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Smart Vogel's Approximation Method SVAM

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Abstract

Data Grid technology is designed to handle large-scale data management for worldwide distribution, primarily to improve data access and transfer performance. Several strategies have been used to exploit rate differences among various client-replica provider links and to address dynamic rate fluctuations by dividing replicas into multiple blocks of equal sizes. However, a major obstacle, the idle time of faster providers having to wait for the slowest provider to deliver the final block, makes it important to reduce differences in finishing time among replica servers. In this paper, we propose a dynamic optimization method, namely Smart Vogel's Approximation Method, to improve the performance of data transfer in Data Grids. Our approach reduces the differences that ideal time spent waiting for the slowest replica provider to be equal or less to the predefined data transfer completion time with minimum prices of replicas.

Keywords

Vogel's Approximation Method, Replica Selection Strategy, Replica Broke.

1. Introduction

Earth System Grid (ESG) provides an infrastructure for climate researchers that integrates computing and storage resources at five institutions [1]. This infrastructure includes Replica Location Service servers at five sites in a fully-connected configuration that contains mappings for over one million files. ESG, like many scientific applications, coordinates data access through a web-based portal. This portal provides an interface that allows users to request specific files or query ESG data holdings with specified metadata attributes. After a user submits a query, the portal coordinates Grid middleware to select a set of replica sites and to deliver the requested data.

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As it is clear that a distributed solution is required, data needs to be discoverable, wherever it is. Data needs to be replicated, and the individual replicas need to be discoverable and distinguishable in their own right. Users need to be sure that all replicas are identical. Finally, because data providers need evidence of use; logging, notification, and citation are all necessary, so that wherever data are obtained, originators and service providers can gain credit. For the most of the software infrastructure Data citations (including interfaces and the data itself) need to be robust beyond the expected life times.

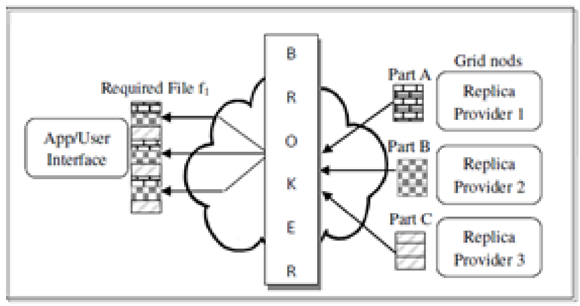

Fig 1. Concurrent bulk data transfer of file from multiple replicas

Data Grid environments with replication and selection techniques serve replicating and selecting popular data in distributed servers [2]. Data replication is used to move copy of common required data and cache it close to users in distributed replica provider sites [1]. Additionally, Data Selection technique is used to discover the list of available replica provider sites in order to select best set of them that matches user's quality of service requirements. Links performance rates vary when downloading large data sets from several replica providers as the varying network connectivity. Download speeds are limited by the Bandwidth traffic congestion in the links connecting clients to replica providers, therefore, Bandwidth quality is the most important factor affecting transfers between client and replica providers [3]. In this paper a new service is added into Data Grid Broker and also added to the middleware of ESG as shown in Figure 1.

To improve the performance, required large datasets can be in parallel downloaded from several providers by establishing multiple connections as shown in Figure 1. GridFTP enables the clients to download data from multiple locations [14]. This improves the performance compared to the single server cases and reduce internet congestion problem.Current work is to extend the selection strategy to enhance the selection performance of our previous work [14]. In this paper a Smart Vogel's Approximation Method used to modify the data transfer strategy with Vogel's Approximation Method to download set of files in a specific predefined period of time with respect to minimum cost (price). The recent work is about improving the selection mechanism of the management system in Data Grid architecture [12]. This paper is to solve an idle time drawback when faster provider site must wait for the slowest provider site to deliver its final block. Experimental results show that our approach is better than previous methods. The results in this paper have been compared with one of previous technique where the Hungarian method has been used as a selection technique, to download files from set of uncongested sites with cheapest cost (price) [12]. Next section gives a brief explanation about VAM algorithm.
remainder of this paper is organized as follows. Related studies are presented in Sect. 2 and Our research approach, Smart Vogel's approximation method is outlined in Sec.3, and experimental results and performance evaluation of our scheme are presented with case study in Sec. 4. In Section 5 a comparison with previous work is explained. Section 6concludes this research paper.

