

# Recommendation System on Knowledge Management System via OAI-PMH

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**Abstract**—Knowledge Management System (KMS) might be a transformation from Library Management System (LMS). This transformation is possible when we add several knowledge processes from KMS not available in LMS. When a KMS is a transformation from a LMS, functionalities derived from librarian system will be also available in KMS. One of this functionality is recommendation system, where patron may receive related and recommended reading, usually based on subject similarity between knowledge documents. However, recommendation is delivered from system directly to patron. There is no recommendation from one system directly to another. This research proposes a communication model to provide recommendation from one KMS to another using LMS interoperability language, OAI-PMH. Although there is no real implementation, authors hope that this model may become a basic reference for a better one. The novelty of this research is how to accommodate recommendation system between KMSs if the interaction is via knowledge sharing protocol, which in this research is OAI-PMH.

**Keywords**—*knowledge management system; library management system; recommendation system; user profiling; OAI-PMH*

## I. INTRODUCTION

User profiling is a common method in website applications such as search engine application and entertainment portal. Its main purpose is to create customer segmentations and classify a visiting customer who interacts with the website. Based on the segment information, website application provides custom approach and personal representation to this visiting customer. One from many applications of user profiling is the recommendation system. In this application, the main goal of recommendation system is to predict whether a visiting customer belongs to a specific segment or not and further address specific recondition to meet the segment expectation.

Most online stores such as amazon.com, already provides recommendation system feature to guide user to explore more of their other products. Even the top 10 online shopping (<http://www.alexa.com/topsites/category/Top/Shopping>) are all provide such recommendation system with several and different names, like:

- Customers who viewed this item also viewed;
- Compare to similar items;
- Explore more options; and

- See what other people are watching.

Online stores design these recommendation systems to guide customers to explore on more products that have certain similarity. This in return gives possibilities for the customers to buy more products or better (more profitable) product.

To provide such functionality, online stores need to track customer's activities while interacting with their web store's user interface, either by cookies or by a logbook. Either cookies or logbook, they will need to ask customers to register as their member, so to make the tracking mechanism becomes valid and right on target. Without membership, all customers will become guest without any means to distinguished one from another.

In term of Library Management System, such functionality to track and record customer activities is not very common. Some implementation similar like recommendation system is by having features in Library Management System, like:

- Other books you might want to read;
- Related books on this subject.

The features above is similar like recommendation system, however this recommendation only based on classification on the books, like subject. With the implementation of recommendation system, we can find additional features in Library Management System, like:

- Your friends also read these books;
- This book has better rating compared to the book you read.

The main difference between the first with the latter recommendations is in the first examples, recommendation is based on the books classification, for example subject classification. This means static recommendation. However, in the second examples, the recommendation uses on previous historical interaction between the system and many other patrons. This means the segmentation is not only about books, but also the patrons.

By transforming Library Management System into Knowledge Management System, we can expect to have capability like workforce management. By using workforce management, we can easily create segments with dynamic variables, such as type of books, books' subjects, patrons' age, patrons' background, patrons' behaviors, etc. [1].

This research proposes a model for user profiling that can be used by recommendation system. This model is specifically designed for Knowledge Management System. In many implementations, recommendation systems are built within the application and designed to be used for direct interaction with the user. However, in this model proposed by this research, the recommendation system is invoked via knowledge sharing mechanism, which is the metadata of the books using OAI-PMH as the protocol.

OAI-PMH designed for interoperability between two systems to share catalog between repositories via metadata. In term of sharing, OAI-PMH also provides capability for knowledge sharing between two Knowledge Management Systems, although some assumption like all metadata are equally trusted and will never altered [2-3].

II. RELATED WORKS

Each recommendation system uses specific algorithm and technology to implement its prediction system. Although there are many algorithms and technologies in recommendation system, [4] explains there are two types or groups of recommendation systems:

- Content-based systems examine properties of the items, group the items, and use these groups as a reference to provide recommendation for visiting customer. As an example in term of Knowledge Management System, if a patron has read many literatures about data mining, then the system will recommend another book in the database as having the same group of properties. Properties in this case may be referenced as its metadata, which is the subject classification.
- Collaborative filtering systems examine the properties of the users, group the users, and use these groups as a reference to provide recommendation for visiting customer. As an example in term of Knowledge Management System, if a patron has read many literatures about data mining, then the system will recommend another book in the database based on similarity measures between users and/or items. This items recommended to a user are those preferred by group of similar users.

