Social TV Analytics: A Novel Paradigm to Transform TV Watching Experience

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ABSTRACT

The blooming online social networks have revolutionized the way information is created, disseminated and consumed, positing significant challenges to the conventional information propagation carriers, especially for the television landscape. In this paper, we design and develop a multi-screen cloud social TV integrated with social media via a second screen as a novel paradigm in response to this trend. Our system comprises three building blocks, including a cloud based social TV system, a social TV analytics system, and a multi-screen orchestration system. In particular, we leverage the cloud infrastructure to improve the system scalability, and design intelligent social media collection & analysis mechanisms to mine deeper social perception. Furthermore, we demonstrate two key features of our system based on a real user case.

Categories and Subject Descriptors

H.5.1 [**Multimedia Information Systems**]

Keywords

Cloud; Social TV Analytics; Second Screen

1. INTRODUCTION

In recent years, we have witnessed the explosive growth in social networks and portable devices, along with great opportunities to transform the traditional TV landscape. New paradigms, such as interactive TV [5], social TV [1], and multi-screen TV [4], have been proposed to enable interactivity among viewers and devices in TV watching experience. Nevertheless, none of them incorporates the blooming online social media, which contains people's everyday thoughts, opinions, and experiences.

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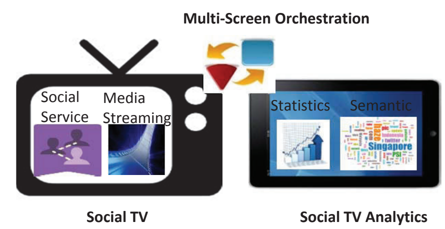


Figure 1: Framework of multi-screen social TV integrated with social TV analytics

To lessen the technology gap, we design and implement a multi-screen cloud social TV integrated with social media. The key idea is to mine social media to bring value proposition to the TV value stockholders. Three key building blocks, including a cloud social TV system, a social TV analytics system, and a multi-screen orchestration system, are developed to build this system. Cloud social TV system leverages the cloud computing technology to integrate the media service with social interactions among viewers. Social TV analytics system aims to crawl social media and mine social perception associated with TV programs. Multi-screen orchestration system provides an intuitive operation pattern to associate the TV watching experience with the corresponding social perception.

In this paper, we will demonstrate two salient features. First, we will show a rich set of analytics results, covering statistical analysis and semantic analysis, to provide deeper insight to the TV value chain from social media. Second, we will show a simple orchestration mechanism to integrate TV watching experience with social TV analytics results, by which viewers can seamlessly acquire the corresponding social media perception across multiple devices.

2. SYSTEM FRAMEWORK

Figure 1 illustrates a systematic view of our multi-screen cloud social TV integrated with social TV analytics. We consider the context that audience is watching TV programs and browsing the related social perception via a second screen at the same time. Our system consists of three key components, including a social TV system, a social TV analytics system, and a multi-screen orchestration system.

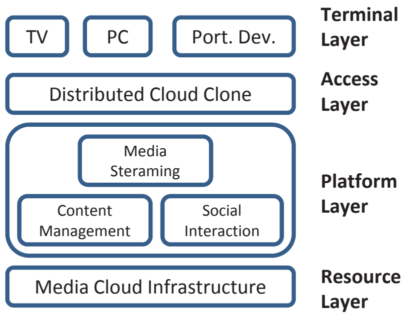


Figure 2: Layered framework of social TV system

Social TV System: implements fundamental TV playback, social, and interactive features. Our system is able to accept all possible content sources, including live TV video streams, and on-demand TV video streams (e.g., Over-The-Top (OTT) contents, VoD, UGC, etc.). Social features integrate the popular social networks, such as Google+, Facebook, and provide private video/text chatting. Interactive features include Video Cassette Recorder (VCR) operations, commenting, and group-watching functions, etc.

