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Economically Viable Conversion of a Pedal Powered Bicycle into An Electric Bike

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Abstract – Among the scarce resources of the network, bandwidth and energy of the mobile devices are influenced by the data dissemination in the wireless network environment. So, it is necessary to have an efficient scheduling algorithm which effectively utilizes them and improves the system performance in terms of database size and client requests. But, the existing scheduling algorithms focused on the assumption that the clients request for the data are identical or fixed. However, the scheduling algorithms should be made available to the variable length (size) data requests and disseminate them using on-demand data broadcast model. In this paper, we introduce existing scheduling algorithms which use average stretch as the metric for data scheduling and propose an Optimal Round Robin scheduling algorithm. The proposed algorithm is then compared with stretch-optimal scheduling for on- demand broadcast. We show by analysis that the proposed algorithm achieves the optimal system performance.

Index terms- data dissemination, data scheduling, on-demand broadcast model and spacing

1. INTRODUCTION

The recent advancement and ever increasing growth in internet has created a huge demand on scarce network resources . This has led to the need for efficient scheduling algorithms for data dissemination. Among scarce network resources bandwidth & energy of the mobile devices are the most important features of data services. Most of the network applications use client- server model where clients request services or data from server and the server responds back to each client. We consider environment where in the available bandwidth of the server is sufficient to serve the clients request one at a time. Broadcasting data to all the clients is efficient to such environment. The client server model is best suited for application such as traffic information dissemination [2] , video on demand [3] , airline information , weather information and emergency services information [4].To utilize the services of network, one has to devise an efficient scheduling algorithm which gives best performance in terms of scalability and data transmission. There are two methods for information delivery for wireless network applications. They are Point-to-Point datadelivery and Broadcast.

In point-to-point only two devices communicate among themselves. Whereas in the later a single broadcast of a data item can satisfy all the outstanding requests for that item simultaneously. As such, broadcast has better performance in terms of scalability i.e., it can satisfy any number of users. There are three kinds of broadcast models, namely *push-based* broadcast, *On-demand* (or *pull-based*) broadcast, and *hybrid* broadcast. In push based broadcast [1, 5], the server disseminates information using broadcast program, generally without any intervention of clients. In on-demand broadcast [6,8,10], the server disseminates information based on the outstanding requests submitted by clients. In hybrid broadcast [7,9], push based broadcast and on- demand data deliveries are combined. Most of the researches [2,6,12] focus on the push based data broadcasting, wherein the server periodically broadcast the data items on the precompiled access patterns. Another kind of broadcasting is on- demand(pull-based) where clients request for the data are sent and then they are served by the server. [10] has initiated the study of on-demand data scheduling.

Many of the scheduling algorithms have studied in the context of operating system [11] are FCFS, Round Robin, SJF. Algorithms such as FCFS, LWT, MRF addressed in [13] are broadcast scheduling algorithms which are similar to the ones in [11].The algorithm given in [13] combines MRF and FCFS but assumes each item has same size(length) which is not suitable to the requests with variable sized data. [14,15] has given the solution for the above issue defining a new metric called Stretch. Stretch of a request is defined to be the ratio of the response time of a request to its service time(generally size is considered as the service time). The service time is the time to complete the request if it were the only job in the system.

The paper is organized as follows. Section 2 focuses on the model used for the proposed algorithm. Section 3 defines the proposed algorithm.

Section 4 evaluates the performance of the proposed algorithm. Section 5 ends up with the conclusion and future work

2. RELATED MODEL

Figure - 1 illustrates the model used for the proposed algorithm consisting of number of clients that send requests which are queued up at the server using uplink channel and server response to them using downlink channel based on the scheduling program. Here we make an assumption that there is a single server to serve the clients. The bandwidth of the downlink channel is much larger than the uplink channel.

