

Improving Diversity and Freshness of Newsletters in Community Question Answering Systems

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Abstract. Newsletters represent a standard way to inform users in online communities about new or interesting content. Their importance is even greater in communities producing large amounts of user-created data, such as community question answering (CQA) systems. Nevertheless, many popular CQA systems only offer generic newsletters. The aim of this work is to analyze existing approaches in personalized content recommendation in CQA systems and design a method for automatic creation of personalized newsletters for individual users of CQA systems. We focus on improving the diversity and freshness of recommendations as a way to prevent filter bubbles and improve user satisfaction and engagement.

1 Introduction

Newsletters, even today, are one of the prevalent ways of distributing news and content to users of online communities. They are mostly used to promote new content, discounted products or special offers, but also as a way to motivate the user to visit the site again. There are couple of methods being used for building the newsletters - manual content selection by an editor, automatic generation of generic newsletters or automatically generated personalized newsletters.

Newsletters are even more important in online communities producing large quantities of user-generated content, a prime example of which are Community Question Answering Systems, or CQAs. We argue that automated personalized newsletters using content recommendation have the most potential to improve user satisfaction in these kinds of communities.

However, many popular CQAs currently only offer generic newsletters, which may not be as engaging for their users, or no newsletters at all. For example, Yahoo! Answers¹ does not offer any kind of newsletter, and individual sites on the Stack Exchange platform² only offer generic newsletters with no content personalized for a specific user. Only Quora³ offers a personalized newsletter to its users, but no details about it are known.

Personalization and recommendation in CQAs is a widely researched topic [5]. In spite of that, we are not aware of any existing work aimed at personalization or recommendation utilized in sending newsletters. Moreover, we argue that only personalization is not enough. Therefore the focus of our work is mainly on improving the diversity and freshness of the recommended content. We approach diversification as an effective way to prevent the standard problem of filter bubbles which is present in most recommendation systems and also as a way to improve user engagement and satisfaction.

We propose a method of automated generation of personalized newsletters for CQA systems with focus on diversity and freshness of the recommended content. We are using question recommendation for generating personalized content and a method of thematic sampling to achieve content diversity. We also consider user interest and user expertise separately as opposed to other works. Our method is designed for use on the Stack Exchange platform, but can be easily adapted to any other CQA system.

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¹ <https://answers.yahoo.com>

² <https://stackexchange.com>

³ <https://www.quora.com>

2 Related Work

Current research in the domain of CQA systems [5] focuses mainly on user behaviour, question routing and recommendation and quality of questions and answers in these systems. However, we are not aware of any research into the role of newsletters in CQA systems.

Question recommendation and routing

There are two ways of recommending questions to the users of a CQA system. The more traditional *pull* method, used in question recommendation, presents a list of recommended relevant questions to the user based on their implicit or explicit request. An opposite method, *push*, is used in question routing, where the process starts with a model of an unanswered question and the system tries to route the question to a specific user who has the most potential to answer it correctly.

Most of the research into content recommendation in CQA systems is focused on routing questions to experts [2]. However, question routing creates a problem of overloading the experts. Thus authors in [3, 4] explore the idea of routing new questions to larger groups of users instead. In our work, we instead use the more traditional method of question recommendation, since it is not as well researched in the area of CQA systems.

Diversification

Thematic diversification is a method which helps to better balance the entire spectrum of users' interests or expertise. Although it can have a negative effect on the accuracy of recommendations, this method achieves better perceived user satisfaction [7].

Authors in [8] propose a method of diversification based on selecting lists with low intra-list similarity. Another method presented in [1] uses diversification based on proportionality.

In the area of CQA systems, the most similar work to ours is presented in [6], where authors explore diversification based on a similar method of thematic sampling, which uses LDA, lexical and categorical models of questions to construct a probability tree which represents the user profile. In contrast, we adopt a different approach to constructing the final recommendation lists and we don't use probabilistic distributions in the user profile.

