AK Tourism: A Property Graph Ontology-based Tourism Recommender System

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ABSTRACT

Recommender system (RS) is used to overcome the problem of information overload over the World Wide Web. Most of the time, users will be returned with a huge number of links when they do a Point of Interest (POI) search for interesting places to visit via the search engine. RS overcomes the problem by analyzing automatically all the possible items information integrates with personalized user profiling (user preferences), and user rating. Specifically, ontology-based recommender system adopts new and alternative trends in recent years. Ontologies define rules to structure data, including interrelations between entities in the database. As such, it offers greater semantic relations within a particular domain. In this paper, we propose: (i) ontology representation, (ii) sample query in Cypher, and (iii) AK Tourism to demonstrate the recommender system in Malaysia tourism domain.

Keywords: ontology, recommender system, user profiling, tourism, point of interest.

I INTRODUCTION

With the booming of data and information in the World Wide Web, in order to get the most needed and accurate information, we need recommender system (Huang & Gartner, 2012; Elahi et al., 2016; Aggarwal, 2016). Recommender system is a system that used to filter large amount of information based on user's preferences and interests and return the output to user. Recommender system has proved to improve quality and decision-making process and bring benefits to both service providers and users. For example, recommender system in e-commerce helps to improve sales and thus increase revenues.

Tourism is one of the main income sources for a country. When a tourist wants to plan a trip, he/she will need to choose Point of Interests (POIs) from travel agencies or travel book guides. Nowadays, most of the tourists will use Internet as a rich source of information to search for POIs and plan their trip. As mentioned above, there are information overloaded from the web, therefore, we need a recommender system to filter and recommend POIs of one's need (Costa et al., 2013; Achmad et al., 2017). As such, in this paper, a new tourism recommender system named AK Tourism is proposed.

The proposed system is a content-based system that utilize ontological information. The ontology structure represents both possible POIs and user profile. It can compute the similarity between user preferences and the characteristics of a POI and then return a list of recommended POIs to user. Proposed system is using property graph database from Neo4j because graph database is better in relationship handling and also data retrieval. The property graph denote an attributed multi-relational graph where by the edges are labeled and both vertices and edges can have any number of key/value properties association. In addition, graph database also good for adapting different business requirements and expanding data model. These can definitely help to enhance the functionality of the system.

This paper is scope to the dataset available from the Ministry of Tourism and Culture Malaysia (MOTAC) (http://www.motac.gov.my/en/) focusing on attraction and accommodation in the states of Kedah, Kuala Lumpur, and Melaka.

II RELATED WORK

Some related works for recommender system are reviewed and briefly described based on categories: Memory-based, Content-based, and Collaborative Filtering based.

A. Categories of Recommender System

Memory-based is a traditional recommendation paradigm that infers ratings by user-to-item matrix. As we known, user-based system predicts the item ratings by most-relevant users on similar ratings while item-based recommender system predicts by most-relevant items similar ratings. An algorithm has proposed by Wang et al. (2006) to unify the user-based and item-based collaborative filtering. Bobadilla et al. (2012) also proposed a method which is similar to user-based using significances of users and items where the significances are still calculated by ratings. This type of recommender systems considers only ratings which caused the rating-diversity problem.

Besides rating diversity, rating sparsity is also a problem for recommender system. Sparse user-to-item ratings cannot offer sufficient information to

predict the exact preferences. When a user's ratings are too few, it is not easy to predict his/her preferences. There are more and more studies trying to enhance the recommendation by taking advantage of additional content information. This type of recommendation is known as content-based system. Fremal & Lecron (2017) proposed weighted strategies on item metadata information to improve the item clustering based on genres for movie dataset. Shepitsen et al. (2008) also proposed an algorithm to promote user's preferences on music. Several attempts to describe users by the inferred user-to-tag ratings are made by Qi et al. (2012) as well.

Content-based recommender system aim at taking advantages of customer's previous choices (Boratto et al., 2017; Xia et al., 2017). Bahramian & Abbaspour (2015) proposed a travel recommender system to overcome the information overload problem. They enhanced the system by using ontological information about tourism domain to represent recommendable POIs and user profile. Garcia et al. (2015) proposed a tourism recommender system that applies hybrid recommendation technique in order to make system is always able to provide recommendation although the user profile contains very little information. More recently, Klotz et al. (2017) implemented DrIveSCOVER, which is a recommender system for places and events based on external factors such as weather and local traffic condition.