Social TV Analytics System: aims to craw social media data around TV programs, and reveal the hidden patterns to benefit the whole TV value chain, from audience, TV channel operators, ad agencies, to program producers. In particular, our system provides different metrics, including degree of interest, geo-distribution, keyword cloud, and topic graph. Degree of interest and geo-distribution reveals the instant engagement of TV audience, while keyword cloud and topic graph demonstrate the social commentary to specific episodes, plotlines, and characters.

Multi-Screen Orchestration System builds a link between TV programs and their social sense. This feature allows consumers to simply shot the quick response (QR) code on the TV screen using the camera of their second screens to obtain the related social sense.

3. SOCIAL TV SYSTEM

Figure 2 presents the hierarchical model of our social TV system. It consists of four layers including, resource layer, platform layer, access layer, and terminal layer from bottom to up. The major design principle behind this hierarchical model is to enable unified multimedia experience across multiple devices with multiple platforms, based on a powerful cloud. We will elaborate the design and implementations on each layers in the followings.

3.1 Resource Layer

The resource layer is based on the media cloud infrastructure, where physical resources including computing, networking and storage are virtualized into a resource pool and provided in the form of virtual machines (VMs) via virtualization techniques. The capacity of VMs can be dynamically tailored in a fine granularity to adapt to the resource demand, while maintaining the service-level agreement.

3.2 Platform Layer

The platform layer implements media streaming service related functions. There are three main sub service modules in this layer, including content management, social interaction, and media streaming.

3.2.1 Content Management

The content management module allows user to operate four categories of content resources including local contents, media sharing center contents, over-the-top (OTT) online contents, and the contents stored in the media cloud. The local content management enables user to browse and publish the multimedia contents directly from their end devices. The media sharing center content module keeps a sharing list of published UGCs, which has relatively low interests (i.e., low viewers) according to the heavily long tail nature. The contents listed in the media sharing center are not really stored on the cloud, but in the client side and probably the caches. As a result, the storage resources on the cloud can be efficiently used for those popular contents to improve the overall service of quality. The OTT online content module offers the service for users to get access to those OTT contents from Youtube and some other popular video sharing website. Finally, the cloud content module caches the content by following the CDN fashion. It also stores those most popular ones to serve massive requests with enhanced quality of experience.

3.2.2 Social Interaction

We achieve the social interaction feature by two distinct schemes. First we integrate our system with Facebook through the official Javascript Facebook APIs to allow users log in with Facebook account. Thereby, the friends and comments on Facebook can be imported. The second mechanism is that we implement an internal social communication message bus based on Extensible Messaging and Presence Protocol (XMPP) for video chat and multi-party conference. As a result, users can gain social experience via our system.

3.2.3 Media Streaming

To enable high quality steaming of media content over the Internet, we adopt dynamic adaptive streaming over HTTP (DASH) to construct the steaming solution. The contents is partitioned into a sequence of small HTTP based file segments, each corresponding to a short interval of playback time. Since our system enables various media outlets under different network environment to enjoy media service, media streaming module integrates the online-transcoding function to convert the media content into multiple versions with different bit rates in an online/offline way.

3.3 Access Layer

To effectively manage different sessions from distinctive media outlets, we implement a distributed cloud clone in the access layer. A cloud clone refers to a personal virtual machine associated with a specific user. Each cloud clone is deployed in the cloud and can be migrated on the cloud infrastructure to best serve its corresponding user. Once a user sends a request, a cloud clone will be instantiated to manage all the session information associated with all the participatory devices. Based on this architecture, we can implement various control and media adaptation algorithms. For example, cloud clone can detect the network environment and the caching status of neighbour cloud clones, and then dynamically determine the streaming strategy to adjust the bit rate or collaborate with other cloud clones.

3.4 Terminal Layer

Our system supports three prevalent types of end devices, including TV, Laptop/PC, and Tablet/Smartphone. To guarantee unified user experience across multiple screens, we customize different client solutions based on flowplayer, a web video player built on Adobe Flash. Besides, cloud clone will determine the end user type, including screen size, network environment, to dynamically configure the client interface, as well as the bit rate of adaptive streaming.

