

## A Comprehensive Review of Recommender Systems

**Gangothri V, Saranya S and Venkataraman D.**

*Department of Computer Science and Engineering  
Amrita Vishwa Vidyapeetham(University), Coimbatore, India.  
E-mail address: [gangothribsc@gmail.com](mailto:gangothribsc@gmail.com)  
[d\\_venkat@cb.amrita.edu](mailto:d_venkat@cb.amrita.edu), [mayukamila@gmail.com](mailto:mayukamila@gmail.com).*

### Abstract

Recommendation systems are the technique to handle large set of datasets. It helps the user to identify the best items from the huge datasets. The items can be anything like cosmetics, medicines, colleges etc. This paper will give you the overview of what is recommendation system, how does it work, what are all the techniques involved to manipulate the best outcome from the huge item sets.

**Keywords** Recommender system, personalized and non personalized recommender, content based system, collaborative filtering system and hybrid filtering system.

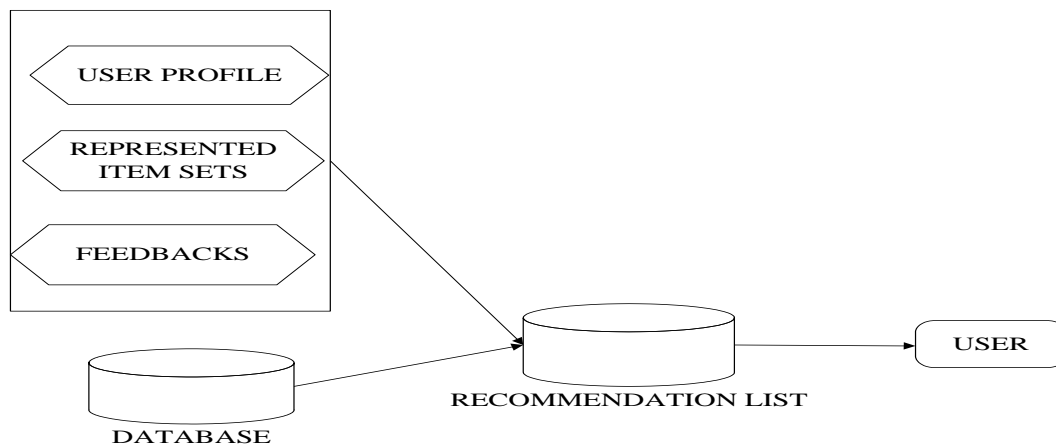
### Introduction

Recommendation systems are helpful to the user to get recommendation of an item from the huge datasets. Usually recommendation is you are recommending some items to others or you are getting recommendation from other to know the feedback about the product which you want to buy. For example if you want to buy a good story book, you might have no idea which one to buy and you may feel hard to find a good one out of huge story books. In this case, the recommendation system will give you suggestions by using personalized or non-personalized recommendations.

In a personalized recommendation system, it provides a ranked list of books and the RS matches the ranked list with the user's need to give the suggestion of a story book. But in a non-personalized recommendation system, it provides the top 10 items from that particular item sets. The user has to pick any one item from the list. It will not do any intellectual work to give the exact results to satisfy the user need. The classic example is if you want to go for a movie, you usually see review about movies in the newspaper or magazines to select the best movie out of the box. This is the real time example for the non-personalized recommendation. Recommendation system gives the recommendation to the user by using various types like implicit or explicit

feedbacks, ratings, maximum number of product chosen by the user etc. Every user actions will be updated in the separate recommendation database so that it will be helpful for the upcoming users to get the suggestions about the product. Nowadays the recommendation system is successful in the website like Amazon, Net flix and You Tube. The recommendation system is not an optional method to be incorporated in the e-business; it is must in some cases like buying products in online.

The main purpose of recommendation system in an e-business is to increase the sales and to make the customer to get the product in an easier way. A well defined Recommendation System increases the user satisfaction. With this user can get the relevant recommendations and they can find interesting one also. For instance, if you search for a phone, you might get the accessories also. It is just to grasp you towards the accessories. This kind of recommendation system will make the sales more than other kind.



