To Optimize the Web Cache Replacement with OMS model

Prapai Sridama, Somchai Prakancharoen, Nalinpat Porrawatpreyakorn

Abstract

The objective of this research increases the hit rate of the web cache memory. The number of people using the web objects is enlarged quickly. This situation affects to the traffic network. In the present, the web cache memory is used to help the traffic network problem. It can keep web objects from original servers and clients can download web objects from the web cache memory. However, the web cache memory is small memory therefore it cannot record any web object. Many techniques are used to solve for this problem but those techniques gave the average hit rate not over 40 percent [1]. Therefore, this research investigates the Optimization with Mathematics and Statistics methods for increasing the hit rate with in the web cache memory as follows: Estimated Value, Interpolation, Cubic Spline, Finding area under the curve and First Order Condition. This research investigates to create the Optimization with Mathematics Statistics (OMS) algorithm for the recommend in the web cache memory management. In addition, this algorithm is tested with the datasets from a University in Thailand. Furthermore, the OMS algorithm is compared the performance of the hit rate with the LRU algorithm. The experimental results of this research can apprize that the OMS algorithm gives the maximum the hit rate at 72.56 percent while the LRU algorithm offers the maximum the hit rate at 53.34 percent. However, the average hit ratio of the OMS algorithm is at 53.8 percent while the average hit ratio of the LRU algorithm amounts 12.99 percent.

Keywords: Web usage pattern, Optimization, Interpolation, First Order Condition, Cubic Spline, Finding Area Under the Curve.

1. Introduction

The internet is popular to use in the global. The high technology is developed to increase the performance of network. Furthermore, the networking can increase the channels for making business. Some countries can make business on the internet or some countries teach and connect students with applications on the internet. Therefore, the traffic network is impacted from those activities.

The number of downloading in each day makes the traffic jam on the network. The bottle neck problem often happens when users want to download the web objects in the same time. The moreover, all downloading have the expenditure.

The web cache memory is used to decrease the number of downloading [2-6] from original servers. It can record web objects from original servers. However, the web cache memory is less space, therefore it removes some web objects when the memory is full. Many techniques are used to decide for leaving some web objects, which the popular techniques such as the Lease Recently Use (LRU) algorithm and the RLU algorithm. Those techniques are used to manage the web objects selection because the LRU algorithm and RLU algorithm are simplest and most easy the web cache management [2][7]. The LRU technique downloads web pages in to the web cache memory from the maximum of web usage at the present time. If a web page is least using then this web page is eliminated from the web cache memory. However, both techniques have the average hit ratio not over 40 percent. The LRU technique and the RLU technique are received the high popular because those techniques can be easy to manage the web cache memory.

This research investigates the OMS algorithm for increasing the hit ratio of web cache memory. Many Mathematical Statistics methods are used in this algorithm such as the Estimated Value, the interpolation with Cubic Spline, the First Order Condition (FOC) and the finding area under the curve.
function. In addition, the number of web usage in the past is used to test in this algorithm and the LRU algorithm.

The objective of this research increases the hit ratio of the web cache memory, which is in the proxy server. However, the performance of the OMS algorithm compares with the LRU algorithm. In addition, this research does not compare the performance of the time processing.

From this point, this paper is divided four main sections as follows. The related research and theories are shown in first section. Secondly, the OMS algorithm is explained and then the results of the OMS algorithm are shown. Lastly, the discussion and conclusion of this research are presented.

2. The related research and theories

The related researches and theories are presented in this section. The principle of OMS algorithm is an algorithm of the web object replacement technique therefore we present the related algorithm with the web object replacement technique. However, some techniques or some algorithms are received high popular because those algorithms are easy to manage and are quickly process. Some algorithms can increase the hit ratio but they are complex function.

