Association-Rules-Based Recommender System for Personalization in Adaptive Web-Based Applications

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Abstract. Personalization systems based upon users' surfing behavior analysis imply three phases: data collection, pattern discovery and recommendation. Due to the dimension of log files and high processing time, the first two phases are being achieved offline, in a batch process. In this article, we propose WRS, an architecture for adaptive web applications. Within the framework, usage data is being implicitly achieved by data collection submodule. This allows for the extraction of usage data, online and in real time, by using a proactive approach. For the pattern discovery, we efficiently used association rule mining among both frequent and infrequent items. This is due to the fact that the pattern discovery module transactionally processes users' sessions and uses incremental storage of rules. Finally, we will show that Wise Recommender System (WRS) can be easily implemented within any web application, thanks to the efficient integration of the three phases into an online transactional process.

Keywords: Adaptive web-based applications, Web usage mining, Recommendation systems, Web personalization, Association rules

1. Introduction

The ability of a web application to offer personalised content and to adapt is determined by its ability to anticipate users' needs and to provide them with the information and content they need. Adaptive web applications [10] can do this only after analysing data resulted from the users' current and former interaction with the system. Based upon the similarities discovered between different types of content and different user groups, one can make a series of recommendations enhancing the capacity of adaptation and personalisation of web applications. Personalisation systems based upon the user's surfing behaviour analysis imply three phases [9]: data collection and preparation, pattern discovery and content recommendation. Thus, a new research branch, called Web Usage Mining came into being, its goal being that of discovering useful information and knowledge as a result of analysing these interactions. The WUM techniques use data extracted from log-files and provide information about activities undertaken by users during surfing sessions. In order to

discover new useful information, WUM applies a series of diverse techniques, like classification, clustering, discovery of association rules or sequential patterns [9].

In our research, we have used the technique of association rules, in order to discover correlations between the pages of a web application, based upon the analysis of the user's surfing sessions. Our efforts were channeled towards finding an efficient solution for implementing a recommendation system within a web application capable to synthesize and to store only those data that are relevant for the recommendation process and within which all three phases to be realized online. Thus, we have proposed a new framework to allow meeting high personalisation requests of actual web applications. The Wise Recommender System (WRS) uses a proactive approach, allowing the extraction of data about users' interaction with the web application. The collecting of usage data is being implicitly achieved, without the need of an explicit request from the part of the users' opinion. Our approach allows the incremental finding and storing, both of the existing connections between frequently visited pages, as well as of those less frequently visited. As a result, the WRS is able to offer a list of personalised pages to each user, depending on the current pages he is just surfing on, without the need for a surfing history or a minimal number of visited pages.

2. Adaptive Websites and Web Personalisation Systems

The concept of Adaptive Websites was proposed by Perkowitz and Etzioni in [10]. Adaptive websites are being defined as those sites using information about the way in which users access them, in order to improve their organisation and presentation. The Web Personalization System is defined in [9] as being any action which adapts information and services provided by a web application to a user's or to a group of users' needs. A personalisation system must be able to provide users with the information they need, without them having to explicitly request it.

During the last years, more and more researchers paid a special attention to WUM domains and to the personalisation of web applications. Among the first researchers who channeled their efforts towards the Web Usage Analysis and WUM were Cooley et al. [7], who proposed WebMiner, one of the first systems offering an overview of WUM. The PageGather [10], is an algorithm of synthesising, using clustering in order to find collections of similar pages within a website. The WebPersonalizer [9] have the goal to make recommendations to the users, based upon the similarity of the surfing behaviour with that of users in the past and contains an offline module, whose role is to filter log files data and to extract the most interesting surfing models. We can also mention SUGGEST [2] and Smart-Miner [3] which can efficiently process terabytes of web log files.

In order to be able to use data residing in log files, it is absolutely necessary that these be cleaned and filtered. The analysis of the log files raises a series of problems, namely: the existance of a high number of irrelevant records for the process of web usage mining, the difficulty of the identification of users and sessions, the lack of information about the content of accessed pages, the data processing is a batch processing, which takes time and resources. Literature known several methods which help to identify and delimit a user's sessions. The most popular approache is the 30

minutes time limit threshold [4], followed by reference length [7], and maximal forward reference [6]. The multiple inconvenients connected to the identification of the users and sessions have led to the development of some so-called reactive and proactive strategies. Reactive strategies want to associate requests with users, based upon web server logs, after they have interacted with the website. On the other hand, proactive strategies want to associate requests with users, during their interaction with the website [11].

