ISSN 1330-3651(Print), ISSN1848-6339 (Online)
UDC/UDK 004.451.6

# CONTROL FRAMEWORK AND SERVICES SCENARIOS OF PROVISIONING N-SCREEN SERVICES IN INTERACTIVE DIGITAL SIGNAGE

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Original scientific paper
In this article, we present the control framework and services scenarios of provisioning N-Screen services in interactive digital signage. Digital Signage provides a variety of high-resolution content and information displays at different public places and events. Provisioning N-Screen services in interactive digital signage enables the service providers to provide content to heterogeneous devices, allows the end user to share content from the digital signage to the user N-Screen devices and vice versa at different locations and times. We provide N-Screen services in interactive digital signage by adapting the content user interface according to user's N-Screen device size, layout, localized content adaptation, synchronization and session continuity over heterogeneous devices. We introduce the N-Screen User Interface Management Server (NUIMS), Digital Signage Management Server (DSMS), and Localized Content and Session Management Agent (LCSMA) to support N-Screen services. Furthermore, the N-Screen Devices Repository (NDR) at the DSMS keeps the users N-Screen devices static profile in order to share the content across all of their devices, and the LCSMA maintains the dynamic profile to synchronize content on heterogeneous devices. In addition, we suggest procedures, protocols and service scenarios to share the content of the digital signage to user's N-Screen devices, methods to synchronize the content display over heterogeneous signage displays with content session continuity and to share with other users using the user information server.

***Keywords:*** *Interactive Digital Signage, Localized Content Adaptation, N-Screen, Session Management, User Interface Management*

## Upravljački sustav i scenariji usluga za pružanje N-Screen usluga u interaktivnom digitalnom znakovlju

Izvorni znanstveni članak
U ovom radu predstavljamo upravljački sustav i scenarije za osiguranje N-Screen usluga u interaktivnom digitalnom znakovlju. Digitalno znakovlje osigurava niz displeja s obavijestima i sadržajem visoke rezolucije na različitim javnim mjestima i događajima. Osiguranje N-Screen usluga u interaktivnom digitalnom znakovlju omogućuje pružatelju usluge osiguranje sadržaja raznovrsnim uređajima, omogućuje krajnjem korisniku slanje sadržaja digitalnog znakovlja do N-Screen uređaja korisnika i obratno, na različitim lokacijama i u različito vrijeme. Pružamo N-Screen usluge u interaktivnom digitalnom znakovlju prilagođavajući sadržaj korisničkom sučelju u skladu s dimenzijom, rasporedom, adaptacijom lokaliziranog sadržaja, sinhronizacijom i trajanjem poruke u različitim uređajima korisnikovog N-Screen uređaja. Predstavljamo N-Screen User Interface Management Server (NUIMS), Digital Signage Management Server (DSMS), i Localized Content and Session Management Agent (LCSMA) kao podršku N-Screen uslugama. Nadalje, N-Screen Devices Repository (NDR) u DSMS-u osigurava da statički profil N-Screen uređaja korisnika raspoređuje sadržaj na sve njihove uređaje, a LCSMA omogućuje da dinamički profil sinhronizira sadržaj na različitim uređajima. Uz to, predlažemo postupke, protokole i scenarije usluga u svrhu slanja sadržaja digitalnog znakovlja do N-Screen uređaja korisnika, metode kontinuiranog sinhroniziranja sadržaja displeja kroz displeje različitog znakovlja i dijeljenja s drugim korisnicima uz upotrebu informacijskog servera korisnika.

***Ključne riječi:*** *interaktivno digitalno znakovlje, N-Screen (N-ekran), prilagodba lokaliziranog sadržaja, upravljanje sesijom, upravljanje sučeljem korisnika*

## 1 Introduction

A Digital Signage (DS) system provides the remote-controlled distribution of information and playback of high-resolution multimedia content over larger displays in public places. The large displays are capable of accommodating multiple standing users, and therefore consist of various display screens including Desktops, LCDs, LEDs and Plasmas to build a large-scale display. The cost of display screens is declining, and the screen dimensions are increasing. Despite this progress, providing high resolution multimedia content over a large screen can still present issues with display jitter and also from the network system perspective where the large screen has the potential issue of bandwidth being dependent on a single receiver. The most common way of building a large-scale display wall is to tile the heterogeneous displays and control them using a cluster of computers. In standard displays and visualization systems, the display devices depend on local rendering to produce an image. The most effective way to provide high-resolution visualization over a large-scale display delegates the rendering to a remote cluster of computers and treats the display screens (tiles) to a large high speed networked buffer. Renambot et al. [1] developed Scalable Adaptive Graphics Environment (SAGE), a distributed visualization environment to support large-scale data visualization over high resolution scalable tiled displays. We extend the SAGE Architecture for the provision of N-Screen services in interactive DS.