To summarize, there is very little research in the domain of question recommendation and freshness in CQA systems, as well as no research with regards to the use of newsletters. This is in contrast to the potential of newsletters and their current state in CQA systems, particularly in Stack Exchange.

3 Proposed Method

We propose a method for assembling personalized newsletters for users of a CQA system, which uses

content-based filtering and question recommendation to provide content recommendations to users.

Key features of the method are as follows:

- We use the method of content-based filtering, as it is more effective than collaborative filtering for users with low activity. We start with a user model, which is assembled from the models of questions they interacted with.
- Diversification is performed as a thematic prefilter before the recommendation process - a separate list of recommendations is created for each individual topic.
- The final list of recommended content is created by merging of the partial lists from previous step.
- When recommending, we consider freshness, as well as diversity of the content.

A high-level overview of the method process is shown in Figure 1.

Question model

The question model consists of three independent models, each considering the question from a different perspective:

1) **Tag-based model** represents the question on the highest level as belonging to particular tags in the CQA system. Each question can belong to multiple tags, represented as an N -dimensional vector of values 0 or 1.

2) **Thematic model** of the question uses the method of Latent Dirichlet Allocation (LDA) to assign each question to multiple latent topics. To optimize the model we ignore topics which fall in the lower 25% of overall distribution of topics for a given question.

3) **Lexical model** of the question uses TF-IDF vector representing the distribution of individual terms in the question title and body as bag-of-words model. To preprocess the texts we utilize lemmatization and stop-word removal in both thematic and lexical models.

User model

The user model is based on the question model and is assembled from the models of questions, with which the user interacted in the system. Unlike most of the previous works on recommendations in CQA systems, we distinguish between user's expertise and interests, and model these factors individually in two separate models with the same structure.

The interest model is constructed from the questions which were asked by the user, or which the user marked as their favourite. Each of these questions will contribute to the interest model with the same weight.

The expertise model is constructed from the questions which the user answered. A positive score of

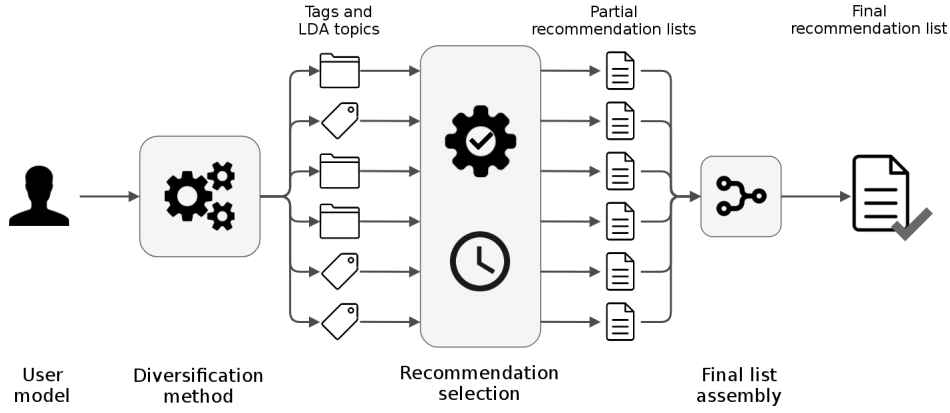


Figure 1. Personalized newsletter assembly schema

their answer will denote their expertise and a negative score will denote the lack of expertise in the question topic. Furthermore, if the user's answer is marked as accepted, it contributes to the model with a weight coefficient of 1.75, determined from the ratio of total answers for a question with an accepted answer.

All the questions to which the user added a comment also contribute to their model. However, since it is not possible to determine interest or expertise from an act of commenting, such questions contribute to both models with a weight coefficient of 0.3, since questions and answers have on average three comments.

The separation of user's interests and expertise allows us to provide a better level of personalization, as we can more accurately provide them with questions they would find interesting, as well as questions for which they have the potential to provide a good answer.

Content recommendation and freshness

The process of recommending questions to a user will use a dot product to match a user model with models of questions.