**Figure 1:** Recommendation method

The other kinds of recommendation system update the details of the product which is visited and reviewed by the user. If the user searches for some other items, it does recommendation of those previous products. This methodology is known as retargeting. It makes the user to get attraction of those items and it leads to buy it. Recommendation System helps not only to sell the best product you may also you can get an unpopular item which has not been famous in the market. Because the primary motive of Recommendation System is to sell products and to make a profit. In this way it helps the producer to sell the diverse items.

Every recommendation system is idle. There are no restrictions for the functionality of the recommender. It depends on the business in which it has been deployed. For instance, a product recommender will do a product recommendation and a book recommender will do a book recommendation it is not a good practice to compare these two recommenders to find which one works efficiently. Because both are not meant for the same purpose and both has been deployed in a diverged item sets.

### **Data Representation In The Recommender System**

Recommendation system needs various kinds of data in order to construct the recommendation. The data is a basic necessity to build the recommender. The item, user and transaction are the most important data to be required for a recommender. These data helps the user to get recommendation. The **item** is an object for which the user needs recommendations. When a user searches for an item he always search in terms of cost, so we need to consider much on the cost of an item. Items can be represented in the various forms of information's which will be separated in terms of complexity and there are many approaches too but we are going to concentrate on the ontological representations.

The **user** object has the information about the user. In common for all the process in the recommendation system each user will be modelled in terms of user data. Those models have the preference details and ratings about an item, according to those ratings the factor value will be generated, each user will be differentiate in terms of factor weight.

The **transaction** is communication between the recommendation system and user. The communication occurs in terms of explicit or implicit feedback given by the user. Binary, numerical, unary, and ordinal ratings are the types of explicit feedbacks. According to those feedbacks the recommendation will be generated. The implicit feedbacks will be generated automatically by the system. In this case the user no need to provide any ratings and also no feedbacks will be asked for an item.

### **Recommendation Techniques**

The recommendation will be provided in the basis of six different approaches. These methods help to filter the items which have fewer matches compared to the user needs. The utility will be predicted based on item, user and transaction objects. As mentioned above these three are the major objects in predicting the recommendation for the user. The six different approaches are:

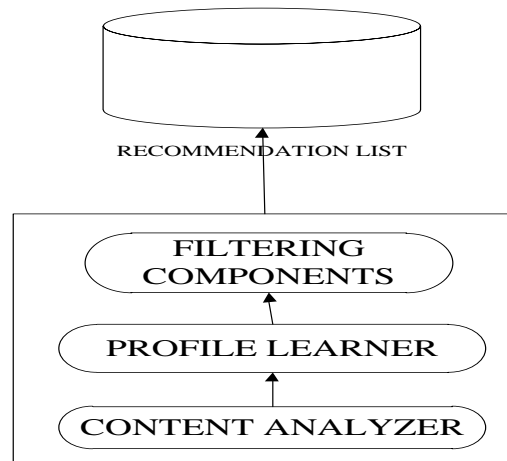
1. Content-Based Recommender System
2. Knowledge Based Recommender System
3. Community Based Recommender System
4. Demographic Recommender System
5. Collaborative Recommender System
6. Hybrid Recommender System

All these types are important to recommend an item. Some of them have been explained in the below.

#### **Content-Based Recommender System**

The recommendation system which uses content-based, will give you the relevant document by matching up the keywords. For instance, if a user wants information regarding semantic web, he has to type "semantic web" in the search engine, it matches the keyword in the database, and finally it retrieves the documents which has high term frequency in the database. This is the working process of content based

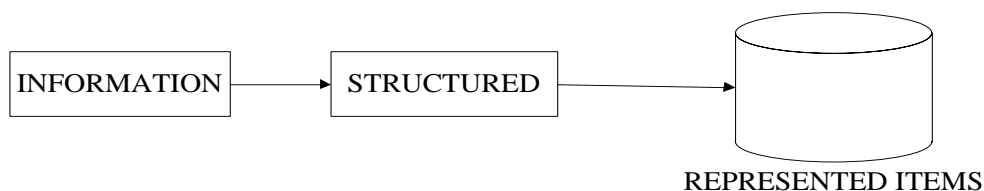
recommender system. In this case the user profile will be designed in such a way that it manages the user's previous interested items, specific web page, etc.



