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Product Recommendation for e-Commerce System based on Ontology

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***Abstract*—The sale and purchase of goods are now starting to move from being offline to online using the internet, or what is known as e-commerce. With the development of the internet and intelligent computing technology, e-commerce is increasingly being used. The products offered through e-commerce platforms is a matter that needs to be considered because it can influence the user's decision in buying a product. This study aims to build a product recommendation system on e-commerce platform according to user needs. There are several methods that can be used to produce recommendations, one of which is Collaborative Filtering. In this study, the Slope One algorithm is used where the input rating is given based on the domain ontology of the product. Domain ontology is used to represent relationships between products. Thus, the product recommendations are expected to be in accordance with the user's interest. So that product sales are right on target and users get products that suit their needs. This recommendation system will be implemented on e-commerce platforms and is expected to help users and sellers. Based on the case studies conducted, the results of recommendations provided with the ontology approach not only provide recommendations for specific products, but also provide recommendations on categories that may be of interest to the users. Thus, the recommendations will be more varied and are expected to be more in line with user interests.**

Keywords—e-commerce, recommendation system, collaborative filtering, slope one, ontology

I. INTRODUCTION

Along with the development of the internet and smart computing technology, e-commerce is now increasingly used [1][2]. Sales and purchase of goods began to move from being started offline to being online using the internet, or known as e-commerce. The e-commerce platforms that are currently developing include Amazon (https://www.amazon.com/), Tokopedia (https://www.tokopedia.com/), Bukalapak (https: //www.bukalapak.com/), and so on. Through this e-commerce platform, sellers and buyers can make buying and selling transactions easily.

The choice of products offered through e-commerce platforms is a matter that needs to be considered because it can influence the user's decision in buying a product. This study aims to develop a product recommendation system on e-commerce platforms. There are several methods that can be used to produce certain recommendations, including Content-based Filtering and Collaborative Filtering [3]. Content-based filtering provides recommendations by exploring user profiles, product descriptions, and factors that can influence user decisions in buying a product. While Collaborative Filtering provides recommendations based on consideration of other similar data users. In this study, Slope One Algorithm, which is a Collaborative Filtering Method, is used to produce personalized product recommendations according to user needs. To produce recommendations that are more related to user interest, the ontology domain is built to represent the relationship between products. Thus, the results of recommendations are more varied but still related to user interests.

The recommendation results are expected to be in accordance with user needs. Thus, product sales are right on target and users get products that suit their needs. This recommendation system will be implemented on e-commerce platforms and is expected to help users and sellers.

II. RELATED WORKS

The recommendation system is used in various fields to help someone to decide something, for example in providing restaurant recommendations that suit certain preferences [4], social network [5], books recommendation [6], and of course product recommendation in e-commerce systems [2][7][8]. Based on the recommendation system taxonomy, especially for e-commerce systems, as shown in Fig. 1, there are three main components of an e-commerce system [9], namely input/output, recommendation methods, and recommendation design.

Input is obtained implicitly or explicitly from the user. Implicit input is obtained from the data of a product's purchase transaction by the user or by monitoring what products are seen by the user. Meanwhile, explicit input is obtained by asking the user to enter a rating on a product. The second component is the recommendation method. The method used in providing recommendations can be done in various ways, including manually, through a statistical approach, based on the correlation between users (user-to-user), or based on the correlation between items (item-to-item).

The third component is design recommendations, which are related to two things, namely how recommendations are presented and how the nature of the recommendations or the level of personalization are. There are 3 ways to present recommendations to users, namely: 1.) *Push*, which is an active form of giving recommendations, such as sending e-mail to users, 2.) *Pull*, i.e., recommendations are only displayed if the user requests, 3.) *Passive*, displays other products related to the product that is being viewed/accessed by the user at that time. Meanwhile, the level of personalization of recommendations given to users consists of two types, namely: 1.) *Personalized*, i.e., recommendations given to users are not the same between one another, depending on the profile of each user, 2.) *Non-Personalized*, this recommendation is general in nature so that it can be given to all users.

