# Inter-Device Media Synchronization in Multi-Screen Environment

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## Abstract

Since the advent of multimedia systems, media synchronization has been an important issue to guarantee the quality of experience (QoE) of any media session. Specially, inter-media synchronization on a single device has been investigated intensively. With the emergence of smart devices, such as smartphone, smart TV, and tablet PC etc, we may own multiple devices and we want to use those devices at the same time or an appropriate device for certain circumstances. The emergence of multiple devices brings about the multi-screen environment in which we can utilize the screens (display areas) of multiple devices simultaneously for the convergence services and interact with multiple screens for better user experience. We discuss the media synchronization issues in multi-screen environments that introduce new pattern in media consumption.

## Introduction

With the advent of broadband wireless Internet, the number of users, who enjoy the video streaming service through mobile smart devices, is increasing drastically [1]. Therefore, the number of networked screens, that interact each other, increases rapidly. These networked screens will bring about the ecosystem of screen, where multiple screens interact with each other and users interact with the screens to provide rich experience. We call this ecosystem of screens as the multi-screen environment.

In the near future, we will live in a multi-screen environment where we use multiple smart devices simultaneously and harmoniously. In a multi-screen environment, the seamless service session migration is getting important. As an example, suppose that user is watching a movie through the smart TV at his home. When the time is up to go for an appointment at the campus, the user wants to keep watching the move with his smartphone on the way to the appointment. While he is waiting for an appointment at the campus, he would want to watch the movie on his notebook for taking advantage of a large screen, a high bandwidth, and some extra processing power. The service session migration is the technique that enables these kinds of services.

Seamless service migration among devices and interaction among services provide seamless multimedia experience over multiple devices and rich user experience by moving services to most appropriate device to the circumstances at any time. Current technological and business environment derives the emergence of multiple devices with different capabilities and user to possess multiple devices. In addition, user moves from one device to another, increasingly expecting a seamless and consistent experience across all devices. Therefore, service providers focus their offering into a more unified, seamless, consistent and flexible online experience no matter which product users are using, where users are entering into it, or what device users are using it on.

## Service Migration Patterns

In this paper, we define the web-based convergence service as the interactive personal convergence service consisting of video, audio, music, image, social network content, and related information in web environment. Therefore web-based convergence will be more complex beyond video, audio, and web pages etc. Our reference architecture for multi-screen services migration is depicted in Figure 1. The server in Figure 1 provides web-based convergence services. The web-based convergence services consist of public service (e.g.,

broadcasting contents, game, etc.) with personal services (e.g., internet poll, social community, personal advertisement etc.)

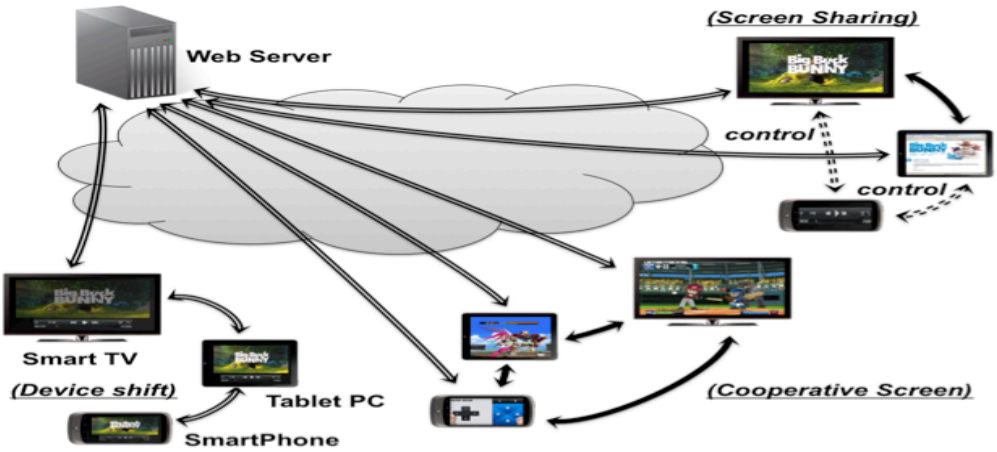


Figure 1. Multi-Screen Service Migration Architecture [2]

The basic multi-screen service is for the service provider to enable viewers to watch the same contents on their various devices (Device shift). When users enjoy the same content service on different devices, the services should work coherently across devices and should be migrated seamlessly across devices.

