

Prototyping of a Browser-Based Social N-Screen Platform

[Building Up for Recommendation Algorithms Testing while Boosting User Experience]

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ABSTRACT

A second screen is a hand-device which is susceptible to provide added value to the TV content consumption. Notube, with their web browser-based second screen application, moved further through this concept, creating an association between the second screen, Web and TV content. Nevertheless, the implementation still lacks completion in order to achieve a full service and its users' satisfaction.

This project shows the development of a social N-Screen prototype. The main goal was to re-design, implement and improve the functionality, interactivity and user experience of the browser-based second screen recommender platform carried out by Notube, in order to provide a functional and attractive platform that can be used to graphically test different recommendation strategies.

1. INTRODUCTION

1.1 Background

1.1.1 The Multi-Screen World

The human being has become throughout the last years into a multi-screener¹ nation. From the appearance of television in our living rooms, until the incorporation of lighter and portable new devices such as smartphones or tablets, users have been including all these devices in their routines until turning them into everyday objects. Consequently, tablets, smartphones, televisions and computers have become the main group of devices with which an average user consumes most of their media content[37].

Despite each archetype provides a particular motivation and practise to users, an important fact is that screen devices as mentioned before are no longer used in isolation but collaboratively. Regarding this device collaboration, two different

¹ *Multi-screening*: use of more than one screen at a time.

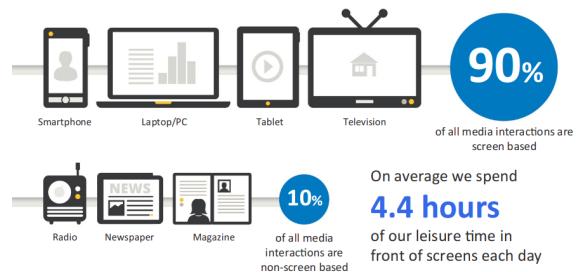


Figure 1: Study of daily media interaction, obtained from [37]

models of multi-screen[37] behaviour are distinguished: sequential and simultaneous. *Sequential usage* refers to moving through more than one device in order to achieve a task. *Simultaneous* concerns the usage of multiple devices at the same time for either related or unrelated activities. Both consumption forms are increasingly becoming the default mode and is surely influencing the way users engage.

Following this scenario comes the necessity to understand how users interact with these screen devices in combination[21]. The opportunity to decide which device to use, where and how makes possible for users to control their own interaction and content flow.

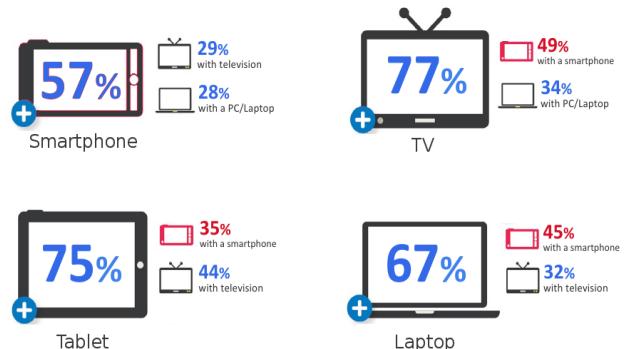


Figure 2: Study of companion devices during simultaneous usage, obtained from [37]

A Google study developed in 2012 [37] exposed how an average consumer makes use of companion devices - smartphone, TV, tablet and laptop - during simultaneous² usage - See Figure 2. There are three main multi-screen combinations:

- Smartphone + TV - 81%
- Smartphone + Laptop/PC - 66%
- Laptop/PC + TV - 66%

Additionally, a research developed by Microsoft in 2013 [25] illustrated how is the user behaviour while multi-screening in simultaneous usage.

- 68% of consumers interact with multiple devices at the same time to access unrelated content; e.g. they may be texting a friend while watching TV.
- 57% of consumers make use of more than one device simultaneously in order to achieve a related activity.

From now on, we will focus our attention in simultaneous usage for *related* activities.

1.1.2 Second Screens

One of our everyday routines that has been altered by this new screen multitasking[43]³ behaviour is that moment while a user watches TV. Viewers no longer focus their entire attention to the TV screen but share it with portable devices.

Figure 3 illustrates how consumers make use of their tablets and smartphones while watching TV. We can observe how indeed users not only surf on the web, but they interact with the device with activities directly related to the program or advertisement that they are watching at that moment. This demonstrates the fact that consumers are not merely interacting with their hand devices as a simple distraction, but sometimes in order to improve their TV content consumption.

