TV6: A Revisit to System Design, User Socialization and Content Recommendation in Social TV

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***Abstract*—The move to social TV has challenged the traditional TV experience by allowing users to interact with their friends and receive social multimedia contents when they are watching videos. Social TV has made the social experience equally important to users as the video contents. The rapid emergence of online social network service and video sharing service in today's Internet, as well as the open interfaces (e.g., Open API) make it possible for a third party to build a social TV system, based on existing social network and online video service infrastructures. In this paper, we share our experience of designing, developing, deploying and operating TV6—a social TV system that embeds multiple online social network systems and online video sharing systems. Through detailed analysis of TV6, we present our observations and insights on provisioning superb social TV experience to users, including social content provision and traditional video content provision.**

Keywords-social TV; video sharing; recommendation algorithm;

I. Introduction

Recent years have witnessed a rapid convergence of online social network service and online video service. Due to this convergence, Social TV, a new TV service, has emerged as important video experience in recent years (e.g., CollaboraTV [1] and Social TV from Motorola [2]). In Social TV service, users receive not only the traditional video contents from the video systems, but also the social multimedia contents from the social networks. Social TV allows users to interact and share their feelings with their friends while watching videos.

Numbers of works have been devoted to the system implementation of Social TV. Coppens et al. have designed AmigoTV, which allows users to communicate with each other using voice, text and animated emoticons. Which communication form is the best one has been fiercely debated (e.g., [3]). Boertjes et al. [4] have designed AOLTV, a Set-Top Box (STB) which offers users the ability to send and receive instant messages and emails on their TV. The commercial social Web TV Joost [5], enables users to do text chatting while watching online videos. Traditional user-generated content (UGC) providers like YouTube are also trying to allow users to communicate with each other through video conference while watching the same video. D. Shamma et al. [6] have studied the integration of Twitter updates during live video streaming.

Previous works are mainly focused on designing a new Social TV system which includes building a new social network system. This can be too expensive to realize especially when there are dominant online social network systems such as Facebook and Twitter. To overcome this problem and build a cheap Social TV system, we propose to implement TV6—a social TV system based on the existing online social networks and online video sharing systems. We only control the logical information flow about how videos and social contents reach different users. The name "TV6" stands for the "Six-degree of separation", which means users are closely connected in the system with diverse video and social sources. As TV6 embeds multiple online social network systems, we can use their social data, such as social graph and users' profiles, to provide superb social experience to users. Our goal is to create a socially watching environment.

In this paper, we share our experience of designing, developing, deploying and operating TV6. A recommendation system is implemented in TV6 to recommend videos for both group and individuals. Our contributions can be summarized as follows: (1) System design and analysis of TV6, without owning any video service system and social network system, are presented in detail; (2) A variety of social experiences are provided to users by using the valuable social relationship and context from the social networks; (3) We present how we recommend videos to users when they are consuming the videos in the social network, e.g., they join social groups to watch a video.

The rest of the paper is organized as follows. We review the related works in Section II. Our system design is shown in Section III. Then social experiences provision and video contents provision are explained in Section IV and Section V respectively. Finally, we conclude the paper in Section VI.

II. Related Work

People may feel closer to their friends when they are synchronously watching TV with them [7]. Traditional web video does not support synchronous viewing. In order to

 ISBN: 978-1-61208-265-3

address these explicit challenges, researchers have developed different solutions. Recently, D. Shamma et al. [7] propose three practical prototypes—“Messenger Zync”, “Web Zync” and “Invisible Zync”, which enable people to watch web video in synchronization. But these solutions have some limitations. The “Messenger Zync” is required to use Yahoo! Messenger for Windows where group conversations are not possible. Though the “Web Zync” and “Invisible Zync” provide group conversation, they do not embed social relationship in the system. It is not convenient for users to start a watching activity through the two prototypes. For example, user has to copy and paste the URL of video to every friend who he/she decides to invite.

Watching TV program with friends or families is considered to be a preferred social viewing experience. People like to share videos with friends and suggest interesting videos to others. The traditional TV or video service does not support video suggestion. When users want to recommend a funny clip to others, they have to send the video’s address through SMS or Instant Messaging(IM). Ambient TV [8] enables users to send video suggestion to others through the TV directly. G. Harboe et al. [8] also show that video suggestion can prompt communication between users and some people even use suggestion as a conversation starter. Explicit suggestions are playing important roles in social influence and pulling participants into a shared TV experience.