On the other hand, Suganeshwari and Ibrahim (2016) outlined the recommender system and explained about collaborative filtering which defines different constraints of traditional recommendation mechanism. They also discussed about the hybrid system that applicable to larger range of applications by emerging the properties of both item-based and user-based collaborative filtering. In another research work by Yang et al. (2014), they presented a survey of collaborative filtering based social recommender systems to prove that information that gathered from social network can be utilized to increase accuracy of recommendations.

B. **Tourism Recommender System**

Currently, there are a number of tourism web applications such as TripAdvisor, Kayak, Touropia, and so on. We find that most tourism applications on the web incorporate recommender systems because tourism is an activity that closely links with personal interests and preferences. All these systems attempt to mimic the interactivity observed in traditional consultation sessions with the travel agents when users seek suggestions for their trip or vacation.

KAYAK aims to provide the world's favorite travel planning tools. It searches other sites to show users the result and information that they needed. This system is mainly focused on flights, hotels, car rentals and vacation packages. In order to ease the travel planning and trip management, KAYAK also offers several tools and features such as KAYAK Trips, Explore, and Price Forecast. All these are able to help users to get more information on different fields. Besides, KAYAK also has its own mobile application which is available on App Store and Google Play. This will definitely help users to plan their trip easily and efficiently.

Attractionsinmalaysia.com is a website that recommends places in Malaysia for travelers. This website contains all the basic POI for tourism which are attraction, restaurant, accommodation, and shopping. Besides showing places directly, it also suggests activities in area of users' choices. For instance, it suggests several activities to do or visit in the area that user chosen. Users can check for the events on the selected location if they wish to join any event or celebration during their trip since Malaysia is a multicultural country. Unfortunately, attractionsinmalaysia.com does not provide accommodation booking function but it will directs users the official pages of a hotel or accommodation of choice for booking purposes.

Touropia is a tourism recommender website that recommends attractions all over the world. It is slightly different to KAYAK and attractionsinmalaysia.com, in that it only provides attraction suggestions and description for the place. It is unlike other tourism recommender systems that provide accommodation, flight, and restaurant. Touropia is most likely to divide the most amazing sights around the world into various "best of" lists. Topics are ranged from landscapes, islands, wildlife, countries, and whatever that we can find it interesting. In these lists way, users can easily know what to see or where to go in a country or city. It is impossible for Touropia or any other recommender systems to cover all the destinations all over the world, therefore Touropia also rely on travel experiences of other people when creating all those travel lists. Although Touropia does not support features for flight, accommodation, restaurant and so on, but it has an awesome feature which is itineraries. This feature provides suggestion on where to go in a country or city with sufficient description and information. Therefore, travelers can plan their trip by referring to the itineraries feature. In addition, itineraries feature will suggest places to stay as well for each of the attraction or destination by comparing the hotel rates.

Table 1 shows the comparison on the three systems reviewed earlier and our proposed system, AK Tourism. In general, KAYAK is a good tourism recommender system but unfortunately it does not have any attraction recommendation. Touropia and attractionsinmalaysia.com are plain tourism website with listing of accommodation and attraction features. From the review, these system lacks of user rating and accommodation booking, which are really needed in a system to generate accurate recommendations. Other than that, a good system should recommend nearby places to user as well. Therefore, an excellent tourism recommender system should include all the features that discussed earlier. As such, AK Tourism will cater these features as shown in Table 1.

Table 1. Comparison between various system and the proposed system.

Features	Kayak	Attractionmalaysia	Touropia	AK Tourism
Accommodation Recommendation	√	√	√	√
User Rating	√			√
Attraction Recommendation		√	√	√
Nearby Places	√		√	√
Accommodation Booking	√			√
User Preferences Setting	√			√

III PROPOSED SYSTEM: AK TOURISM

This section describes the research methodology carried out to implement the property graph ontology recommender system.

A. The motivation for Property Graph Ontology System

Relational databases have been widely used by software applications since the 80s until now. They store highly structured data in relations that consist of rows and columns basis with predetermined schemas. These relations are joined from one to the others by primary-key and foreign key link. Thus, it takes a longer time for query retrieval especially on huge databases. This subsequently causes costly computation and memory resource problems.