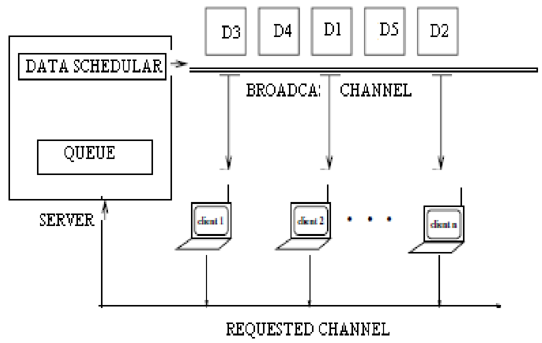

Figure - 1. On-Demand Broadcast Model

2.1 Related Algorithms

The authors [1] defined scheduling algorithms which use stretch as the metric for variable-sized data, Based on stretch, different algorithms have been investigated [8,10]. The algorithms considered are preemptive in the sense that the scheduling decisionis reevaluated after broadcasting data item

1. Preemptive Longest Wait First (PLWF): This is the preemptive version of the LWF algorithm. The LWF criterion is applied to select the subsequent dataitem to be broadcast.

2. Shortest Remaining Time First (SRTF): Thedata item with the shortest remaining time is selected.

3. Longest Total Stretch First (LTSF): The data item which has the largest total current stretch is chosen for broadcast. Here, the current stretch of a pending request is the ratio of the time the request has been in the system thus far to its service time.

4. MAX Algorithm: A deadline is assigned to each arriving request, and it schedules for the next broadcast the item with the earliest deadline. In computing the deadline for a request, the following formula is used:

deadline=arrivaltime+service time × S_{max} where S_{max} is the maximum stretch value of theindividual requests for the last satisfied requests in a history window. To reduce computational complexity, once a deadline is set for a request, this value does not change even if S_{max} is updated before the request is serviced.

5. First Come First Serve (FCFS) : Broadcast the data items in the order they are requested. To avoid redundant broadcast, request for data items that are already have entries in the queue are ignored.

6. Longest Wait Time (LWT) : Select the data item which had pending requests with largest waiting time.

7. Most Request First (MRF) : The item with the more pending requests are broadcasted first

8. Stretch – Optimal Scheduling Algorithm: The data items are selected on the maximum stretch value and then they are broadcasted. Here the stretch of each data item is calculated as

$$S(i)=\sum_{k \in Qi}(1/s^{2}_{i})$$

Where s_i is the size of the data item.

2.2 Assumptions:

Here, we make few assumptions for our algorithm.

1. We assume a system with a single server and multiple clients where uplink bandwidth is much less than the down-link bandwidth. i.e single channel for data dissemination.
2. Clients use separate channel to send the requests to server which is different from the broadcast channel. Every requested item is broadcasted by the server andis received by all the clients.
3. Let N be the number of data items at the server which have different lengths.
4. Let S_i be the size of each data item requested by the client . We also assume that the size of the item is the time taken to transmit the requested item to different clients.
5. Pi, is the access probability of i^{th} data item, which follow the Zipf's distribution with access skew- coefficient θ [16].

6. slice, is the time quantum.
7. Let wt_i , denote the waiting time of the i^{th} data itemin the queue, defined as

$$wt_i = SP_i * \lambda_i / S_i$$

where λ_i =pi* λ and λ arrival rate of the system. Andaverage waiting time is $awt = \sum^{N}_{i=1} wt_i / N$
8. avgstretch , is the time the client makes a requestand the time it finishes receiveing. Given as

$$avgstretch=T+ awt/N* b$$

where b is the bandwidth and T is the start time ofscheduling.

3. Optimal Round Robin Scheduling Algorithm:

Before presenting our scheduling algorithm, let us define the metric used for our algorithm. Let S(i) be the broadcast scheduling function called stretch, for data item i and is calculated as

$$S(i)=\sum_{k \in Qi} (1/s_i)$$

where Qi is the request queue of the data item i which is maintained at the server. Here we introducethe concept of spacing. It is defined as the amount ofcompletion time between successive broadcasts of parts of a data item. Let SP_i be the spacing for the i^{th} data item.

