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A Suggested Algorithm of Recommender System to Recommend Learning Objects from Digital Library to Learning Management System

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Abstract: Digital Library (DL) and Learning Management System (LMS) have been widely used in many educational institutes without any integration of their local LMS and local DL, which let students suffer from Information Overload problem arising from searching DL. This study provides background of DL, LMS and Recommendation Systems (RS) as well as some examples. In addition, it discusses the suitability of main RS approaches to recommend digital objects from DL to support students' needs. Finally, it presents a new proposal of RS algorithm in LMS which could automatically recommend suitable digital learning objects from a big list of DL.

Key words: Recommender system, digital library, LMS, DL, RS

INTRODUCTION

Many educational institutes used an eLearning platform Learning Management System (LMS) to automate the administration of their training events. In the same time, these institutes have local Digital Library (DL) without any integration of their local LMS and local DL. As a result, the students have to search the DL about learning objects related to their LMS Course. Consequently, the students suffer from the Information Overload problem, when they find thousands of results that are not suitable and related to their LMS course (eCourse).

To solve this problem, the institute needs RS to present interesting learning objects (relates to student eCourse as well as fit his preferences) from local DL with little efforts, which could be listed automatically in a particular eCourse upon suitable priorities. Figure 1 shows between DL and LMS.

Digital library: Terms such as digital library, electronic library and virtual library are often used synonymously. However, digital library will be used in this research. Digital library as collections can be defined as an organized and focused collection of digital objects, including text, images, video and audio along with methods for access and retrieval and for selection, creation, organization and maintenance (Witten *et al*., 2009). In fact, DL is more than a collection of books, documents and materials of traditional library on an electronic (digital) form it also contains any digital material, e.g., Software, multimedia. One can review a list of digital libraries in Yahoo! Search directory, <http://dir.yahoo.com/Reference/Libraries/Digital_Libraries>. Besides the DL, the majority of the modern traditional libraries have been automated and computerized by saving information of objects and resources (e.g., books, magazines, CD's, etc.). Furthermore, some of these libraries adopt also some DL functions (electronic resources) by saving digital objects. Consequently, the user can search for these resources via internet anywhere to review full content of eBook or to see some information about a paper based book. This kind of library could be named as On-Line Library.

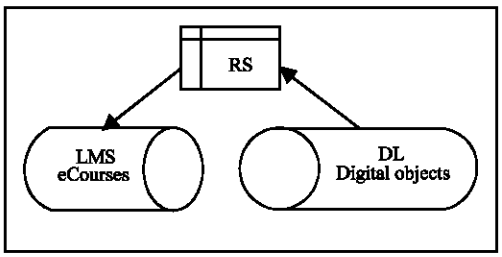

Fig. 1: A general structure of RS algorithm

Digital library software packages: The market of Digital Library Software is growing some of those Packages are commercial Software, while others are free Open-Sources. The following list shows some examples:

Commercial packages:

- SirsiDynix digital library, <www.sirsidynix.com/Solutions/Products/digitalarchive.php>

- Content manager-IBM's Digital Library Software,< www-306.ibm.com/software/data/cm/cmgr>
- DigiTool (of Ex Libris), <www.exlibris.co.il>
- Artesia digital asset management-DAM, <http://www.artesia.com/our-products.aspx>

Open-source packages:

- DSpace, <www.dspace.org>
- Greenstone Digital Library Software, <www. greenstone.org>
- EPrints, <www.eprints.org>
- Fedora digital object repository management system, <www.fedora.info>

Targeted DL software: This proposed algorithm will use Digital library software package to recommend digital objects to a LMS. Upon the proprieties of DL Package, some of them may need very small changes to implement this algorithm. Therefore, this algorithm can be implemented on:

- All the Open-Source DL Software Packages
- Any Commercial DL Software Packages which do not need any changes
- Other Commercial Packages which can be modified

The same way, the aforementioned On-Line Library, can deal with the algorithm where the recommendation objects could be as information about hard object in the library or digital object from electronic resources.

Learning management system: The LMS/CMS is an eLearning platform which is considered as an important part of eLearning solutions (Itmazi *et al*., 2005). Moreover, there are some concepts similar to LMS (with a small difference), e.g., LCMS (Learning Content Management System) and Portal Learning.

