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SENSE AND CACHE – A NOVEL CACHING SCHEME FOR MOBILE USERS IN A CELLULAR NETWORK

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Abstract: - Internet, the largest database in the universe has become an indispensable source of information in every ones life. With the tremendous growth in cellular network infrastructures, there is a need from the mobile users also to access the internet on the fly. As the users in a cellular network switch between base stations frequently, caching is used to improve the internet access of mobile users. Several caching schemes available in literature cache the documents in a single central database which can be accessed by any mobile user. To increase the data availability, caching on mobile devices is also used. Though these schemes provide the documents requested by the mobile user at some point in time, they fail to provide uninterrupted internet access to mobile users during handoff. Moreover, as the documents are cached in a single central database, when more users request for the cached documents, these schemes increase their response time and the possibilities of congestion in the network. *To overcome these problems, a novel sense and cache scheme which prefetches and keeps the documents ready once a mobile user enters the coverage area of a base station and which periodically exchanges a Mobile Prediction Vector between base stations to provide uninterrupted internet access to mobile users is proposed in this paper.*

Key-Words: - internet, cellular network, mobile users, caching, handoff, response time

1 Introduction

With the change in lifestyle and with tremendous growth in the number of Mobile Users (MUs) in the recent years, there is a growing need for mobile users to browse the internet on the fly. The Cellular Network (CN)[10] infrastructure is to be improved to support online transactions to MUs. This enables them to do their day to day activities, viz., reading daily news, weather forecast, browsing emails, net banking, participate in online transactions, etc., on the fly. Most of the MUs browsing these sites travel through the same route almost regularly. Existing techniques [5,6,7] provide these services by caching the pages for each user in a central server of a CN to reduce the response time. But with the increase in the number of MUs, this central server will become overloaded and the possibilities of congestion in the links leading to the central server is also on the rise. Additionally, if the central server crashes, then the internet access to the entire set of MUs is lost. Moreover these schemes fail to provide seamless internet access to MUs during handoff. To provide an uninterrupted internet access to MUs with reduction in response time, bandwidth utilization, call dropping rate, and hence cost, a sense and cache
scheme with a periodic exchange of a Mobile Prediction Vector (MPV) is proposed in this paper.

Our simulation results show that e our sense and cache scheme improves the QoS in a CN as it reduces the response time, bandwidth utilization, call dropping rate, and the possibilities of congestion in internet access. The remainder of this paper is organized as follows: Section 2 discusses the related work, Section 3 gives the motivation for this paper. Section 4 discusses the proposed model, proposed scheme, and the results of simulation. Finally Section 5 concludes the paper.

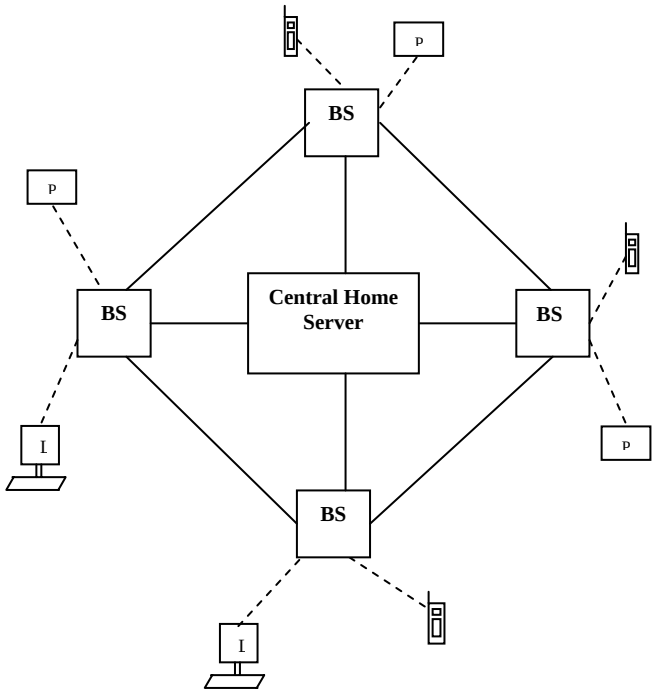
2. Related work

The recent advances in Mobile computing infrastructure enables MUs to avail some location dependent services from the CN. Many methods to locate cellular handsets have been proposed in [1]. These methods make use of angle of arrival (AOA), time of arrival (TOA), differential time of arrival (DTOA), assisted global positioning system (AGPS), etc., to locate the mobile devices .A location determination system based on Received Signal Strength (RSS) is proposed in [2]. An accurate cellular location system based on RSS is proposed in [3].These methods are of immense use in military, police or fireman radio networks where it is very critical to know about the precise location of each