The use of DS systems is entering lives rapidly. The declining cost of display screen, computing, storage and cloud-based architecture is causing static display sign boards, billboards and posters to be replaced by interactive DS. The signs are becoming ubiquitous, and the cost of LCD screens in the last decade has decreased more than tenfold making it feasible to build 100-screen video walls in public places [2]. Most of the DS systems simply display the content and do not provide interactivity. But some of these screens provide the interaction through both Mouse/keyboard and gesture interaction with a camera. The existing DS systems restrict the users to be within the vicinity of the digital signage as well as the interactive devices with the digital signage. In our previous work [3] we proposed the control architecture for an N-Screen based interactive multi-vision system that gave free choice of interactive device. In this paper, we provide the framework necessary to provide a dynamic user interface according to user screen size and layout. In addition, the Localized Content and Session Management Agent (LCSMA) adapt and manage

the content session locally to share the signage display content with any N-Screen device.

**Table 1** World Wide Device Trend, 2012-2014 (k-unit)
(Source: Gartner, Compiled by Digitimes, October, 2013)

| Device Type | 2012 | 2013 | 2014 |
|---|---|---|---|
| PC | 341 273 | 303 100 | 281 568 |
| Ultramobile | 9787 | 18 598 | 39 896 |
| Tablet | 120 203 | 184 431 | 263 229 |
| Mobile Phones | 1 746 177 | 1 810 304 | 1 905 030 |

The number of smart gadgets such as IP/Smart TVs, Tablet PCs, Smartphones and Notebooks is rapidly increasing and necessitates a platform to view and share content on any device at any time from any location. Tab. 1 shows a worldwide devices usage trend compiled by Digitimes [4]. The trend shows that mobile devices are entering rapidly in lives. N-Screen services allow users to view and share content on various devices with different specifications, e.g. CPUs, screen sizes, resolutions and media codecs at different locations and times. The classification of N-Screen services and different services scenarios that can be accommodated using N-Screen devices are presented in [5]. N-Screen services enable the user to take advantage of the seamless continuity of the content session over heterogeneous devices as well as networks like 3G/4G, WiFi/WiMax and Fixed Networks. Kim Jaewoo et al. [6] proposed the architecture and protocols for the dynamic addition and deletion of a user's device in an N-Screen environment. User location-aware multimedia content delivery platform for the N-Screen service are suggested [7], and network and visual quality aware N-Screen content recommender system is suggested in [8]. Kassinen et al. [9] provided the model for mobile advertising in the N-Screen environment using the computer-supported cooperative work. The critical issue with N-Screen services is to provide seamless continuity over heterogeneous devices, heterogeneous access networks and network conditions at different locations and times. Most of the previous works in the N-Screen era are related to the definition and classification of N-Screen services. In this paper, we introduce the mechanism that provides the DS content on user's N-Screen devices taking into consideration the user device attributes and the access network conditions in order to ensure the expected visual resolution quality.

In the DS (large-scale) displays one of the critical challenges is in the synchronization among the display nodes/receivers in order to display seamlessly on high resolution visual displays. Kim et al. [10] provided a method of providing the multi-vision (large-scale) display services that detect the main display screen and surrounding auxiliary screens and how to distribute the video signal to the auxiliary screens. A two-phase inter-node synchronization mechanism [11] where among the cluster of nodes/computers there is a master node which synchronizes the content display and also synchronizes each display node's buffer. Elhart et al. [12] presented the key challenges of scheduling faced to display high resolution application data and content over open pervasive display networks. N-Screen services provisioning in interactive DS have the critical issues of scheduling and synchronizing content; because the user's N-Screen device may be at a different location and have a different access network as compared to that of the traditional signage that have their own high speed network. In order to provide seamless imagery on a user's N-Screen device, we acquire the user device & access network static and dynamic profile in order to estimate the expected multimedia quality in order to share the DS content or split the DS session over user's N-Screen devices.

Mobile multimedia technologies are growing industries nowadays. The multimedia Quality of Service and user Quality of Experience depends on the user's current device and access network. To efficiently provide multimedia services to various devices at different locations the vital requirements are the available bandwidth, user device attributes such as screen size, resolution, media codec, and the multimedia content frame rate [8]. Catellieret al. [13] analysed the impact of multimedia quality on mobile devices and showed that user experience changes with a change of device. The psychological experiment carried out in [14] by changing the different image parameters to measure the user's perceptual visual quality showed that excellent image quality on mobile devices changes the user perception of the content. The multimedia perceptual quality estimates the user opinion about multimedia quality on the user's display device. ITU standard ITU-T J.144 [19] estimates the multimedia quality in digital television applications where the original reference signal is available to compare with the received noisy signal. ITU-T G.1070 [20] is a standard to estimate the multimedia perceptual quality in an IP-Packet network that considers access network conditions and the user device attributes. In this paper, we suggest estimating the visual quality on different tiles of the DS using the ITU-T G.1070 at the LCSMA to provide localized session adaptation and management for a seamless multimedia effect. The LSCMA also provides local content adaptation for providing the DS content to user N-Screen devices taking into consideration the device attributes and access network.

We organize the rest of the paper in the following way: Section 2 explains the details of the control framework to provide N-Screen services in interactive digital signage. The procedure and protocol to receive content streaming on user's N-Screen device and the service scenarios of N-Screen services in interactive DS is described in Section 3. Finally, we conclude the paper in Section 4.