2.1. Related Research

This part presents comprehensive overview of different proposals for web cache replacement method on LRU algorithm. The applied LRU [8] considers the largest memory of web page when the number using the web page from users is equal and it is used at least in the present time. This technique gives higher hit ratio than LRU algorithm if the web cache memory is large memory. Furthermore, the LRU-Min technique [9], and SHA-226 [10] can give the hit ratio higher than LRU algorithm if the web cache memory is huge space that the organization pays to increase for maintenance and to employ experts. Other than, the LRU algorithm is used for improving the web cache memory such as the Mix model which applied GAM [11], the ICWCS technique [12], Markov model for predicting web page accesses [13] and Naïve Bay algorithm [14]. In addition, recent studies have introduced the machine learning technique to solve the web proxy cache [2,15,16,18,19], but all technique can give the hit ratio higher than LRU algorithm 40 percent.

2.2. Theories

Many Mathematics and Statistics theories are calculated for creating the OMS algorithm. Therefore, these methods and algorithm are explained in this section that we clearly present the process and examples.

2.2.1. Estimated Value

The Estimated value is used to calculate an average value that the random variable can give with this method [20],[21]. The estimated value has two types, which are based on the discrete random variable and the continuous random variable. Though, the continuous random variable is used in this research that it is shown in the equation 1.

\[ E(x) = \int_{1}^{\infty} xf(x)dx \]  

(1)

2.2.2. Interpolation with cubic spline algorithm

Interpolation is a technique to predict some value that miss or lack of the data collection [22]. Besides, the interpolation solves to estimate some data which equals zero number. In addition, the interpolation has implements for search the answers. However, each implement does not give best value in all variables that this research uses interpolation with the Cubic spline algorithm when to search some value.
The Cubic spline is a function to link between data to data with the curve to the third power. The
distribution concave and concave out which is continuous between the point and the point is given
from the Cubic spline [23]. The Cubic spline is presented in equation 2. The smooth curve of graph is
received from the Cubic spline so some scientists call this technique that the Natural Cubic spline.

\[ f_i(x) = a_i x^3 + b_i x^2 + c_i x + d_i \quad ; i = 1, 2, 3, ..., n \]  

A function has four unknown variables. If one searches a phase then one has unknown variable equal
4n variables. So, one has equation equal 4n equations too. However, we clearly explain procedures of
those equations in the next section.

2.2.3. First Order Condition (FOC)

The average slope values are calculated with the FOC algorithm [22] and the trend values are given
from the FOC algorithm too. Furthermore, the FOC is used to approximate convex values and concave
values [24][25]. In addition, this research uses the FOC to look the trend of requesting of users.

2.3.4. Interpretation of the First Derivative

The first derivative function is used to find the derivative value. We can know that a function is the
increasing function or the decreasing function from the first derivative function [26]. This function is
shown in equation 3.

\[ y' = f'(x) \]  

where \( f'(x) \) is the slope of the function at an \( x \) point.

Let \( f'(x) > 0 \) is the increased function at the point of \( x = x_0 \), \( f'(x) < 0 \) is the
decreased function at the point of \( x = x_0 \), and \( f'(x) = 0 \) is the consistent function at the
point of \( f'(x) = 0 \).

2.3.5. Interpretation of the Second Derivative

The interpretation of the second derivative function can calculate the changed rate of the first
derivative function. The label of this function is \( f''(x) \) [26]. It gives two means that are
\( f''(x) > 0 \) (the slope of the curve line is increased trend) and \( f''(x) < 0 \) (the slope of
curve line is decreased trend).

2.3.6. Finding the area under the curve

Finding the area under the curve function is used for calculation the area under the line graph. We
can know volumes of web usage from this function, which is shown in equation 4.

Figure 1. The area of the line graph and sub phases on the horizontal axis
Figure 1 shows sub phases on the horizontal axis and the line graph of the continuous function. We get the phase of \([a, b]\), which is represented with \(A\). If we divide this area to sub phases then we get \([x_{n-1}, x_n], [x_1, x_2], \ldots, [x_{n-1}, x_n]\). Thus, breaking point is \(a = x_0 < x_1 < x_2 < \ldots < x_{n-1} < x_n = b\) and widths of each phase (\(\Delta x_i\)). In each of \(\Delta x_i\) have size to approach zero when \(n\) is the expanded value.

