A Web-Based Aggregated Platform for User-Contributed Interactive Media Broadcasting

Jingjing Liu, Yalou Huang, Dong Li, Fanghao Wu, Bin Li
IIP Lab, Nankai University, Tianjin, China
nkicestone@gmail.com, {huangyl, ldnet, fhwu, binli}@nankai.edu.cn

ABSTRACT
In this paper, we present a web-based aggregated platform, DJ DreamFactory, which enables average users to effortlessly participate in and contribute to interactive media broadcasting over the Internet. The platform overcomes several shortcomings of existing Internet-based broadcasting systems, such as inconvenience in channel surfing and content browsing due to the scattering and isolating of broadcasting stations, difficulties in setting up a broadcasting station, lack of communications between broadcasters and audience, and little support for personalized experience. The proposed platform facilitates users' media access by seamlessly aggregating sporadic broadcasting stations run by individual hosts, and enables a virtual community where grassroots users can contribute to media broadcasting, sharing, organizing and annotating through social networking. In addition, it supports real-time multimodal interaction between audience and hosts, provides customized services for both broadcasters and audience, supports personalized media experiences by mining and managing audience's preferences, and facilitates the organization of unstructured media data collections as well as collective human intelligence on the Web.

Categories and Subject Descriptors
C.2.1 [**Network Architecture and Design**]: Network Communications

General Terms
Performance, Design, Reliability, Human Factors

Keywords
Internet Broadcasting, System Design, Interactive Broadcasting

1. INTRODUCTION
With the rapid growth of networking and multimedia technologies, the Internet plays a more and more important role in the next generation of media communication. The development of IP Multicast [1] and the wide deployment of commercial streaming media systems such as Apple QuickTime Streaming, Cisco IP/TV, Microsoft Windows Media, and Real Networks, all have contributed to the popularity of streaming media on the Internet.

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Internet media broadcasting has become one of the most popular web-based media services. Internet broadcasting can avoid the geographical coverage problem in traditional terrestrial radio broadcasting. It is able to potentially offer better media quality by taking advantage of the state-of-the-arts media codecs. Moreover, it can also achieve much better bandwidth efficiency to support true audio/video on demand. Furthermore, the media data on the Internet are unlimited and the Internet-based user interactions are prosperous and flexible. Taking the Internet as a platform, average users can contribute numerous media resources as well as human intelligence to enable better media broadcasting, sharing and searching services.

In practice, there are many popular web-based media sharing services available today. For example, Youtube.com [2] provides video sharing service, blinkx.com [3] provides video search and aggregation service, and PPLive [4] provides Internet TV service built upon P2P streaming technologies. However, such systems suffer either from the lack of real-time broadcasting capability which otherwise provides synchronized experience among audience, or from not allowing average users to control or contribute to the broadcasting.

On the other hand, there have also been studies on Internet broadcasting recently. Nullsoft Inc. [5] uses distributed server functionality and offers the ability for an end user to become a potential broadcaster. Dutta et al. [6] propose an architecture for IP-based radio and TV networks, MarconiNet, which is built on standard Internet protocols and allows users to build virtual radio networks, similar to traditional AM/FM radio and TV networks. MCI Worldcom in collaboration with Real Networks offers a new multicast-based multimedia streaming service called uucast [7] within its Intranet. However, the broadcasting functions provided by these systems all require much technical background on computer, networks and multimedia, which makes it difficult for average users to effortlessly launch network broadcasting stations. Moreover, the stations supported by these systems are normally isolated and independent of each other. Thus, it is rather inconvenient for audience to browse isolated stations with different IP addresses searching for available programs, or freely communicate with the broadcasters. All of these call for an integrated platform for Internet broadcasting which can aggregate isolated broadcasting islands into unified channels and provide for the audience with a seamless and uniform experience. Moreover, the platform should make it easy to set up a broadcasting station and democratize network broadcasting to average users with no technical background.

Some researchers are also working on improving webcasting experience in various practical scenarios by making it more "real." Machnicki & Rowe [9] and Yu et al. [10] propose a live webcast control system, virtual Director Console, which integrates

conventional broadcast television techniques into webcasts. However, the system still fails to achieve an equivalent to radio broadcasting in the "real" world. For example, one important feature is still missing: audience can only receive broadcasting (i.e., "unidirectional" broadcasting) but have no privilege to participate in the broadcasting as in real-life radio programs. Therefore, to provide a richer user experience, a broadcasting system should take an additional step to provide interactive communication between audience and broadcasters (i.e., "bidirectional" broadcasting).

2. SYSTEM ARCHITECTURE

To address all the problems in the aforementioned existing network broadcasting services, we build up a web-based platform, DJ DreamFactory, which is an integrated platform for interactive Internet broadcasting and where average users can set up broadcasting stations with minimal effort. DJ (Disc Jockey) here refers to the users who host the broadcasting programs.