## 2 Propose control framework of provisioning N-Screen services in interactive digital signage

In this section, we present the proposed control framework and components functional details to provide the N-Screen services in the interactive DS. Fig. 1 shows the control framework required to accommodate the N-screen services in the interactive DS. For N-Screen provisioning in interactive DS, we introduce the DS Management Server (DSMS) that keeps the users N-Screen devices repository (NDR), information about the content application servers and the Localized Content & Session Management Agent (LCSMA) and N-Screen User Interface Management Server to dynamically adapt

the user interface according to user N-Screen size and layout. Furthermore, the User Profile Management Server shares session with other users. We extend the SAGE architecture for the provision of N-Screen services. We are going to explain the functional details of each node/component in the control framework.

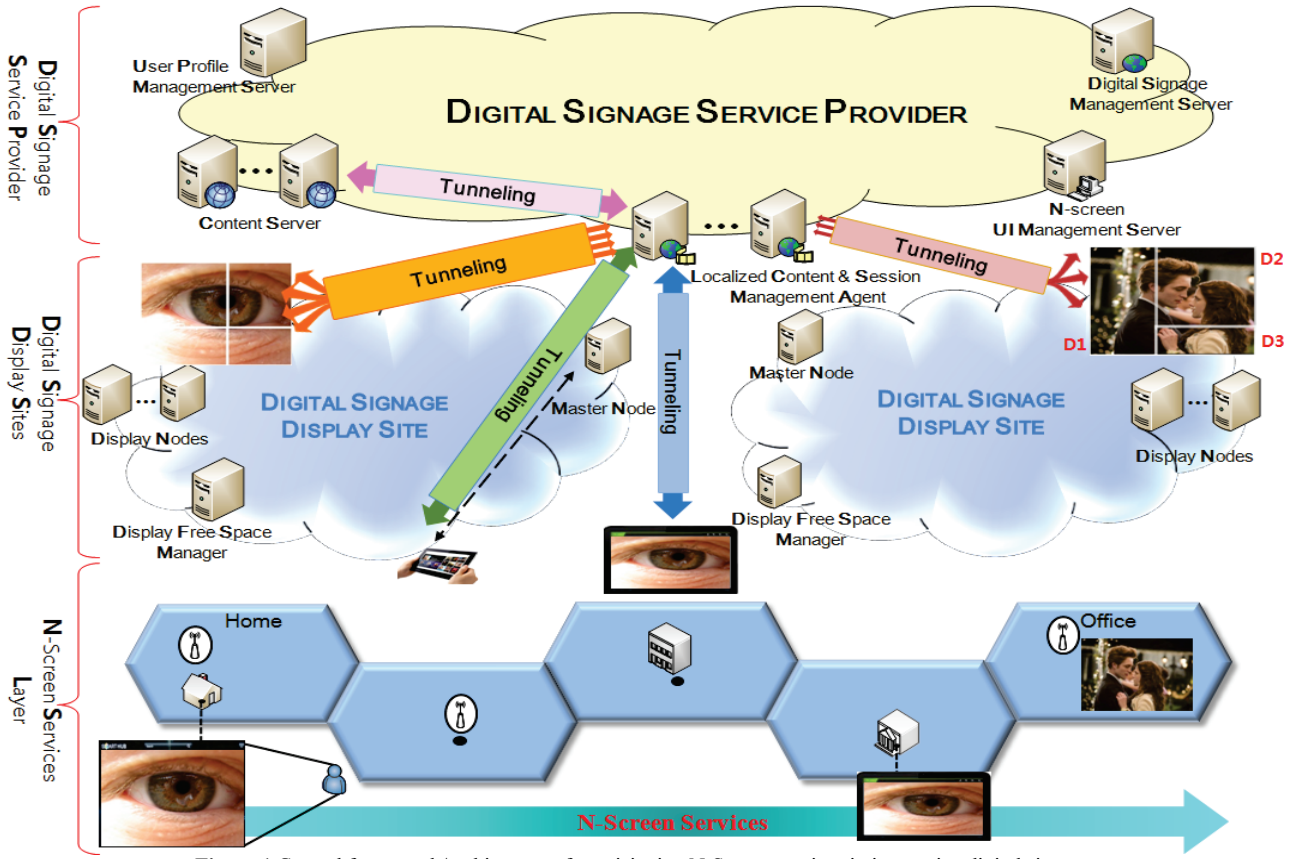


**Figure 1** Control framework/architecture of provisioning N-Screen services in interactive digital signage

### 2.1 Digital Signage Management Server (DSMS)

To provide the seamless continuation of the content, there should be a node in the framework that captures the entire signage network information. In the framework, the DSMS is the central component that stores the information of the user N-Screen devices repository, the content server, the LSCMA and the user profile management server. The NDR maintains the users N-Screen device static profile and the device activation status. Tab. 2 shows the N-Screen Device Repository information. The DSMS maintains the NDR in order to provide the seamless content adaption in terms of N-Screen device layout and also the content adaption considering different frame rates, access network conditions and network speed. Fig. 2 shows the procedure to collect the user's N-Screen device attributes collection and registration.

