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GRAPH-BASED RECOMMENDATION MODEL ENVISIONED FOR VARIOUS DOMAINS

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ABSTRACT

Recommender systems are envisioned and design to serve automatic recommendations for various services and products to active consumer. Such systems can find similar items and sort to generate top N suggestions as per users past transaction, location, knowledge, profiles, preferences or choices of otherpeople. This research illustrates potential use of graph-based model intended for recommendation system and designed for various domains. The ultramodern graph technology and state-of-the-art graph query tool is prime motivation behind this research work. The implementation has been carried out with profound online graph management tool known as 'neo4j' and recommendation algorithm has been executed with graph query language called 'Cypher'. The experiment and evaluation shows success of proposed model for increasing efficiency of the system which is emerging need of the present. The outcome of this research has great potential which can be put into practice and it can offer course of action for advance technical revolution in forthcoming era of Big data. This research also encourages anyone who wants to implement graph-based model for recommendation system.

Keywords: *Recommendation system, Recommendation techniques, Graph database, neo4j, Cypher*.

I.   INTRODUCTION

Wikipedia defines 'Recommender Systems' or 'Recommendation Systems' (also known as 'Recommendation Engine') as a new kind of information filtering system that look for similar items which user would like or in other words predict an item the user will prefer to buy [1]. Recommender systems are also define as an on-the-go information filtering systems that personalized the information serving to an active user based on users interests, relevance of the contents etc. Recommender systems provide recommendations or suggestions for items to buy, movies, news, articles, restaurants, places to visit etc. Today, the most commonly used websites on Internet are Facebook, YouTube, LinkedIn and they had already incorporated recommender system (RS). For instance, Facebook suggests other users to widen friend network using 'People You May Know' section. Similarly, LinkedIn suggests other users to connect with 'People You May Know' facility and YouTube has a provision of 'Relevant videos' based on previous browsing history. Even we use the suggestions or advices every other day, without even knowing more about "How recommendations generates?" Generally, recommendation system personalized contents on the basis of user's past or current preferences to improve the user experience.

This paper focuses mainly on literature review related to graph-based recommendation systems design and various methodology currently used for recommendation. This research work also intended to propose graph-based models for few domains. The rest of this paper is organized as follows. In Section 2, various conventional as well as recent techniques of recommendation are discussed. The Section 3 describe few graph-based recommendation model described in various literature is presented. The Section 4 provide outline of innovative graph-based recommendation model proposed for different domains. The implementation methodology as well as experimental results is presented in Section 5 and 6. Finally, in Section 7 conclusion and future works is presented

II.   BACKGROUND

a.   Conventional Recommendation Techniques

There are two primary methods of recommendation system (RS), content-based (CB) method and collaborative filtering (CF) method. Content-based method means that it analyses the features of item to produce suggestions. Here, item refer to the product or any other thing for which recommendations has to produce like movies, news, books etc. Features refer to the attributes of items like movie tags, words frequency in news, the keywords which describe the items etc. Many commercial websites uses content-based method especially when feature based item similarity could be possible.

The other method is user-to-user collaborative filtering method; the key idea of this method is to find a group of other similar people who has similar interest or test as you. These focus on finding similar-minded people by analyzing the similar ratings on items. These people also refer as t 'neighborhood of the current user'. The principle idea behind this is "If an item is liked by most people in neighborhood, then it is very possible to be liked by the current user also" [41]. The collaborative filtering method is used by many. There is another kind of collaborative filtering method known as item-to-item collaborative filtering

method. This concept was made popular by Amazon. The main idea of this method is instead of finding neighborhood users, it finds the items been purchased together with the current item.

