Regular Data Broadcasting Plan with Grouping in Wireless Mobile Environment

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Abstract—The broadcast problem including the plan design is considered. The data are inserted and numbered at predefined order into customized size relations. The server ability to create a full, regular Broadcast Plan (RBP) with single and multiple channels after some data transformations is examined. The Regular Geometric Algorithm (RGA) prepares a RBP and enables the users to catch their items avoiding energy waste of their devices. Moreover, the Grouping Dimensioning Algorithm (GDA) based on integrated relations can guarantee the discrimination of services with a minimum number of channels. This last property among the self-monitoring, self-organizing, can be offered by servers today providing also channel availability and less energy consumption by using smaller number of channels. Simulation results are provided.

Keywords—Broadcast, broadcast plan, mobile computing, wireless networks, scheduling.

I. INTRODUCTION

An efficient broadcast schedule program minimizes the client expected delay, which is the average time spent by a client before receiving the requested items. The expected delay is increased by the size of the set of data to be transmitted by the server. A lot of work have been done for the data dissemination with flat and skewed design [1],[2],[3],[4]. For the flat design when the cycle becomes large the users have to wait for long until they catch the data in case they had lost them previously. When the broadcast cycle has long size, the flat scheduling needs many channels to avoid the user delay. The regular design with the equal spacing property [1] can provide broadcasting for single and multiple channels with average waiting time less than the one of the flat design. It also provides channels availability and less energy consumption. The data are considered homogeneous or heterogeneous with multiple of a basic size. Data can be sent by a single channel or a set of channels.

Finding the number of channels that can send a group of data providing also the equal spacing of repeated instances of items could be a very interesting issue. GDA finds directly the number of channels that produce an efficient RBP. The surplus of the available channels from both grouping algorithms may be used for other RBP. The rest of the paper is organized as follows. In section II the Model Description is described. In section III and IV the RGA and GDA are developed respectively. Simulation results are provided in section V.

II. MODEL DESCRIPTION

A. The Relations in the Broadcasting Plan

In our approach three sets $S_i$ ($i=1,2,3$) with their sizes $S_i$ so that $S_3 \geq S_2 \geq S_1$ are considered. The possibility of providing full BP (it does not include any empty slot) is examined iteratively using relations starting from the last level of hierarchy $S_3$. The number of $S_i$ items (or items of multiplicity $(it_{mu})$) will be sent at least one from $S_i$, while for the other two sets at least two. Given the size $S_3$, $S_2$, $S_1$ from the integer divisions of $S_3$, using array $(arr)$, a set of relations $S_{div}$ ($j \leq S_3$), with different number of relations $(n_{rel})$ and subrelations in each set $(i-subrelation, i=1,2,3)$ can be created. A set of relations including their subrelations by considering items of different size from each set is created. Each relation has three subrelations.

The following definitions are essential:

Definition 1: The size (or horizontal dimension) of a relation $(s_{rel})$ is the number of items that belong to the relation and it is equal to the sum of the size of the three subrelations $(s_{sub1}) x (n_{rel})$. The number (or vertical dimension) of relations $(n_{rel})$ with $s_{rel}$ define the area of the relations $(area_{rel})$.

Example 1: The relation $A=(a, b, c, d, f)$ has the following three subrelations starting from the end one; the 3-subrelation $(f)$ with $s_{sub3} = 1$, the 2-subrelation $(b, c, d)$ with $s_{sub2} = 3$, and the 1-subrelation $(a)$ with $s_{sub1} = 1$. The $s_{rel}=5$

Definition 2: The area of the $i$-subrelation $(area_{i-sub})$ is defined from its size $(s_{sub})$ and the number of the relations $(n_{rel})$ that are selected. It is given by $(s_{sub}) x (n_{rel})$.

Example 2: From a relation with $s_{rel}=5$ and if $n_{rel}=3$ then the area of this relation is $5x5$. Hence there are 25 locations that have to be completed.

Example 3: If two relations are: $(1,2,3,5,6,7)$, $(1,3,4,8,9,10)$ with $s_{sub1}=3$, $s_{sub2}=2$, then we have subrelations $(2,3)$ and $(3,4)$. The last two subrelations $((2,3),(3,4))$ comes from $S_2 = (2,3,4)$ having 3 as repeated item.

Definition 3: A BP is full if it provides at least 2 repetitions of items and it does not include empty slots in the area rel. A BP is regular if it is full and provides equal spacing property [1].

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Definition 4: The number of items that can be repeated in a subrelation is called item multiplicity (it mu) or number of repetitions (n-rep).

Definition 5: A subrelation i (i-subrelation) that belongs to set S is strong if, in its area, it can provide the same number of repetitions of all the items of a set (without empty slots) for all the relations. The strong i-subrelations create strong relations.

Definition 6: Integrated relations (or integrated grouping) is when after the grouping, each group contains relations with all the data of S2 and S1. This happens when: (S2 ∪ (S2sub)) = S2. See example 8 for details.