person. With a variety and a large amount of data on the internet, accessing internet on the fly has becomes increasingly popular in recent years. This enables the MUs to get information viz., daily news, traffic reports, weather forecast, browse email, to participate in online transactions, video conferencing, etc. on the fly. As MUs travel, they switch between Base Station (BS)s frequently. To provide internet access to to MUs, the internet, a procedure referred as service handoff is proposed in [7,8]. Though this scheme balances the workload of servers and makes the system fault tolerant, it doesn't guarantee uninterrupted access to the internet when the MUs switch between BSs. The location aware cache replacement proposed in [5,6] caches the documents in the mobile devices. As such it cannot be used by other MUs in the same coverage area requesting for the same documents from the internet. Moreover, the amount of data that can be cached depends upon the size of the device and as such is not suitable to download lengthy documents from the net. To overcome these problems and to provide fast and timely internet access to the MUs, a novel sense and cache scheme is proposed in this paper.

3. Motivation

With the exponential growth in the need of MUs to access internet on the fly, it is required to support more users to access the internet at any point of time. Caching of frequently accessed pages by the MUs is one solution. As the MUs travel at different speed, they switch between BSs very frequently. So, the pages requested by them under one BS may not be available to them when they enter the new coverage area. If they place a request afresh under each BS's coverage area, then this leads to inefficient bandwidth utilization as the document gets downloaded many times as the MU moves along and not being accessed most of the time. This increases the network traffic, response time, and the possibilities of congestion in the network. Moreover, as the MU stays in one BS coverage for a short duration, he will not get the feel of browsing internet during his stay in that coverage. To enable MUs to get an uninterrupted access to the internet on the fly, and to improve the QoS in internet access to MUs, a sense and cache scheme is proposed in this paper. The location of the MU is sensed by [1,2,3] once he enters the coverage area of any of the BS. Then the cache scheme is used to provide the documents requested by the MUs at the earliest.



____ Wired link , P-PDA
-------- Wireless link, L- Laptop
Fig. 1. Proposed Model

4. Proposed Approach

The proposed model and the proposed sense and cache scheme are discussed in the following sections.

4.1 Proposed Model

The Cellular network (CN) consists of a number of BSs each controlling a specific area. To support sense and cache scheme, a novel architecture is proposed in this paper as shown in Fig. 1. In the proposed architecture, each BS in a CN is provided with a high speed processor and a cache server. The high speed processor in the BS maintains the user profile and deals with the signaling needed to sense MUs entry into the BS coverage area. The cache server is used for caching the frequently accessed pages by the MUs. The BSs which cover a region of around 35km radius are connected to a central server named the Central Home Server (CHS) of the CN. The downloaded information is maintained in the cache of the respective BS. The cache contents are refreshed by the LRU algorithm. The deleted pages from any of the cache servers are loaded into the CHS, and if they are not accessed for a long time, they are deleted from the CHS.

4.2 Proposed Sense and Cache scheme

The sense and cache scheme involves locating the position of MUs once they enter the BS's coverage area and pre-fetching the pages that are requested frequently by the MUs. To provide fast and timely access to the internet, the sense and cache scheme maintains an user profile in each of the BS of a CN. The entries in the user profile are based on how regular a MU is at visiting a BS. When a MU visits a BS for the first time, an entry is made in a Temporary User Profile (TUP) which maintains all the details about non-regular visitors for each BS.

Each entry in TUP holds the details of all the pages requested by the MU and a count about the number of times of access of each page by the MU. When the count of any entry reaches a particular threshold, then the entry is moved to the PUP. A MU is considered a regular visitor to a particular BS if he visits the BS at a specific time regularly at least five times within a gap of two days between each visit. This is applicable for all MUs who follow the same path daily to their workplace, residence, colleges, etc. For such users, an entry is created in the PUP and the pages requested by the MU to this BS are logged. An entry in the TUP/PUP is deleted only when the mobile host has not visited the BS continuously for a period of fifty days. To provide smooth handoff and an uninterrupted access to internet to roaming users, a MPV is periodically exchanged between the BSs. The fields of the MPV are as shown in Table.1. The first field gives the serial number with which the number of MUs currently in a BS can be found out. This gives the traffic in a particular coverage area. The second field is the MU's id which is sensed and loaded by the BS once the MU enters its coverage area. The third field, the Direction of Travel (DOT) will have one of two possible values 1 or 0. If a MU is entering a BS, then its DOT field in the MPV is set to 0. If the MU is moving away from a BS, then its DOT filed is set to 1.Whenever MPV is received by a BS, it counts the number of entries with 0 in DOT and with a 1 in DOT. Let it be M and N. N indicates the increase in traffic in the respective cell and m indicates the increase in traffic in the neighboring cell. With this knowledge, the BS can properly plan and give preference to handoff calls rather than local calls and thus reduce the call dropping rate. The fourth field Time of Entry (TOE) is loaded for regular users together with the URLs they access in the fifth field. The fourth and fifth fields are used to give smooth internet access to MUs.

