Designing more Reliable Web Sites with Performability Modeling

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Abstract

In this paper, the reliability, in a greater sense, of a Web site is considered. This concept is extended in order to take into account the design of it as a major factor of its general performance. For this purpose a performability indicator modeled by Non Homogeneous Markov Chain is provided for evaluating the efficiency of the site.

1 Introduction

Vast investments for the creation of new Internet sites have taken place in order to simplify and improve many kinds of public services or to advertise new products, companies and innovations. That intense use of Web sites requires a detailed research of their reliability [10] in order to stand up for such exploitation.

The reliability of an Internet site depends on two basic factors, initially, the down time of the system and secondly the amount of users that are served successfully. The first factor is obvious for the smooth operation of the site and the increase of the reliability indicator, but taking into account only this suggestion, the amount of the successful service of customer's tasks, which will finally judge the quality of the Web site, is ignored.

A visitor's task is served successfully when the information or the service demanded is precisely located. Hence a well designed site, with its pages well placed and the proper references between contents should guide precisely all visitors according to their search.

A Web site that fulfils all the above requests, forms an indication of good performance by the reception of many visits with extensive walkthroughs and large sojourn times in the visited pages. On the other hand sparse visits and extensive walkthroughs without spending time in the visited pages generally mean that small volume and sparse supply of information is delivered, resulting in a large number of customers that fail to be served successfully and in a low overall performance of the Website itself. This is also a serious indication of malfunction and poor design structure because the visitor was either misguided or the contents of the page were irrelevant to his interests.

Hence, computing the performability [1] [2] [3] [4] [7] [9] [10] of a site, the reliability is also defined directly, taking into account a serious factor which is visitor's behavior through the site.

In order to evaluate the overall performance, a performability indicator was defined. The visitor trip through the pages of the Website has been modeled with a Markov chain. However, since the measured hits on the pages are not constant over time, the use of a homogeneous Markov chain seems inappropriate. In fact, the flow of users varies from hour to hour, but a daily periodicity may be observed, and as a result a cyclic non-homogeneous Markov chain [5] was used.

For the performability model a time dependant cost has been assigned and an impulse reward was created referring to visitor's transition from one page to another. Hence by taking into consideration the previous facts, the asymptotic total cumulative reward can be evaluated over a 24 hour time period.

In the last session, an analytical example is considered.

2 Website performability indicator and Page reward

When trying to evaluate a certain page of a Web site according to its ability to serve most of the visitors adequately, it is vital to take into consideration the event of visiting page *i*, at time *k*, remaining in that page for *s* units of time the transition to the destination page *j* and its respective cost as $C_{i,j,k,s}$, cf.[8].

$$A_{i,j,k,s} = \{X_{k-1} \neq i, X_k = i, \ldots, X_{k+s-1} = i, X_{k+s} = j\} \tag{1}$$

Hence the performability indicator will be given as follows:

$$E[A_{i,j,k,s}] = \sum_{i,j,k,s} C_{i,j,k,s} \Pr(A_{i,j,k,s}) \tag{2}$$

Another formula that is a special case of the above is the following which evaluates the ability of the pages to guide the customers to specific Web places. These pages should not have great sojourn time but they must lead users to the desired pages rapidly. Thus:

$$A_{i,j,k} = \{X_{k-1} = i, X_k = j, X_{k+1} \neq j\} \quad (3)$$

$$E[A_{i,j,k}] = \sum_{i,j,k} C_{i,j,k} * \Pr(A_{i,j,k}) \quad (4)$$

The main objective of a well designed Web site is the proper promotion of some pages which are called *target pages.* This demands that the visitor should have one of these pages as his final destination and at the same time he should stay there as much as possible. On the other hand the rest of the pages are of great importance for the performance of the whole site, therefore visitor should also pay attention to them. Irrelevant to the subject or uninteresting pages should harm the main objective of the site, because users may give up from tracking down the desired pages. Another aspect of great importance is the design of the site itself. Generally a target page should accept a large volume of visitors. That means that it should accept many links of the rest pages and the choices for exiting from there should be limited. The places of the site that are linked to target page should not accept a large number of undesired links, such as pages irrelevant to the subject, because they misguide users. Time of visiting pages is also important because rewards of a time period where volume of hits is reduced should not affect directly the result of the study.

Taking into account all the above reasons, the cumulative reward depends on some factors that take place simultaneously. Hence the generic form of the reward is a tree that has five levels each one of which has some threshold points.

The first level refers to the hitting time of page i. Page i is the directly linked page to page j which is the target page. There are three threshold points which refers to the three different time period according to the volume of the hits of the study period. The second level refers to the time spent at page i. The longer the sojourn time is, the greater the reward is. The third level refers to the number of links that page i accepts. The larger the number is, the larger the cost is because more amount of users are likely to visit target page. The fourth level refers to the number of exits with which page i is equipped. The less exit links it has, the greater reward is because visitors are well guided to the desired page. The fifth level refers to the number of links that target page accepts. Visitors should have a variety of paths but with a common destination.

The reward is cumulated in the following way. At each level every page belongs to one of the threshold points. At each point there is a percentage increase of the existing reward. That increase is added to the previous reward. The process ends when it reaches the final level.