b.   Advanced Recommendation Techniques

A survey of various recommendation systems has been presented in literature [10]. Knowledge based recommendation, demographic recommendation and utility recommendation systems are advancedmethodology which implies expert knowledge, users' demographic features and user's need respectively. The term hybrid recommendation system defines any recommendation system that incorporates multiple recommendation techniques together to yield final output. The current trend in RS is to take advantages of social information such as tags, comments, opinion, and other social network information. Successful implementation of many social information based recommendation has been observed recently [11]. Social tagging is also very popular now-a-days because that allow annotating of online resources with arbitrary labels, hence it expands rich information spaces called as folksonomies. Due to this new component, tag based recommendation systems be necessary of the social information analysis. Another novel idea of using spatiotemporal information for news recommendation system has been also noticed [28]. A new trend of location-based recommendation system is also discovered [29, 30, 31, 32, and 33]. methodology which implies expert knowledge, users' demographic features and user's need respectively. The term hybrid recommendation system defines any recommendation system that incorporates multiple recommendation techniques together to yield final output. The current trend in RS is to take advantages of social information such as tags, comments, opinion, and other social network information. Successful implementation of many social information based recommendation has been observed recently [11]. Social tagging is also very popular now-a-days because that allow annotating of online resources with arbitrary labels, hence it expands rich information spaces called as folksonomies. Due to this new component, tag based recommendation systems be necessary of the social information analysis. Another novel idea of using spatiotemporal information for news recommendation system has been also noticed [28]. A new trend of location-based recommendation system is also discovered [29, 30, 31, 32, and 33].

c.   Various Domains Of Recommendation System

A significant effort has been observed in the direction of serving personalized services for a wide variety of domains like e-commerce, e-business, e-learningand e-government. In various research work, successful implementations also found to facilitate for varied range of products such as recommending news [20,21,22,23], movies [12], books[18,19], music[13,14,15], videos [24,25], exhibitions[27], events[28] and television programs[16,17]. It has been also served as tools of personalized services like e-governance [26], e-learning [38, 37], e-commerce [39, 40], e-tourism [34], web search [35, 36] and others.

III.   RELATED WORK FOR GRAPH-BASED RECOMMENDATION SYSTEM

A graph based recommendation system has been proposed in literature [2] for digital library. This system comprised of two-layer bipartite graph which allows integration of user-user, item-item and user-item. This graph based framework proven beneficial for integration of CB and CF techniques. Another literature [3] demonstrates random graph model for recommendation system which allows integration of social network data also. Furthermore, this research work tries to analyzed complexity of computational task for the same. This research effort also attempt to find cluster of people with related interest. Recently, in another literature [4] graph based model for RS has been proposed called GRankwhich uses tripartite graph structure and that designed to address data sparsity issue for CF. This research incorporate tripartite preference graph (TPG) model that facilitate integration of contextual information along with preference data. This TPG allows integration of heterogeneous data about user, presences and items. The author claimed significant improvement in recommendation quality and solving data sparcity problem with use of this. In research literature [5], session based temporal graph has been proposed which leverage users' long-term and short-term references over time which helps to facilitate temporal recommendation. Along with this a novel recommendation algorithm has been presented called injected preference fusion for the same. In the paper [6], proposed a unique geographical probabilistic factor analysis framework which takes various factors into consideration such as location, users' preferences anduser mobility behaviors to provide personalized recommendations of places of interests such as restaurants for mobile users. The research paper [7] focuses on development of graph-based multidimensional recommendation method and implemented Personalized PageRank algorithm. In this work, graph is constructed using an implicit feedback dataset from music listening log and a set of other entities which facilitate to rank entities according to a given query. The main advantage of this model is flexibility as well as it helps to solve sparsity issue. Another literature [8] has proposed a collaborative recommendation framework, called UPS-CF, which considered user preference, proximity and social data. This model helps to make location based recommendation for a place near her hometown even if the user is traveling out of town using multilayer graph structure.The research work [9] uses unified hypergraphs to model multiple typesof entities and relations for music communities,which help to organized high-order relations among various types of entities with accuracy. This work focus on music recommendation and considered it as a ranking problem on pregeneratedhypergraph to find the music tracks that each user desires.