On the other hand, a graph database provides more efficient solutions to problems in knowledge representation as its visual representation helps to understand a wide diversity of datasets through rich semantic relation representation. Graph database takes relationship as first priority which means application does not have to infer the primary-key and foreign-key link, and thus the performance of graph database stays constant even as your data grows. In addition, the graph database model is much simpler and yet more expressive than those of traditional data storage. Due to better handling of relationships, a graph database simplifies the adding of a new node and its relationships, and is also more flexible when expanding a data model compared to relational databases.

B. Data Pre-processing

Figure 1 shows the dataset for attraction, while Figure 2 and 3 are the datasets for homestay and hotel respectively. The dataset contains information such as name, address, description, contact number and so on. All these datasets are open data obtained from the MOTAC (http://www.motac.gov.my/en/). However, parts of the datasets are not that complete. As such, we have expanded it with additional information such as price and category for attraction dataset (see Figure 1), star, price, and facilities for homestay dataset (see Figure 2), and rating, price and facilities for hotel dataset (see Figure 3) to enhance the accuracy of the recommender system.

id	state	name	address	description	website	email	tel	Price	Category/Type
1	KEDAH	Langkawi	Langkawi, 07	This cluster of 99 isla	http://ww	-	604-966 7789	-	Beaches, Landm
2	KEDAH	Langkawi Cable Car	Jalan Telaga	A cable car ride that	http://ww	info@pan	604-959 4225	30-55 /pe	City_sightseein
3	KEDAH	Langkawi Mangroves	Jalan Ayer H	One of the largest m	http://ww	whitesan	017-430 4800	150 /boat	Nature
4	KEDAH	Pulau Payar Marine Pa	Kuah, 07000	This beautiful marin	http://ww	utlkedah	04-733 9086	-	Nature, Aquaria
5	KEDAH	Tree Top Walk	Kampung Se	The world's longest	http://ww	info@tree	04-4901588	-	Nature,Park
6	KEDAH	Mahathir's Birth Place	No. 18, Loro	Rumah Kelahiran Ma	http://ww	-	04-7722319	-	Historic_District
7	KEDAH	Pekan Rabu	Jalan Sultan	'Pekan Rabu' which l	http://peker	@pekan	04-735 5523	-	Landmark, City_
8	KEDAH	Ulu Legong Hot Spring	PUSAT REKRI	There is five natural	http://ww	prapul@n	04-473 2284	-	Nature, Park
9	KEDAH	The Paddy Museum	Lot 798 Jalan	Located in Gunung K	http://ww	-	04 735 1315	3/adult, 1	Museums, Histo
10	KEDAH	Kilim River Cruise	Bandar Kami	For the adventurous	http://ww	info@lan	04-966 7789	-	Nature, Park, Ci

Figure 1. Dataset for Attraction.

id	state	name	address	description	website	email	tel	star	price	facilities
12	Kedah	Homestay Jerej	Homestay	Unpretentiou	www.go	agrotour	604-794 0	2	120/nig	W,L,A,T
13	Kedah	Homestay Kamp	Homestay	Immerse you	www	go2dyens	30 604-9666	3	115	W,A
14	Kedah	Homestay Wan	Homestay	Homestay De	www.go	langkaw	6016-461	2	108	W,L,A
15	Kedah	Homestay Rela	Homestay	Sri Impian Se	www.go	honeym	6013-435	3	110	L,A,T
16	Kedah	Homestay Kamp	Homestay	Homestay Pa	www.go	-	604-95915	2	105	A
17	Kedah	Homestay Kamp	Homestay	Homestay Kg	www.go	-	6017-401	3	100	W,L,A,T
28	Melak	Ayer Limau Hon	Batu 19 1/2	Kampung Ave	www.ave	zohaime	06 384 78	2	155	W,L,A,T

Figure 2. Dataset for Homestay.