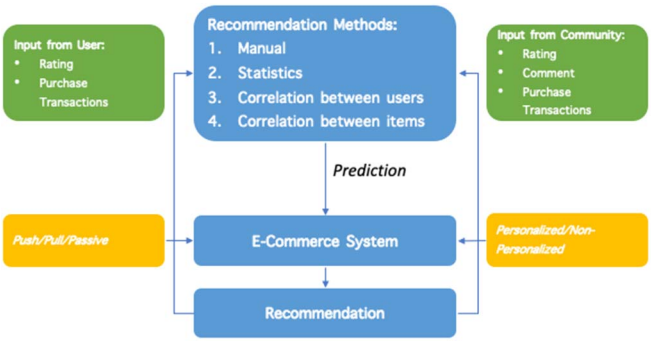

Fig. 1. Recommender System Taxonomy [10][9].

The following will explain one of the algorithms used to build a recommendation system, namely Slope One. Then it will be explained about the ontology concept used in this study.

A. *Slope One Algorithm*

Slope One Algorithm was first proposed by Doctor Daniel Lemire in 2005. Slope One Algorithms are easy to implement, efficient to query, reasonably accurate, and they support both online queries and dynamic updates, which makes them good candidates for real-world systems [11]. This algorithm is used in the recommendation system, for example, recommendations on restaurant [12], personalized e-commerce web [10], and other recommendation systems.

The Slope One Algorithm performs calculations based on a linear relationship of preference or weight values for each item compared. The general estimation of the basic calculation of this algorithm is the linear function y = mx + b, assuming the gradient m = 1, so that the function becomes b = y-x. The way the Slope One algorithm works are to find the difference from an item with other items compared.

The calculation of the Slope One algorithm can be formulated with equation (1) for difference calculation.

$$dev_{j,i} = \sum_{u \in S_{j,i}(x)} \frac{u_j - u_i}{card\ (S_{j,i}(x))} \quad (1)$$

$dev_{j,i}$ = average item *i* rating difference for item *j*

u_j = item *j* rating

u_i = item *i* rating

x = training set

$S_{j,i}(x)$ = collection of all evaluations $u \in x$ which includes item *i* ans *j* in $i, j \in S(u)$

$card\ (S_{j,i}(x))$ = the number of elements in $S_{j,i}(x)$

If it is known that the average item *i* rating difference for item *j*, then can be calculated the rating prediction for item *j*, which is formulated by equation (2).

$$P^{SI}(u)_j = \frac{\sum_{i \in S(u)-\{j\}} (dev_{j,i} + u_i) c_{j,i}}{\sum_{i \in S(u)-\{j\}} c_{j,i}} \quad (2)$$

$P^{SI}(u)_j$ = Slope One prediction for item *j*

$c_{j,i} = card\ (S_{j,i}(x))$ = the number element in $S_{j,i}(x)$

B. *Ontology*

In computer science, ontology is a formal representation of the knowledge by a set of concepts within a domain and the relationships between those concepts. It is used to reason about the properties of that domain and may be used to describe the domain. Ontologies are used in Artificial Intelligence, Semantic Web, Systems Engineering, Software Engineering, Biomedical Informatics, Library Science, Enterprise Bookmarking, and Information Architecture as a form of knowledge representation about the world or some part of it. Design criteria for ontologies, including clarity, coherence, extensibility, minimal encoding bias, and minimal ontological commitment [13].

An ontology represents concepts and relationships in a particular domain of interest, books for example [14]. Ontology is widely used for various fields of research, for example to integrate region-based Open Data using semantic web [15], construction risk knowledge management in BIM [16], and of course in a recommendation system, namely personalized book recommendation based on ontology and collaborative filtering algorithm [6].

III. Research Methodology

Based on the taxonomy of the recommendation system described earlier, this study focuses on the input component, both from users, and from the community. As explained earlier, input can be obtained from users, either explicitly or implicitly. Input is explicitly obtained by the way the user is asked to enter a rating for a product. While implicit input is to monitor user activity or view a list of purchase transactions.