To make the rectangles high is equal the highest of each piece. The next, \(x_i\) point is selected from each sub phase and calculates the height of \(x_i\). We can calculate with \(f(x)\). Therefore, the area has size equal \(f(x_i) \Delta x_i\). Lastly, the function for this result is solved with the equation 4.

\[
f(x_i)\Delta x_i + f(x_2)\Delta x_2 + \ldots + f(x_n)\Delta x_n
\]  

(4)

From equation 4, we can rewrite to equation 5.

\[
\int_a^b f(x)\Delta x
\]

(5)

where \(\int\) is integral sign. \(f(x)\) is the function is made be integration. \(\Delta x\) is the differentiation operator.

2.3.7. Performance Comparison

Normally, the web cache replacement’s evaluation uses the equation 6 to decide. If the hit ratio is high then this web cache replacement is high performance [47].

\[
HR = \frac{\sum Hi}{\sum Ri}
\]

(6)

where \(Hi\) is the number of the web request at the web cache memory that web objects are in the web cache memory, \(Ri\) is the number of all web request.

3. Task allocation algorithm design

The objective of this research increases the hit rate of the web cache memory. This section presents two parts as follows: Data type in this research and Elements of the OMS algorithm.

3.1. Data type in this research

The datasets of web usage were collected with the squid program of a University in Thailand (approximately 10,000,000 datasets). However, we cleaned datasets before to use for testing the OMS algorithm.

3.2. Procedures of the OMS algorithm

OMS (the Optimization with Mathematics Statistics) algorithm is created in this research. The OMS algorithm is designed for increasing the hit ratio and it can predict the web object requesting in the future. If OMS algorithm can download some web objects from origin web servers for recording in the web cache memory that web objects are greatly called to use in the future then the hit ratio will be increased value.
The procedures of the OMS are five procedures as follows: 1) the Data Preparation Process element, 2) the Cache Feature Preparation, 3) the Cache Replacement, 4) the Testing of prediction and 5) the Performance comparison.

3.2.1. The Data Preparation Procedure

The Data preparation procedure is the cleaning process. The first step of this procedure changes the data from the log files to the text files with Perl programming. Some incomplete data are eliminated in this procedure.

Step 2 is calculation the number of web usage in each webs. However, we calculate the number of web usage from 9.00 a.m. to 12.00 a.m. because the staff high downloaded the web objects. In addition, we can to know the top ten in this step. The top ten of web objects are shown in Table 1.

<table>
<thead>
<tr>
<th>No.</th>
<th>The name of web object</th>
<th>The number requesting</th>
</tr>
</thead>
<tbody>
<tr>
<td>web1</td>
<td><a href="http://google.com">http://google.com</a></td>
<td>628,545</td>
</tr>
<tr>
<td>web2</td>
<td><a href="http://youtube.com">http://youtube.com</a></td>
<td>333,212</td>
</tr>
<tr>
<td>web3</td>
<td><a href="http://ptvcdn.net">http://ptvcdn.net</a></td>
<td>183,451</td>
</tr>
<tr>
<td>web4</td>
<td><a href="http://ytimg.com">http://ytimg.com</a></td>
<td>134,558</td>
</tr>
<tr>
<td>web5</td>
<td><a href="http://gstatic.com">http://gstatic.com</a></td>
<td>76,020</td>
</tr>
<tr>
<td>web6</td>
<td><a href="http://teennee.com">http://teennee.com</a></td>
<td>74,819</td>
</tr>
<tr>
<td>web7</td>
<td><a href="http://kapook.com">http://kapook.com</a></td>
<td>46,685</td>
</tr>
<tr>
<td>web8</td>
<td><a href="http://adobe.com">http://adobe.com</a></td>
<td>46,265</td>
</tr>
<tr>
<td>web9</td>
<td><a href="http://dropbox.com">http://dropbox.com</a></td>
<td>45,971</td>
</tr>
<tr>
<td>web10</td>
<td><a href="http://4shared.com">http://4shared.com</a></td>
<td>45,578</td>
</tr>
</tbody>
</table>

Table 1 shows the number requesting of top ten from original web servers. If other web objects were not the top ten then this research ignored. Especially, we use datasets from the top ten.