This research proposes a recommendation system on Knowledge Management System using both approaches. Grouping on knowledge document's subject uses approach on content-based system, while grouping on patrons uses approach on collaborative systems. Fig. 1 explains the difference between the two approaches in term of Knowledge Management System. Using content-based approach, we can expect to have several groups of documents, like history, art, and fiction. Using collaborative filtering approach, we can expect to have groups of users, like students, guests, and lecturers [4].

Just like Library Management System, a Knowledge Management System should have a module to manage and maintain groups of users. This is due to each of the knowledge

processes needs different group of users. Starting from knowledge creation and capture, we need specific subgroup of users to be eligible to propose, submit, edit, review, and approve a knowledge document. Followed by the second process, which is knowledge sharing and enrichment, we need specific group of users to be allowed to share each knowledge document and another group of users to enrich and extend the knowledge like expert and lecturer. The third process, which is information storage and retrieval, also needs another group of expert users like librarians. The fourth and last process, which is knowledge dissemination, needs specific expertise to handle the dissemination, like librarians and lecturer [5-6].

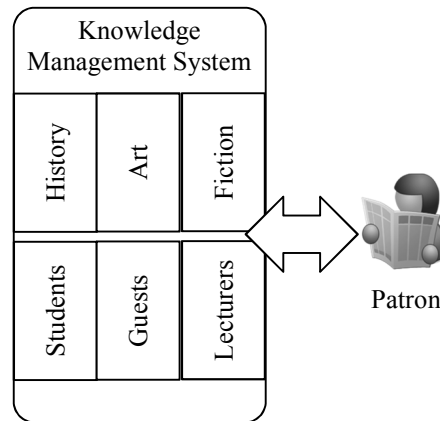


Fig. 1. Two approaches of recommendation system, content-based and collaborative filtering approach on Knowledge Management System

Implementation of recommendation system in Knowledge Management System might be in the second and third process where interaction can take place. However, instead of using interaction between system and patron, if we use the second process for recommendation system then it means a knowledge sharing is done between systems.

This research implements recommendation system in the second process by using knowledge sharing between Knowledge Management Systems. A specific protocol, OAI-PMH for knowledge sharing is chosen to accommodate recommendation system between systems. Fig. 2 explains this machine-to-machine recommendation.

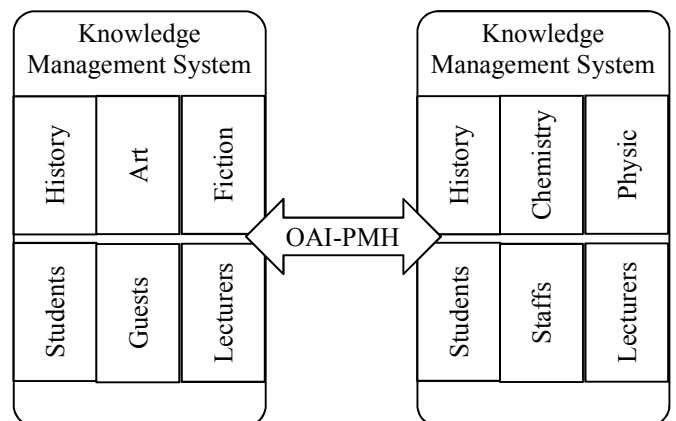


Fig. 2. Recommendation system via OAI-PMH

OAI-PMH stands for Open Archives Initiative – Protocol for Metadata Harvesting (<http://openarchives.org>). OAI-PMH provides language to query metadata of one or a specific group documents. Metadata of a document contains unique properties, such as the title of the document, the author(s) of the document, the description (may contain the abstract) of the document, and the physical location of the document [6].

This research proposes a model of machine-to-machine recommendation system using OAI-PMH. Machine-to-machine means the recommendation system is between a Knowledge Management System communicates with another Knowledge Management System. A Knowledge Management System query another another Knowledge Management System to obtain not just the document's metadata but also recommendation to query another related document's metadata.

Fig. 3 explains how the OAI-PMH works [6-9]. Between the interactions, one Knowledge Management System becomes the harvester and another Knowledge Management System becomes the repository. A Harvester is the one that sends the query message (request) to obtain a metadata and a repository is the one that has the metadata and answering request with response. In client-server mechanism, harvester would be the client and repository would be the server.