**Figure 2.1(a):** Content Based Recommender System

Content-based Information filtering system needs the platform to organize items and user preferences. It also needs the methodology to compare the items and the user preferences. To manage this process we required content analyzer, profile learner and filtering components. Each one will be considered as a separate component and it has been explained briefly in below.

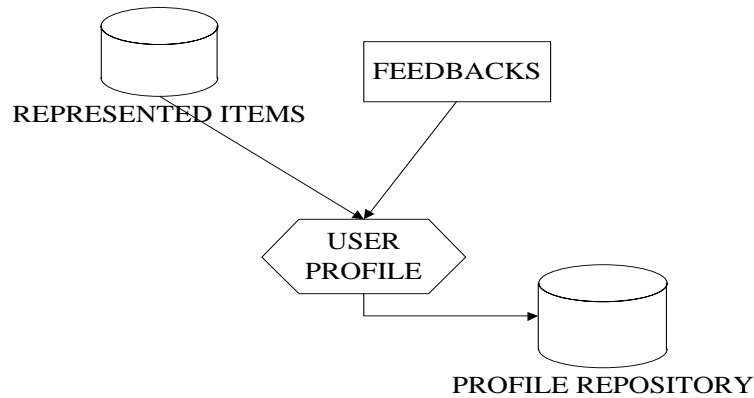
### Content Analyzer



**Figure 2.1(b):** Content Analyzer

In this component the information will get a structure form to generate the recommendation. This is the first phase in the content based recommender system so the data will be in the form of unstructured. After user types the data, it will directly go to this phase. It intakes the data and perform some pre-processing methodologies to convert those information into a structured data. It takes the data from the information source, form a structured item sets and those item sets will be stored in the separate database. These stored data sets will be the input for next two phases i.e. profile learner and filtering components.

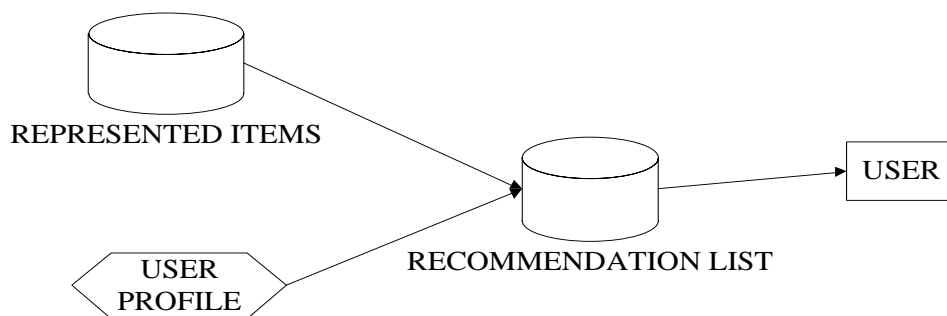
**Profile Learner**



**Figure 2.1(c): Profile Learner**

This phase input will be the represented items generated by the content analyzer as an input. The main goal of this phase is to construct the user profile with the help of machine learning techniques. The machine learning techniques will be used to design the user profile; it concentrates on the user preferences like in what items they have an interest, ratings given by the user and feedbacks. The work of this phase is to combines the represented items with the feedbacks, and then it compares with the user profile and sends it to the filtering components.

**Filtering Components**



**Figure 2.1(d): Filtering Components**

The input of the filtering components will be the user profile and the represented items. It intakes the represented items against the user profile and it does match between them to generate the list of recommendations according to the user feedbacks. This is the last component in the process of content based filtering system. So the output of this phase will be the result of recommender system.