Step 3 sums the requesting from ten web objects (top ten). We sum the requesting any week (30 weeks) that we calculate the total in any minute. Those totals can be shown in Table 2.

<table>
<thead>
<tr>
<th>Monday</th>
<th>The number of a web of top ten (in each second) between 9.00 a.m. – 12.00 a.m.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>9.00</td>
</tr>
<tr>
<td>No.1</td>
<td>1,200</td>
</tr>
<tr>
<td>No.2</td>
<td>1,234</td>
</tr>
<tr>
<td>No.3</td>
<td>1,505</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>No.30</td>
<td>1,709</td>
</tr>
</tbody>
</table>

Table 2 shows total numbers of web usage in each minute of a web object of the top ten. Necessarily, the OMI algorithm calculates total number of web usage of all web objects. Figure 2 shows the line graph of a web object that we use data from the Table 1.
The figure 2 shows the line graph of a web object that those lines were made from the total number of a web object (30 weeks).

The estimated value function is used in the final step. Indispensably, we calculate the estimate value in each web objects of the top ten because we require to find the agency value from 30 sets to 1 set therefore the estimate value function is used to calculate stead values. The figure 3 presents the agent of web objects (top ten) after we calculate with the estimated value function.

The number of requesting

**Figure 3.** The number of requesting to use web objects

Figure 3 presents the number of requesting to use web objects. These lines are made from the estimated value function.

**Step 4: Interpolation with Cubic Spline algorithm**

The fitting curve is presented in this step. The cubic spline is a technique of interpolation and it can give smooth lines. The cubic spline equation is presented in equation 7.

\[
S_j(x) = a_j + b_j(x - x_j) + c_j(x - x_j)^2 + d_j(x - x_j)^3
\]  

where \(0 \leq j \leq n - 1\) and \(s_j(x)\) is spline of \((x_j, x_{j+1})\)
Figure 4. The Example of a line which is made with the Cubic spline.

Figure 4 shows a line of a web object. Indispensably, the cubic spline equation helps to adapt total values which are estimated from the estimated value equation.

3.2.2. The Cache Feature Preparation procedure

The cache feature preparation procedure is an important procedure to make decision. Therefore, we use many Mathematic methods. However, steps in this procedure are explained minutely.

However, after this procedure is completed. We able to achieve a new algorithm for making the decision to web cache replacement.

The OMS algorithm can be explained as following;

Step 1: To calculate the average value any ten minutes (18 values)
This step calculates the average value in every ten minutes in any web object of the top ten. The equation for this problem is shown in equation 6.

\[
AVG(j) = \frac{\sum_{i=1}^{i=9} j_i}{i+9}
\]

where \(i\) is the number of time of each minute. \(i = 1, 11, 21, 31...,171\).
\(j\) is the number of web usage in each minute.

Step 2: Finding the area under the curve values
Finding the area under the curve values evaluates with equation 5. This research divides the area under the curve (\(A\)) value to 18 sub areas. Therefore, the equation 5 is used to evaluate 18 times of all web objects (top ten).

\[
A_{1}^{2} = \int_{\frac{t_1}{2}}^{\frac{t_2}{2}} f(t)dt
\]
\[
A_{2}^{3} = \int_{\frac{t_1}{2}}^{\frac{t_2}{2}} f(t)dt
\]
\[
A_{3}^{4} = \int_{\frac{t_1}{2}}^{\frac{t_2}{2}} f(t)dt
\]
\[
A_{17}^{18} = \int_{\frac{t_{17}}{2}}^{\frac{t_{18}}{2}} f(t)dt
\]
\[
\therefore \ A = A_{1} + A_{2} + A_{3} + ... + A_{n}
\]
The $f(t)$ in each period $(t_1, t_2, ..., t_{18})$ is solved with an application online that those equation are the polynomial functions.