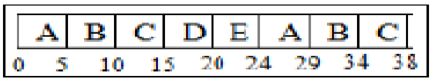

Figure - 2.Example

For example from the above Fig. the spacing for theitem A will be calculated as 29-5=16

3.1 <u>Algorithm</u>

This algorithm has II Phases. In the first Phase, data items are broadcasted for a period of slice by findingthe data item with maximum stretch. In the second Phase, based on their remaining service time the items are broadcasted.

Input: N data items, D_1, D_2, …… DN are the data items ordered such that $P_1 \geq P_2 \geq P_3 \ldots \geq P_N$;
Output: Average Stretch
Begin
1. Phase I:
   a. Calculate the stretch for each data item
   b.Arrange the data items in the increasing order based on the stretch values
   c. Broadcast the part of the data items for a period of time quantum, slice, considering the size to be as the service time.
   d. Calculate the remaining size (service time) for each item.
2. Phase II:
   a. Arrange the items in decreasing order with shortest remaining service time.
   b. Broadcast the items until they finish with their service time.
3. Calculate wt_i for each data item
4. Calculate avgstretch
end

Figure 3

3.2 An Example :

Consider five data items D1,D2,D3,D4 and D5 with given size(length/service time) and the stretch valuesof each data item.
Let the time quantum be 5ms (slice)

Table 1 Data items with sizes and stretch values

Data item	Size	stretch
D1	22	2
D2	18	4
D3	9	5
D4	10	3
D5	4	1

According to the proposed algorithm:
Phase I: A data item with highest stretch is broadcasted first for a slice of 5ms. In the same manner the other items are broadcasted according totheir stretch values for the given time quantum.

D3	D2	D4	D1	D5

0 5 10 15 20 24

Figure- 3. Order of broadcastingAfter the phase

Table 2 Items with remaining sizes

Data item	Size
D1	17
D2	13
D3	4
D4	5

Phase II: Broadcast the items with decreasing orderon their sizes

D3	D2	D4	D1	D5	D3	D4	D2	D1

0 5 10 15 20 24 28 33 46 63

Figure. 4. Broadcasting the data items Average waiting time is 63 if the access probabilitiesof the items are 44,72,45,30 and 4 and T=10,b=1 andλ=1 and Average stretch =22.5

4. PERFORMANCE EVALUATION

In order to evaluate the performance of Optimal Round Robin Scheduling algorithm, we have implemented a simulation model in section 4.1. Performance analysis is shown in Section 4.2

4.1 Simulation model

The number data items which are to be broadcasted are N and the *Pi*, is the access probability of i^{th} data item, which follow the Zipf's distribution with access skew-coefficient θ [16]: P_i = $\{1/i^{\theta}\ \sum^{N}_{i=1}\ (1/i^{\theta})\}$. Here, the items are arranged in decreasing order of their access probabilities. i,e $P_1 \geq P_2 \geq P_3 \ldots \geq P_N$

It can be verified that the access frequencies become increasingly skewed as the value of θ increase.

The data items are randomly generated between 1 to
10 for conducting experiments.The performance metric employed in this study is the average stretch, measured in *broadcast units*. The effectiveness of ORR Scheduling Algorithm is studied in terms of average Stretch obtained by varying the database size , Zipf parameter, bandwidth and arrival rate. The results obtained from the studies are analyzed. The simulation model is converted into Java program.

4.2 Performance Analysis:

The proposed algorithm is compared with stretch-optimal scheduling algorithm [15].