### Gains and Shortcomings

- **Structure Dependent** – The content based recommender system is fully structure oriented process. It has three phases called content analyzer, profile learner and filtering components. These three will be processed one by one. So it works in a neatly organised manner which makes the work flow to be very smooth. Because there will not be any interrupter to distract the working process. And also each component divided the work equally so it helps to avoid over loading the work on the one component.
- **User friendly** – This system gives the friendly environment to the user to be recommended for an item. It stores the user's previous details of their likes regarding the items they want to purchase and it does recommendation at the time when you search for it. It will be really impressive for the customer to get things sooner and it makes their work easier. It handles in the way which user wants a system to recommend an item for them. So it is very user friendly.
- **New items** – In Content based recommender system the user may get the recommendation of new items which means an item which has not been rated by anyone. This may help the user to know about the other products too rather than selling the routine products and also it invites the new items as equal to an old one. Each item will be differentiate only with their ratings.

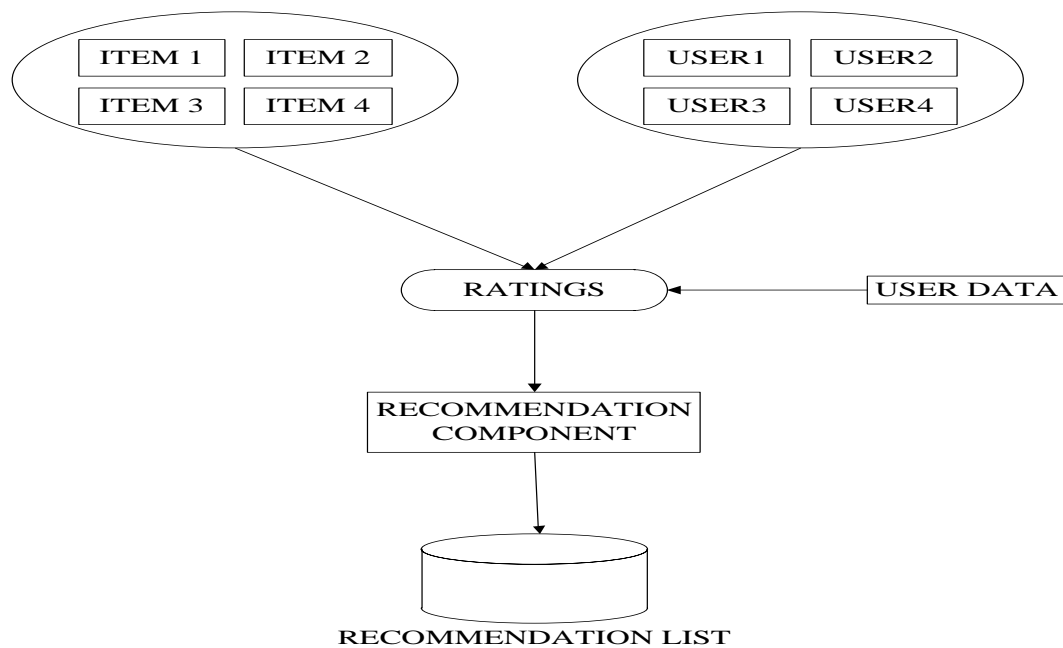
The **shortcomings** of content based recommender system. They are

- **New items** – This system helps user to get the recommendation of newer items which is not has been a popular in the market. This may leads to the recommendation of bad items because it recommends an item without any survey among the user. Introducing new item is a good practice but we should not experiment that with our users. It has to do some pre-processing techniques to overcome from this riddle.
- **Time Management** – In this technique we it can handle only a limited set of recommendations in a time. It is a huge process to come across the three major steps in the content based recommender system to get the finalized list of recommendations for an item. So it will be tough for the system to handle more recommendations in a time.
- **Domain Knowledge** – Content based recommender system just matches the content profile with the user profile to produce the recommendation. The chance of retrieving the relevant and non relevant document is depending on the matching process. It will not have any domain knowledge in order to retrieve the relevant document. So domain knowledge is needed to extract the most relevant document even when the user does not have the appropriate keywords and knowledge about it.