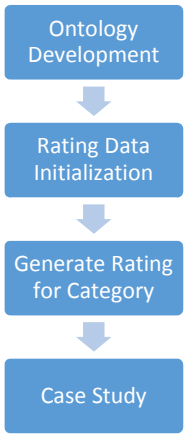

Fig. 2. Research Methodology.

As shown in Fig. 2, the first stage carried out in this study was to build a domain ontology. In addition to monitoring user activity or viewing a list of purchase transactions, there are other important factors to analyze, namely the relationship between products both seen and purchased by users. The relationship between these products needs to be analyzed to get recommendations that are more in line with user needs. For this reason, RDF / OWL (Resource Description Framework / Web Ontology Language) has been developed to describe the concepts and relationships between products. In the following section III.A will be explained ontology domain development carried out.

After building domain ontology, the next step is giving the initial rating of the products. However, rating for specific products seen or purchased by users is not considered sufficient to represent user interest in a product. For this

reason, rating/weight is also given to the categories of products. Giving rating/weight to product categories are based on the domain ontology that was built. A more detailed explanation of the rating/weighting of this product category will be explained in section III.B

At the end, implementation of the recommendation system is carried out in a case study. The case study will give an overview of the implementation stages of the method proposed.

A. *Ontology Development*

In order to acquire item semantic information, we must understand the hierarchy concept of structured object extraction from category of the products. The ontology was created based on RDF/OWL standard, using Protégé (https://protege.stanford.edu/). There were four main components to form an ontology, including classes, object properties, data properties, and individuals.

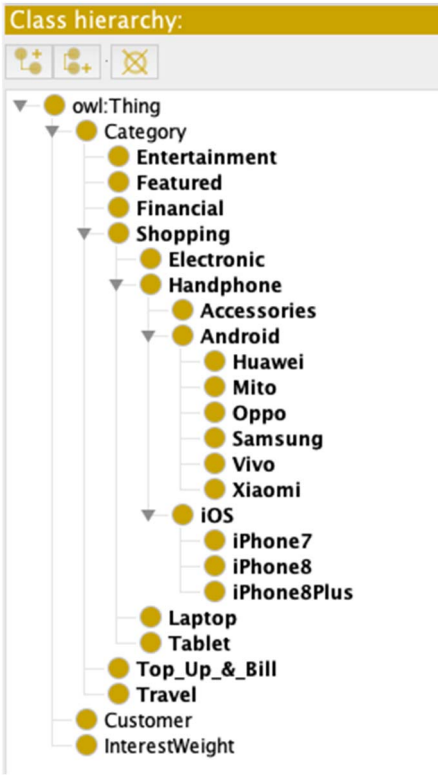

Fig. 3. Ontology Classes Structure.

In the ontology that was built, there are 3 main classes, namely Category, Customer, and InterestWeight, as illustrated in Fig. 3. The Category Class contains other sub-classes that explain the hierarchy of product categories in an e-commerce system. Customer Class represents customers who use e-commerce systems. While InterestWeight Class represents the rating given by the user for a particular product or category.

To connect the Customer and Category classes, there is hasCustomer and hasInterest Object Properties that represent the user rating for a particular product or category. Object Properties can be seen in Fig. 4.

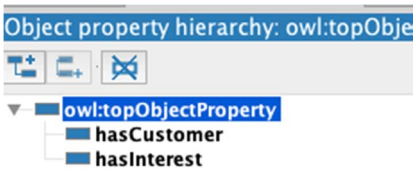

Fig. 4. Class Relationship using Object Properties.

B. *Generate Category Rating based on Ontology*

As explained earlier, this study focuses on the input component, which is giving a rating to a product by the user. However, rating given only for products is not enough to represent the interests of users. For this reason, it is necessary to give a rating other than for the product, also for the category or superclass of the product.