Lemma 1: The basic conditions in order from a set of data to have a regular broadcast plan are: k = S2s | S3s, (1) and m = it mu2 = S2s | k (2) (item multiplicity). If (s_sub3 / s_sub2) >1 the r_p = S2s | k (2) (item multiplicity). If (s_sub3 / s_sub2) >1 the r_p = 4 (2*2). From the geometric representation of data (Fig. 1) with s_sub1 = 1, the continuous bold line with r_p = 4 (=2*2), from (2) if mod b = 0 (i.e. 14 mod 2=0). The relation with the maximum value of n_rel provides the opportunity of maximum multiplicity for all the items of S2 and S1 and finally creates the minor cycle of a full BP. The major cycle is obtained by placing the minor cycles on line.

B. Some Analytical Results

Two basic Lemmas provide the possibility of the FBP and RBP construction. Proofs and details for the case of empty slots BP are not included in this work due to limited space.

RGA provides a geometric approach to the construction of a RBP. After making sure that there is a RBP the data from the array (the minor cycles for each array line) are transferred to queues for broadcasting. For multiple channels, the data from integrated relations are grouping with GDA and then are broadcasting.

Example 4: The relation A= (a, b, c, d, f) has the following three subrelations (s_sub) starting from the end one; the 3-subrelation (f) with s_sub = 1, the 2-subrelation (b, c,d) with s_sub = 3, and the 1-subrelation (a) with s_sub = 1. The size of relation (s_rel) = 5.

Example 5: (full BP) Consider the case of: S1 = {1}, S2 = {2,3}, S3 = {4,5,6,7,8,9,10,11,12,13}. Moreover k = S2s | S3s = 8(2) and m = 2(4/2) the it mu2 = 2=4/2. The relations for the full BP are: (1,2,4,5), (1,3,6,7), (1,2,8,9). Since (s_sub / s_sub) >1 the r_p = 4 (2*2).

From the geometric representation of data (Fig. 1) with s_sub = 1, the continuous bold line with r_p = 4 (=2*2), (such as: (2.5), (3.7), (2.9), (3.11)) shows the possibility of the RBP solution.

If it is not possible to create the piecewise continuous bold line, the RBP is not provided due to limited space.

Example 6: Let's consider S1 = {1}, S2 = {2,3,4,5}, S3 = {6,7,8,9,10,11,12,13}. Again, k = 2(8/4), m = it mu2 = 2(4/2).

Hence the FBP is (1,2,3,6,7), (1,4,5,8,9),(1,2,3,10,11) ,1,4,5,12,13). The subrelations (2,3) ∪(4,5). Since s_sub / s_sub = 1 the r_p = 2 repeated parallel lines.

From the geometric representation of data (Fig. 2) there are 2 parallel bold lines that are connected with dashed ones. If it is not possible to create the parallel lines it is not possible to create an RBP with subset multiplicity. Details for subset multiplicity are not provided here, due to limited space.
III. THE REGULAR GEOMETRIC ALGORITHM (RGA)

The pseudocode of RGA is as follows:

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//input: the S1, S2, S3 , num_set (=2) //output: define k the max. # of relations (n_rel) that can support a full BP //variables: k,m,n ∈ I, n=common divisors of S2s and S3
if (k= S2s | S3s ) and m= it_mu2= S2s | k { there is an RBP with it_mu2 = k2/S2s } {r_p_l = it_mu2 } //repeated par.lines if (k= S2s | S3s ) and m= it_mu2= S2s | k { there is an RBP with it_mu2 = k2/S2s } { there is an RBP for (s_sub / s_sub2) >1 \{ r_p = S2s * it_mu2 \} //repeated points if (k= S2s | S3s ) and m= it_mu2= S2s | k } { there is a full BP for S2s with k lines each item of S_n (i=1,2) will be repeated for m times, if (s_sub / s_sub2) >1 \{ r_p = S2s * it_mu2 \} //repeated points if (s_sub / s_sub2) >1 \{ r_p = S2s * it_mu2 \} //repeated points
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From all the above the model steps are: (a) partition of data according to their popularity using probably dynamic programming[2], (not shown in this work), (b) construction of FBP and RBP, (c) grouping of data lines and (d) sending them to the minimum number of channels.

IV. THE GDA

The GDA works with creation of the groups using fewer channels. Economy of channels is very important factor for large size of broadcast cycle. The grouping is made so that the AWT3 must be less than a predefined average waiting time for S1 data. Additionally with GDA the unused channels can be used for another broadcast data circle dissemination in case the server works with more than one BP. Our goal is to share the integrated relations to the channels without changing the RBP. The pseudocode of GDA is as follows:

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GDA input: n_rel: # of relations from RGA, n_rel_per_s: is the integrated # relations for S2 n_ch: #of channels that provide RBP, pre_av_wt3: is the predefined aver. waiting time for the S1 n_int_rel: is # of integrated relations from a RBP variables: AWT3: the aver. waiting time for the concatenated relations for data of S1 output: min_n_used_ch : the min # of channels that will be used with predefined AWT3, for (i= 2: n_ch; i++) {
    n_int_rel = n_rel / n_rel_per_s
    if (n_int_rel = 2p, p∈ I ) { find k, the integer divisors of n_int_rel //k1,>k2,>..,>k_n , K={k1,k2,k3,....,k_n } for each k ∈ K // # of channels { ma = n_int_rel / k grouping by m integrated relations and create the k concatenated relations if (AWT3 ≤ pre_av_wt3) { min_n_used_ch = k ; send k concatenated relations to k channels} { } } if (n_int_rel = 2p+1, p∈ I ) { we work with 2p integrated relations as in (A) and the last one (the 2p+1) is added to the last channel } } } // end for
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Example 9: Let us consider S1 = 1, S2 ={2,3,4}, S3 = {5,…,76} with: S1s = 1, S2s = 3, S3s = 72, pre_av_wt3 = 40. Here S3s >> S2s >> S1s. Using RGA, k= 24 (72/3), it_mu2 = 8(24/3), a RBP with 24 lines is created. The 24 relations (n_rel) are: (1,2,5,6,7),(1,3,8,9,10), (1,4,11,12,13), (1,2,14,15, 16),...,(1,4,75,76). The 8 integrated relations (with n_rel_per_s =3) can be created from the 24 relations are: ((1,2,6,7),(1,3,8,9,10), (1,4,11,12,13),...,(1,2,68,69)), (1,2,70,71,72,73,74,75,76). If a single channel is used, AWT3 is 72. (72>40) grouping is needed with multiple channels in order to have less AWT3. The n_int_rel = 8 (24/3), and the int. divisors of 8 are: 4,2. For k=4, ma =2 (8/4) the grouping integrated relations for 2 channels are as follows:

channel 1: ((1,2,5,6,7),(1,3,8,9,10), (1,4,11,12,13), (1,2,14,15, 16), (1,3,17,18,19), (1,4,20,21,22), (1,2,23,24,25), (1,3,26, 27,28), (1,4,21,30,31), (1,3,22,33,34), (1,3,35,36,37), (1,4,38, 39,40),
channel 2: ((1,2,41,42,43), (1,3,44,45,46), (1,4,47,48,49), (1,2,50,51,52),(1,3,53,54,55),(1,4,56,57,58), (1,2,59,60,61), (1,3,62,63,64), (1,4,65,66,67), (1,2,68,69,70), (1,3,71,72,73), (1,4,74,75,76)).

The AWT3 is: 58. Since 58>40 a new loop for k=4 is needed. For k=4, m=4 (8/2) the four integr. relations for the four channels are: channel 1: ((1,2,5,6,7),.., (1,4,20,21,22), channel 2: ((1,2,23,24,25),.., (1,4,38,39,40),
channel 3: ((1,2,41,42,43),.., (1,4,56,57,58),
channel 4: ((1,2,59,60,61),.., (1,4,74,75,76)).
The $\text{AWT}_3 = 28 < 40$. Hence, the minimum number of channels is: 4 and this can guarantee the existence of RBP (keep the service discrimination for all the sets).

V. SIMULATION

For our simulation, a system with three cooperative levels is developed: The Application, the Queue and the List level. In the Application level the items from the arrays are inserted into the queues. Poisson arrivals are considered for the mobile users’ requests. The items are separated into three categories according to their popularity using Zipf distribution. The space of queues is considered as non-restricted. For our experiments it is considered that the server has additional bandwidth (weight) available in order to be able to adjust the weights. Two scenarios have been developed:

Scenario 1: In Fig. 3, data in various sizes with equal spacing (RBP) from $S_1$ and $S_2$ sets, and flat (for all the sets) with long broadcast cycle size are depicted. For the data with equal spacing the AWT is less than the one of the flat data. It is considered a single channel service. The same results of the RBP are provided for the users interested in data of $S_1$, $S_2$ if more channels were used.

Scenario 2: Three set of data are used and three cases (each one for each set) are developed starting from left to right in Fig. 4. All of them have the same $S_1$ data. The second set has more data (relations) of $S_1$ and the same size of $S_2$ data (relations). Because of this, in the second case four channels are used instead of three in order to provide the same AWT3. The number of channels are selected according to GDA considering $\text{pre}_\text{av}_\text{wt}_3 = 40$sec. The third set has more data on $S_3$ and less data on $S_2$ comparing with the data of the second set. Because of this there is an increase of AWT3 (18 sec comparing with 16sec) and a decrease of AWT2 (from 8sec to 6sec).

VI. CONCLUSION

A new broadcast data model plan has been presented. A relation developed method provides the design of regular broadcast plan. The GDA with RGA can guarantee the creation of an RBP and the grouping with the minimum available channels. The next generation servers and their components with the scale up possibilities, tools etc applying these kind of algorithms can enhance their self-sufficiency, self-monitoring and they may address quality of service, and other issues with minimal human intervention.

REFERENCES