Anyway, LMS is software that automates the administration of training events; it manage the log-in of registered users, manage course catalogs, track learner activities and results as well as provide reports to management. The market of LMS is increasing very fast and there are >70 vendors some of LMSs are commercial Software, while others are free Open-Source LMSs. The following list shows some LMSs:

- Commercial LMS: e.g., WebCT <www.WebCT.com> and eCollege <www.ecollege.com>
- Open-Source LMS: e.g., MOODLE <http://moodle.org> and ILIAS <www.ilias.de>

Recommendations systems: Last decade, RSs have been widely implemented and accepted in many sectors of Internet. We are familiar with recommendations of products (e.g., books, music, movies) and of services (e.g., restaurants, hotels, Web sites), likewise recommendation is not arising from the digital era but an existing social behaviour in daily life. In everyday life, we rely on recommendations from others.

More and more information is available electronically; moreover, the World Wide Web is still growing faster as a result, the users suffer from the Information Overload problem when searching on Internet. Generally, the aim of RSs in Web applications is to present interesting information that fits the users tastes and preferences with little effort. In contrast, sometimes RSs are used to hide special information! and specifically, the aim of RSs in eLearning applications (e.g., LMS) is listing the closest available learning objects to what the instructor describes as the module's content (Calvo, 2003).

Current usage of RS: RSs have been widely used in many Internet activities. It is worth mentioning some examples of the current actual uses of RS.

eCommerce: RSs are used to suggest products to their customers and provide consumers with information to help them decide which products to purchase (Schafer *et al*., 2001). Examples: Amazon.com and barnesnoble.com.

Web pages: RS is used to solve the overload problem in the Internet, when using search engines (e.g., Google, Yahoo) which produce thousands of pages to one researched item, most of them have worthless relation to the researched item or of no interest to the user. Example of search engines which used RS: Mi Yahoo! http://my.yahoo.com and Alexa.com.

Censorship systems: RSs used to protect children from accessing undesirable material on the internet. e.g., cyberpatrol.com as well as Prevent citizens from exploring some Web sites; which some governments already did.
Other sectors: Examples:

- News: e.g., <www.lemonde.fr>
- Encyclopedia: e.g., <http://en.wikipedia.org>
- Software: e.g., <www.download.com>
- Stores: e.g., <www.drugstore.com>
- Tourist information: e.g., <www.viamichelin.com>
- Digital library: e.g., <www.elibraryhub.com>

RS and eLearning: eLearning somehow is a new field to apply RS, which may be used to recommend the most appropriate content to students. In this study, the focus will be at the use of RS in LMS or CMS. Some researchers mentioned the abilities of using RS in eLearning systems

in general and LMS in particular. For example, Calvo (2003) presented the RS as an important feature within the Intelligent LMS.

Andronico (2003) presented a project of three Italian universities, which aims to integrate a multi-agent RS that suggests educational resources to students into a mobile learning platform in a university context. Lu (2004) presented a framework of personalized eLearning material recommender system and discusses related technology. Itmazi and Gea (2008) develop algorithm of RS at open source LMS.

MATERIALS AND METHODS

The suitability of RS approaches: Actually, RSs consist of approaches everyone has techniques. However, there are many systems that use Hybrid Recommender System (HRS), which combines two or more recommendation techniques to gain better performance.

Here, we are going to study the suitability of the main RS approaches to recommend digital objects from DL to a LMS.

Content-Based System (CBS): In this type, the objects are selected by having correlation between the content of the objects and the user's preferences. Examples: Infofilter (Elkhalifa, 2004) and InfoFinder <http://infofinder.cgiar.org>. In the case of LMS, CBS can be used within LMS as a primary approach to recommend digital learning objects from DL by detecting similarities between the current eCourse attributes (name, keywords, abstract etc.) and the digital objects attributes from DL.

Collaborative Filtering Systems (CFS): It recommends items or objects to a target user based on similar users' preferences and on the opinions of other users with similar tastes. It employs statistical techniques to find a set of users known as neighbours to the target user, examples: Amazon.com and ebay.com.

CFS has some methods to calculate the likeliness from the rating matrix, the suitable one to our RS is Memory-Based Algorithm (also known as k-Nearest Neighbour Method), because it is suitable to environments where the user preferences have to be updated rapidly.