Traditional network broadcasting runs in a distributed client-server model as shown in Fig. 1. The servers are isolated broadcasting stations run by individual broadcasters, and the clients are computers used by audience. To receive broadcasting programs from the isolated stations, the audience need to access individual stations with different IP addresses of the corresponding servers. Servers can only deliver unidirectional broadcasting to the clients but have no reverse path to receive feedbacks from the clients.

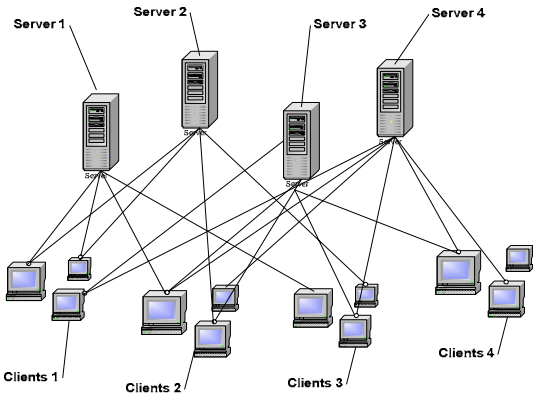

Fig. 1. Architecture of traditional Internet broadcasting.

DJ DreamFactory changes the distributed client-server model of traditional network broadcasting into a server-centric model, as shown in Fig. 2. The clients could be either broadcasters or audience or both. The platform serves as an integrated server console, i.e., a "hub" for network broadcasting, where average users can cooperate as a virtual team in a "channel" (integrated station). Within each channel, many DJs can work on a unified schedule and broadcast in different time slots on individual local machines. On one hand, DJ does not need to set up a network broadcasting station on his/her local server. By accessing the integrated platform, DJ can take the platform as the remote console, easily launch a network broadcasting station, and carry out broadcasting through the platform. On the other hand, by visiting the integrated platform, the audience can receive various broadcasting programs from multiple channels, without the effort of manually switching between individual local broadcasting servers. Moreover, the platform is adaptable to multiform output devices, such as personal computers and various mobile devices.

The integration mechanism liberates the burden of local/personal servers by shifting and aggregating the loads into the central platform. With a highly capable server or a server farm supporting the platform, the problems of low efficiency and low transfer speed in traditional network broadcasting can be resolved effectively.

When the broadcasting time of a "live program" approaches, the DJ hosting the program logs on the platform, takes over the corresponding channel and activates the broadcasting. The platform will assign the IP address of the DJ's local machine to the Microsoft media player embedded in the client-side web interface of the channel, through which the audience can receive the broadcasting. For non-real-time broadcasting, the DJ can upload a "recorded program" to the platform server. The program will be activated and delivered to the audience automatically at the pre-set broadcasting time, without the DJ's participation.

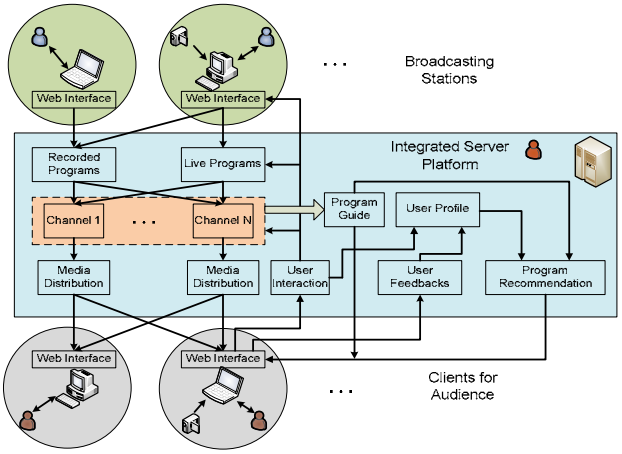

Fig. 2. Architecture of the DJ DreamFactory platform.

The scheduling of the platform is controlled by a background console, which we name as "Platform Manager." Platform Manager supervises the schedule of each channel, monitors the activity within channels, and activates the broadcasting programs at respective time slots.

3. HIGHLIGHTED FEATURES

DJ DreamFactory serves as a collaborative platform where amateurs with no technical background can jointly run a broadcasting channel and cooperate by broadcasting at different time slots. It provides an aggregated platform where users can receive broadcasting programs from various channels at one place, and liberates the audience from tedious browsing through isolated stations. The platform provides interactive broadcasting, where audience can not only "view" or "listen to" the programs, but also can "speak" and "write" to the hosts with real-time text/voice interaction. It also works as a virtual community where users can contribute uncountable human intelligence such as data annotating, media rating and comments sharing, which in turn will be used to help the system better organize the media data, help the hosts improve the programs and help the audience search for desired media contents. At this point, DJ DreamFactory is an ideal user-contributed application under the Web 2.0 concept.