### Collaborative Filtering System

Collaborative filtering system recommends the user to get items by using the past details like history of item that have been purchased, viewed and reviewed. It gets help from all these details to predict the value for a certain item which has to recommend to the user. The recommender system have to manage various kinds of

users, all the user's input will not be in the same manner. So it automatically needs some pre processing techniques to manipulate those inputs to a data. Collaborative filtering approach is the most familiar in the recommender systems to generate the list of recommendations. This is the one which has been applied most in the many e-commerce applications. The explicit feedback helps to increase the efficiency of the collaborative filtering system. Because in this method the users have been allowed to tell their interest and likes about an item frequently. So it gives the accuracy on user's likes in order to find the appropriate item for a user.



**Figure 2.2(a):** Collaborative Filtering System

The Collaborative filtering approach has two main techniques to filter the items from the item set. They are *neighbourhood approach* and *latent factor models*. **Neighbourhood approach** uses the user's rating for an item to find a new item in a set. It works in the basis on the relationship between item to item and user to user. An item to item approach recommends an item to a user by using the ratings given by him and it searches for the item which has similar ratings in the data set. For instance, if a user wants to buy a book it searches the ratings of an item and also find the item which has similar ratings in the data set. On the other hand, the user to user approach recommends an item to a user by using the ratings given to the item by the neighbours. For example, if a user wants to buy a mobile it searches the ratings of the item and it notice what the books are bought by the neighbours and finally it produce the list of recommendations from this comparison between the user data and the neighbour ratings.

**Latent factor model** is the one which forms the matrix and do matrix factorization to obtain the ratings of an item to be recommended. The matrix formation will be helpful in terms to form a structured data from unstructured information. This is also

known as SDV based model. There are several methodologies to do the matrix factorization in the collaborative filtering system. The most familiar approach is SDV, SDV++, Time aware factor model, etc. These techniques help to form a matrix in order to predict the recommendation using user preference.

### **Benefits and Difficulties**

- ***Different content*** – It is an improvement to the content based recommender system. The content based recommender will suggest an item only if the content profile has a good value to compare with the user profile. But in case of collaborative system it recommends an item even when the content profile is not available. So it improves the efficiency of the recommendation system.
- ***User independence*** – This is user independent, it allows the user to decide what they want and to fix what they like. It is recommending an item to the user with the help of ratings provided by the neighbours. Since the judgement is based on the user community results there is a less chance of a system to recommend bad items.

The **difficulties** of collaborative filtering system are

- ***New items*** – The newer items cannot be recommended if no neighbours have not been chosen it. The functionality of recommendation is fully dependent on the judgement of the ratings given by the neighbours. So if the neighbour has not chosen any particular item means it will not be recommended to the user who needs it. It recommends only a well-liked item but not the matchless one.
- ***Expensive*** – This system will be expensive in order to maintain the huge number of items in a while. We will get a situation to be stopped in between the process because of dumping loads to the system. And it works in a different environment the time management should play a major role in the recommendation process.

### **Demographic Filtering System**

The demographic filtering system will have a demographic class; each user will be assigned here based on their user preferences. Every demographic class will have a cluster of user which has stereotype and archetype to perform justification for recommending an item. The recommendation given by the demographic filtering system is based on stereotypical; because it produce the recommendation based on the assumption given by the users belongs to that demographic class. It takes decision based on the cluster preferences, because all the users grouped according to their basic preferences for their products. The demographic filtering system is very quick and easy for recommendation because it searches the item which has been preferred by the cluster.

### **Benefits and Disadvantages of Demographic Filtering System**

- ***No History***- It does not require the history of the user to perform the recommendation because it prefers the stereographic method to do it. The



other approaches like content-based and collaborative filtering system need the user's previous data to manipulate the recommendation to a current item.

- **Easy** – This approach is quick and easy to get recommendation. It cluster the persons based on their preferences. So it leads to an easy and quick way to recommend an item when compared to other approaches.