The goal of the association rules mining [1], [5] is to discover correlations or relations of association between existing records in a dataset. In [5] fundamental association rules have been mentioned, from their emergence and up to the present moment. These works present both classic algorithms like: Apriori, Eclat, Clique, FP-Growth, a.s.o., as well as the generical optimisations they were provided with. In [8], some practical and efficient methods are being presented, in order to find association rules in the case of less frequent items.

3. Wise Recommender System (WRS), the proposed architecture for web personalisation

In order to increase the capacity of adaptation and personalisation of web applications, we have integrated several submodules in an innovative manner. Thus, the collecting submodule allows the extraction of usage data, online and in real time, by using the proactive approach. The extraction of data about the users' surfing behavior, preferences and activities is being implicitly accomplished, without the necessity of explicitly involving these into the collection process. The data extracted in this manner are quality data, complete, noiseless and error-free. Even more, WRS also considers the content very rarely, occasionally accessed. In figure 1, one can see the architecture of the WRS system we propose.

The crawler identification submodule allows the identification of search engines from human users. This submodule has access to a table which contains the names and the IPs, respectively the IP intervals that are alloted to the main web crawlers. It has the role of filtering web crawlers and of sending the users' identification submodule only the traffic generated by human users.

The goal of the user identification submodule is to identify, within a web application, uniquely human users. In order to achieve this goal, the submodule implemented by us successfully uses the newest web technologies allowing session work and uniquely identifies each user, taking into consideration the IP address, but at the same time also considering the fact that it could be behind a proxy. Thus, it will associate to each user a unique session ID, valid from the moment the user accesses the application and up to the moment he will close the web browser.

The content identification submodule must identify the content accessed by the user, uniquely. The identified content will be stored in a table, together with the number of hits it had over time. Should a page be accessed several times by a user within a surfing session, its accessing value will be incremented by a unit.

The goal of the session identification submodule is to identify surfing sessions for each user. This is quite simple, due to the fact that these ones are already uniquely

identified by the users' identification submodule. Furthermore, all pages the web application generates for a user, will be accompanied by their session ID. In order to identify and delimit users' sessions, we based our implementation on the W3C approach, one session being made of the totality of pages accessed by a user, from the moment the user opens the web browser and up to the moment the user closes it.

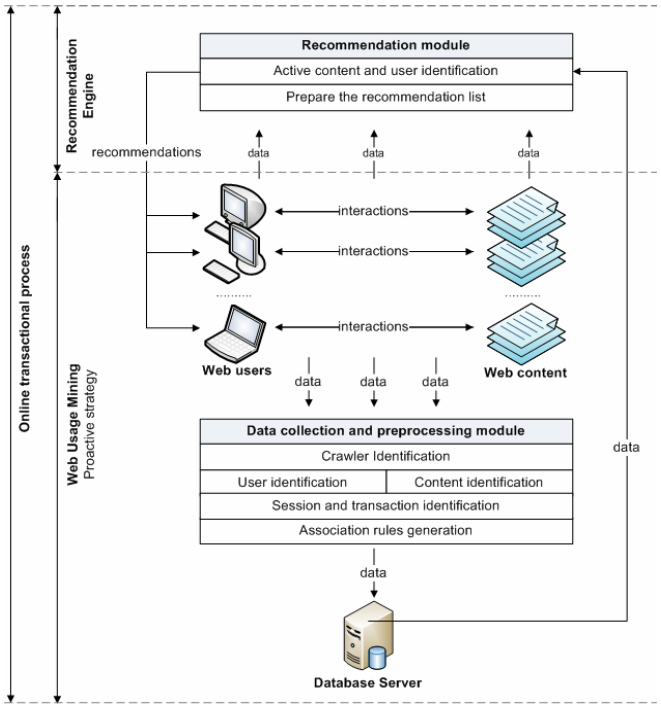

Fig. 1. WRS. The proposed architecture for web recommendation and personalization

The association rules generation submodule can access, in real time, data taken over by the other submodules. Thus, it will connect to the identification submodule of the sessions and will take over from this one users' sessions, in order to generate association rules. The generating of association rules is being done online, in real time, in a transactional process. Once the session has been processed, rules extracted and inserted, it will be deleted from the sessions table. Due to the innovating method of processing sessions and storing of association rules, we succeeded in achieving a scalable model, able to work in real time with a large volume of data.