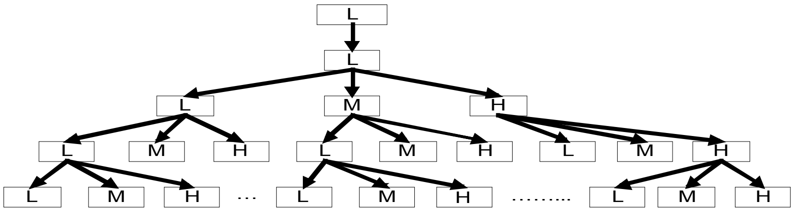

Figure 1. Generic form of the reward tree

For the second reward's function, cost is cumulated with a three-level tree. The first level refers to the hitting time and has the same threshold points as the first tree. The second level refers to the number of links that are the inputs to page j. The more inputs there are the more increase is recorded. The third level refers to the number of outputs and the increase follows as above. The pattern that follows the cumulative cost is directly connected to the fact that there should be a way of measuring the ability of each page, to receive and spread visitors.

3 Numerical Results

In order to evaluate the effectiveness of the performability equations, these were tested on the site of the Aegean University. The time window T of the study was defined at 24 hours and there were three time zones. These zones were chosen according to their significance for a site. Thus it was assumed that the low zone was from 0:00 to 08:00, the medium zone was from 8:01 to 16:00 and the high zone was from 16:01 to 23:59. The reward function which defines the costs for each case of the study was defined so that every level should have 3 threshold points, low medium and high

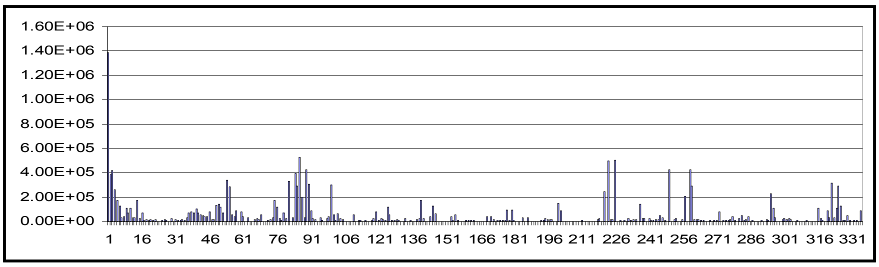

Figure 2. Performance of each page assuming each one as target page

Analyzing the graph, page 1, which is the homepage of the whole site, appears to have the highest performance through the rest of the pages. It contains all the links to services and information for both departments. Another characteristic of that page is that it accepts a vast number of links, these are 57. The outputs are 42, thus its price is one of the highest. The next page of the site that appears with the second higher performability is page which contains information of the library from the site of the department of Information and Communication Systems Engineering, page 86. That page has only 5 inputs from other pages, which are possibly to guide a vast number of visitors to page 86 and there are few exit links from that page, which implies to a good price. An example of a poorly designed part of the site is at page which refers also to the library from the site of the department of the Mathematics, page 23. Although it receives 5 links from other pages and there is no exit point from that page. Its performance is still poor because the probability of receiving visitors from other pages is very low. Another defective point of the site is page 10, which is the homepage of the department of the Information and Communication Systems Engineering. The page has one of the worst performances of the site. The reason is that it accepts only two links and provides users to 40 different pages. The number of inputs that accepts cannot justify the vast number of exits hence the price is too low.

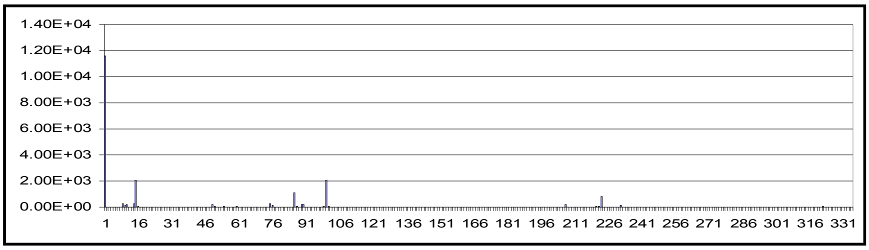

Figure 3. Performance of each page assuming each one as node page

The only page that appears to satisfy the standards of the equation (4) is page number 1. Page 1 accepts 57 links and distributes users through 42 links to other places of the Web site. The advantage of these node points of the site is that they can help important pages to be successfully promoted. The proof is that a few of pages which are directly linked to page 1 seem to have greater performance than the others. From figure 3 it is obvious that this page serves the rest of the site quite successfully. Page number 10 constitutes a defective point of the site and this fact is proved by equation (4). Although it guides users to 42 different pages the inputs are only two. Thus there is not enough number of users to cover the 42 links. Thus pages that are connected directly to page 10 sparsely accept visitors from there.

From equations (2) and (4) we can extract a few general rules about the successful design of a site. A target page should be connected to pages that are capable to provide vast users there and should not have lots of exit links so that visitor should pay more attention. Pages that distribute users to the rest of the places of the Web site are of high importance because pages that have links to them appear to have an increased performance. On the other hand it is crucial that these knot points should be well designed with a good navigation, so that users are not misguided during their search. Hence, designers with these criteria can change the structure of the Web place and promote each target page more effectively.

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