id	state	name	address	description	website	email	tel	rating	price	facilities
253	Kuala L	Berjaya Times Square	No 1, Jalan	Berjaya Times	www.ber	bth.rsvn@	603-2	5	434.60, 62	W,P,F,L,A
254	Kuala L	Doubletree By Hilton I	The Interm	DoubleTree by	doubletre	KULDT.Do	603-2	5	330, 370,	W,P,F,L,A
255	Kuala L	Grand Hyatt Kuala Lur	Jalan Pinan	When in Kuala	kualalum	kualalump	603-2	5	700, 775,	W,P,F,L,A
256	Kuala L	Grand Millennium Kua	160, Jalan I	Strategically lc	www.mil	enquiry.gr	603-2	5	422, 550,	W,P,F,L,A
257	Kuala L	Holiday Inn Glenmarie	1 Jalan Usa	For a successfu	holidayin	kulhi_rese	603-7	5	197.10, 25	W,P,F,L,A
258	Kuala L	Hotel Istana	73, Jalan R	The 5-star, 23-	www.hot	general@	603-2	5	324, 565,	W,P,F,L,A
259	Kuala L	Hotel Maya Kuala Lum	138, Jalan /	If you are looki	www.hot	-	603-2	5	290, 348,	W,P,F,L,A
260	Kuala L	Intercontinental Kuala	165, Jalan /	A jewel in the I	intercont	info@inte	603-2	5	388, 445.5	W,P,F,L,A

Figure 3. Dataset for Hotel.

C. Property Graph Diagram

Figure 4 shows the Property Graph Diagram. Each node represents a resource. Data are categorized by colors which are actually entities. Referring to the graph, purple codes represent facilities, green node represents price range, blue nodes represent places, red nodes are states in Malaysia, and yellow node represents registered user whereas pink nodes are the transaction histories. Besides, star rating and place types are represented as grey nodes. All the nodes are linked by different relationships. For example, KS preferred Homestay and went to some homestay, Homestay Jereju is a 2-star Homestay which located in Kedah, and it provided some facilities and services but only costs within RM 200.

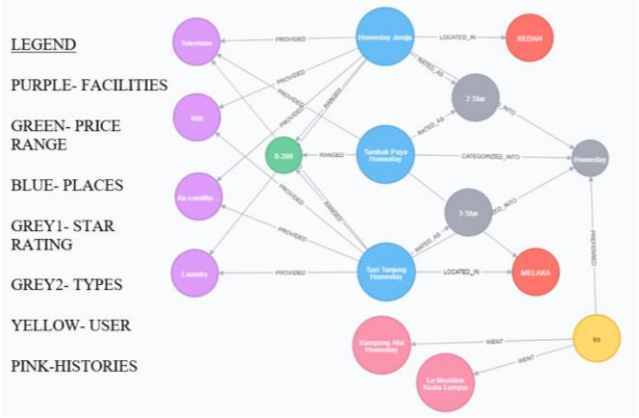

Figure 4. Property Graph Diagram.

D. Data Dictionary

Table 2 shows the data dictionary for relationship while Table 3 described the nodes in property graph diagram, which are actually classes that differentiated with different colors. Lastly, attributes of classes which are known as *properties* are briefly described in Table 4.

Table 2. Description of Relationship.

Relationship	Description
CATEGORIZED _INTO	Attraction and accommodation are categorized down into few types such as zoo, museum, beach, homestay, hotel, etc.
LOCATED_IN	Indicates places located in which state in Malaysia.
PREFERRED	Indicates what kind of places a person like or prefer.
PROVIDED	Indicates facilities that provided by an accommodation.
RANGED	Indicates price ranges of attraction and accommodation.
RATED_AS	Indicates star rating of an accommodation
WENT	Indicates that user made booking for certain places before.

Table 3. Description of Classes.

Class	Description
Facilities (PURPLE)	To indicate the facilities provided by accommodation. Eg: Gym, Laundry, Wifi, etc.
Price Range (GREEN)	Contains range as its attribute to indicate the range of price.
Places (BLUE)	Contains info of places like name, address, description, contact number, etc.
Country State (RED)	Indicates which states that places are located in Malaysia.
Registered User (YELLOW)	Stores user's info such as name, username, password, email, etc.
Transaction Histories (PINK)	Stores info of places that user made booking before.
Star Rating (GREY 1)	To indicate the star rating for accommodation. Eg: 1-star, 2-star, 3star, etc.
Types (GREY 2)	To indicate the types for attraction and accommodation. Eg: Zoo, Museum, Homestay, Hotel, etc.

Table 4. Description of Properties (Attributes).

Property (Attribute)	Description
Name	Name for places, users, types, facilities, states.
Username	Username of registered users and admin.
Password	Password of registered user.
Address	Address for attraction and accommodation.
Description	Description of places for both attraction and accommodation.
Email	Email address of places, users.
PhoneNum	Contact number of places, users.
Url	Url link to attraction or accommodation webpages.
Range	Price range as attribute for each attraction and accommodation node itself.
Price	Price for attraction and accommodation.