III. SYSTEM DESIGN AND IMPLEMENTATION

In this section, we present how we build TV6 as a third-party application, based on three large online social network systems and several large online video sharing systems, without real control of these systems.

A. System Architecture and Data Flow

Social network sites, such as Facebook [9] and Twitter [10] have begun to offer APIs to developers to access users’ profile data and social graph in order to create their own applications. Leveraging the APIs, we can quickly construct a social TV application.

TV6 is based on the design philosophy to incorporate social relations and user profiles from social network sites (SNS), and videos (only the title, URL and tag information) from video sharing systems. In particular, the social network sites used in TV6 are illustrated as below:

- Weibo [11]: A twitter-like service of Tencent company (Tencent is one of China’s largest Internet service portal)
- QQ [12]: An instant messaging service of Tencent company
- QZone [13]: A friend social network of Tencent company

TV6 server can retrieve the social graph and user profile from these three SNS after obtaining users’ authorization.

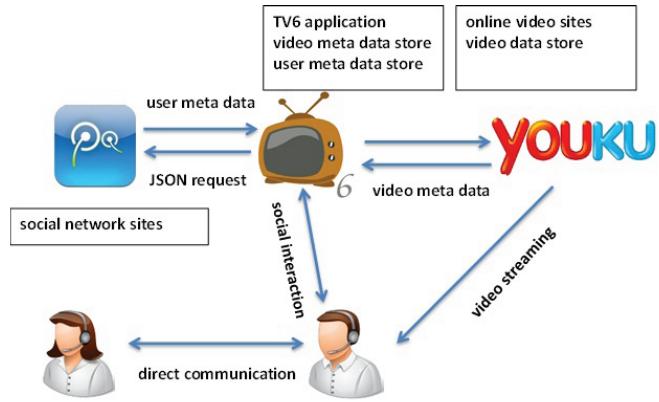

Figure 1. Overview of system architecture

The video sharing systems used in TV6 contain dominant video sharing sites in China, such as Youku [14] and Tencent video [15].

Fig. 1 provides an overview of the system architecture which is basically consisted of three parts. The actual TV6 application is set up on our own server which occupies the central position in the architecture. The application collects user meta data from the server of social network system and video meta data from the server of video sharing system periodically. These meta data are stored in the database of TV6 application. When a user performs an action, such as sharing a video or posting a comment, the TV6 server handles the request. Then the application generates appropriate answers which are JSON or XML responses and pushes these to the SNS server. The chat message are actually sent through the SNS server or application server. But it seems users can communicate with each other directly (described in Section IV-A). Both the TV6 server and the SNS server do not handle the requests of video steaming. Once a user begins to watch a video, the video data is loaded from the server of video sharing system. The system’s architecture is divided into three parts. The TV6 server plays a central role in the system and controls the logical data flow in the system. The SNS stores the user meta data and handles request from TV6 server. The video sharing system stores the video data and directly provides the video streaming for the user.

B. Social Information Collection

Our system is designed to make use of user profiles hosted by the existing online social networks. The open protocol OAuth is used in TV6 to access users’ profiles. When a user uses TV6 for the first time, he/she is asked to authorize our system to use his/her social profile via Open APIs provided by these online social networks. After the authorization, TV6 is able to access these information: (1) user’s social connections, including which users they are following and which users are following them; (2) users’ posted microblogs , including the ones with video links; (3) the number of

 ISBN: 978-1-61208-265-3

shares of a particular video link, which can later be used for video content provision.

C. Video Information Collection

As video links imported from different video sharing sites are collected in the microblogs from users' profiles, we are able to retrieve the video information from these video sharing sites. TV6 only collects the meta data, i.e. titles, URLs and tags of the videos, to reduce bandwidth and save storage. When users play videos in TV6, they will receive streaming data from the original video servers of the video sharing sites. After obtaining video titles and tags, we will use the word segmentation method to find patterns of words in them. These patterns of words can be clustered into several topics which can be used to describe the content of the videos. This is very important for the recommendation system, which will be described in Section V.

D. Content Presentation

After collection of social profiles and video meta data, the contents are presented back to users by TV6 as below. (1) *Video sharing list*: This page contains videos that users' friends have shared. Because users are probably interested in the content generated by their friends [16], they may want to watch the videos in the video sharing list. (2) *Watching list*: Users can see what their friends are watching now and viewing histories of their friends. (3) *Personal page*: It contains user's personal information such as his/her profile photo, viewing history and sharing history. (4) *Player page*: User can watch TV programs or videos on this page and chat with friends through text or voice at the same time.