Table 1: Fields of MPV

Sl.No	MU id	DOT	TOE	URL

4.3 Simulation and Performance analysis

A cellular network with few BSs and a set of MUs is simulated in our Institute network The TUP and PUP are maintained at each of the BS. Each BS is also provided with a cache server whose contents are updated as per user's request. In the simulation, a MU entering the BS for the first time is loaded into the TUP. The MU is considered a regular visitor to a particular BS if he visits the BS at a specific time at least five times within a gap of two days between each visit and an entry is created for him in the PUP. When a BS senses a regular MU entering its coverage area it immediately finds out the pages regularly browsed by the MU from the entries in PUP. It prefetches such pages and keeps it ready to provide it to the MUs upon request. Such downloaded pages can be used not only by this BS but also by any BS in the

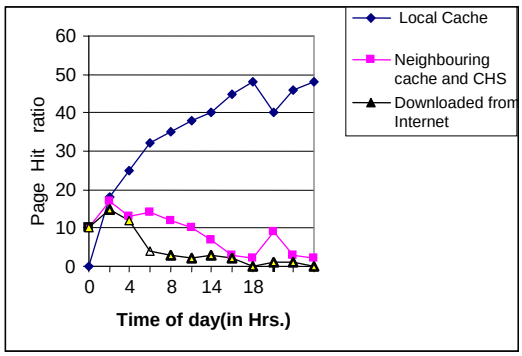


Fig.2.Time of Day Vs Page Hit ratio

CN. A graph plotted with the Page Hit Ratio Vs Time at a BS is shown in Fig.2. From the graph in Fig. 2, it is inferred that initially to service the MU requests, the number of pages loaded in the cache of each of the BS increases with time. When a page is not available in the BS, it is fetched from the neighboring BS and if it is not even there, then it is downloaded from the web. As time progresses, each BS loads into its cache almost all of the frequently requested pages by the MUs in its coverage area. So, there are no further requests serviced by neighboring BS and this is shown by the drop in curve in Fig.2. Also it can be seen from the graph that as each BS is provided with the cache and a page is downloaded

Table 2. Internet Bandwidth Utilization

Number of Users	B/W utilization	
	with SAC	without SAC
0	0	0
5	2	5
10	3	10
15	4	15
20	6	20
25	3	25
30	2	30

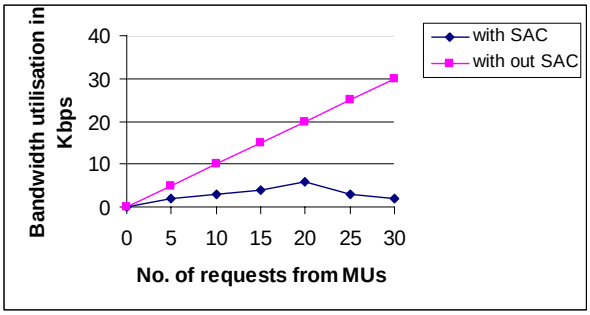


Fig. 3.No.of Mobile user requests Vs Internet B/w utilization

from the web only if it is not present in any of the cache servers in the CN, the number of pages accessed from internet is drastically reduced. This in turn reduces the utilization of bandwidth and the possibilities of congestion. The results of simulation are tabulated in Table 2. A graph plotted with these values is shown in Fig. 3. From the graph in Fig. 3, it is inferred that the B/W utilization with Sense and Cache (SAC) is less compared to that without SAC. As the BS in a CN are connected by a wired link and as most of the requests from the MUs are serviced from the BS's cache itself, the response time for the internet requests from the MUs is very less in our sense and cache scheme. Our simulation was carried out with a range of 0 to 30 page requests, with each page of size 50KB. The results of the simulation are tabulated in Table 3.A graph No. Of User Requests Vs. Response time is plotted with these values and is shown in Fig. 4. From the graph in Fig. 4, it is inferred that the response time for user requests is less with SAC scheme and more without this scheme. Moreover, to reduce the call dropping rate and to provide a smooth handoff, MPV is periodically exchanged between the BS and the results of the simulation are tabulated in Table 4. A graph plotted with these values is shown in Fig. 5. From the graph, it is inferred that the number of calls dropped is less in a CN with MPV compared to that without MPV.