E. Jaccard Index

Our recommender system will first match a list of places from graph database, and then rank them with an index which called Jaccard Index for recommendations part. Jaccard Index is a number between zero and one that measure how similar between two finite sample sets. It is known as intersection over union as well because it is calculated by dividing the size of intersection by union of two sets. One (1) will be returned for two identical sets and zero (0) will be returned for two sets that do not have any common element (see Equation 1.)

$$J(A,B) = \frac{|A \cap B|}{|A \cup B|} \quad (1)$$

This formula is used to measure the similarity between two places and rank the places from a list of recommendation. Places with higher index means they have more similarities compared to places with lower index. Places with more similarities indicating that they are more suitable to be recommended. In our setting, the system will only return recommended places with Jaccard Index that higher than 0.5, so that user can get a better, more accurate and related recommendation. Nevertheless, the threshold value is adjustable as one wishes.

F. Sample query using Cypher

Query 1: Find attraction that located in Kedah

The following Cypher query matches attractions which are located in Kedah and return the result. Figure 5 shows the attractions that are located in Kedah after executing the following query:

```
match (a:Attraction)-[r:LOCATED_IN]-
>(b:State{name:"KEDAH"}) return a,b
```

Query 2: Find attraction that categorized into 'Beach'

The following Cypher query matches attractions which are categorized into Beach and return the result. Figure 6 shows the attraction that are categorized as 'Beaches' after executing:

```
match (a:Attraction)-[r:CATEGORIZED_INTO]-
>(b:Type{name:"Beach"}) return a,b
```

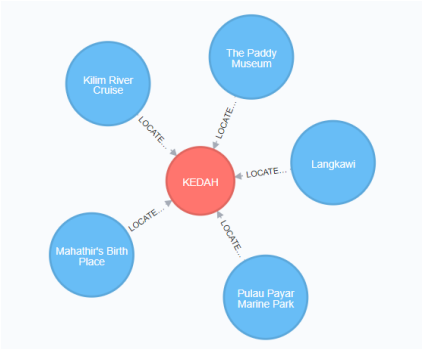

Figure 5. Returned result of Query 1.

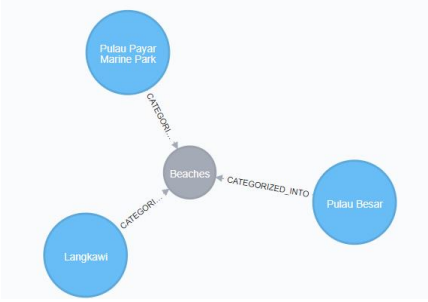

Figure 6. Returned result of Query 2.

Query 3: Set user preferences as 'Zoo' and 'Homestay'

The following Cypher query creates a 'PREFERRED' relationship to indicate user preferred attraction types. Figure 7 shows the user's preferences after executing:

```
match (n: RegisteredUser{ username: "abab"}),(t: Type{ name:
"Zoo"}) create(n) -[r: PREFERRED]->(t)

match (n: RegisteredUser{ username: "abab"}),(t: Type{ name:
"Homestay"}) create(n) -[r: PREFERRED]->(t)
```

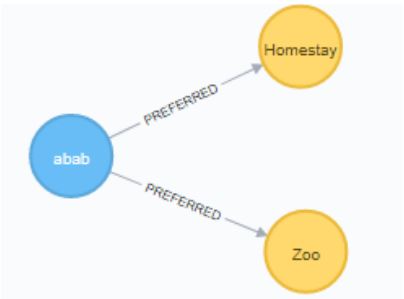

Figure 7. Returned result of Query 3.

Query 4: Register for new account

The following Cypher query creates a new node for a new user with user's info as properties. Figure 8(a) and 8(b) shows the newly created user and the user's info respectively after the following is executed:

```
CREATE (n:RegisteredUser {username:"imnew",
password:"imnew", name:"ksshe", email:"wilsonsks@abc.com",
phoneNum:"012-3456789"})
```

(a)

n.username	n.password	n.name	n.email	n.phoneNum
"imnew"	"imnew"	"ksshe"	"wilsonsks@abc.com"	"012-3456789"

(b)