Demographic-Based System (DBS): It uses prior knowledge on demographic information about the users and their opinions for the recommended items as basis for recommendations (Nageswara and Talwao, 2008). It aims to categorize the user based on personal explicit attributes and make recommendations based on demographic group that a user belongs to such as (income, age, learning level or geographical region) or a combination of these clusters/groups. Examples: Grundy, a book RS, where people's descriptions of themselves were used to build a user model and then predict characteristics of books that they would enjoy (Rich, 1979) and the Free e-mail suppliers put advertisements based on the user demographic information such as RS used in Hotmail and Yahoo.

The DBS could be used in the process of recommending digital objects as a complementary approach.

Rule-Based Filtering (RBF): It is filtering information according to set of rules expressing the information filtering policy (Terveen and Hill, 2001). These rules may be part of the user or the system profile contents and it may refer to various attributes of the data items. In general, this system is used widely with:

Censorship: RBF is useful in the protection domain e.g., the protection of kids from accessing some materials, e.g., Cyberpatrol.com and Cybersitter.com (Itmazi and Gea, 2006).

Spam filtering: RBF is useful to be used against the Spam e-mails, e.g., Spam Assassin <spamassassin.apache.org/> and MailEssentials <www.gfi.com>. In RS, RBF could be used to filter the recommendations list of digital objects upon some rules of system and student.

Hybrid Recommender System (HRS): It combines two or more recommendation techniques to gain better performance with fewer of the drawbacks of any individual one (Robin and Burke, 2002). Examples of systems: Tapestry (Goldberg *et al*., 1992), which mixed CBS and CFS, hybrid algorithm system (Vozalis and Margaritis, 2004) which mixed CFS and DBS and Information lens, which combines the CBS with the RBF (Mackay *et al*., 1989).

RESULTS AND DISCUSSION

A general RS proposal: The suitable RS approach to recommend digital objects from local DL to LMS will not be a pure one but it will be a HRS, which mixed some of the previous approaches. The following general RS structure could be suggested to be used in LMS to recommend digital objects (Fig. 2). We list some consideration of this proposal structure:

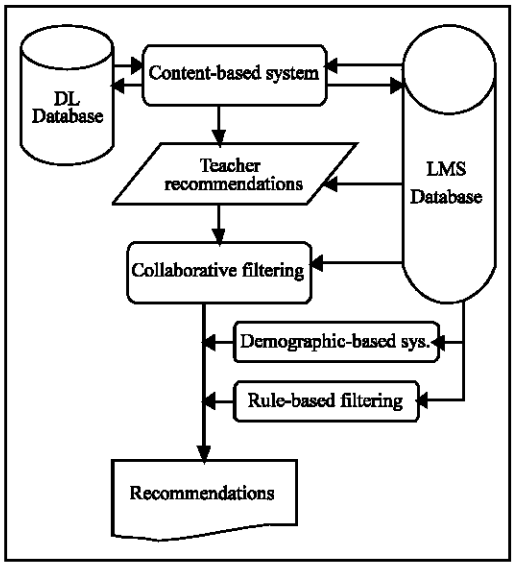

Fig. 2: A general proposal structure of RS algorithm

- CBS is used as a primary approach because it can give comprehensive, related and sufficient recommendations by using the objects attributes in the recommendation process
- CFS is not used as a primary approach because this approach becomes useful only after a critical mass of opinions, which means less numbers of recommendations or null recommendations
- DBS and RBF used as complementary approaches, because the demographic information of DBS and the rules of RBF are not useful to be a primary approach
- The recommendations will appear at the eCourse window when the student enters his eCourse

The stage of content-based system: In this stage, the digital objects are selected by detecting similarities between the items of current eCourse (the active eCourse which the student already enters) and the items of digital objects in the DL. These eCourse items include: name, keywords, abstract etc. Therefore at the first stage, the CBS retrieves a list of the related digital objects from the DL database.