### Difficulties

- **Clustering** – In this case the clustering is the major role to recommend an item. But it is difficult to form a cluster among huge number of users. We are going to cluster the user, based on their preferences it is such a hard task to find the user who like the similar items.
- **No similar interest** – We are recommending an item based on the stereographic method which sorts an item by using the user preferences who belongs in the cluster. If the system could not find the cluster with similar interest means there will be problem to recommend an item.

### Hybrid Recommender System

Hybrid recommendation system provides the chance for the recommender approach to improve the efficiency of the recommendation by providing the combination of two or more types of recommendation approach together. In a simple word, hybrid recommendation is the combination of two or more recommender systems to overcome from the negative aspects of an individual system and to enjoy the additional features from those recommendation systems. We can combine any two or more recommenders but the most familiar and successful combination is content based and collaborative recommender system. Table shows some of the combination of methods that have been employed.

Hybridization Method	Description
Weighted	The ratings of several recommendation techniques are combined together to produce a single recommendation
Switching	The system switches between recommendation techniques depending on the current situation
Mixed	Recommendations from several different recommenders are presented at the same time
Feature Combination	Features from different recommendation data sources are thrown together into a single recommendation algorithm
Cascade	One recommender refines the recommendations given by another
Feature Argumentation	Output from one technique is used as an input feature to another
Meta-level	The model learned by one recommender is used as input to another

**Figure 2.4:** Hybrid System Categories [2]

## **Trust- Based Recommendation System**

Trust based recommendation technique is the concept of evaluating the evaluators. The recommender system is one of the web 2.0 applications. The recommendation is useful for recommend an item in the basis of information provided by the user and relationship between the users. Trust enhanced recommender system makes use of the knowledge which has been provided in the trust network to generate the personalized recommendation. The strength of the recent recommenders is trust propagation and trust aggregation. The trust propagation is calculating the value of trust given by the third party and the trust aggregation will combine many trust estimation into one to get the final trust value which helps to recommend an item. Recommendation techniques and trust metrics are the two important processes to build the trust enhanced recommendation. The trust models can be framed in many different ways. They are probabilistic and gradual approach.

The probabilistic approach uses the single trust value in a black and white manner. It checks whether an agent or source can be trusted each other and returns the result in the probability of the trust on the agent. This will be helpful to predict the agent who has higher probability on the trust enhancement. The higher probability will be given the higher priority when compared to others.

The gradual approach estimates the trust values with the help of result of that functionality. If you give information the system might understand in the wrong manner which the user does not mean it. So in order to come over from this the gradual approach uses the different way of methodology to enhance the trust based recommendation to recommender an item to the user. It will not generate the probability for a trust network instead of that the outcome of the higher trust value implies the higher trust about the network. This gives us the feel that the value of trust is very important in the case of recommendation.

Since we are giving more importance to the trust network we have to think about distrust also. Because whenever we check the trust degree, the calculation of distrust degree also needed to reduce the distrust in future enhancement.

The trust model has to work on the basis of seven roles which make the trust network more meaningful and it provides the knowledge about the process of the RS.

1. Transparency
2. Scrutability
3. Trust
4. Effectiveness
5. Persuasiveness
6. Efficiency
7. Satisfaction

All these concepts are important to build the recommendation system. Each one plays the separate role to develop the trust among the agents. The Transparency explains the functionalities of the system like how does it work etc, Scrutability permits the user to tell if the work which has been done by the trust is wrong, trust is used to increase the user beliefs in the system, effectiveness helps the agent or user to finalize a good decision, persuasiveness is used to convince the user to buy an item,

efficiency helps the user to make finalize the decision faster and finally satisfaction is to increase the joy of user to enjoy the available recourses.

## Conclusion

The recommender system and the functionalities have been discussed detailed in this paper. We can choose any approach among this to build the recommendation as we need. This recommendation system approach helps us to get the correct item among the huge number of data sets by using various methodologies. But among this the trust based recommendation is very popular surrounded by the other approaches.

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