2. Literature Review

Several selection strategies were provided in the previous works [4, 5, 6, 7, 8, 9, 10, 11, 12, 13], Rough Set theory [7, 8, 9, 11] and association rules technique of Data Mining approach [5, 6] are used to enhance the selection strategy when files are concurrently downloaded from multiple providers.

3. Vogel's Approximation Method VAM

This section is to explain VAM method. Assume a simple file transportation problem which can be solved using VAM method. Table 1 is called as File Transportation Table FTT where the problem is simulated in. Assume that a client asked to get four files which are (f1, f2, f3, f4) with sizes (60, 40, 30, 110) GB respectively. The list of available replica providers are (S1, S2, S3) with speed (120, 70, 50) GB/Sec with varieties offer costs listed in Table 1. To get better selection decision the following strategy is used.

Table 1: File Transportation Table

Replica Providers Sites					
Requested File	S_1	S_2	S_3	S_4	Demand
f_1	× (19)	× (30)	× (50)	× (10)	7
f_2	× (70)	× (30)	× (40)	× (60)	9
f_3	× (40)	×(8)	× (70)	× (20)	18
Capability	5	8	7	14	

Algorithm1: Vogel's Approximation Method VAM

Notations:

- ✓ Requested file(s), f_i, $i=\{1,2,\ldots,n\}$, where n represents number of files
- ✓ Replica providers sites, S_j, $j=\{1,2,\ldots,m\}$, where m represents number of providers sites
- ✓ Cost (price) of each file $C_{i,j}$ (Cost of f_i in replica provider j)
- ✓ *Demand* is to determine required sizes of each file
- ✓ *Capability* is to determine the ability of suppliers to send files in KB/Sec.
- ✓ *Penalty* P_i, represents the difference of the distribution costs between the two lowest unit costs (first best route and second best route)

Begin

Step 1: For each row and column, find the *Penalty* P_i

Step 2: Identify the row or column with the largest Penalty values

Step 3: Assign as many demand units as possible to the lowest cost supplier that belongs to the row or column selected

Step 4: Eliminate any row when its ability of the supplier becomes zero. Eliminate any column when its demand file becomes zero

Step 5: Re-compute the cost differences for the transportation table, omitting rows or columns crossed out in the preceding step

Step 6: Return to step 2 and repeat the steps until an initial feasible solution has been obtained

End

4. Smart Vogel's Approximation Method SVAM

The following steps explain how SVAM algorithm is used in Data Grid environment

Begin

Step 1: Determine set of uncongested sites which can work concurrently by applying a selection technique called Efficient Set Technique. This is result of our previous paper

Step 2: Monitor Links between computing site and providers using Network Monitoring Service NMS (it sends small equal size packets to the replica provider sites to calculate the speed of downloading)

Step 3: Form a matrix (Table) where columns represent replica providers and rows represent requested files
- ✓ Fill last column of the FTT with the sizes of requested files.
- ✓ Fill last row of the matrix with the download capability of replica provider site. For example, the download capability of $Site_1$ is *N* MB/Sec
- ✓ Fill cells of the matrix with values of cost (price) of downloading a unit of file. Each replica provider has its own price to download a unit of the file. For example the price of 1 MB of F_1 is *$19* in $Site_1$ whereas it costs *$30* in $Site_2$ *as shown in Matrix 1 below*

Step 4: Apply the VAM algorithm to transfer the files

End

5. Study Case of SVAM

A simple example is used to illustrate the SVAM Technique. Assume that Data Grid job has three files need to be downloaded, which are, F1, F2 and F3 in a specific time, say 5 minutes. To transfer the required three files in the specific period of time, SVAM technique procedure is applied as shown below.

At the beginning, we should determine the set of sites which may use for downloading the files by:

1- Use EST technique (our previous paper) [9] to determine set of uncongested replica provider sites, in our example they are: {S_1, S_2, S_3, S_4}.

