed as a physical setting using ad hoc wireless connections between the mobile devices which is carried by users physically for the places like University campus, work premises, Shopping Mall, Airport, Railway Stations, Hospitals and other public places. Due to the existence of such SWNTs, an alternative approach to content access by a mobile device would be as follows: Initially search the local SWNT for the requested content before downloading it from the Content Provider's server. By doing in this way, the expected content provisioning cost of such an approach can be gradually decreased, since the download cost to the CSP would be avoided when the content is found within the local SWNT. This mechanism is termed as **cooperative caching**.

As there was limitation for mobile hand held devices in case of storage facility, different mobiles will have different storage capacities based on model and price of usage mobile, they are not expected to store all previous downloaded content for a very long time. This clearly tells that after downloading and using a purchased electronic content at the specified time, a hand held device may remove it from the storage location after some days. For example, if we look at Amazon Kindle clients (iPhone, iPad, etc.) an archive mode is available using which a user simply after reading the E-Book, he removes a book, although it was downloaded by paying amount for the CSP server. Based on the above two key questions which was raised by pricing model and data storage model for cooperative caching ,these are the questions that remained unanswered till today : *How to store contents in nodes such that the average content provisioning cost in the network is minimized*?

1.1 Optimal Result

In this paper, we mainly target to show that none of the above defined extreme approaches can minimize the content provider's cost. We also show that for a given pay-to-download-cost ratio, there exists an policy which is somewhere in between those already defined two extremes, and can able to minimize the content provider's cost by striking a balance between the greediness and full cooperation [3]. This is referred to as optimal object placement policy in the rest of this paper.

1.2 Selfish Users

Selfish users are one among the several users who always try to earn more and more money by deviating the network wide optimal policies. Any such deviation by selfish users is always expected to incur higher network-wide provisioning cost. In this current research work, we mainly try to analyze the impacts of such a selfish behavior users on object provisioning cost and the earned rebate within the context of an SWNT. In other words, we can also tell that, when the selfish node population is beyond a certain critical point, selfish behavior ceases to produce more benefit from a rebate standpoint.

1.3 Our Project Contributions

By considering all the assumptions what we have discussed till now, we will try to give following new project contributions for our proposed model.

- First, a new stochastic model for the CP's cost computation is developed based on a practical service and pricing case what we observed.
- Second, a cooperative caching strategy and a Split Cache are

proposed, based on networks with homogenous content demands.

- Third, Distributed Benefit based new strategy, is proposed to minimize the provisioning cost in heterogeneous networks.

- Fourth, the impacts of user selfishness on object provisioning cost and earned rebate is analyzed.

Finally, numerical results for all the above strategies are validated using simulation and compared with a series of traditional caching policies and finally in our conclusion we will try to draw a graph for those comparisons based on the technology what we choose for implementing this paper.

2. Related Work

This section mainly deals with network services and pricing model that was used for our proposed model.

2.1 SWNT Network Model

In this Network model, which is shown clearly in Fig. 1 illustrates an example SWNT within a local University campus. End Consumers carrying mobile devices form SWNT partitions, which can be either multi-hop (i.e., MANET) as shown for partitions 1, 3, and 4, or single hop access point based as shown for partition 2. A user mobile device can download an object (i.e., content) from the CP's server using the CSP's cellular network, or from its local SWNT partition.

SWNTs are mainly divided of two types. The first one involves mainly on stationary [5] SWNT partitions. Which means, after a partition is formed, it is maintained for sufficiently long so that the cooperative object caches can be formed and reach steady states. To investigate this effect, caching technique is applied to SWNTs formed using human interaction traces obtained from a set of real SWNT nodes [6].