4. SOCIAL TV ANALYTICS SYSTEM

Microblog services provide an essential platform for users to share everyday thoughts, opinions, and experiences. Parts of these UGCs reflect and reveal their interests, concerns and criticisms about TV programs. The aim of social TV analytics system is to associate the public perception with ongoing TV programs. The system can be decomposed into two stages: relevant data collection, and emerging characteristic modeling of detected topics [2].

To mine the social sense from UGCs, the first step is to crawl a relatively complete set of messages associated with the designated media content. This is not a trivial task as most of the live microblog services set limits on the amount and frequency of data that can be crawled. Besides, because of the size limit on microblog messages, many related messages do not contain the expected keywords, while the relevant ratio to specific media content is usually quite low. To tackle this problem, we design four types of items to describe a TV program, i.e., fixed keywords, dynamic keywords, known users, and dynamic users. Fixed keywords are first manually selected to uniquely identify the media content. Similarly to fixed keywords, known users are manually selected to identify a set of media content related users, such as the official account, the director of the ongoing program, etc. Dynamic keywords and key users are extracted from the tweets sets crawled by fix keywords and known accounts. Given a set of keywords or keyusers related to a TV program, we implement a distributed crawler module to collect tweets. Figure 3 presents the architecture of our proposed distributed data crawler. Each TV program is depicted by four types of items. Each item corresponds to a set of query tasks. Considering the access constraint, we implement a resource pool to maintain the constraint rules related resource (named rare property), for instance, application keys, IP address. In addition, we exploit Zookeeper [3] to monitor the running status of all machines. According to the system status, the scheduler will dispatch the tasks, as well as the rare property, to the execution nodes (say worker) in a load-balance way. We have implemented the html parser to extract tweets directly from query results. When the allocated task is accomplished successfully, the worker will notify the status, including the balance of the rare property, to the scheduler and the resource pool. Once Zookeeper detects one node is down, the allocated task will be re-scheduled to another active node. In the end, all tweets are stored to our storage system.

The second step employs machine learning, text and image analytics techniques to discover knowledge from the data, such as media context, geo-location, and key users. The data collected from four items are a mix of relevant and irrelevant tweets. In order to filter the noisy data, we utilize a standard two-class SVM classifier. For the training data,

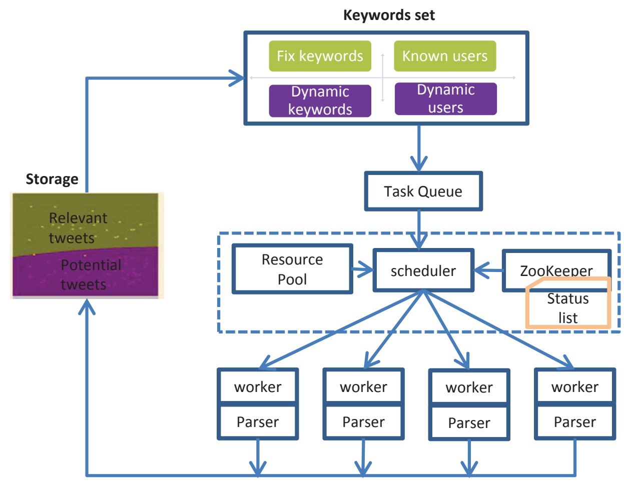


Figure 3: Architecture of the distributed data crawler subsystem

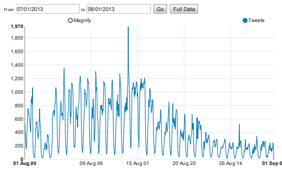
we regard all the tweets from the fix keywords and known users as relevant. Thereafter, an online or incremental clustering algorithm is first used to discover topics to guarantee the real-time performance. Then we analyze the emerging topic-related features, including user authority, tweets influence, and emerging keywords. These features are incorporated into a topic learner to identify the emerging topics in a timely manner. The social sense is determined by providing the analysis results in terms of statistics of crawling data, geo-distribution, keyword cloud, and topic graph.