2- Use Network Monitoring Service such as Ipref service to specify speed of downloading (capability) of replica providers sites. The capabilities of the selected providers are {5, 8, 7, 14} for each site accordingly, as shown in *Table 1*.

3- Fill the costs' cells $C_{i,j}$ with prices offered by providers as it is shown in *Table 1*.

4- Determine the following:
- Penalty: means difference between smallest two values for each row and column.
- Demand: is the total size of file that we want to download. In Table 9 the demand of S_1 is 20GB that mean file can be downloaded from S_1 within 5 minutes.
- Capability: means how many units (KB, MB, GB, etc) replica provider can download within the given time (5 minute in our example).
- Cost (Price): the cost of downloading file in dollar per one unit (KB, MB, GB, etc) which is stored in cell values of the matrix.

5- Apply VAM algorithm (Algorithm 1)

Select the row and column for which the penalty is the largest and allocate the maximum possible amount to cell (3, 2) with the lowest cost (8) in the particular column (row) making x3, 2=8.

If there are more than one largest penalty rows (columns), select one of them arbitrarily. After that cross out the column/row in which the requirement has been satisfied and find the corresponding penalties correcting the mount of available from site S2 construct the first reduced penalty matrix.

Table 2: File Transportation Table

	Replica Providers Sites					
Requested File	S_1	S_2	S_3	S_4	Demand	Penalty
f_1	× (19)	× (30)	× (50)	× (10)	7	9
f_2	× (70)	× (30)	× (40)	× (60)	9	10
f_3	× (40)	8 (8)	× (70)	× (20)	18	12
Penalty	21	22	10	10		
Capability	5	8	7	14		

Table 3: File Transportation Table

Replica Providers Sites					
Requested File	S_1	S_3	S_4	Demand	Penalty
f_1	5 (19)	× (50)	× (10)	2	9
f_2	× (70)	× (40)	× (60)	9	20
f_3	× (40)	× (70)	× (20)	10	20
Penalty	21	10	10		
Capability	5	7	14		

Table 4: File Transportation Table

Replica Providers Sites				
Requested File	S_3	S_4	Demand	Penalty
f_1	× (50)	× (10)	2	40
f_2	× (40)	× (60)	9	20
f_3	× (70)	10 (20)	0	50
Penalty	10	10		
Capability	7	4		

Table 5: File Transportation Table

Replica Providers Sites				
Requested File	S_3	S_4	Demand	Penalty
f_1	× (50)	2 (10)	0	40
f_2	7 (40)	2 (60)	0	20
Penalty	10	50		
Capability	0	0		

Table 6: File Transportation Table

Replica Providers Sites					
Requested File	S_1	S_2	S_3	S_4	Demand
f_1	5 (19)			2 (10)	7
f_2			7 (40)	2 (60)	9
f_3		8 (8)		10 (20)	18
Capability	5	8	7	14	

Table 7: File Transportation Table

Replica Providers Sites					
Requested File	S_1	S_2	S_3	S_4	S_5
f_1	$20	$22	$25	$22	$18
f_2	$11	$26	$24	$24	$21
f_3	$23	$24	$17	$19	$18
f_4	$22	$20	$21	$23	$20
f_5	$18	$23	$25	$21	$25

Table 8: File Transportation Table using EST

Replica Providers Sites					
Requested File	S_1	S_2	S_3	S_4	S_5
f_1	**2**	**4**	**6**	**1**	**0**
f_2	**0**	**9**	**6**	**4**	**4**
f_3	**7**	**8**	**0**	**0**	**3**
f_4	**2**	**0**	**0**	**0**	**0**
f_5	**0**	**5**	**6**	**0**	**7**

Table 9: File Transportation Table using SVAM

Replica Providers Sites							
Requested File	**S_1**	**S_2**	**S_3**	**S_4**	**S_5**	**Size**	
f_1	$20	$22	$25	$22	$18	15	2
f_2	$11 3	$26	$24	$24	$21	3	10
f_3	$23	$24	$17	$19	$18	12	1
f_4	$22	$20	$21	$23	$20	18	1
f_5	$18	$23	$25	$21	$25	22	3
Demand	20	8	15	12	15		
	7	3	4	1	2		