Algorithm of CBS: The general steps of the CBS (Fig. 3) are:

- Getting the current eCourse attributes (Name, Keywords and Abstract)
- Reading the attributes of the digital object from the DL database, (Name, Keywords and Abstract)
- Making the attributes comparison between the current eCourse and the digital object

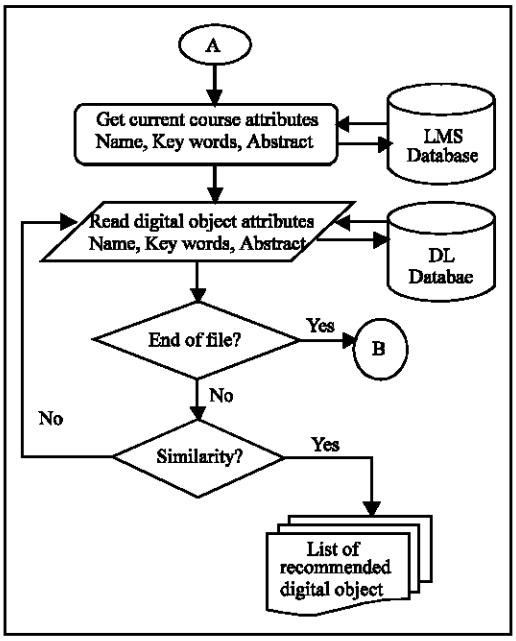

Fig. 3: Algorithm of the CBS stage

- Putting the link of the digital object at the recommendation list if it is related to the current eCourse
- Repeat the previous process until finished all the digital objects
- Finally, the recommended digital objects are passed to the next stage

The stage of teacher recommendations: The teacher recommendations are the resources which the teacher put in his eCourse as recommended ones. They could be:

- Internal LMS resources (e.g., eCourses from the local LMS)
- Internal DL resources (digital objects from the local DL)
- External resources

The algorithm filtered the resources to allow only the digital objects from the local DL to be added to the recommendation list.

Algorithm of teacher recommendations: The general steps of the teacher recommendations stage (Fig. 4) are:

- Receiving the list of the recommended digital objects from the previous stage
- Reading the (teacher recommendations) resources from the LMS Database
- Choosing the internal DL digital objects from these resources and give them high priorities

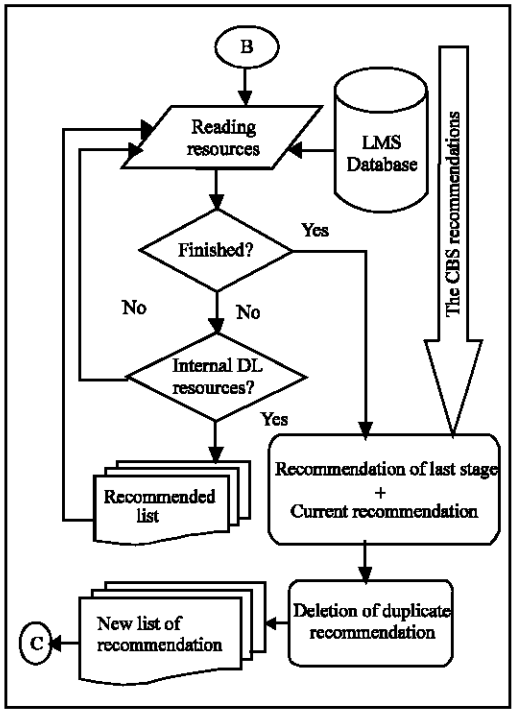

Fig. 4: Algorithm of the teacher recommendations stage

- Deleting the duplicate low priorities recommendations
- Finally, adding the chosen resources to the recommended list from the previous stage and passing all of them to the next stage

The stage of collaborative filtering: We use CFS as a complementary approach to organize the priorities of the recommendations. The general mechanism of CFS based on defining subgroups (every subgroup known as the nearest neighbours) whose preferences are similar to the active user, so the nearest neighbours of the active student are those students who share the same institute (department, school). Then this stage calculates the average of the subgroups rating to order the recommendations upon the high rates.

The rating matrix: The target LMS, must have a way to capture the rating by explicit, implicit methods or mixture of them. These students' rates of the digital objects saved in the LMS database as a table of two dimension matrix where the row represents all the rates of one student on all digital objects, while the column represents all the rates of all students on one digital object (Table 1).