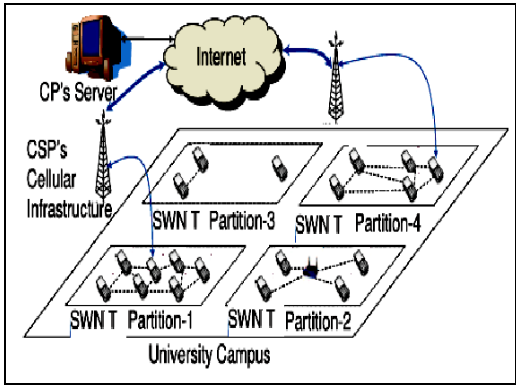


Fig. 1. Content access from an SWNT in a local University Campus.

2.2 Pricing Model

We use a pricing model in assumption similar to the Amazon Kindle business model in which the Content Provider (e.g., Amazon) pays a download cost C_d to the CSP when an End-Consumer downloads an object from the CP's server through the CSP's cellular network not from the local cache [7]. Also, the pricing model is applied whenever an EC provides a locally cached object to another EC within its local SWNT partition, the provider EC is paid a rebate C_r by the CP. Optionally, this paid rebate can also be distributed among the provider EC and the ECs of all the intermediate mobile devices that take part in content forwarding. Fig. 2 clearly demonstrates the cost and content flow model. As it is shown in Fig. 2, Cd corresponds to the CP's object delivering cost when it is delivered through the CSP's network, and C_r corresponds to the rebate given out to an EC when the object is found within the SWNT (e.g., node A receives rebate C_r after it provides a content to node B over the SWNT). For a given C_r = C_d ratio, the paper aims to develop optimal object placement policies that can minimize the network-wide content provisioning cost.

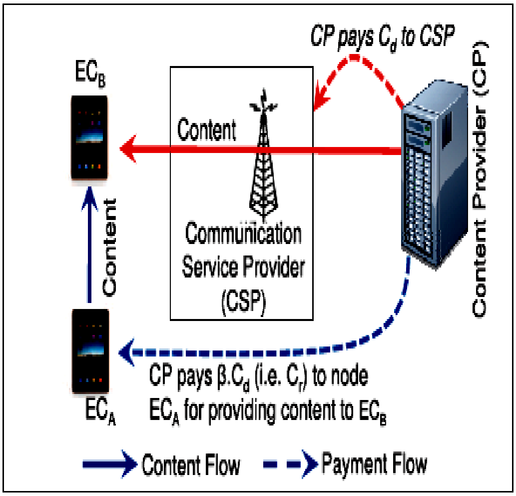


Fig. 2. Content and cost flow model.

3. Cost under Homogeneous Request Model

In this section, we mainly compute the average object provisioning cost under a homogenous request model where each and every device is having same functionalities. Let us assume for observation P_L be the probability of finding a requested object from the local cache (i.e., local hit rate) and, P_V be the probability that a requested object can be found in the local SWNT partition (i.e., remote hit rate) after its local search fails, and P_M be the probability that a requested object is not found in the local cache and in the remote cache (i.e., miss rate). We can write P_M in terms of P_V and P_L as

$$P_M = 1 - P_L - P_V.$$

According to the pricing model in Section 2.2, the Provisioning cost for an object is zero if it is found in the local cache, C_r when it is found in the SWNT and C_d when it is downloaded from the CP's server through the CSP's network. Thus, the average content provisioning cost.

$$Cost = P_V C_r + P_M C_d.$$

Expressing C_r / C_d as β and substituting PM from above equation, cost can be expressed as

$$Cost = (1 - (1 - \beta) P_V - P_L) C_d.$$

Where

$$P_L = \frac{1}{m} \sum_{i=1}^{N} n_i p_i,$$

4. Tree Optimization Technique

In this section, we initially consider the sub problem of finding the optimal positions of relay nodes for a routing tree given assuming that the topology is fixed. We assume the topology is a directed tree in which the leaves are nothing but sources and the root nothing but as the sink. We also assume that separate messages cannot be compressed or merged, that is, suppose if two distinct messages of lengths m_1 and m_2 use the same sink node (s_i, s_j) on the path from a source node or leaves to a sink node , the total number of bits that must traverse link (s_i, s_j) is $m_1 + m_2$