Step 3: to calculate for average slope of all top ten with First Order Condition (FOC)

This section finds slope values with FOC equation of each top ten web page usage for five forward time unit. However, all values are between +4 and -4 only. This research calculates any minute and they are shown with equation below.

$$\text{FOC : } \frac{\partial (Y_{t+1})}{\partial t} = \frac{\partial (Y_{t+2})}{\partial t} = \cdots = \frac{\partial (Y_{t+18})}{\partial t}$$

3) The OMS algorithm calculates goodness of fit testing any 10 minutes.

The Goodness of fit with Chi-square is presented in this process. The equation is shown at equation 7. Let the df value $= 1$ and the significant value $= 0.05$.

$$x^2 = \sum \frac{(O - E)^2}{E}$$

where $E$ is the probability of sample value. $O$ is the frequency observing.

If the goodness of fit value is higher than the significant value then the maximum likelihood estimation technique is used for adjusted number of web usage. After that, the average slope calculation is used again. The maximum likelihood estimation function is shown in equation 8.

$$L(\theta) = \prod_{t=1}^{18} f(t_i; \theta)$$

Step 4: to update Cache Replacement Table (CRT) with average slope.

In this step, one transfers FOC value of top ten web pages into CRT table which is in the database.

<table>
<thead>
<tr>
<th>Top ten of web usage</th>
<th>Top ten of web usage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Web 1</td>
<td>Web 2</td>
</tr>
<tr>
<td>Average slope at $t_i$</td>
<td>+2</td>
</tr>
</tbody>
</table>

The CRT has recorded the average slope values from the evaluation of the maximum likely hood equation. This step decides five web objects at 9:00 a.m., meanwhile the OMS algorithm records the requesting the web objects. However, those data value have been evaluated any ten minute.
3.2.3. The Cache Replacement procedure

This research has used the optimization technique to decide web objects. This research divides the cache memory to 5 slots for recording web objects. Therefore, this procedure can be applied as following:

Step 1: Optimizing from maximum cost
   Step 1.1: To plan for the next ten minutes

After ten minutes to pass, this algorithm eliminates the oldest value of using web objects and increases the newest value (from 9.00 a.m. to 9.10 a.m. in the present) and then the estimated value equation and finding the area under the curve function are used to calculate again. However, the OMS algorithm makes this step in any ten minute.

Step 1.2: To evaluate web objects with the Normalized Least Recently Used (N_LRU) method for removing from CRT

The N_LRU method is designed by this research and it can be shown in equation 9.

\[
N_{\text{LRU}} = \frac{\text{MaxCachereserved} - \text{LRUofEachCache}^{\#i}}{\text{MaxCachereserved}}
\]  

(9)

where \( \text{MaxCachereserved} \) is the total of slot or channel for download web objects,

\( \text{LRUofEachCache}^{\#i} \) is the number of requesting a web object and this web object is in the web cache memory.

Step 1.3: To evaluate the cost of downloading

This step uses the finding area under the curve equation and some values for creation the new method, which is shown in equation 10.

\[
RC = \left[ (t_2 - t_1) \cdot c - \int_{t_1}^{t_2} f(t) \, dt \right] \cdot CB
\]

(10)

where \( RC \) is reverse of cost.

\( t_2 \) is the average value of a web page from top ten at \( t_2 \)

\( t_1 \) is the average value of the same web page of \( t_2 \)

\( c \) is the first order condition equation of \( f(t) \)

\( f(t) \) is the quadratic/cubic polynomial equation

\( \int_{t_1}^{t_2} f(t) \, dt \) is the integration of the quadratic/cubic polynomial equation or the area of under the curve.

\( CB = \text{cost of downloading} \) (Bath/kb.)