IV. SOCIAL EXPERIENCE PROVISION

In this section, we will present how social information and interactions are provided to users.

A. Talking to Friends

Social communication is the basic feature in TV6. Rich communication tools with different purposes are provided in TV6.

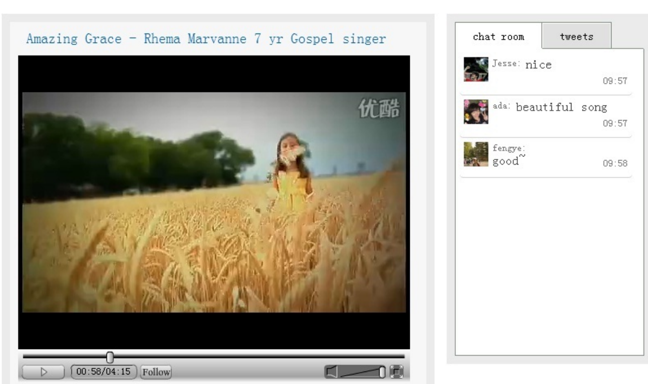

Figure 2. An example of public chat room in TV6.

1) IM-like Communication: The most important facility of the Internet-based Social TV is that it connects friends located distantly, allowing them to watch videos simultaneously, as if they were sitting on the same couch [17], [18]. TV6 offers various ways of communication to supply the distant communication among different users. (1) Single chat via voice and/or text is offered between users in pairs. (2) Group voice chat is also offered in this system. Participants can speak simultaneously just like they were talking face to face. (3) Users in (1) and (2) are both chatting in privacy. TV6 also provides public chat rooms for users watching the same video to discuss and comment on it. Each video has its own chat room which is seperate from other's. The new comments will be pushed to all users who are watching the same video by using the AJAX technology, as illustrated in Fig. 2.

2) Email-like Communication: The IM-like communication requires users to be online to join the discussions timely. We also provide the Email-like communications to sustain longer period responding. In particularly, we use the *Tencent Weibo* and *Tencent QQ* to achieve the email-like communication. A TV6 user can leave comments to his friends by posting a message. The message will be sent to *Weibo* and *QQ* by the TV6 server. With the "@" function, the designated friend will notify the comments immediately when he/she login *Weibo* or *QQ*.

B. Knowing about Friends

In a Social TV system, it is important for users to be aware of their friends. In TV6, a user knows not only about what videos his friends have watched and are watching, but also about the exact playback position that his friends are currently at.

1) Knowing Videos Watched by Friends: When a user watch a video, TV6 stores the video record into the user's viewing history list. He/She can add his/her favourite videos to favorites list. The user's viewing history and favorites list are public to his/her friends. Users can figure out what their friends have watched in the past and what they like. This facility allows users to learn more about others' video viewing habits and preferences, and fosters a sense of connectedness.

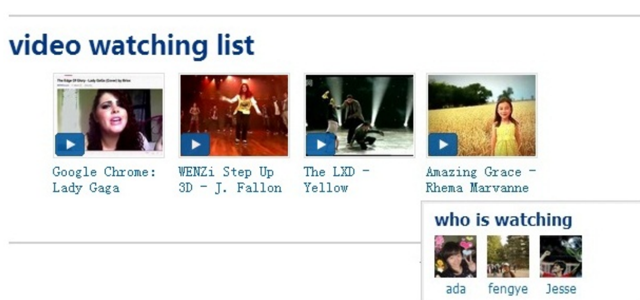

Figure 3. Knowing videos being watched by friends.

 ISBN: 978-1-61208-265-3

2) Knowing Videos Being Watched by Friends: In TV6, we also extended user's awareness to what videos are being watched now by his/her friends. TV6 provides a "video watching list", which contains the videos that the user's friends are watching, as illustrated in Fig. 3. Moving the mouse pointer upon the title of video in the watching list, we can see profile photos and names of users who are watching this video.

3) Knowing the Exact Playback Position of Friends: In TV6, user knows the exact playback position of his/her friends. There is a module embedded in our video player that can display the playback position of user's friends. When user moves mouse pointer upon the seek bar of the player, he/she can see photos of his/her friends who are watching the same video currently upon the seek bar, as illustrated in Fig. 4. The position of a friend's profile photo indicates his/her playback position. User's playback position is available to his/her friends by default and user can hide his/her playback position by change personal setting.