In this section, we will explain the key features of the system brought by the main components of the architecture: interactive broadcasting, multimedia integration, grassroots contribution, personalized resource management, adaptability and agility.

3.1 Interactive Broadcasting

Existing Internet broadcasting services provide various programs that audience can download or watch online (e.g., PPlive video streaming [4], Youtube.com video sharing [2]). However, in these services, the process of editing programs and that of receiving programs are parallel and independent of each other. Audience cannot participate in the programs in real time since the media files are pre-edited and pre-uploaded.

Distinguished from these Internet broadcasting services, DJ DreamFactory provides an interactive broadcasting function, allowing real-time communication between audience and broadcasters. It supports "live" broadcasting with a real-time communication (RTC) service (e.g., NetMeeting [11]) embedded. DJ can launch RTC service with a "hotline controller" on his/her web interface of the system, and audience can call into the "hotline" using a "hotline caller" on the web interface for audience. After a caller is put through by the DJ, his/her IP address is identified by the system and RTC connection between the caller and the DJ is established, through which the caller can talk to the DJ as well as to other audience within the channel.

3.2 Multimedia Integration

The platform also provides other types of program besides real-time interactive broadcasting. One is recorded program, which is uploaded to the platform server beforehand by DJ and can be automatically activated by Platform Manager at the pre-set time. Another one is downloadable program, which is uploaded to the resource center in the platform by DJ and can be downloaded and played back on the audience's local machine at anytime.

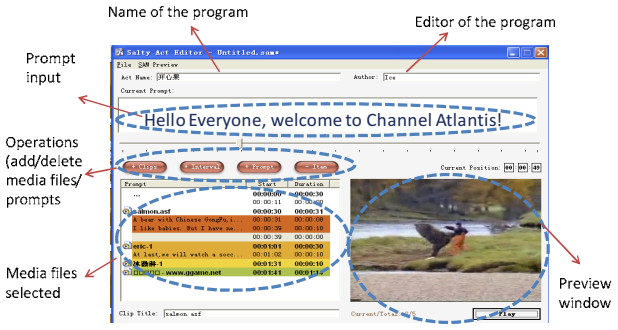

Fig. 3. Program Editor.

Most of current Internet broadcasting services only support raw multimedia files such as video or audio clips. In DJ DreamFactory, we implement an automatic integration scheme for combining video, audio and text information into a complete program. We define an XML format, "AMI" (Automatic Multimedia Integration) format, and develop a program editing tool, "Program Editor," which can automatically integrate video, audio and text files into a complete program and write out a corresponding AMI format file. As shown in Fig. 3, users only need to choose some media files, set the order and durations of these files, and type in some text scripts as prompts between the media files. Program Editor will translate the text into human voice with text-to-speech (TTS) [12] technology and generate an AMI file recording the format information of the edited program. By decoding the uploaded AMI file, Platform Manager will activate the program automatically at the pre-scheduled time slot. Fig. 4 gives an exemplary AMI format file of a well-edited program. Notice that we omit some words in the prompts to save the space.

3.3 Grassroots Contribution

One significant feature of DJ DreamFactory that distinguishes it from other broadcasting systems is the aggregation of grassroots contribution, i.e., using human intelligence for automatic annotation and indexing of multimedia contents. By building up a virtual community composed of DJs and audience, the platform allows users to publish comments on programs, vote for the DJs/channels, and tag the media data when collecting favorites.

There are also a large amount of annotated data from program editing and broadcasting, including the titles, the descriptions and the scripts of the programs written by DJs, the linkage information between media contents, the hits data by audience which reflect the popularity of media contents, the metadata of media contents (such as location, time, origin, genre and content descriptions) which is gathered through either human interaction or automatic generation, etc.

All these rich data beyond the media contents can be harnessed as collective user-contributed intelligence to facilitate media management or search tasks, and create media social network. This turns the unorganized media data on the Internet into a structured and organized collection. With the grassroots contribution on data annotation and media management, the platform can provide more intelligent web-based services, such as sharing users' tags or votes of media files, and providing for users an at-a-glance view and a better understanding of how other experienced users tagged/rated on the media resources.

```
<?xml version="1.0" encoding="utf-8" ?>
<act author="Jacky" name="Happy New Year" version="1.0"
xmlns="http://www.DJDreamFactory.net/SaltyAct.xsd">
    <clips>
        <clipInterval duration="20">
        </clipInterval>
         <clip duration="147.433"
              src="HappyNewYear.wmv"
              time="00:00:15" title="NewYearSong">
        </clip>
        <clipInterval duration="48">
        </clipInterval>
         <clip duration="123.51" src="Gifts.wmv"
               time="00:00:43" title="GiftsForKids">
        </clip>
    </clips>
    <prompts>
        <prompt duration="15" time="00:00:00">
            Happy New Year, everyone!...
        </prompt>
        <prompt duration="8" time="00:00:35">
            OK, hope you like the New Year song....
        </prompt>
    </prompts>
</act>
```

Fig. 4. An exemplary AMI format file of a program.