To represent the gradual change of users' interest over time, we introduce an exponential decaying factor to the process of creating the user model. On each user model update, we decrease the weight of existing data in the model proportionally to the amount of activity since the last update.

Thematic sampling diversification

As illustrated by Figure 2, the process of diversifying the recommended content is designed as follows:

1. For each user, we randomly select from their model k_1 tags and k_2 topics, only considering tags and topics above the median to suppress low-relevance tags and topics, where $k_1 + k_2 = n$ and

n is the number of recommendations in the final list.

2. For each tag and topic we then construct a list of n recommendations using the aforementioned method, while only considering questions from the given tag or topic.
3. Then we randomly sample items from the individual lists to the final list of recommendations, where the probability of selecting a question from a given list is proportional to the relevance of the particular tag or topic to the user.
4. Specific items from the individual lists will be randomly selected from *top-M* questions, where M is the relative relevance of the topic or tag.

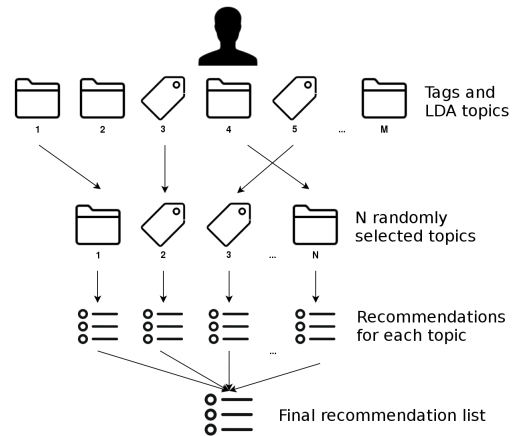


Figure 2. Schema of the recommendation diversification method of thematic sampling

4 Evaluation

We evaluate our proposed method of personalized content recommendation and diversification in an online uncontrolled experiment on the users of the Stack Overflow site from the Stack Exchange Network. This experiment has the form of a regular newsletter that every user of the platform can subscribe to.

The effectiveness of the proposed method is currently evaluated in a time-based A/B test:

1. Control experiment - Users received a newsletter with simple personalization based on tags.
2. Method A - Users receive a personalized newsletter without content diversification.
3. Method B - Users receive a personalized newsletter using the thematic sampling diversification method.

As of this writing, we are in the middle of the experiment and we alternate between methods A and B on a weekly basis, with the control experiment as a baseline, which was already concluded. We currently have more than 30 individual users subscribed to our newsletter, with more than 1800 sent daily and weekly newsletters. The subscribers have since provided more than 1300 instances of feedback.

Online experiments such as this are very rare in the domain of CQA systems, as most of the existing research was evaluated on offline data. For the purposes of this experiment we implemented an experimental infrastructure named StackLetter which was deployed in early November of 2017.

Our hypothesis states that by recommending questions from a wider area of users' interests and by considering their freshness we will avoid the problem of filter bubble, thus achieving higher degree of user's interest and activity.

Metrics

To evaluate the proposed method we compare its results with the non-diversified personalization method, as well as the baseline from the control experiment. We use the following metrics to evaluate different aspects of our method:

- Click-through Rate - To measure the effectiveness of the method and user engagement.
- Discounted Cumulative Gain - To measure the quality of the ranking.
- Precision@N - Precision of the recommendation on position N .
- Intra-list similarity - To measure the level of diversity in the recommendation lists

We expect to see a slight drop in precision and

DCG of the recommendations when using our diversification method, but we expect CTR to be higher, thus proving higher user engagement.

5 Conclusion

In this work, we proposed a method for automatic creation of personalized newsletters for CQA systems with a focus on improving the diversity and freshness of the recommendations. To the best of our knowledge, this is the only research into the use of newsletters in CQA systems. We also use question recommendation as opposed to the more widely researched method of question routing and we consider users' expertise and interests separately.

Finally, we evaluate our methods in an online uncontrolled experiment on real users, using our experimental infrastructure StackLetter, which is designed universally to support any future research in the domain of newsletters in CQA systems.

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