Our above algorithm in figure 3, starts by an odd/even labeling step followed by a weighting step. To obtain very best consistent labels for nodes, we start the labeling process from the root using a breadth first traversal of the tree. The root gets labeled as even. Each of its children gets labeled as odd. Each subsequent child is then given the opposite label of its parent. We define m_i , the weight of a node s_i , to be the sum of message lengths over all paths passing through s_i. This computation starts from the sources or leaves of our routing tree. Initially, we know $m_i = M_i$ for each source leaf node s_i. For each intermediate node s_i , we compute its weight as the sum of the weights of its children.

```
procedure OPTIMALPOSITIONS(U^0)
    converged ← false;
    j ← 0;
    repeat
        anymove ← false;
        j ← j + 1;
        ▷ Start an even iteration followed by an odd iteration
        for idx = 2 to 3 do
            for i = idx to n by 2 do
                (u_i^j, moved) ← LOCALPOS(o_i, S(s_i), s_i^d);
                anymove ← anymove OR moved
            end for
        end for
        converged ← NOT anymove
    until converged
end procedure
```

Fig. 3. Centralized algorithm to compute the optimal positions in a given tree

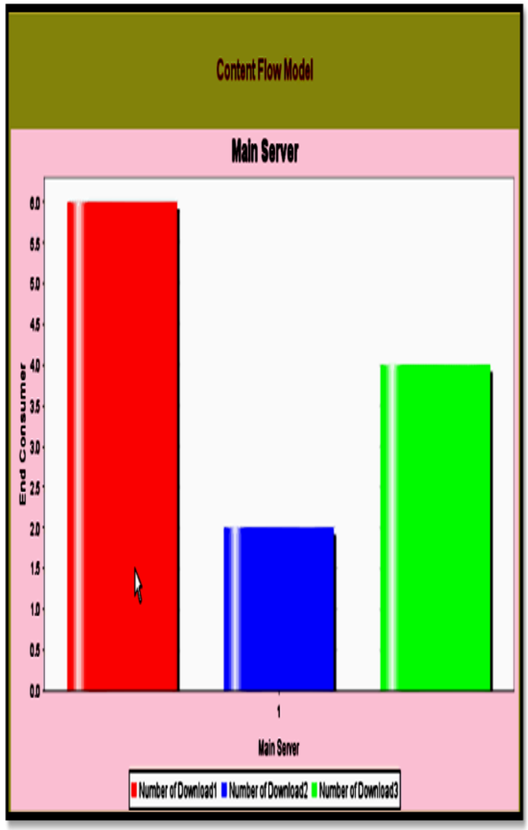
5. Experimental Results

In this section we will show the experimental results what we have observed by implementing the proposed techniques in this paper. For obtaining these results we have used Java as programming language for implementing this proposed new cooperative caching technique. The following are the results what we obtain after implementing the algorithm. As users try to download the data from both Content Providers and Content Service Providers, we get the following chart obtained from Admin point of view.

Admin Management Window

In the above window if we click on file upload link what we observe in that screen, the admin can able to upload any files or documents which is required for downloading by the users who participate in this task. For this uploading of various types of files we use the upload file option in Admin management window. Below that we will find one more option like View Graph, if that was clicked by admin, he can get the obtained results by various users who wish to download the data.

Content Flow Model Window



In the above window, we will find out the content flow model graph between End Consumers and Main server through which number of downloads takes place.

6. Conclusion

In this paper, we proposed a very new approach to minimize the total energy consumed by both mobility of relay nodes and wireless transmissions. Our proposed new approach improves the initial configuration of our nodes using two iterative schemes. The first scheme inserts new nodes into the tree. The second scheme computes the optimal positions of relay nodes in the tree given a fixed topology. This algorithm is appropriate mainly for a variety of data-intensive wireless sensor networks. Our simulation results clearly show that our proposed method is substantially reduces the energy consumption by up to 43%.

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