3.4 Personalized Resource Management

To provide user-centric experience with customized services, we implement personalized resource management in DJ DreamFactory. One typical service is media recommendation. In DJ DreamFactory, the system automatically tracks and analyzes the logs of a user's activities, such as programs viewed or participated in, comments published, programs or media contents voted for, programs produced or delivered. We build a profile for each user from all these information sources and mine the preferences and interests of individual users from the profiles [13]. We call the component that provides this service as "Smart Agent." Based on the analysis and mining, Smart Agent will automatically

recommend to each user the latest programs that suit the user's taste and interest, and rank the numerous media resources provided in the platform according to the user's preference.

3.5 Adaptability and Agility

The platform automatically adapts to networks and user device capabilities, by providing a seamless integration with output devices through reconfigurable web services. Users can access the broadcasting system through either a PC or a mobile device. Fig. 5 shows the interfaces of the system on mobile phones and pocket PCs.

We also implement a convenient interface designing component, which allows users to design customized interfaces by simply dragging layers/components and choosing styles from predesigned templates. This is a lightweight module independent of others, and the customized interfaces can easily replace existing ones.

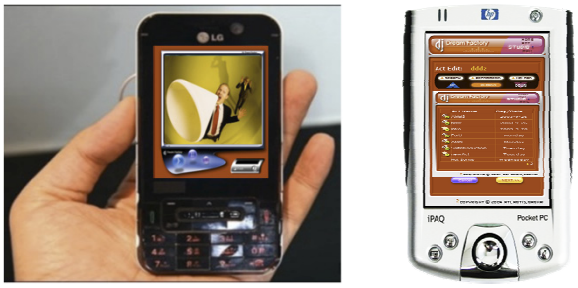

Fig. 5. System interfaces on mobile devices.

4. PROTOTYPE

To realize the architecture of the proposed DJ DreamFactory platform, we implemented a prototype system. Fig. 6 shows a screen cut of the client-side web interface on PCs, which includes a rank list of channels with respect to *popularity* (voted by audience), a list of recommended programs for a specific user, and a set of hottest topics recently discussed in the forums. Detailed user scenarios in the prototype system can be found in our demonstration work [8]. The standard hardware and software configurations of the prototype system are as follows.

Fig. 6. Platform Interface on PCs.

Server configuration:

Hardware: CPU：PIII 667+; memory: 256M+; hard drive: 20G+.

Software: Windows Servers 2003; Microsoft .NET Framework v1.0375; Internet Information Server 6.0; SQL Server 2000 Enterprise Edition; Media Service 9 Series.

Client configuration:

Hardware: no special requirement; supports PCs, Pocket PCs, and Windows mobile phones.

Software: Microsoft Media Player 9; Microsoft Net Meeting 3; Microsoft Speech Add-in.

We tested the system within a lab-scope of users. 20 users were asked to test the performance of the system, which hosts 20 channels at the same time. The 20 testers were asked to access the same channel and receive programs at one time. Feedbacks from the testers indicate that the system runs smoothly under such configurations. The low requirement of hardware for both server and client makes the platform of DJ DreamFactory easy to implement and feasible for large-scale applications.

5. CONCLUSION

In this paper, we have presented the DJ DreamFactory, a web-based platform for interactive network broadcasting, which aggregates individual network broadcasting stations into a unified environment. On one hand, DJ DreamFactory allows a DJ to set up a network broadcasting station with minimal effort, and to host video/audio broadcasting programs in a collaborative fashion. On the other hand, audience can receive various broadcasting programs from multiple channels in the unified platform, liberated from the inconvenience of browsing through isolated stations. Furthermore, we implemented a scheme for live broadcasting, with which the audience not only can "listen to" or "view" programs, but can also "talk" and "write" to the hosts via real-time voice or text interaction. The platform aggregates unlimited media resources as an intelligent media center and provides personalized data management such as automatic media recommendation. It also serves as a social community collecting uncountable grassroots' contributions and human intelligence. In short, DJ DreamFactory is an ideal incarnation of the Web 2.0 concepts in media broadcasting space. Although initiated from media broadcasting applications, the platform can also be leveraged in multimedia-based remote education applications.

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