4) Privacy Protection in TV6: The privacy issues arise when users know everything about their friends' viewing status [19]. In TV6, we allow users to choose if their status is available to their friends. Every user has two states: on-line and away. The away state indicates that this user is not watching TV now. When he logs out, his state will be set to be away automatically. User's state is public to his friends by default. If user wants to watch video in privacy, he can set himself to be invisible and his friends won't know his status.

C. Watching with Friends

1) Following A Friend's Playback Progress: In Social TV, users are interested in sharing the same playback progress with their friends. The most popular Internet application, web video, does not support synchronous social conversation. People have to watch videos alone and the most common interaction in video sharing websites confines to asynchronous comment. But many people want to watch some TV programs or videos, such as football games, with their friends synchronously. Their demand may be difficult to be satisfied. When a user's friend provides a feedback or a commentary on the video's interesting moment, it is hard for the user to figure out which part of the video attract his friends. From our survey, in order to achieve the goal of synchronous watching, people may send the URL of a video to their friends and appoint a time when they start to watch it. Apparently, this is inconvenient.

In TV6, users can "follow" the playback progress of their friends by just clicking on friend's name or profile photo. Then the user will have a synchronized viewing experience with friends. The user can interrupt the synchronization at any time.

2) Making Any Video Live in A Social Group: Furthermore, our system also provides a functionality that users can create activities to invite their friends to watch videos synchronously. Assuming that there is an important match tomorrow and you want to watch it with your close friends, you can create a private activity to invite your friends. After the activity is created, all the invited participants will get notifications about the activity. There is a conceptual "room" for every activity and the creator of the activity is the room's "master". The playback progress of participants in one activity are the same and synchronous experiences are shared. Since the number of participants may be very large, nobody except the "master" is authorized to control the playback progress, i.e., to pause, rewind or load a new video (change channel). At the same time, participants can communicate with each other through text and voice. Owing to this technique, remotely located friends and families can share watching experience together.

Figure 4. Friend's profile photo indicates playback position.

In order to guarantee the synchronization, a server was used to control the playback progress of participants. If the "master" changes playback status (pause, rewind or change channel), the server will inform other participants and change their status synchronously. All the other participants' progress synchronizes with the master's progress. The server checks every participant's progress regularly to guarantee the synchronization.

The synchronization module supplies a virtual co-present "watch together" and "on-the-couch" viewing experience. This feature offers social experience combining online video and traditional TV program which might become a very important characteristic of future social TV.

V. Video Content Provision

A. Group Recommendation

As described in Section IV-C2, users may form social group to enjoy co-present viewing experience. As a result, the concept of group interactions in such systems has been boosted. Such group viewing provides great potential for users to find videos that interest members in the group, namely, group recommendation [20].

In TV6, group characteristics are affected not only by inside group members, but also outsiders (e.g., followings). Furthermore, in our system, the relation within group is sparse. The information that we can use is not enough. So the recommendation that is only based on information within group is not accurate. According to [20], using information from *external experts* ("External Experts" indicate the people who are friends of the group members but do not belong to the group), can help us make more accurate recommendation. Our system adopts this method which has proved its availability.

The database stores information of more than 30,000 videos which contains URLs, titles and tags. We use *Topic Model clustering algorithm* [21] to find out videos' *eigenvectors* by using their titles and tags. After words segmentation by *LDA* and *data training*, we obtain 10 topics by Topic Model clustering algorithm which have probability statistical significance and each video has a 10-dimension vector on them.

We calculate the characteristics of external experts by making use of their history behavior. If the video viewing history of an external expert contains N videos denoted as $v_i(i = 1, 2...N)$ and we use V_i to represent the eigenvector of v_i. Then the preference of the external expert, denoted as P, can be calculated by

$$P = \frac{\sum_{i=1}^{N} V_i}{N} \tag{1}$$

Users of online social networks are often very interested in the content generated by their friends and there is strong relation between friends' preference and user's interests. So the group members' interests can be represented by their external experts' preference. As different external expert has different level of impact on group members, we need a weight to describe their different contribution to group members' interests. Here we set two kinds of weights. One is Weight of Friends Number since we know that friendship relation can get people with similar interest together. The other is Weight of Common Behavior as we have measured that common behavior is an important indicator of similar interest. So we count total two kinds of weights between an external expert and inner group members. Then summate them to be Weight of External Expert, denoted as w, to describe the contribution of the external expert to group members' interests.