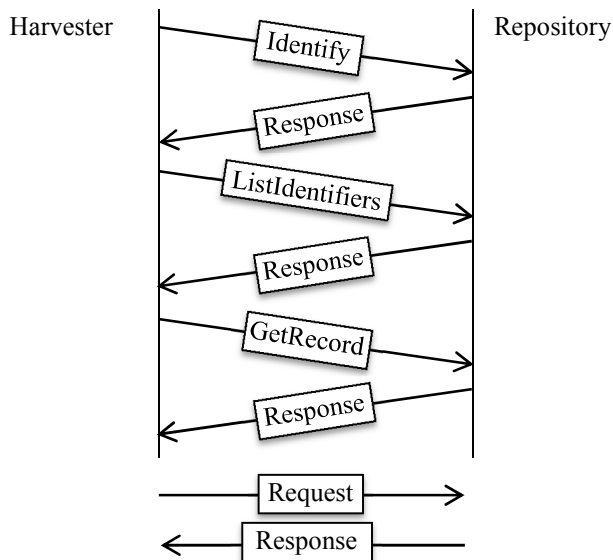


Fig. 3. Message transaction between harvester and repository [7]

In OAI-PMH, query message have unique name, which is verb. There are six verbs provided by OAI-PMH [6-9] to query a specific document's metadata or to query a group of document's metadata. The six verbs are:

1. Verb=Identify, used by harvester as the first query to obtain identity of a repository, such as repository's name and person in charge;
2. Verb=ListIdentifiers, used by harvester to obtain list of all possible document's identifiers (unique identification for each document) from a repository;

3. Verb=ListMetadataFormats, used by harvester to obtain list of all possible metadata formats from a repository, such as oai\_dc, olac, perseus, or oai\_marc;
4. Verb=ListRecords, used by harvester to obtain list of all records (all document's metadata) from a repository;
5. Verb=ListSets, used by harvester to obtain list of all sets (group of similar records) from a repository;
6. Verb=GetRecord, used by harvester to obtain specific record (a document's metadata) from a repository based on unique identifier of the record;

Verb "ListIdentifiers" and "ListRecords" may return a very long list of all documents' id or metadata in a repository. To minimize this long list, OAI-PMH provides selective harvesting, for filtering the response [6], such as date stamp of the record and predefined group of documents. List of group of documents available in a repository can be obtained using verb "ListSets" with the possibility of creating several levels of sets (groups), such as set=music or set=musicJazz.

OAI-PMH uses HTTP as the application protocol for interaction between Knowledge Management Systems. Fig. 4 shows a typical request message for ListSets [7]. An example of ListSets request message is <http://citeseerx.ist.psu.edu/oai2?verb=ListSets>, although CiteSeerX does not provide sets, as we can see from the response "<error code='noSetHierarchy'>This repository does not support sets</error>".

<http://domain/oai2?verb=ListSets>

Fig. 4. Request message for verb=ListSets [6]

OAI-PMH, just like SPARQL and KQML, is a language for interoperability. However, we can use these languages for knowledge sharing purposes [10], where a machine-to-machine communication can be achieved autonomously. This research uses part of knowledge sharing mechanism to provide recommendation capability between Knowledge Management System, which is an upgrade from Library Management System.

### III. RECOMMENDATION SYSTEM VIA OAI-PMH

This research proposes a mechanism on how to use OAI-PMH as a communication language between two Knowledge Management Systems with the purpose is to offer recommendation system. Recommendation System follows two steps mechanism:

1. An already classified patron interact with the Knowledge Management System by reading or rating a knowledge document;
2. Recommendation System chooses whether to use recommendation approach based on the patron's segment or based on the knowledge document's segment and provides recommendation to the patron.

In term of machine-to-machine interaction, there will be additional steps compared to the patron and Knowledge Management System interaction.

1. An already classified patron interact with the Knowledge Management System by reading or rating a knowledge document;
2. The Knowledge Management System ask for a recommendation to another Knowledge Management System;
3. The other Knowledge Management System's Recommendation System chooses whether to use recommendation approach based on the patron's segment or based on the knowledge document's segment and provides recommendation to the original Knowledge Management System;
4. The original Knowledge Management System provides this recommendation to the patron.

Fig. 5 shows this interaction between patrons – original Knowledge Management System – another Knowledge Management System. From Fig. 5 we can see that the other Knowledge Management System is the one to provide recommendation to the patron.