Table 10: File Transportation Table using SVAM

Replica Providers Sites							
Requested File	**S_1**	**S_2**	**S_3**	**S_4**	**S_5**	**Size**	
f_1	$20	$22	$25	$22	$18	15	2
f_3	$23	$24	$17 12	$19	$18	12	1
f_4	$22	$20	$21	$23	$20	18	1
f_5	$18	$23	$25	$21	$25	22	3
Demand	20-3=17	8	15	12	15		
	2	3	4	1	2		

Table 11: File Transportation Table using SVAM

Replica Providers Sites							
Requested File	S_1	S_2	S_3	S_4	S_5	Size	
f_1	$20	$22	$25	$22	$18	15	2
f_4	$22	$20	$21 3	$23	$20	18	1
f_5	$18	$23	$25	$21	$25	22	3
Demand	20-3=17	8	3	12	15		
	2	3	4	1	2		

Table 12: File Transportation Table using SVAM

Replica Providers Sites						
Requested File	**S_1**	**S_2**	**S_4**	**S_5**	**Size**	
f_1	$20	$22	$22	$18	15	2
f_4	$22	$20 8	$23	$20	18	0
f_5	$18	$23	$21	$25	22	3
Demand	20-3=17	8	12	15		
	2	3	1	2		

Table 13: File Transportation Table using SVAM

Replica Providers Sites					
Requested File	**S_1**	**S_4**	**S_5**	**Size**	
f_1	$20	$22	$18	15	2
f_4	$22	$23	$20	7	1
f_5	$18	$21 12	$25	22	3
Demand	20-3=17	12	15		
	2	1	2		

Table 14: File Transportation Table using SVAM

Replica Providers Sites				
Requested File	**S_1**	**S_5**	**Size**	
f_1	$20	$18	15	2
f_4	$22	$20	7	1
f_5	$18 10	$25	10	7
Demand	20-3=17	15		
	2	2		

Table 15: File Transportation Table using SVAM

Replica Providers Sites				
Requested File	**S_1**	**S_5**	**Size**	
f_1	$20	$18 15	15	2
f_4	$22	$20	7	1
Demand	20-3=17	15		
	2	2		

Table 16: File Transportation Table using SVAM

Replica Providers Sites			
Requested File	**S_1**	**Size**	
f_4	$22 7	7	1
Demand	20-3=17		
	2		

Repeat all the above procedure till all allocations have been made Successive reduced penalty matrices are obtained. Since the largest penalty (21) is now associated with the cell (1, 1) so allocate x11=5. This allocation (x11=5) eliminates the column 1 giving the second reduced matrix a shown.

The largest penalty (50) is now associate with the cell (3,4). Therefore, allocate x34=10. Eliminate row 3. The third reduced penalty matrix is as shown.

Now, allocate according to the largest penalty (50) as x14=2 and reaming x24=2. Then allocate x23=7.
Finally we can constrict the last table from the required solution as shown : Total cost is = 5(19) + 8(8) + 7(40) + 2(10) + 2(60) + 10(20) = 95 + 64 + 280 + 20 + 120 + 200 = $779
Therefore, the required three files f_1, f_2 and f_3 can be downloaded within 5 minutes with minimum cost of $779 if we follow the following suggestions:

- ✓ Download 5 units of f_1 from site S_1 and 2 units of f_1 from site S_4.
- ✓ Download 7 units of f_2 from site S_3 and 2 units from of f_2 from site S_4.
- ✓ Download 8 units of f_3 from site S_2 and 10 units of f_3 from site S_4.

In this case, multiple replica providers concurrently worked to download the required files. The gathered portions of files from different links are transferred to the client (computing site)

6. Comparison of the file transmission time of requested files using EST and SVAM

In this section a comparison between proposed method, SVAM and previous method Efficient Sites Technique EST where Hungarian algorithm is used [9]. Assume that costumer asked to get five files which are (f1, f2, f3, f4, f5) with sizes (15, 3, 12, 18, 22) GB respectively. The list of available suppliers are

(S1, S2, S3, S4, S5) with transfer ability (20, 8, 15, 12, 15) GB/Sec with varieties offer costs listed in Table 7. In other words, 1 GB of f1 costs $20 if it is taken from S1 whereas it costs $22 from S2.