Now we can calculate profile to group G from the preference of group members' external experts. We assume group G has M external experts. The preference of the external expert j is denoted as P_j and the weight j is denoted as w_j. We carry out the profile of group G, represented by F_G, as below:

$$F_G = \frac{\sum_{j=1}^{M} P_j \times w_j}{\sum_{j=1}^{M} w_j} \tag{2}$$

We get a "virtual external expert" profile for each group with Group Preference Model. We can use Topic Model to find out the *eigenvector* of each video in candidate list. Then we calculate the similarity, denoted as $sim(G, i)$, between each group profile and each video in the candidate list. We carry out the similarity computing formulation as below:

$$sim(G, i) = \frac{V_i \cdot F_G}{\|V_i\| \times \|F_G\|} \tag{3}$$

We can sort the videos in the candidate list by $sim(G, i)$ and the sorted video list is the final group recommendation results.

With the above steps, we can get a comprehensive group recommend proposal which can fully meet needs of a more open social network with features of great dynamic and sparse tightness.

The algorithm of individual recommendation is almost the same as group recommendation.

B. Recommendation Experiments

We conduct experiments based on real-world group to evaluate the performance of our recommendation algorithm. We compare our algorithm with three other algorithms—Average satisfaction, Least Misery and Most Pleasure [22]. We invited 18 groups to form various scale of groups including 8 groups of 3 people, 6 groups of 5 and 4 groups of 8. These participants are college students and graduates with various profession backgrounds. People in one group enter into TV6 to watch videos together and our server automatically collect their meta data from SNS. When video play ends, TV6 recommends videos for them using the four recommendation algorithms. The group members mark scores ranging from 1 to 5 for the results. Then we calculate the average scores for each algorithm. The higher scores indicate better performance. As we have three group size:3, 5, 8, we compare the four algorithms under different group size. Fig. 5 illustrates the results. Apparently, our algorithm performs better than other algorithms.

In face of sparse relation among group members, traditional algorithms have a poor performance. In contrast, our algorithm concerning the influence of external experts is more effective. Because group members are very interested in content generated by their friends, using external experts' history behavior can well reflect group members' interests. Our algorithm can also be used in other situation, such as e-commerce if we use tweets with e-commerce content instead of video content.

VI. Conclusion and Future Work

We discuss how to design and deploy TV6, a novel social TV system, embeds multiple social network systems and online video sharing systems in this paper. The TV6 application is publicly available now and more than five thousand people have installed it. A number of users give us their experience and some valuable advice. Based on the users' feedback, we learn about how users use the social TV system. TV6 is also currently used as an experiment platform in a course of Tsinghua University and students are conducting experiments on it.

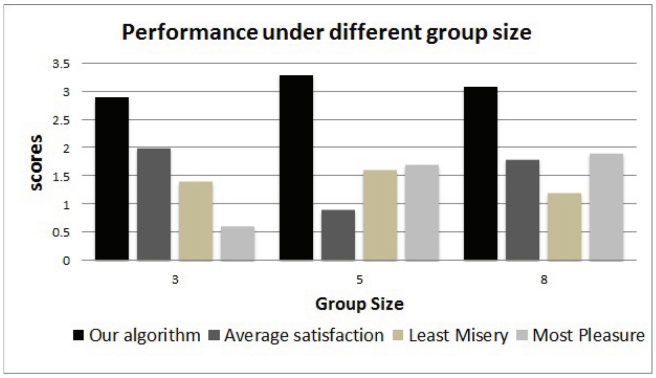

Figure 5. Performance under different group size.

We found that the awareness of friends in TV6 can make users more engaged into the social television experience and foster a sense of connectedness through television. Some users say that they like to watch videos in their friends' viewing history and favorites. After they login TV6, they may go directly to the video watching list to view videos that their friends are watching currently. Users are often interested in the content generated or shared by their friends. Some users even use their friends' viewing history and favorites as schedules of program that they plan to watch. Provided viewing history and favorites of users' friends can help users to learn about their friends' interests. Given the access to know what others are watching and their playback progress, users find social TV viewing an opportunity to communicate with each other. Users may feel closer to others while interact with their friends and the sociability among users is also enhanced.

For future work, we will combine the internal and external factors to see whether the comprehensive method can enhance the group recommendation. We will also do some experiments on larger groups as the group size are relatively small now.

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