

# Hybrid Systems for Personalized Recommendations

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**Abstract.** A variety of techniques have been proposed and investigated for delivering personalized recommendations for electronic commerce and other web applications. To improve performance, these methods have sometimes been combined in hybrid recommenders. This chapter surveys the landscape of actual and possible hybrid recommenders, and summarizes experiments that compare a large set of hybrid recommendation designs.

## 1 Introduction

Recommender systems are personalized information agents that provide recommendations, suggestions for items likely to be of use to a user [17, 25, 26]. They have been applied to many information access problems from news and email filtering to e-commerce product selection.

Recommendation techniques can be distinguished on the basis of their knowledge sources: where does the knowledge needed to make recommendations come from? In some systems, this is the knowledge of other user's ratings of the items in question. In others, it is ontological or inferential knowledge about the domain, added by a human knowledge engineer.

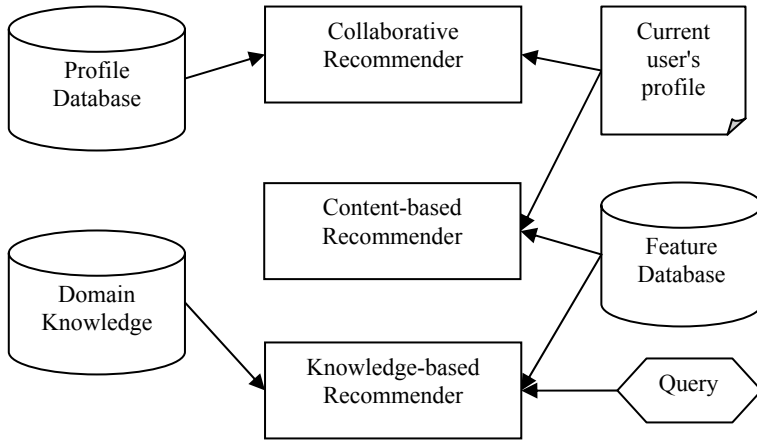
Specifically, recommender systems have *background data* that the system has before the recommendation process begins; *input data* that the user must communicate to the system in order to generate a personalized recommendation; and an *algorithm* that combines background and input data. On this basis, we can distinguish three commonly-used recommendation techniques: collaborative, content-based, and knowledge-based.<sup>1</sup>

### 1.1 Collaborative Recommendation

Collaborative recommendation is probably the most familiar, most widely implemented and most mature of the technologies. As shown in Figure 1, the collaborative recommender uses a profile from the current user and a profile database

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<sup>1</sup> My earlier survey [7] includes two additional techniques: demographic and utility-based. Utility-based recommendation is a special case of knowledge based recommendation. Demographic recommendation is rarely used in a web context because users are generally reluctant to provide the personal data that would make such a technique effective.



**Fig. 1.** Recommendation techniques and their knowledge sources

of other users. The system recognizes commonalities between the current user and those in the profile database, and generates new recommendations based on inter-user comparisons. A typical user profile in a collaborative system consists of a vector of items and their ratings, continuously augmented as the user interacts with the system over time. Some of the most important systems using this technique are GroupLens/NetPerceptions [25], Ringo/Firefly [30], Tapestry [14] and Recommender [17].

The greatest strength of collaborative techniques is that they are completely independent of any machine-readable representation of the objects being recommended, and work well for objects whose qualities are relatively intangible such as music and movies where variations in taste are responsible for much of the variation in preferences.

## 1.2 Content-Based Recommendation

Content-based recommendation is an outgrowth and continuation of information filtering research and is based on the idea of recommendation as classification [3]. Figure 1 shows the content-based recommender drawing from the user's profile and also from a feature database. For example, text recommendation systems like the newsgroup filtering system NewsWeeder [20] use the words of their texts as features. A content-based recommender learns a profile of the user's interests based on the features present in objects the user has rated. The type of user profile derived by a content-based recommender depends on the learning method employed. Decision trees, neural nets, and vector-based representations have all been used. As in the collaborative case, content-based user profiles are long-term models and updated as more evidence about user preferences is gathered.

## 1.3 Knowledge-Based Recommendation

Knowledge-based recommendation is similar to content-based recommendation in that it draws from the features of the recommended objects, but a knowledge-based