**Table 2** N-Screen Device Repository (NDR)

| Device.ID | U.ID | Media Codecs | Screen Size | Resolution | Network Interface | Frame Rate | Activ.Status |
|---|---|---|---|---|---|---|---|
| D1 | F5629 | MPEG-4, H.263, H.264, etc. | 10" | 720 pixel | WiFi | 25 | 1 |
| D2 | F5629 | MPEG-2, MPEG-4, H.264, etc. | 40" | 1080 pixel | Ethernet | 60 | 0 |
| D3 | B8606 | MPEG-4, H.263, H.264, etc. | 5,5" | 1080 pixel | 3G | 50 | 1 |

**Table 3** Information about Content/Application Servers at DSMS

| Content. ID | Content / App. Server IP | Serving LCSMAs IPs | Available Bandwidth | Used Bandwidth | Location |
|---|---|---|---|---|---|

The DSMS also maintains the content server information. In the interactive DS, we provide high resolution visualization content over a large-scale display which reduces the load on the content server. In the framework, the content servers provide content to the LSCMA which adapts the content according to the DS display and the user's N-Screen device. The DSMS should know the content servers (Application Nodes) location and its load in terms of available and used resources. We define the resources in terms of the available and used bandwidth. Tab. 3 shows the information about the content/application servers at DSMS.

Furthermore, the DSMS should also know the LCSMA information in order to assign the LCSMA for seamless services and reduce the core network load. The LCSMA finds the used and available resources (bandwidth) to be based on the number of serving display nodes at DS sites, user N-Screen devices and the frequency of interactions with DS. Based on the available bandwidth and the geographical location of the LCSMA,

the DSMS decides which LCSMA is to be assigned to which DS display site and which user's N-screen. Tab. 4 shows the information about the LCSMA at DSMS.

**Table 4** Localized content & Session management information at DSMS

| LCSMA IP | Available Bandwidth | Total Bandwidth | Location |
|---|---|---|---|

In addition to this, the DSMS maintains information about the user profile management server and the N-Screen interface management server (NUIMS). When a user's N-Screen device requests some content, the DSMS provides the device specifications to NUIMS in order to provide the User Interface (UI) according to the device layout.

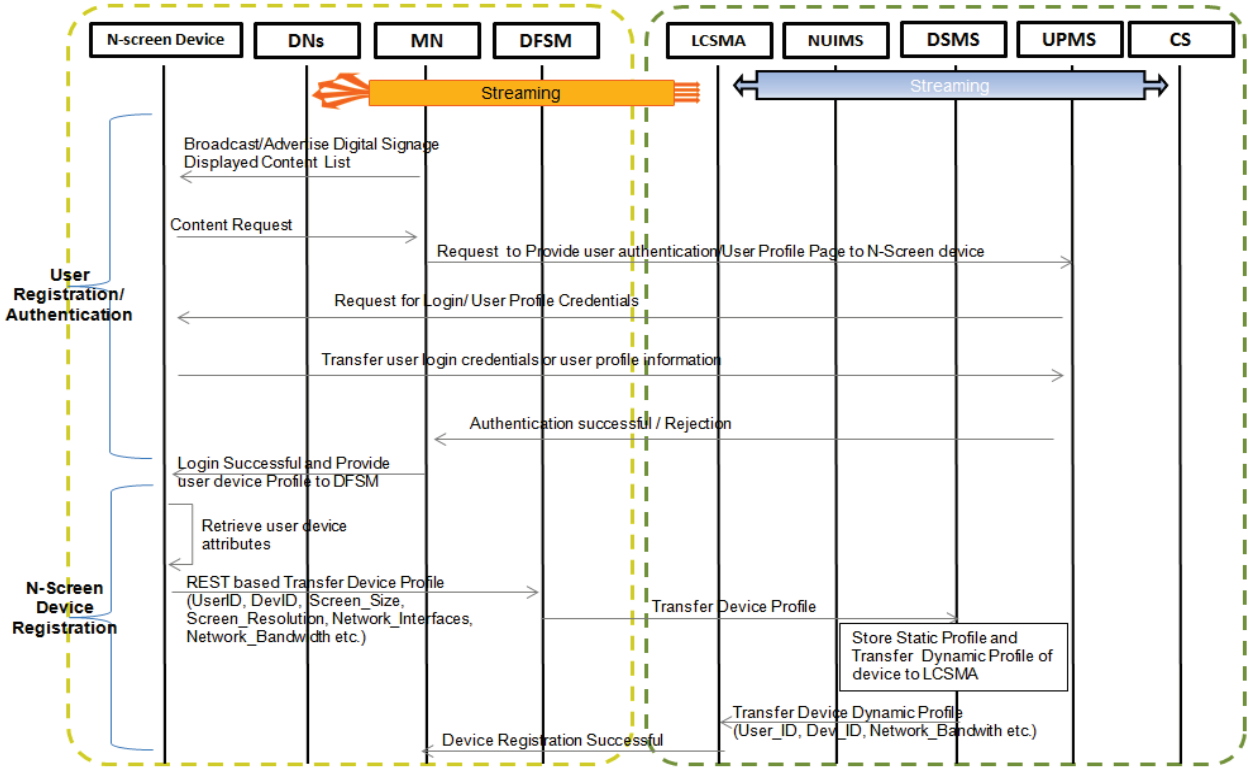


**Figure 2** User profile registration/Authentication & N-Screen device registration

## 2.2 User profile management server

The user profile management server (UPMS) maintains the user information database. The UPMS helps to maintain the user information in order to authenticate the user in case of the restricted content, user social networks and its friend list for sharing content. Using the UPMS, we can provide multiple services in the interactive DS environment such as the Chat capabilities and Help line support services. We can also implement different services at the top of the DS such as for making reservations at restaurants, ticketing and tele-voting, etc. The UPMS saves the users not to provide the user information every time for a service. Fig. 2 shows the procedure to collect the user profile for registration and authentication for various DS services.