Algorithm of the collaborative filtering: The general steps of this stage are as the following (Fig. 5):

Table 1: Rating matrix

	Digital objects			
Student	DO1	DO2	…	DOm
1				2
2	5	3	3	
…			3	5
n	3		5	

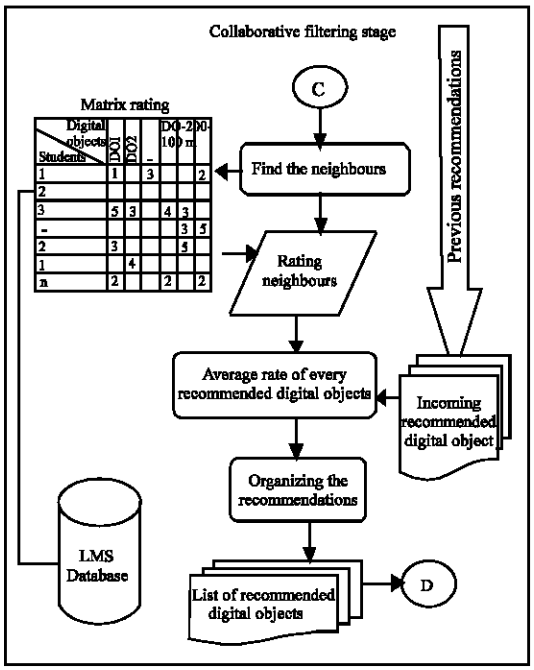

Fig. 5: Algorithm of the CFS stage

- Receiving the list of the recommended digital objects from the previous stage
- Finding the neighbours of the active student
- Finding the average rates of the neighbours for every recommend digital object
- Organizing the recommendations upon the highest average firstly, organizing the set of the teacher recommendations which already have the higher priorities then organizing the other recommendations set which came from CBS stage
- Finally, the recommended digital objects are passed to the next stage

The stage of demographic-based filtering: Theoretically, the role of DBF in a LMS is to filter the incoming recommendations from the previous stage upon the students' demographic (and personal) data that related to education issues. For example, the following demographic-personal data could be related to the education issues: preferred language, student specialization, study level year faculty and department.

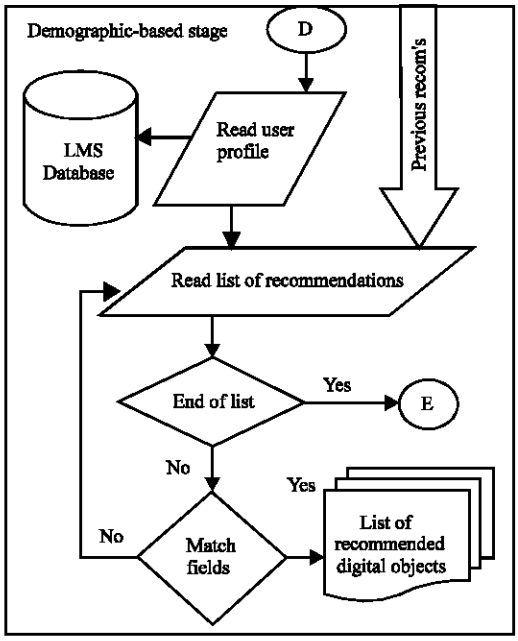

Fig. 6: Algorithm of the CFS stage

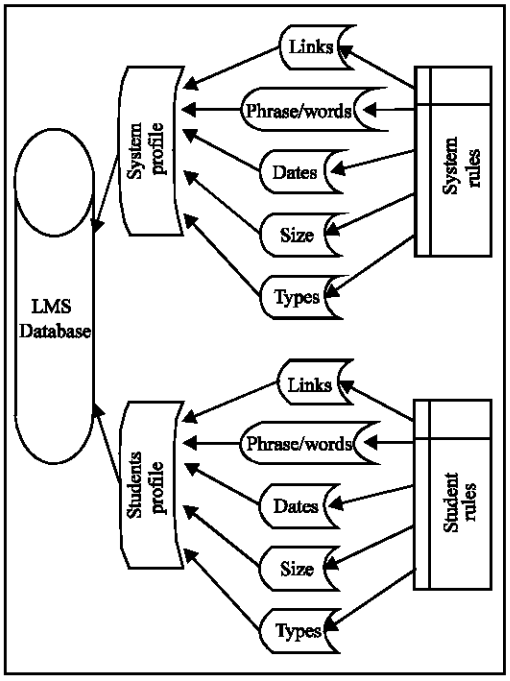

Fig. 7: Student and system rules

The language filtration as an example, means that the active student needs all the recommended digital objects in his preferred language, so any language of digital objects in the recommendations list defer from his preferred language will be deleted.