This new practice has led to the creation of the new concept *second screen*. Second screen is a hand-device which is susceptible to provide added value to the TV content consumption. These devices such as tablets or smartphones play a role as companion screens that 'connect' viewers to complementary interaction opportunities while they watch TV via applications, additional show-oriented content or in-synch functionalities [17].

This new activity has become such important that a survey developed by Nielsen Holdings N.V. [29] reported 'Using a tablet or smartphone while watching TV is more common than not'. Nearly half of tablet owners - 43% - and smartphone owners - 46% - declared that while watching TV they are making use of their devices as second screen every day. As a consequence of this fact, there are emerging

²Usage for either related or unrelated activities.

³'Human multitasking' is the apparent performance by an individual of handling more than one task at the same time.'

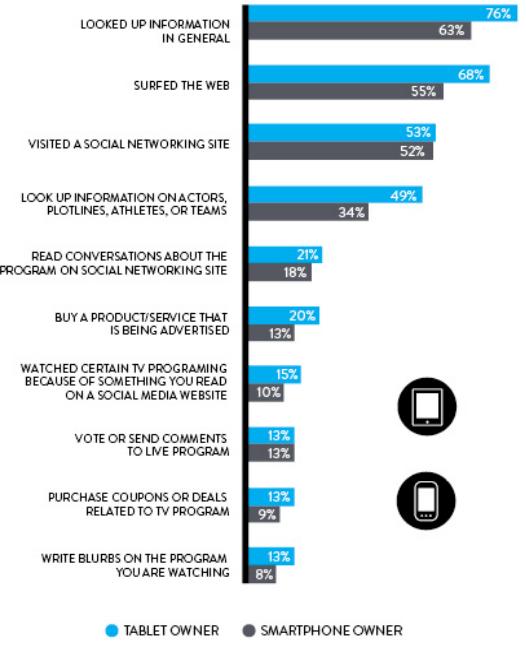


Figure 3: Tablet or smartphone activities while watching TV, obtained from [29]

new apps[41]⁴ which take advantage offering second screen experiences that can improve even more this interactivity while watching TV.

Second screen apps [16] are intended to enable viewers to interact before, during and after the broadcast of a programme using a laptop, smartphone or tablet. The most competent apps, instead of distract, have the potential to increase the viewers' attention and enjoyment on the watching programme. According to [16], eight types are distinguished in order to categorize these apps based on their functionalities:

- Socializing
- Loyalty
- Recommendation
- Transaction
- Information
- Program guides
- Participation
- Creation

On that account, second screen apps arised as a manner to unlock new research and business models due to the wide range of potential possibilities they offer.

⁴'App is an abbreviation for application. An app is a piece of software. It can run on the Internet, on a computer, on a phone or other electronic device.'

1.1.3 Use case

This project is based on an already existing platform developed by Notube^[5]. Notube, is a project funded on 2009 that was specialized in second screens and Web merging. Their motivation was getting the Web and TV closer together via shared data models and content across multiple devices. They developed their own N-Screen⁵ prototype, a Web browser-based^[15]⁶ second screen application⁷ for small group exploration of on-demand content, both in the same room and remotely, with each individual having their own second screen device. It integrates different combinations of recommendation strategies and allows to decide within a closed group to watch a selected program sharing a 'virtual television', that in their case is the hand device itself.

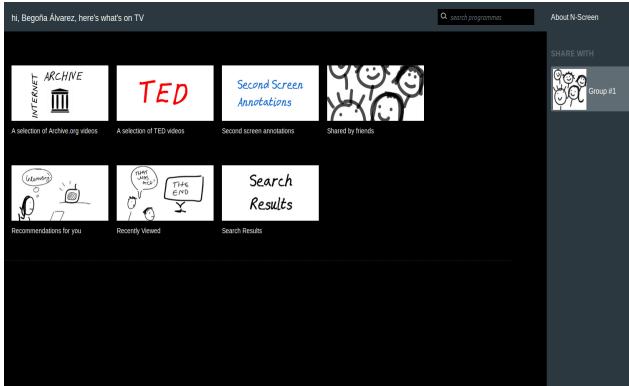


Figure 4: Notube N-Screen screenshot, source code obtained from the public repository <https://github.com/notube/n-screen>

It is developed following a *user-centric approach*⁸ in order to explore main aspects of users' content customisation demands, interaction requirements and entertainment preferences. Their main goal was to investigate if making decisions in collaboration might guide people to find something interesting to watch.