Based on the domain ontology, we can see the relationship and hierarchy of the data used. Thus, giving a rating for product category (superclass) is easy. We can do a query to retrieve all categories (superclasses) of a product with the query shown in Fig. 5.

For the weighting rules for a given rating, in principle the weight given for a product must be greater than the weight for the category (superclass). The consideration is that users certainly have a higher interest in products that are seen or purchased compared to that product category (superclass). Thus, for products that are seen or purchased the user will be given a weight of 2. While the product category (superclass) will be given each weight of 1.

```
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX owl: <http://www.w3.org/2002/07/owl#>
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
PREFIX xsd: <http://www.w3.org/2001/XMLSchema#>


SELECT ?subject ?object
    WHERE { ?subject rdfs:subClassOf ?object }

```

Fig. 5. SPARQL Query to Retrieve Superclass.

With this hierarchy and weight, the recommendation results not only give the results of additional recommendations in the form of categories (superclass), but what products are first offered from a category based on their weight. This method is implemented in a case study in the next chapter to give a clearer picture.

IV. Case Study

In this section, a case study will be explained to implement the proposed method. The initial rating data used amounts to 8 data from 3 different users, as shown in Table I. Users with the name James give ratings on A3s, A83, and F1s products, which are the Oppo branded Android phones. Based on the hierarchy of the built ontology, the user with the name James automatically gives a rating on the Oppo, Android, Handphone and Shopping categories, as shown in Table II. Likewise, for the other two users, Bella and Anna. Generated ratings for categories will be given automatically by the system.

TABLE I. Initial Rating Data

No.	User	Product	Rating
1	James	A3s	2
2	James	A83	2

3	James	F1s	2
4	James	F5	2
5	Bella	F5	2
6	Bella	A3s	2
7	Anna	iPhone7	2
8	Anna	iPhone8Plus	2

TABLE II. GENERATED RATING FOR CATEGORY

No.	User	Product	Rating
1	James	Oppo	4
2	James	Android	4
3	James	Handphone	4
4	James	Shopping	4
5	Bella	Oppo	2
6	Bella	Android	2
7	Bella	Handphone	2
8	Bella	Shopping	2
9	Anna	iOs	2
10	Anna	Handphone	2
11	Anna	Shopping	2

After the user gives a rating on the product and system generates a rating for its category, the next step is that this data will be used as input for the Slope One algorithm to provide product recommendations that meet the user's needs. In this case study, a new user gives a rating, as shown in Table III. The new user gives a rating on iPhone8 and F5 with a value of 2. Based on the data that was previously inputted, using the Slope One algorithm, the results of the recommendations obtained are shown in Table IV.

TABLE III. RATING FROM NEW USER

No.	User	Product	Rating
1	New User	iPhone8	2
2	New User	F5	2

As shown in the results of the recommendations in Table IV, the recommendations do not only provide recommendations for specific products, but also provide categories of interest to the users concerned. The recommendations show, in addition to specific products, users may also be interested in the Shopping, Mobile, Android, Oppo, and iOS categories. With the recommendation of this category, the system can present recommendations for other products from the categories of interest.

TABLE IV. RECOMMENDATION RESULTS INCLUDING SUPERCLASS

No.	Recommendation	Rating
1	Shopping	4
2	Handphone	4
3	Android	4
4	OPPO	4
5	iOS	2
6	Oppo	4
7	iPhone7	3
8	iPhone8Plus	3
9	A3s	2
10	F1s	2
11	A83	2
12	F5	2
13	iPhone8	2

V. CONCLUSION AND FUTURE WORKS

The choice of products offered through e-commerce platforms is a matter that needs to be considered because it can influence the user's decision in buying a product. Therefore, the products offered must pay attention to user needs. There are several methods that can be used to build a recommendation system, including Content-based Filtering and Collaborative Filtering.

This study focuses on giving input ratings by paying attention to the relationship between a product and other products. Giving a rating other than for the product is also given for the category or superclass of the product. Using ontology, giving a rating for this superclass is easy. We can do a query to retrieve all the superclass of a product with an easy SPARQL query.