Figure 8. Returned result for Query 4

Query 5: Generate recommendation

The following Cypher query creates a 'PREFERRED' relationship to indicate a user prefers an attraction type. Figure 9 shows the recommended places and its Jaccard index after executing:

```
MATCH(a:RegisteredUser{username:"john"})-
[s:PREFERRED]->(c:Type)
MATCH (other:Attraction)-[:CATEGORIZED_INTO]-
>(c:Type)
MATCH(m:Attraction{name:"Aloft Kuala Lumpur Sentral"})-
[:LOCATED_IN|:CATEGORIZED_INTO|:RANGED]-(t)<-
[:LOCATED_IN|:CATEGORIZED_INTO|:RANGED]-
(other:Attraction)
WITH m, other, COUNT(t) AS intersection
MATCH(m) -[:LOCATED_IN
|:CATEGORIZED_INTO|:RANGED]-(mt)
WITH other, intersection, COLLECT(mt.name) AS s1
MATCH(other) -[:LOCATED_IN
|:CATEGORIZED_INTO|:RANGED] - (ot)
WITH other, intersection, s1, COLLECT(ot.name) AS s2
WITH other, intersection, s1, s2
WITH other, intersection, s1+filter(x IN s2 WHERE NOT x IN
s1) AS total
WITH other, intersection,((1.0 * intersection) / SIZE(total)) AS
jaccard
where jaccard>0.5
RETURN distinct other.name,jaccard order by jaccard
DESC,other.name
LIMIT 10
```

other.name	jaccard
"Ambassador Row Serviced Suites"	1
"Ancasa Hotel Kuala Lumpur"	1
"Boulevard Hotel Kuala Lumpur"	1
"Concorde Hotel KL"	1
"Corus Hotel"	1
"Crown Regency Service Apartments"	1
"Crystal Crown Hotel Kepong"	1

Figure 9. Partial returned result for Query 5

G. User Interface Diagram

Figure 10 shows the hotel (home) page of our system with some random recommended places. Logged in users or visitors are able to find

accommodation by choosing a location, and the application will then display the accommodations which are located in the selected location.

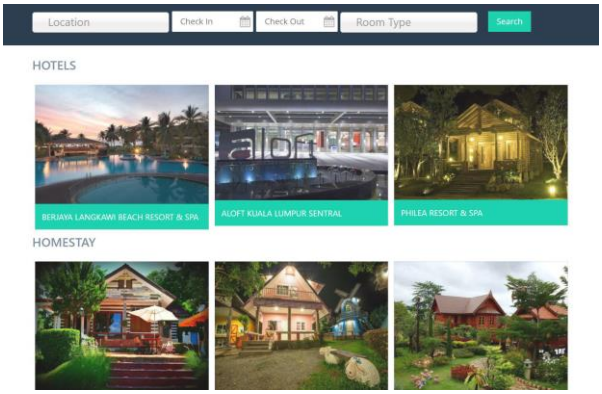

Fig. 10 Hotel (Home) Page.

Every logged in user has a profile that displays his/her own information. A new user has to set his/her preferences on the profile in order to get recommendation by user preference.

Figure 11 shows the recommendation page which can only be accessed by logged in users. This page will automatically display accommodations and attractions that are based on the user's preferences and transaction history. This recommendation is generated based on the Jaccard Index elaborated earlier.

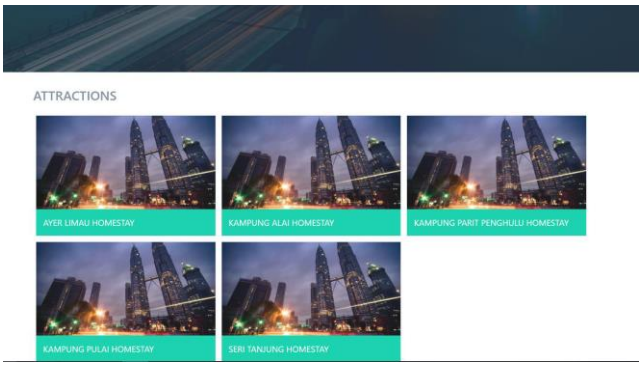

Fig. 11 Recommendation page

IV CONCLUSION AND FUTURE WORK

In this paper, we have proposed a property graph-based tourism application based on user preferences and transaction histories. This system focuses on knowledge representation using the property graph. Property graph has rich semantic relation representation to model the relationship through its visual representation. The system is able to recommend places to user by using Jaccard Index to rank the places that are more suitable for recommendation. However, there is room for improvement such as combining some other recommendation techniques such as semantic based weighted graph or even deep learning to get more accurate results.

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