5. MULTI-SCREEN ORCHESTRATION

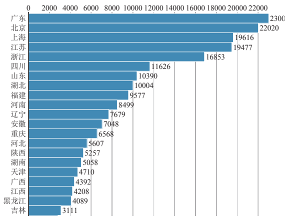
The general idea of multi-screen orchestration is to build a link between TV programs and their social sense. This feature allows consumers to simply shot the quick response (QR) code on the TV screen using the camera of their second screens to obtain the related social sense. The main advantage is that our scheme supports session migration without recalling and typing password, or interrupting TV watching experience. User only needs to register all their terminals and bind them together in the beginning. Two main components are involved, including cloud clone management and session migration.

Since each user corresponds to a unique cloud clone, the profiles and status of all the application running on media outlets can be orchestrated by cloud clone via the inter-device message bus. As a result, we can easily search, synchronize status of distinct devices belonging to the same user. In order to achieve fast routing and information retrieval, all the cloud clones form a logical ring via the distributed hash table (DHT). In the DHT key space, each cloud clone is uniquely determined by a key. As a result, the route length can be limited at $O(\log n)$, where n is the total number of nodes in the DHT ring.

To start a session migration, users are required to login to the cloud to get authentication. Upon the confirmation, users shot QR code on the TV screen, and send the session migration request to the cloud. Based on this request, the cloud clone will process to recognize the sessions and make confirmations accordingly. After the users receive this con-

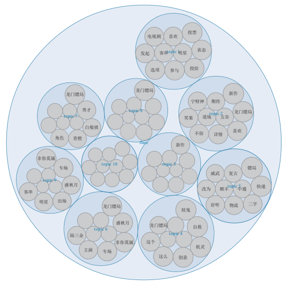


(a) Degree of interest



(b) Geo-distribution

(c) Keyword cloud



(d) Topic graph

Figure 4: Social perception features

firmation message, they can eventually trigger the session migration, and obtain the social sense data.

6. FEATURE VERIFICATION

We will demonstrate two salient features of our multi-screen social TV system integrated with social media, including a set of analytics results based on the tweet messages and a multi-screen mechanism to connect the TV watching experience with social perception. Interested readers are referred to our online video demo to better understand the proposed features [1].

Social TV Analytics: Social perception is determined by identifying who are saying what about the media contents, and where they are. Taking "Long Men Express", a very famous Chinese comedy TV program, as an example, our system provides four aspects of social sense, including degree of interest, geo-distribution, keyword cloud, and topic graph, as shown in Fig. 4. Degree of interest (Fig. 4(a)) refers to the potential discussion level of TV programs in the context of social media, as reflected by the tweet count. Geo-distribution (Fig. 4(b)) demonstrates the geographical distribution of potential audience. Keyword cloud (Fig. 4(c)) shows the set of keywords extracted from crawled messages and their weight. Topic graph (Fig. 4(d)) presents what audience are talking about on the this program.

Multi-screen orchestration: Fig. 5 shows the intuitive multi-screen orchestration process, which consists of four steps. First, user holds his mobile phone/tablet in front of the TV, to obtain the authentication details through the QR code (Fig. 5(a)). He then presses the "sense" icon to select the social sense information (Fig. 5(b)). Once the cloud is ready for social sense transmission, he triggers the process by performing a flipping-in gesture (Fig. 5(c)). After those simple steps, the social sense information is displayed on his mobile phone/tablet (Fig. 5(d)).

[1]http://www.youtube.com/watch?v=qWIqZ6h4IQI

(a) Screen shot

(b) Interest indication

(c) Gesture triggering

(d) Social sense acquisition

Figure 5: Different steps to complete a session migration to the second screen

7. CONCLUSIONS

In this paper, we presented our multi-screen cloud social TV integrated with social TV analytics as a novel paradigm to transform the traditional TV watching experience. Besides providing the fundamental social TV features, our system dynamically crawls the live tweet messages from online social networks and mines the related social response to provide deeper insight. This system had been developed on top of a private cloud at Nanyang Technological University (NTU), and opened in NTU campus.

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