The active content and user identification is a submodule whose role is to identify the active user and the page this one is visiting. The moment a user accesses a web page, an identification ID is sent, in order to identify the active page of the recommendation list generation submodule. The recommendation list generation receives an identification ID of the current page and has the role of selecting from the database the recommendation list will contain the pages in a descending order, according to the degree of confidence.

4. Description of experiments we have carried out

In order to prove the scalability of the proposed model, we have undertaken a series of experiments on two popular Romanian websites: Intelepciune and BizCar. The two websites total over 380.000 unique online visitors, respectively over 1,6 million page views per month. We have implemented the proposed model on the two above-mentioned sites and in figure 2 one can notice the dynamics of content, sessions and rules over a period of 32 days in classifieds section.

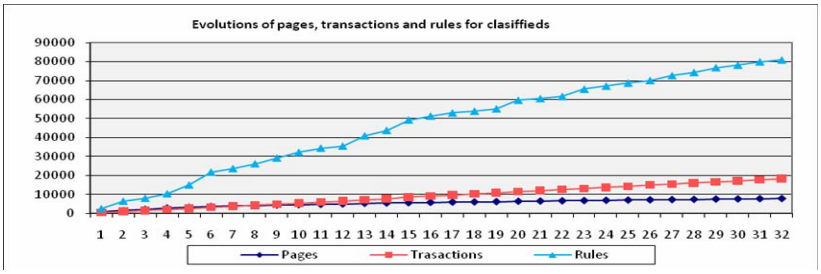

Fig. 2. The evolution of pages, sessions and rules in classifieds section

Unlike other approaches, in the model we propose, the recommendation period is not being influenced by the number of recorded sessions. In table 1, we can notice the time necessary in order to generate a recommendation list depending on the evolution in time of the number of pages, sessions and rules generated for Intelepciune.ro.

Table 1. The time, number of pages, sessions and generated rules

Page No.	1072	3589	5234	7525	9669	17230	20453	22564
Sessions	667	2687	4922	9723	10799	19952	25637	33628
Rules	3497	18774	33337	53558	63711	99135	116110	142131
Time	0.002	0.008	0.013	0.039	0.052	0.085	0.139	0.159

By looking at the data from the table 1, one can notice that the time in order to generate a list of recommendations is being influenced by two factors: the number of generated pages and rules. As a result, we undertook to analyse the dependence between the recommendation time and the two factors of influence with the help of a regression model. As a result of a statistical analysis, we obtained Multiple R = 0,988572, which shows that there is a strong connection between the two variables, the number of generated pages and rules. We obtained R Square = 0,977274, a fact showing us that 97% from the variation of the recommendation time is being explained by the two variables. The average square variation (Standard Error) = 0,009048, the result being that the points on the regression are approaching a straight. Due to the fact that in the case of the number of pages, the P-value is 0,00399 < 0.05, the result is that this coefficient is of significance. For the generated rules of the P-value = 0,884357 > 0.05, the result is that we are talking about an insignificant coefficient. From here, we can conclude that this variable can be eliminated from the model, thus resulting a simple linear regression model.

Conclusions

One of the most important goal of an adaptive web application is the content recommendation in a period of time as short as possible. In this article, we proposed WRS for content recommendation and we used association rules in order to model existing connections between the pages of a web application. The proposed system brings an additional benefit, because it allows the finding and maintaining in the system of the rules existing between those pages that are not frequently being accessed by users, too. In this article, we proposed a different approach for a recommendation system, by integrating the pattern discovery phase and that of data collection and filtering into a single module. Following the undertaken experiments, it resulted that the proposed model is very efficient in order to recommend the content and can be easily implemented within any web application. In future, we wish to continue the optimisation of recommendation system by incorporating different resulted particularities from the type of content existing in different web applications. Likewise, we would like to exploit knowledge extracted over a longer period of time, in order to see the evolution of the intensity of connections discovered over time.

Acknowledgement: This work is supported by the Romanian Authority for Scientific Research under project IDEI_2596.

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