The second migration is to utilize multiple devices for sharing a single content or multiple contents. In order to share a single content with multiple screens, the elements of the content migrate to appropriate multiple screens separately. As a result, multiple screens constitute one large virtual screen. In addition, multiple contents may migrate to multiple screens appropriately depending on the content types and users' convenience. We classify this into the partial service migration. In the partial service migration, we define sub migration patterns according to the relationship among multiple contents; cooperative screen and screen sharing.

In the screen sharing, supplemental information of movie, drama, and sport on the smart TV (e.g., the information about the favorite actor, actress, or player) migrates to the smartphone in order to use whole TV screen for displaying video content. The social network TV, which users communicate others, who watch the same content through the smart TV with their smartphone, is another example of screen sharing [3]. In the cooperative screen, the multiple screens interact each other to provide rich service experience after migration happens.

These migration patterns introduce specific inter-media synchronization issues. Internet applications evolving around TV content may need synchronization between the application and the TV content. In cooperative screen, synchronization between mobile devices and the TV screen may be needed. Synchronization between different TV receivers may be needed in social TV. According to the service migration pattern in multi-screen environment, new synchronization technique should be considered to achieve a satisfying user experience.

## Use Case

In the previous section, we discuss several migration patterns that can be considered in multi-screen environment. In this section, we summarize the use cases that require inter-device media synchronization.

- Synchronized media presentation on each individual screen in a multi-screen environment is necessary to have a coherent orchestration of multiple devices content presentation experience [4].
- Synchronously seamless migration of the content stream that runs on one screen initially to another browser.
- Synchronously seamless replication of the content stream that runs on one screen initially to another browser.

- Synchronization between TV content and Internet supplementary contents that provide related information to the TV content.

## General Architecture

In order to provide inter-device media synchronization, exchanging playback timing information between multiple devices via IP network is basically required. The timing information consists of a media timestamp and the corresponding system time, when the stream has been played out. Based on this information, the receiving client is able to calculate all subsequent information required for inter-device synchronization. The system clocks of the devices should be adjusted to a common reference time and this clock synchronization should be executed in regular intervals to overcome the significant drifts in playback on the devices.

The actual inter-device media synchronization algorithm consists of exchanging timestamps, computing time offsets according to the round-trip delay between the server and client, and adjusting the system time.

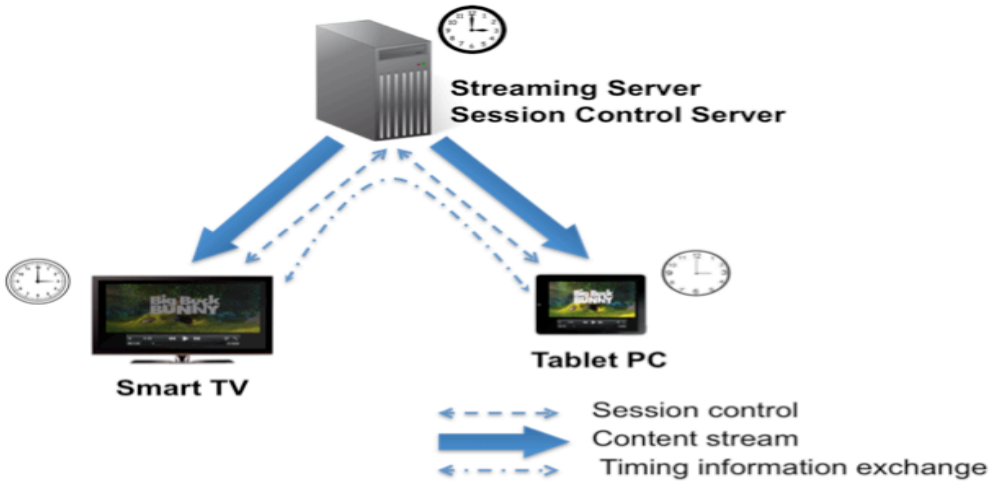


Figure 2. General Architecture for Inter-Device Synchronization

## Conclusion

In this paper, we investigated the issues related to the inter-device media synchronization in multi-screen environment and discussed the general architecture for inter-device synchronization. The standards of technologies required for the inter-media synchronization mechanism in multi-screen environment should be considered to guarantee interoperability.

## Acknowledgement

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