## 2.3 N-Screen user interface management server

In the N-Screen interactive DS, the user can access the signage content over large-scale displays and user N-Screen devices. In N-Screen, the users have multiple devices each having various screen sizes and capabilities. We introduce the N-Screen User Interface Management Server (NUIMS) that converts the application content user interface dynamically according to the user device screen size and capabilities to provide seamless content imagery irrespective of the device. The DSMS provides the related information about device to the NUIMS and also directs the content/application server to provide the original user interface (UI) of the requested content in order to transform the UI dynamically.

In case of an interaction with the DS, the screen layout information is provided by the Display Free Space Manager (DFSM) and the content UI information by LCSMA. In the last few years many research studies have been carried out to provide Scalable User Interface. Kurakake et al. [15] in their Patent, disclosed the scalable graphical user interface architecture to provide a device platform independent user interface. Speicher et al. [16] patented a way to scale the user interface according to the device or network limitations. They used the limitation of the access network and the device in the network to provide the scalable user interface. Yuseok Bae et al. [17] provided a scalable UI framework to support multiscreen services. Using the concept of scalable UI, we introduce the NUIMS to dynamically scale UI according to the user interaction with DS and N-Screen device. Fig. 3 shows the procedure for transforming the UI according to the user device when a user requests content.

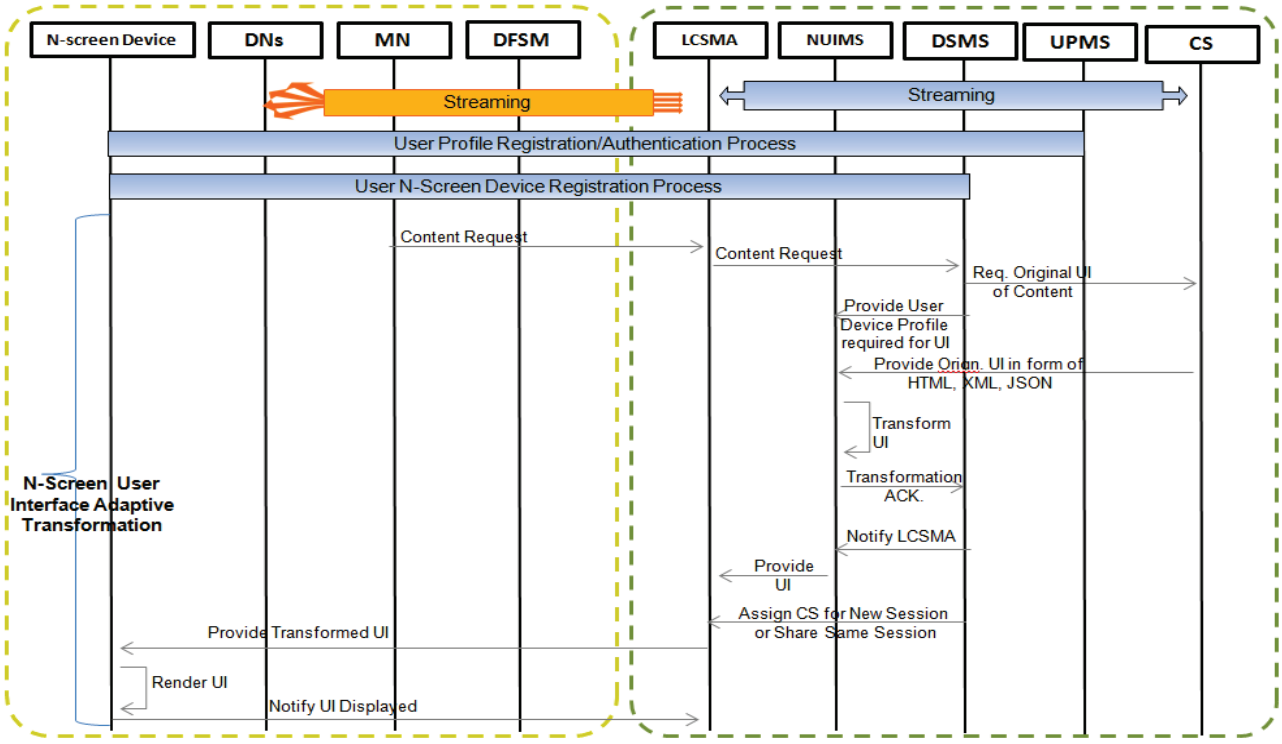


**Figure 3** Protocol/Algorithm for N-Screen dynamic user interface adpatation

## 2.4 Localized content and session management agent (LCSMA)

In the interactive DS, we provide high resolution visualization content to make a single display that tiles multiple screens. To make a single display with multiple screens, there should be some mechanism to adapt the UI and also the content quality according to the display and access network capabilities. In the framework, the NUIMS adapts dynamically the user display layout and the LCSMA acts to partition and trans-code the multimedia content according to the UI being displayed. The transcending mechanism is not covered in the scope of this article, and but we will provide it in future research. We suggest the use of ITU-T G.1070 to estimate the multimedia quality on the display (tile of the DS or the user's N-Screen device) and adapt the content accordingly. Tab. 5 and Tab. 6 both show the simulation results carried through the G.1070 simulator [18].