Based on the case studies conducted, the results of recommendations provided with the ontology approach not only provide recommendations for specific products, but also provide recommendations on categories that may be of interest to the users. Thus, the recommendations will be more varied and are expected to be more in line with user interests.

As future work, we will implement this method on e-commerce systems. Thus, the success of this method can be evaluated by using more relevant data. In addition, evaluations of user acceptance can also be made on the results of recommendations with the proposed method.

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REFERENCES

[1] S. S. A. K. L. Shunmuganathan, "Role of Agent Technology in Web Usage Mining : Homomorphic Encryption Based Recommendation for E-commerce Applications," *Wirel. Pers. Commun.*, 2015.

[2] L. Yan, "Personalized recommendation method for E-commerce platform based on data mining technology," *Proc. - 2017 Int. Conf. Smart Grid Electr. Autom. ICSGEA 2017*, vol. 2017-Janua, pp. 514–517, 2017.

[3] P. Aggarwal, T. Vishal, and A. Kathuria, "Comparing Content Based and Collaborative Filtering in Recommender Systems," *Int. J. New Technol. Res.*, vol. 3, no. 4, pp. 65–67, 2017.

[4] A. U. Martliong and N. M. S. Iswari, "Rancang Bangun Sistem Rekomendasi Restoran Menggunakan Metode AHP dan VIKOR pada Platform LINE," *J. Ultim. Comput.*, vol. 10, no. 1, pp. 27–33, 2018.

[5] Z. Wang, J. Liao, Q. Cao, H. Qi, and Z. Wang, "Friendbook: A semantic-based friend recommendation system for social networks," *IEEE Trans. Mob. Comput.*, vol. 14, no. 3, pp. 538–551, 2015.

[6] L. Cui, H. li, C. Wang, and B. Yang, "Personalized Book Recommendation Based on Ontology and Collaborative Filtering Algorithm," *Open Cybern. Syst. J.*, vol. 8, no. 1, pp. 632–637, 2018.

[7] E. Guiyang, "E-commerce Personalized Recommendation Technology Based on Expert System," no. 1, pp. 342–345.

[8] Sung-Shun Weng and Mei-Ju Liu, "Personalized product recommendation in e-commerce," pp. 413–420, 2004.

[9] J. . Schafer, J. . Konstan, and J. Riedl, "E-commerce recommendation applications," *Springer*, pp. 115–153, 2001.

[10] F. Masruri and W. F. Mahmudy, "Personalisasi Web E-Commerce Menggunakan Recommender System dengan Metode Item-Based Collaborative Filtering," *Pers. Web E-Commerce Menggunakan Recomm. Syst. dengan Metod. Item-Based Collab. Filter.*, vol. 3, no. 1, pp. 1–12, 2007.

[11] D. Lemire and A. Maclachlan, "Slope One Predictors for Online Rating-Based Collaborative Filtering," pp. 471–475, 2007.

[12] D. Pratama and S. Hansun, "Aplikasi Rekomendasi Tempat Makan Menggunakan Algoritma Slope One pada Platform Android," *IJCCS (Indonesian J. Comput. Cybern. Syst.*, vol. 11, no. 1, p. 11, 2017.

[13] D. Man, "Ontologies in Computer Science," *Ontol. Theory, Manag. Des.*, vol. 31, pp. 43–46, 2013.

[14] A. Sieg, B. Mobasher, and R. Burke, "Ontology-based collaborative recommendation," *CEUR Workshop Proc.*, vol. 606, pp. 20–31, 2010.

[15] A. A. G. Y. Paramartha, "Integration of Region-based Open Data Using Semantic Web," in *International Conference on Informatics and Computing*, 2018.

[16] L. Y. Ding, B. T. Zhong, S. Wu, and H. B. Luo, "Construction risk knowledge management in BIM using ontology and semantic web technology," *Saf. Sci.*, vol. 87, pp. 202–213, 2016.