IV.   PROPOSED GRAPH MODELS FOR VARIOUS RECOMMENDATION SYSTEMS

As stated above, there are lots of benefits of using graph as a data model for RS into various domains. In this section, distinguished graph model designs have been presented along with suitable recommendation strategy. This model intended to design and implement to enhance performance of recommendation system as well as recommendation algorithms. The large volume of data has been used for evaluation but, for demonstration purpose only a small portion of it has been used to increase readability and understandability.

a.   Graph Model For Friend Network System

This graph model is consist of single entity nodes called 'PERSON' and directed edges among them labeled as 'KNOWS', this kind of graph are also known as single relation graph. This model could generate recommendations for friends who is not known current user but known by his / her network (friend of friend). The following figure 2 shows the graph model for the same.

This model could also generate recommendations for common friends of two persons. This model could also generate recommendations for chain of persons to reach to a particular person by finding shortest path between two persons as shown into figure 3.
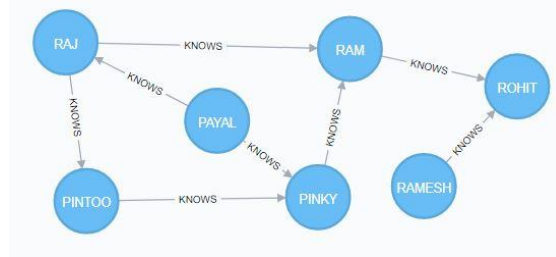
FIGURE : 2Graph Model for Friend Network

FIGURE : 3Shortest Path between Two Person

b. Graph Model For Online Dating Website

For an online dating websites, a graph modelis created which consist of multiple entities like 'USER', 'CITY' and 'HOBBY'. Here, user nodes could be connected with hobby nodes and city node via directed labeled edges having edge labels'LIKE' and 'LIVE' respectively. The following figure 4 shows the graph model for the same. In this graph model, nodes can have various attributes of entities which stored as node properties. The user node has node properties such as name, gender, age etc.The user can have more than one hobby and that could be shown by connected edge between user and hobby node.The graph structure is flexible enough to accommodate new hobby node as well as city could be change at any point of time
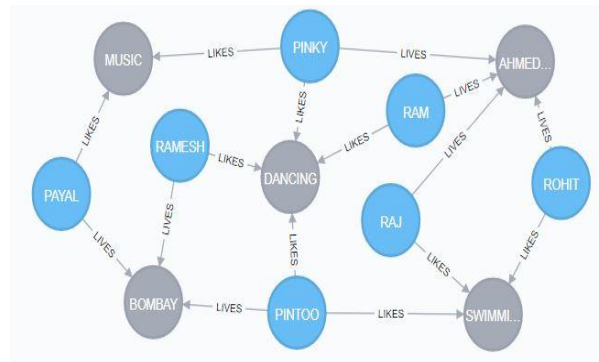

FIGURE 4 :Graph Model for Dating Website

The recommendation system has to suggest another user with different gender having same city and similar hobby. The main complexity involved here is to find another user who lived in the same city which will be connected with particular city but gender is not same and having same hobby. The figure 5 shows generated recommendation for active user named 'PINKY'. The associative property of graph is very helpful to perform above stated operation as user node is connected with city node, which improves system performance a lot.
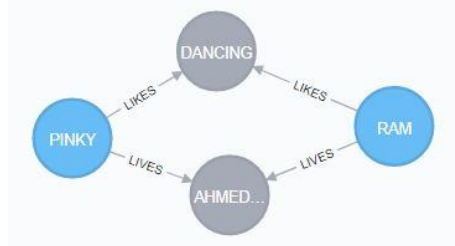