In the Tab. 5 and Tab. 6 we show the mean opinion score (MOS) values for various bit rates and frame rates. The colour cells' values show that if we provide the content such as that shown in Fig. 4 over the heterogeneous displays, we have to adapt the content to provide seamless imagery over the display and synchronization either using the bit rate or the frame rate adaptation. Also the LCSMA estimates the visual quality when users access the content over heterogeneous access networks and adapts the content accordingly in order to provide seamless continuity of the session. The LCSMA maintains the dynamic profile of the user device and access network, and gets the layout information from the DFSM/NUIMS to adapt the content accordingly. The introduction of LCSMA, NUIMS and NDR in the interactive DS enables the user to share the DS content over N-Screen devices at any time and from any location.

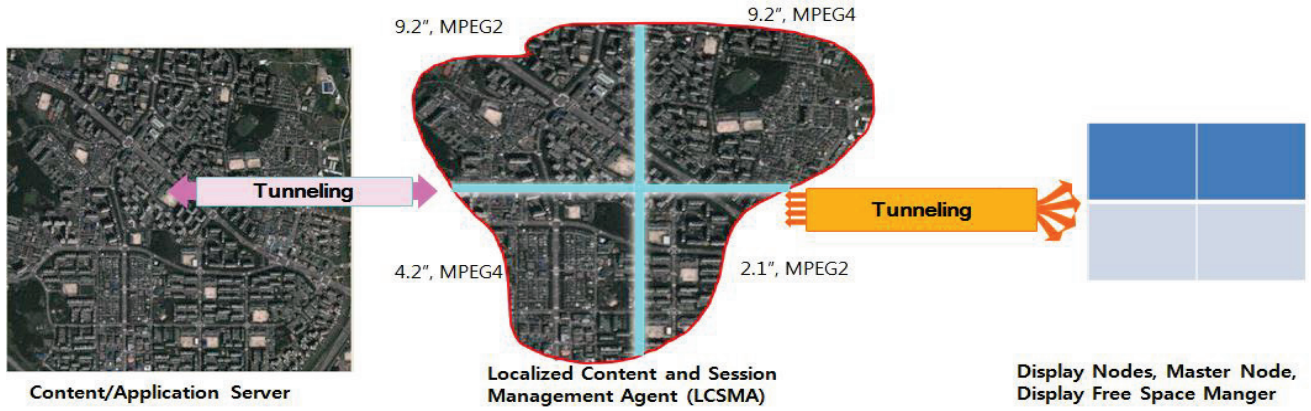


**Figure 4** Procedure of content delivery in interactive digital signage system

**Table 5** Visual Quality (MOS) over heterogeneous devices at different Bit Rates and Constant Frame Rate of 30 fps

| Bit Rates (kB/s) | 9,2", MPEG2 | 4,2", MPEG4 | 2,1" MPEG4 | 9,2", MPEG4 |
|---|---|---|---|---|
| 100 | 1,44 | 1,45 | 2,10 | 1,28 |
| 200 | 1,82 | 2,11 | 3,18 | 1,63 |
| 300 | 2,17 | 2,69 | 3,71 | 1,96 |
| 400 | 2,47 | 3,14 | 4,00 | 2,26 |
| 500 | 2,72 | 3,49 | 4,17 | 2,52 |
| 600 | 2,92 | 3,74 | 4,28 | 2,75 |
| 700 | 3,07 | 3,94 | 4,35 | 2,95 |
| 800 | 3,19 | 4,08 | 4,39 | 3,13 |
| 900 | 3,28 | 4,19 | 4,41 | 3,28 |
| 1000 | 3,35 | 4,27 | 4,43 | 3,42 |

**Table 6** Visual Quality (MOS) over heterogeneous devices at different frame rates and constant Bit Rate of 1000 kB/s

| Frame Rate (fps) | 9,2", MPEG2 | 4,2", MPEG4 | 2,1" MPEG4 | 9,2", MPEG4 |
|---|---|---|---|---|
| 5 | 2,87 | 3,30 | 3,29 | 3,41 |
| 10 | 3,27 | 3,45 | 3,95 | 3,74 |
| 15 | 3,35 | 4,20 | 4,23 | 3,74 |
| 20 | 3,49 | 4,28 | 4,36 | 3,65 |
| 25 | 3,43 | 4,30 | 4,41 | 3,54 |
| 30 | 3,35 | 4,27 | 4,43 | 3,42 |

### 2.5 Digital signage display sites

The DS display sites have a setup to receive the content and to display it over large-scale display. The display site includes the Display Nodes, Master Node and Display Free Space Manager (DFSM). The display nodes receive the content from the LCSMA and display the content on one or more tiles (screen) in the large-scale display. A display node can support more than one display screen. The master node controls the synchronization of the content being displayed, and when a display node receives the content it sends an 'Acknowledgement' to the master node. Then, when the master node receives ACKs from all the display nodes participating in specific content display the master node sends the command to display content from the graphic display buffer over the screen. The DFSM controls the free space over the large-scale display.