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4.2.1 Effect of Access Patterns on AverageStretch:

To show the effect of performance on average stretch we have increased the Zipf parameter (θ) from 0.2 to 1.0 taking N, the database size to 100 and λ to 0.01 and bandwidth to 100

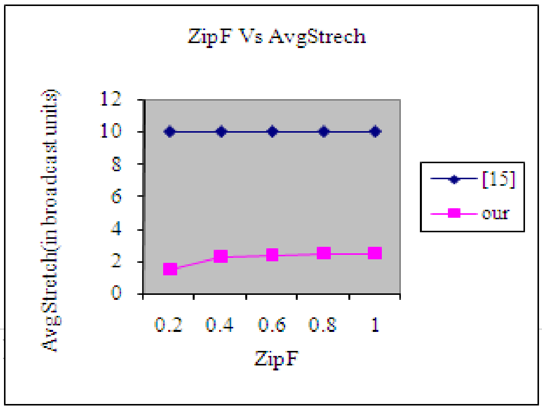

Figure - 5

Figure – 5 shows that as the value of θ increases the average stretch increases. The proposed and the scheduling algorithm in[15] performs significantly better indicating the very advantage of exploiting the feature of variable data item size scheduling algorithm

4.2.2 Effect of Database Size on Average Stretch:

To show the effect of performance on average stretch we have varied the database size from 100 to 500 and made Zipf parameter (θ) to 0.6, λ to 0.01 and bandwidth to 100.

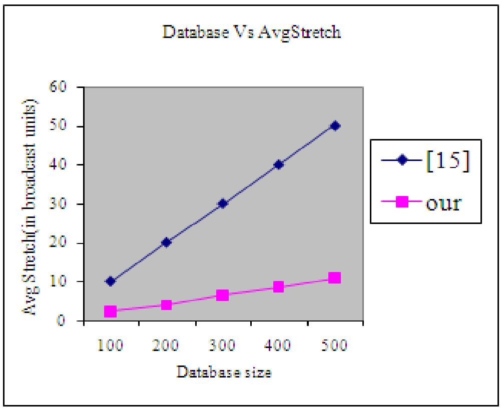

Figure – 6

Figure – 6 shows that as the value of database size increases the average stretch increases. The proposed and the stretch-optimal scheduling algorithm performs well by making the intuition true that as database increases the average stretch increases.

4.2.3 Effect of Bandwidth on Average Stretch:

To show the effect of performance on average stretch we have varied the bandwidth from 20 to 100 and made Zipf parameter (θ) to 0.6, λ to 0.01 and database size to 100.

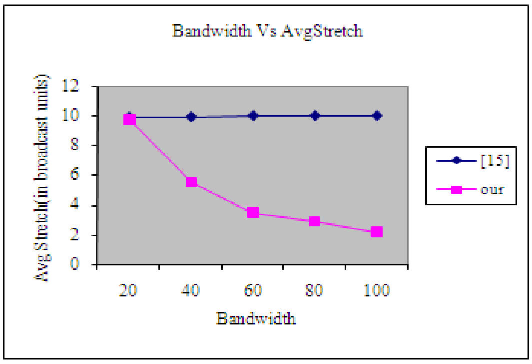

Figure – 7

Figure – 7 shows that as the value of bandwidth increases the average stretch decreases. The proposed and the stretch-optimal scheduling algorithm performs best by utilizing the network resource efficiently.

It is shown by our analytical results that the ORR scheduling algorithm is not only able to produce good results but also best suited for the broadcast environments with variable sized data requests.

5. CONCLUSION AND FUTURE WORK

This paper has addressed the challenges of on- demand data broadcasts for satellite networks and wireless networks. In such environments, the scheduling problem is different from that in the point-to-point communication environment. Moreover, when variable-sized requests are considered, most of the previously existing scheduling algorithm could not perform well when compared with our proposed algorithm. As stretch is widely adopted as a performance metric for variable-size data requests, we proposed a broadcast scheduling algorithm to optimize the system performance in terms of stretch. Performance of proposed algorithm was analyzed and sensitivity analysis on several parameters, including the number of data items, ZipF parameter and bandwidth was conducted. Simulation results demonstrated that our algorithm significantly outperforms existingscheduling algorithms under various scenarios. In this paper we have assumed single channel for data dissemination. The work can be extended to utilize hybrid data model using multi channel data dissemination.

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