Step 1.4: Normalization \( RC \)

This step calculates \( N_{\text{RC}} \) value because this research limits the RC value from 0 to 1. The \( N_{\text{RC}} \) is shown in equation 11.

\[
N_{\text{RC}} = \frac{A \cdot CB - RC}{A \cdot CB}
\]

(11)

Step 2: To decide web objects for the web cache memory

This research investigates \( D \) equation for selecting web objects from the top ten. It is presented in equation 12.
\[ D = (W_1 \times N_{-LRU}) + (W_2 \times N_{-RC}) \]  

where \( W_1 \) and \( W_2 \) are defined by the system administrator that \( W_1 + W_2 = 1.0 \). However, If the decision maker gives the weight of the number of web usage then \( W_1 \) value can be higher than \( W_2 \). Whereas, if the decision maker gives the weight of the cost of downloading then \( W_2 \) value can be higher than \( W_1 \).

### 3.2.4 The Testing Prediction

This research divided two groups. The first group was the training sets and the last group was the testing sets. Those data were taken a random sampling that this research took the data sampling any minute from the datasets. However, we used the same datasets for the LRU algorithm and the OMS algorithm.

### 4. The Result of Experiment

This section shows the result of the research. Those datasets are presented at Table 4. The simple random sampling technique is used for sampling because all data sets have an equal chance.

<table>
<thead>
<tr>
<th>Time</th>
<th>Slot1</th>
<th>Slot2</th>
<th>Slot3</th>
<th>Slot4</th>
<th>Slot5</th>
<th>Hit ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>9:00-9:10</td>
<td>Web1</td>
<td>Web2</td>
<td>Web3</td>
<td>Web4</td>
<td>Web5</td>
<td>29.15</td>
</tr>
<tr>
<td>9:11-9:20</td>
<td>Web1</td>
<td>Web2</td>
<td>Web3</td>
<td>Web4</td>
<td>Web5</td>
<td>48.90</td>
</tr>
<tr>
<td>9:21-9:30</td>
<td>Web1</td>
<td>Web2</td>
<td>Web3</td>
<td>Web8</td>
<td>Web9</td>
<td>33.67</td>
</tr>
<tr>
<td>9:31-9:40</td>
<td>Web1</td>
<td>Web2</td>
<td>Web3</td>
<td>Web5</td>
<td>Web8</td>
<td>57.55</td>
</tr>
<tr>
<td>9:41-9:50</td>
<td>Web2</td>
<td>Web3</td>
<td>Web3</td>
<td>Web5</td>
<td>Web9</td>
<td>63.83</td>
</tr>
<tr>
<td>9:51-10:00</td>
<td>Web1</td>
<td>Web2</td>
<td>Web3</td>
<td>Web4</td>
<td>Web10</td>
<td>61.11</td>
</tr>
<tr>
<td>10:01-10:10</td>
<td>Web1</td>
<td>Web2</td>
<td>Web3</td>
<td>Web8</td>
<td>Web10</td>
<td>42.34</td>
</tr>
<tr>
<td>10:11-10:20</td>
<td>Web1</td>
<td>Web2</td>
<td>Web3</td>
<td>Web4</td>
<td>Web10</td>
<td>72.56</td>
</tr>
<tr>
<td>10:21-10:30</td>
<td>Web1</td>
<td>Web2</td>
<td>Web3</td>
<td>Web4</td>
<td>Web9</td>
<td>69.80</td>
</tr>
<tr>
<td>10:31-10:40</td>
<td>Web1</td>
<td>Web2</td>
<td>Web3</td>
<td>Web4</td>
<td>Web10</td>
<td>70.35</td>
</tr>
<tr>
<td>10:41-10:50</td>
<td>Web1</td>
<td>Web2</td>
<td>Web3</td>
<td>Web4</td>
<td>Web9</td>
<td>57.30</td>
</tr>
<tr>
<td>10:51-11:00</td>
<td>Web1</td>
<td>Web2</td>
<td>Web3</td>
<td>Web10</td>
<td>Web9</td>
<td>42.95</td>
</tr>
<tr>
<td>11:01-11:10</td>
<td>Web1</td>
<td>Web2</td>
<td>Web3</td>
<td>Web4</td>
<td>Web5</td>
<td>65.50</td>
</tr>
<tr>
<td>11:11-11:20</td>
<td>Web1</td>
<td>Web2</td>
<td>Web3</td>
<td>Web4</td>
<td>Web9</td>
<td>38.77</td>
</tr>
<tr>
<td>11:21-11:30</td>
<td>Web1</td>
<td>Web2</td>
<td>Web3</td>
<td>Web4</td>
<td>Web9</td>
<td>64.62</td>
</tr>
<tr>
<td>11:31-11:40</td>
<td>Web1</td>
<td>Web2</td>
<td>Web3</td>
<td>Web4</td>
<td>Web7</td>
<td>30.04</td>
</tr>
<tr>
<td>11:41-11:50</td>
<td>Web1</td>
<td>Web2</td>
<td>Web3</td>
<td>Web4</td>
<td>Web6</td>
<td>51.95</td>
</tr>
<tr>
<td>11:51-12:00</td>
<td>Web1</td>
<td>Web2</td>
<td>Web5</td>
<td>Web4</td>
<td>Web6</td>
<td>69.12</td>
</tr>
</tbody>
</table>