## 3 Procedure to receive content streaming and N-Screen interactive digital signal services scenarios

In this section, we explain the procedure to access the DS content on user's N-Screen device and two service scenarios of N-Screen interactive DS.

### 3.1 Procedure to receive content streaming on user's N-Screen device

At the DS, when a user wants to launch an application on the display site, first it executes the DFSM and then the DFSM transfers the display profile to the DSMS, and finally transforms the UI according to the layout. To display the content on the user's N-Screen device, the precondition is that there should be some content displayed on the DS display and the Master node advertises this signage content. Fig. 5 shows the sequence diagram to access the DS content on the user's N-Screen device.

### 3.2 Real world services scenarios in N-Screen interactive digital signage

Many real world applications can be implemented at the top of the suggested N-Screen interactive DS framework. We are going to explain a few of them on how they can be supported by our suggested control framework.

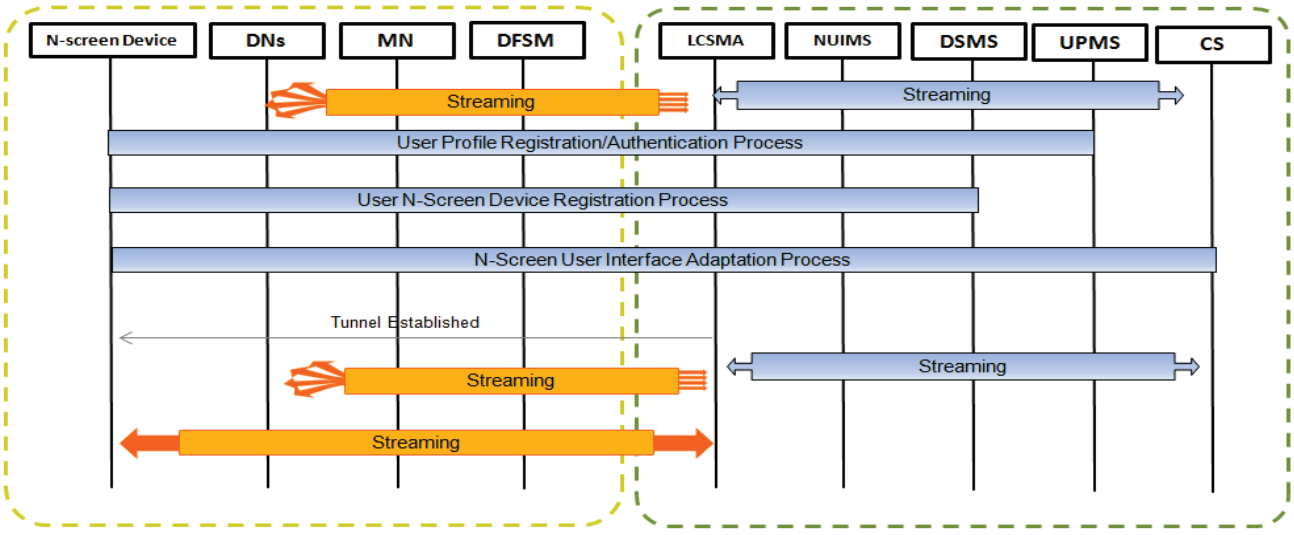


**Figure 5** Procedure to receive content streaming

#### 3.2.1 Sharing the multimedia audio session while keeping the session at DS

As the DS displays various multimedia content simultaneously in public places, normally it is not feasible to provide/play the audio of the multimedia (movie/advertisement). Fig. 6 shows the procedure and the service of sharing the audio session. The precondition of the scenario is that the multimedia session displayed on DS has audio. In Fig. 6, the left side of the figure shows the scenario and the right side shows the procedure of how to incorporate the service on the top of the framework.