Table 3: Response time

Number of user requests	with SAC(ms)	without SAC(ms)
0	0	0
5	1	1
10	1.3	2
15	1	3
20	1.2	4
25	0.8	5
30	0.5	6

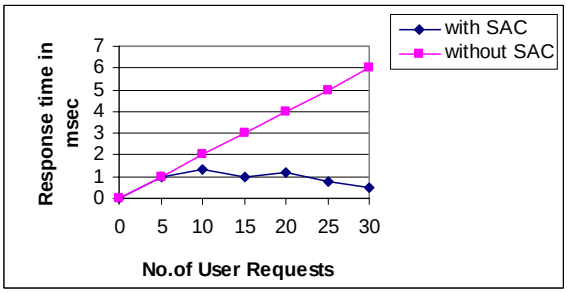


Fig 4. Number of User requests Vs Response time

Table 4: No. of Calls dropped

No. of Users	With MPV	Without MPV
0	0	0
5	1	3
10	2	8
15	3	13
20	4	18
25	5	23
30	6	27

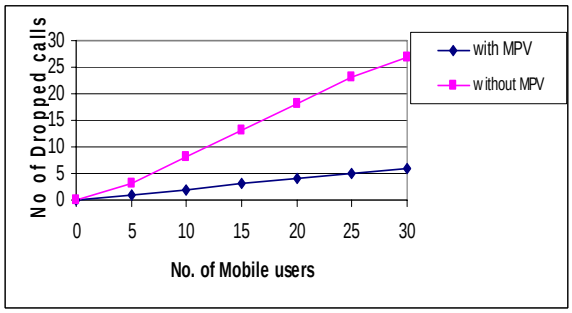


Fig. 5. No. of users Vs No. of Calls Dropped

5. Conclusion

With the tremendous growth in mobile computing and the need to access internet for day to day activities, there is a growing demand to provide internet access to mobile users through caching. To

provide fast, timely, and uninterrupted access to mobile users with efficient utilization of network bandwidth, a sense and cache scheme based on location of mobile users is proposed in this paper. Our simulation results show that this scheme not only reduces the response time but with the use of a Mobile Prediction Vector reduces the possibility of call drop during handover.

References

[1] M.A.Spirito,"On the accuracy of cellular mobile station location estimation," IEEE Transactions on Vehicular technology, vol.50,pp.674-685, May 2001.

[2] M.Sather, J.Snapp, and A.MacDonald, "Mobile Assisted Network Location System (MNLS) overview," FCC docket 94-102, April 4, 2001.

[3] Anthony J. Weiss, "On the accuracy of Cellular Location System Based on RSS Measurements," IEEE transactions on Vehicular technology, vol. 52, no.6, pp1508-1518, Nov 2003.

[4] Neal Patwari, Robert J.O'Dea, and Yanwei Wang, "Relative location in Wireless networks," IEEE proceedings of the Vehicular Technology Conference, 2001.

[5] Kwong Yuen lai, Zahir tari, and Peter Bertok, " Location – Aware Cache Replacement for Mobile Environments ," in the IEEE proceedings of Global Telecommunications Conference, vol. 6, pp. 3441-3447, Dec 2004.

[6] J.Xu,X.Tang, D.L.Lee, and Q.Hu, "Cache coherency in location dependent information services for mobile environments," ion the proceedings of the International conference on Mobile Data Access, 1999, pp.182-193.

[7] Wen-Chih Peng, Ming-Syan Chen, "Design and Performance studies of an Adaptive Cache Retrieval scheme in a Mobile computing environment ," IEEE Transactions on Mobile Computing, vol. 4, No.1, Jan 2005.

[8] U.Varshney and R.Vetter, "Emerging Mobile and Wireless Networks," ACM vol 43, No. 6, pp. 73-81, June 2000.

[9] Charles Perkins, "Mobile networking in the Internet," Mobile Networks and Applications, 1998.

[10] Jochen Schiller, "Mobile Communications", 2nd edition, Pearson Education, 2003