- **Cost of files using EST**

In the EST technique, Hungarian algorithm is used. Each site sends a complete file not part of it. In other words, each file can be taken from a single site provider S1. In this case when the download speed varies among the providers, the fast site completes his task faster than the poor site. The total transfer time for all files is equal to longest time of the slowest site. It means there is no benefit of having a fast site as this has to wait the final packet of data transferred from slowest site. This was the drawback of EST because of the criteria used to select best set of providers depended on choosing the cheapest sites whether these sites have fast or slow download speed. Using EST, the result of Table 7 is f1 (the largest file) is taken from S5 (the slowest site). The total cost is $1329 with long transfer time as shown in Figure 2.

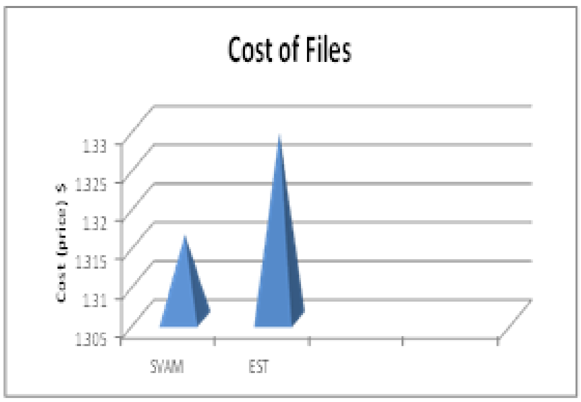

Figure 2: Comparison between EST and SVAM

- **Cost of files using SVAM**

When *SVAM* is applied the total cost of transferring files is *$1316*. The total price in the proposed technique *SVAM* is less than EST with *$13* as shown in *Figure 2*.

7. Conclusion and Results

Figure 3, represents the maximum downloading capability of a replica provider comparing with files' sizes site according to their downloading capacity, which are [20, 8, 15, 12, 15] respectively, same values are used to compare results with *SVAM* when the required files are needed within 5 minutes as the previous example. Results show that EST technique has a drawback as two files (*f1*, *f2*) cannot be downloaded because their sizes are more than sites' downloading capability while in *SVAM* technique results are acceptable.

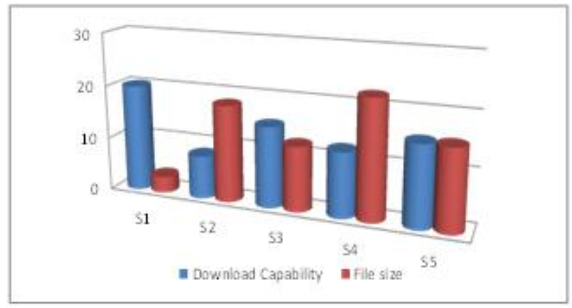

Figure 3: Comparison between EST and SVAM

Figure 4, represents the ability of *SVAM* to download the required files within 5 minutes. Results show those S_1 sends 20 parts of f_1, 7 parts of F4 and 10 of f_5 so the total is 20 parts which is the capability of downloading S_1 to download 20 parts within 5 minutes.

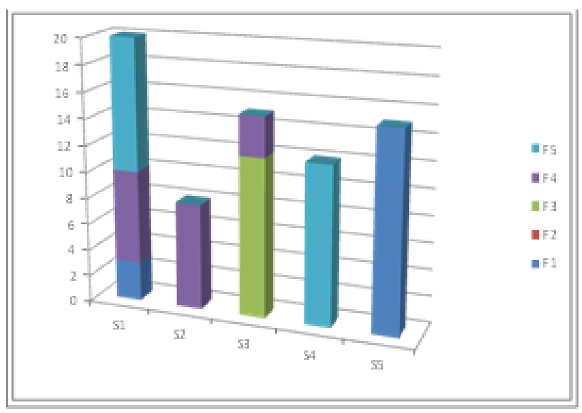

Figure 4: SVAM

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