Algorithm of the demographic-based filtering: DBF could be work as follow (Fig. 6):

- Receiving the list of the recommended digital objects from the previous stage
- Reading the related demographic and personal data of the active student profile
- Matching the related fields of each digital object from the list with the fields of the active student profile, so if the matching process is not positive; the digital object will be deleted from the list
- Finally, the recommended digital objects are passed to the next stage

The stage of rule-based filtering: RBF will filter the incoming recommended digital objects upon a set of rules, which could be found in the student profile and in the system profile. The system administrator put some rules in the system profile, while the student can put his own rules in his profile.

We suggest that the following types of rules that could be used in the student profile and the system profile to filter the listed digital objects (Fig. 7):

Link: The system will filter out any digital object whose link found in the rules profiles.

Phrase or word: The system will filter out any digital object which his name, keywords or abstract match any phrase or word found in the rules profiles.

Date: The system will not show any digital object does not fit the date criteria.

Size: The system will not show any digital object does not fit the size criteria.

Type: The system will not show any digital object does not fit the type criteria.

Algorithm of the rule-based filtering: RBF could be work as follow (Fig. 8): Receiving the list of the recommended digital objects from the previous stage. Reading the following fields of the system rules:

- Field which contains link of digital object
- Field which contains keywords
- Fields of maximum and minimum dates
- Field which contains the allowed size
- Field which contains the forbidden types

The system deletes from the recommendations list every digital object that matches any link or keywords as well as any digital object whose dates are out of the

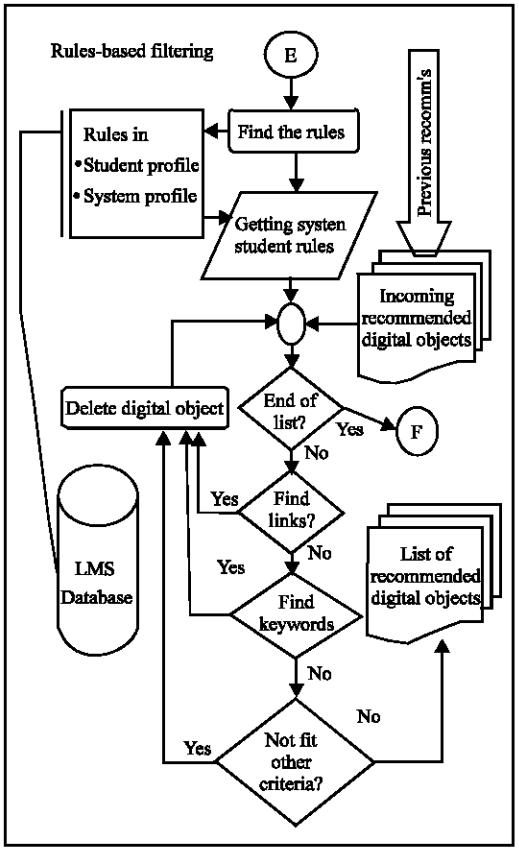

Fig. 8: Algorithm of the RBF stage

minimum-maximum dates. It also deletes any digital object, whose size is larger than the allowed size and whose type matches the forbidden types. Reading the same fields of rules from the student profile and repeating the filtration process. Finally, the recommended digital objects are prepared to be presented in a suitable way on the windows of active student eCourse.

CONCLUSION

Rss have been widely used in many Internet activities, mainly to overcome the information overload problem, which the user faced while searching any item and getting thousands of unrelated results. This research tries to solve the overload problem when user searches DL about suitable and related digital objects to their current eCourse as well as preferable objects to their needs and taste.

This research summarizes some essential information about DL, LMS and RS. In addition, it studies the suitability of RS approaches to recommend digital objects from DL to LMS. Furthermore, the studies and presents a new RS algorithm to recommend suitable digital objects from DL to students while entering an eCourse in LMS. These proposed algorithm is considered as a HRS which consist of some RS approaches; Content-Based System, Collaborative Filtering, Rule-Based Filtering and Demographic-Based System.

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