41

FIGURE 5 :Recommendation for Dating Website

c. Graph Model For Online Book Library

A more complex graph model has been generated having distinguished entities like 'SUBJECT', 'KEYWORD', 'USER', 'LANGUAGE' and 'BOOK'. Along with that there are multiple kind of relationships among BOOK and SUBJECT node labeled as 'BELONGS', USER and BOOK node labeled as 'READ', USER and SUBJECT node labeled as 'LIKES'. The following figure 6 shows the graph model for the same.In this graph model, BOOK nodes can have various attributes of books which stored as node properties such as author, category, no of pages and book rank. The user node has node properties such as name, gender, age etc.The user can have read more than one books and that could be shown by connected edges between user and book node.The graph structure is flexible enough to accommodate new book nodes as well as subject could be change at any point of time. The graph structure is flexible enough to provide accommodations that book can belong to multiple subjects.
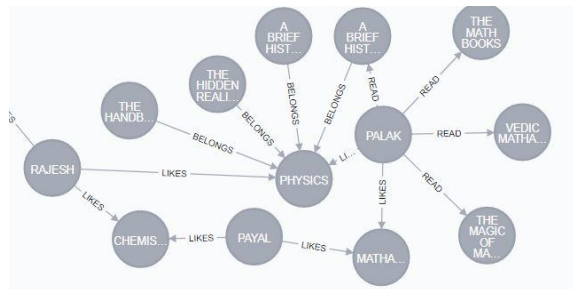

FIGURE 6 :Graph Model for Online Book Library

The recommendation system has to suggest other books to active user which has not been read by user and having same subjects of books which one is liked by user in the past. The system could also generate recommendation based on liking of the user for specific subjects. The figure 7 shows generated recommendation for current user named 'Palak' who liked physic subject in past, so the books not read by her and belongs to same subject is suggested by system.
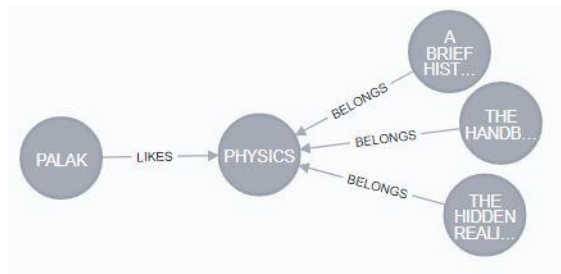

FIGURE 7 :Recommendation for Online BookLibrary

V.   IMPLEMENTATION AND EVALUATION

The various graph models presented here in this research has been implemented with well-known online graph database management tool called 'neo4j'. That allows creation and management of graph data using property graph model. The data has been import using CSV files and various nodes, nodes properties and edges has been created. After that various recommendation algorithms written in 'cypher' query language has been executed to get recommendation for particular user.

The primitive goal of this research is to examination suitability of graph database and 'cypher' based recommendation algorithm for development of recommendation engine. The experimental evaluation mainly

focuses on execution time of algorithm against number of nodes and number of edges. The observation of experiments has been presented into Table 1.

Table 1: table for efficiency measurement

	Nodes	Edges	Process Time
Friend Network	10,150	508	108 ms
Dating website	23,459	12,180	12045 ms
Book Library	112,509	567,304	27809ms

Based on the results, it has been proven that the efficiency of recommendation algorithms could be increase with use of graph database. Hence, graph based recommendation engines are most suitable for online environment where huge amount of data is to compute. The key reason behind this is associative property of graph data i.e. nodes are directly connected to each other, so it requires less time to find connected data.

VI.   CONCLUSION AND FUTURE ENHANCEMENT

The enormous growth of internet and huge success of a wide variety of web applications has given promotion to web personalization and hence encourage development of recommendation system. In recent years, significant efforts have been taken towards serving personalized online services and recommendation system as integrated part of web sites for diversified areas such as e-commerce, e-tourism, e-learning and e-government. The main advantage of recommender systems is that it suggests the right products or services to active user based on explicit or implicit data for faster decision making. Many successful applications using recommendation techniques have implemented for various products and services such as news, movies, books, videos, exhibitions, and events.

This research work aims to build a graph-based recommendation system instead of conventional database to support efficient processing in online environment which is an emerging demand. A very few graph based model in literature are found to study. A graph-based models presented in this research is design intended to work for online dating website, online book library and friend network. The proposed graph models are very innovative and have huge potential for putting into practice for real life problems.

The recommendation model presented here are very primitive and intended to experiment with graph database. The models are further enhanced with more complex algorithm for real time system. The model has to also test for accuracy of the recommended results and various other aspects. A lot many other parameters related to accuracy and performance has been already proposed in numerous research literatures. This research work could extend further to test with other parameters as well as for real world data testing
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