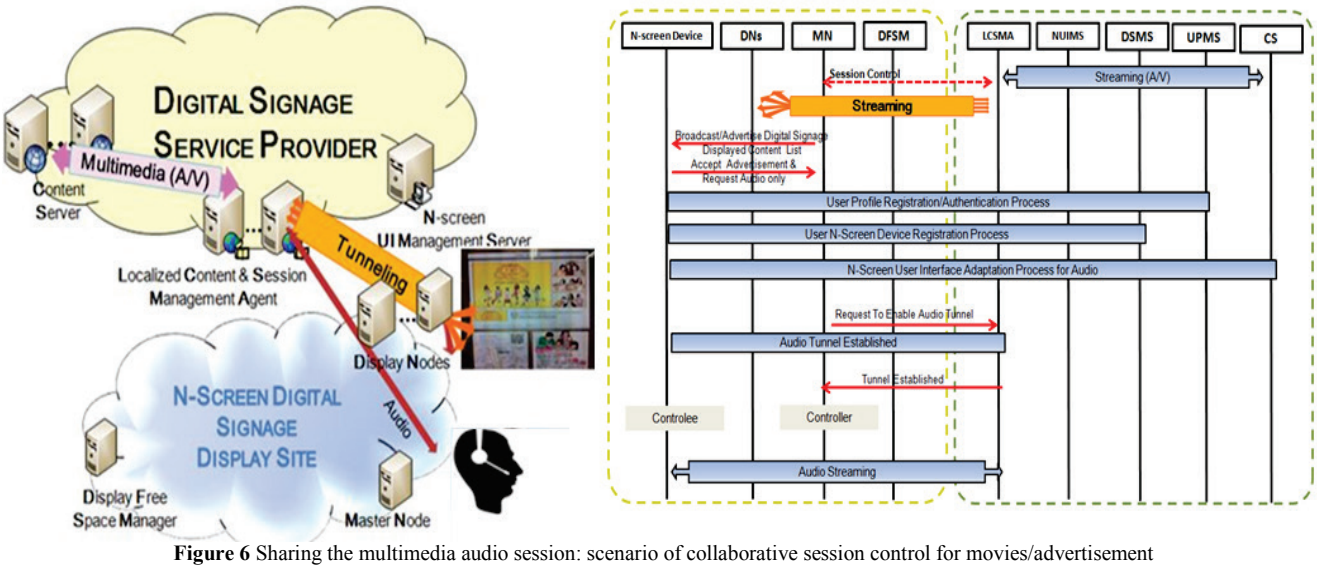


**Figure 6** Sharing the multimedia audio session: scenario of collaborative session control for movies/advertisement

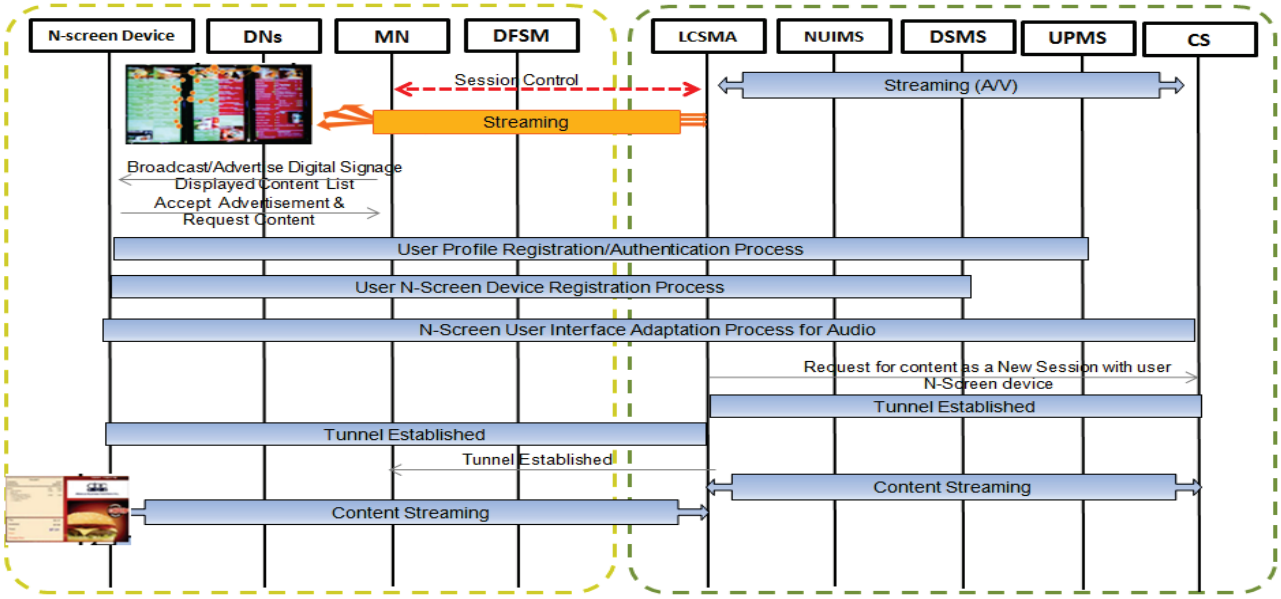


**Figure 7** Retail service (fast-food) scenario in N-Screen interactive DS

### 3.2.2 Retail service provider scenarios

Fig. 7 shows the retails service scenarios, and considers a Fast-Food service provider as a scenario. Due to the space limitations they display the menu but not its details. However, in order to provide the details on the user N-Screen can help to provide good service quality and avoid the rush on the counter premises.

## 4 Conclusion

In the article, we provide a control framework for provisioning of N-Screen services in interactive digital signage. We introduce the components as N-Screen Device Repository, N-Screen User Interface Management Server and a Localized Content & Session Management Agent (LSCMA). These components are introduced in order to provide the signage content over users N-Screen devices by dynamically adapting the content layout and quality in accordance with the devices attributes and screen layout. The N-Screen User Interface Management Server dynamically changes the user interface for the content according to the screen size and layout, and the LCSMA adapts the content according to the access network conditions and display screen attributes. Furthermore, we also provide the different procedures and protocols for provisioning N-Screen in interactive digital signage and also the different services scenarios that can be implemented at the top of the suggested framework.

## Acknowledgements

This work was supported by the ICT R&D program of MSIP/IITP. [13-912-03-901, Development of Context-Aware Tele-Screen System Technology]

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