Table 4 presents the hit ratio of the OMS algorithm. The maximum hit ratio is 72.56 percent and the average hit ratio is 53.8.

Next table show the hit ratio of the LRU algorithm. It is compared with the OMS algorithm.
Table 5. The hit ratio of LRU algorithm

<table>
<thead>
<tr>
<th>Time</th>
<th>Hit ratio</th>
<th>Time</th>
<th>Hit ratio</th>
<th>Time</th>
<th>Hit ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>9.00-9.10</td>
<td>8.21</td>
<td>10.01-10.10</td>
<td>8.12</td>
<td>11.11-11.20</td>
<td>6.70</td>
</tr>
<tr>
<td>9.11-9.20</td>
<td>18.25</td>
<td>10.11-10.20</td>
<td>8.12</td>
<td>11.21-11.30</td>
<td>4.35</td>
</tr>
<tr>
<td>9.21-9.30</td>
<td>7.65</td>
<td>10.21-10.30</td>
<td>6.70</td>
<td>11.31-11.40</td>
<td>9.31</td>
</tr>
<tr>
<td>9.31-9.40</td>
<td>12.76</td>
<td>10.31-10.40</td>
<td>14.72</td>
<td>11.41-11.50</td>
<td>53.34</td>
</tr>
<tr>
<td>9.41-9.50</td>
<td>8.00</td>
<td>10.41-10.50</td>
<td>5.30</td>
<td>11.51-12.00</td>
<td>9.10</td>
</tr>
<tr>
<td>9.51-10.00</td>
<td>9.30</td>
<td>10.51-11.00</td>
<td>3.24</td>
<td>11.11-11.20</td>
<td>40.76</td>
</tr>
</tbody>
</table>

Table 5 presents the hit ratio of the LRU algorithm. The average hit ratio is 12.99 percent and the maximum hit ratio is 53.34 percent.

It can be shown that the OMS algorithm can give the hit ratio higher than the LRU algorithm by 17 times. In addition, 15 times of the OMS algorithm are higher than 40 percent while 2 times of the LRU algorithm are higher than 40 percent.

5. The discussion

This article has given exhaustive comparing of the results two algorithms (OMS algorithm and LRU algorithm). The percentage of the hit ratio of the OMS algorithm is higher than the LRU algorithm by 17 times. However, the OMS algorithm has the hit ratio not over 75 percent in any time.

6. Summary and Suggestion

In this paper, we have proposed a new algorithm called the OMS algorithm for web usage forecasting and increasing the hit ratio. The OMS algorithm improves the LRU algorithm with Mathemetic methods. However, we do not preset the cost of downloading but it is difficult for calculation and we would like to present this problem in next research report. Lastly, we will research a new approach to enhance efficiency of web cache replacement.

10. References