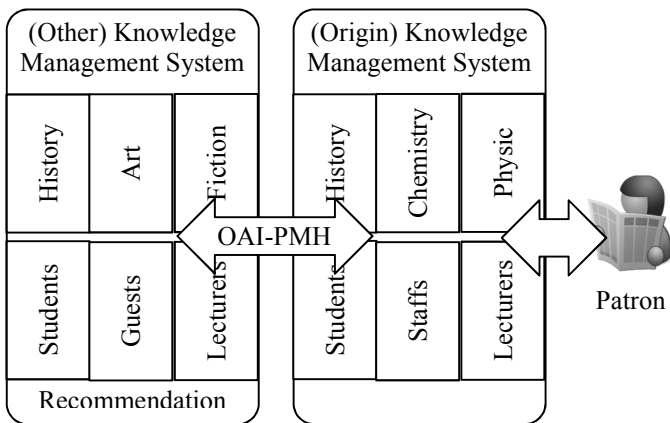


Fig. 5. Recommendation from another Knowledge Management System

To provide such mechanism from Fig. 5, there will be two pairs of OAI-PMH request and response. The first pair queries list of groups available in the other Knowledge Management System and the second pair queries the list of documents' metadata available in the other Knowledge Management System. The first pair uses verb=ListSets to obtain the list of groups available in the other Knowledge Management System. The second pair uses verb=ListRecords to obtain the list of knowledge document available on the other Knowledge Management System.

Fig. 6 shows an example which respond to a query of verb=ListSets based on Fig. 5. The response shows two levels of groups, i.e. user for the first level and user:(Students), user:(Guests), and user:(Lecturers) for the second level. Another two levels of groups also provided, i.e. subject for the first level and subject:(History), subject:(Art), and subject:(Fiction) for the second level.

The response shows in Fig. 6 is a response of a verb=ListSets query:

<http://openlibrary.telkomuniversity.ac.id/oai2?verb=ListSets>

```
<OAI-PMH...>
<responseDate>2002-08-11T07:21:33Z</responseDate>
<request verb="ListSets">
  http://openlibrary.telkomuniversity.ac.id/OAI2
</request>
<ListSets>
  <set>
    <setSpec>user</setSpec>
    <setName>Group of users</setName>
  </set>
  <set>
    <setSpec>user:(Students)</setSpec>
    <setName>Group of Students</setName>
  </set>
  <set>
    <setSpec>user:(Guests)</setSpec>
    <setName>Group of Guests</setName>
  </set>
  <set>
    <setSpec>user:(Lecturers)</setSpec>
    <setName>Group of Lecturers</setName>
  </set>
  <set>
    <setSpec>subject</setSpec>
    <setName>Knowledge Document's Subject</setName>
  </set>
  <set>
    <setSpec>subject:(History)</setSpec>
    <setName>Documents about History</setName>
  </set>
  <set>
    <setSpec>subject:(Art)</setSpec>
    <setName>Documents about Art</setName>
  </set>
  <set>
    <setSpec>subject:(Fiction)</setSpec>
    <setName>Documents about Fiction</setName>
  </set>
</ListSets>
</OAI-PMH>
```

Fig. 6. A response to a query verb=ListSets

Fig. 7 shows a response to a verb=ListRecords using selective filtering based on groups information obtained from verb=ListSets in Fig. 6. The response shows in Fig. 7 is a response to a verb=ListRecords query using group of subject:(art):

[http://openlibrary.telkomuniversity.ac.id/oai2?verb=ListRecords&set=subject:art&metadataPrefix=oai\\_rfc1807](http://openlibrary.telkomuniversity.ac.id/oai2?verb=ListRecords&set=subject:art&metadataPrefix=oai_rfc1807)

```
<OAI-PMH...>
<responseDate>2002-06-01T19:20:30Z</responseDate>
<request verb="ListRecords" set="subject:art"
  metadataPrefix="oai_rfc1807">
  http://an.oa.org/OAI-script</request>
<ListRecords>
  <record>
    <header>
      <identifier>16.04.2546</identifier>
      <datestamp>2012-03-30</datestamp>
      <setSpec>subject:art</setSpec>
      <setSpec>drawing</setSpec>
    </header>
    <metadata>
      <id>16.04.2546</id>
      <entry>January 1, 2014</entry>
      <title>The painting in Bali</title>
      <author>Unknown</author>
      <date>March 30, 2012</date>
```

```

</metadata>
</record>
</ListRecords>
</OAI-PMH>

```

Fig. 7. A response to a query verb=ListRecords with selective filtering

#### IV. CONCLUSION

OAI-PMH originally designed to overcome interoperability problem between repositories like Library Management System. By upgrading Library Management System to Knowledge Management System, we can use functionality like recommendation based on patrons' segment and/or knowledge document's subject. Using two pairs of OAI-PMH messages, we can provide recommendation system between two Knowledge Management Systems. These two pairs of messages including the first query with verb=ListSets to obtain lists of group and the second query with verb=ListRecords to obtain specific group of knowledge document's metadata.

#### V. FUTURE WORK

For the next research, authors will conduct some researches to extend the capabilities of recommendation system, not just based on groups but also based on patron behavior during the interaction with the Knowledge Management System.

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