1.2 Goals

The main goal of the project is to re-design, implement and improve the functionality, interactivity and user experience of the browser-based second screen recommender platform^[36]⁹ carried out by Notube, in order to provide a functional and attractive platform that can be used to graphically test different recommendation strategies.

⁵ *N-Screen* because it might be the primary screen, or one of a bunch of equals.

⁶ 'Browser-based' refers to computer tools and applications which run on a web browser via the Internet without accessing the operating system of any individual computer. These applications are accessed through web pages and can be used by people who are prevented from downloading software applications by firewalls.'

⁷ All the source files used to generate this application can be accessed at the public repository: <https://github.com/notube/n-screen>

⁸ Placing user's goals at the heart of development.

⁹ A *platform* is a group of technologies that are used as a base upon which other applications, processes or technologies are developed.'

Most of the second screen apps in the market are not successfully developed because they are focused on enhance activities that do not fulfil the real consumer needs^[16]. Consequently, the audience engagement fails. This fact is crucial and it must be taken into account in order to make the platform valuable.

In addition, the platform must be designed taking into account a possible future recommendation system integration. Furthermore, the project must accomplish certain requirements for a potential release to final users. It needs to be developed offering user-based content, due to its recommendation feature. It is required to provide engaging content and interaction activities, as well as offering an intuitive appearance. Moreover, the platform must be flexible and scalable, so it will not need to be entirely redone with every particular change. Hence, it is needed to reach a complete solution covering all these features, overcoming the gaps and deficiencies that other platforms show.

Here, the main goal is fragmented into more specific sub-goals:

- *Analysis of previous conclusions and results.* Study of already tested aspects. Definition of new tests to provide new data of interest. These data will help in making decisions about the implementation of interaction activities.
- *Requirements definition.* Study of needs and constraints.
- *Software design.* Global design of the new involved software. Debugging and optimization.
- *Platform development.* Implementation and integration in order to achieve the development of the final demo.
- *General purpose tests.* Tests oriented to prove the proper operation and verify the achievement of the requirements and constraints compliance.
- *Results analysis and conclusions.* Achievement evaluation. Study of weaknesses or possible improvements. Definition of further studies.

1.3 Project Organization

The organization of this project is described as follows:

- *Analysis of previous conclusions and results.*

At this first stage, N-Screen-related information and specific knowledge was acquired. An approach to the development tools was also outlined. Goals:

- Second screen state-of-the-art review. Review of the current commercial solutions.
- Adaptation to the development of the platform as well as required tools (repository, client and server side programming languages research and learning, etc...).
- Analysis of related projects results, either completed or under development.

- *Software design.*

This phase covered from the first software definitions and specifications, to the platform implementation until reaching a final demo. Goals:

- Software design and implementation for required features.
- Content dataset migration.
- *Alpha*-version deployment. Source code debugging and improvement.
- *Beta*-version deployment. Source code debugging and improvement.

- *Tests and evaluation.*

At last, the final demo was evaluated and the results were analyzed. Goals:

- Technical Test.
- User experience test.
- Results interpretation and conclusions review. Statement of further studies and future development lines. Found problems evaluation.

- *Documentation generation.*

Dissertation and other required documentation writing.

1.4 Outline

Section 2 introduces the state of art of TV recommender second screens systems. Section 3 presents a review study to define our platform. Section 4 explains every aspect concerning the platform development. Section 5 shows the final evaluation and illustrates obtained results. Section 6 reports our conclusions and future lines.

2. STATE-OF-ART

The development of a hand device service to be used in a TV environment is not new. Already in 1996[32] it was introduce an innovative system concerning hand devices in order to accomplish TV interaction. Since the exponent emergence of interactive systems involving TV and hand devices, used as second screens, a wide set of research is emerging around it. Concerning second screen recommendations systems, much work have been done in order to help users with extensive quantities of on demand content provided by the TV. The TV-Advisor[13], the PTV system [11], EPG [4] and the multi-agent TV recommender[24] present some of the earliest TV recommender systems. Furthermore, TiVO[2] and Predictive Networks[20] launched commercial systems to provide TV recommendations.

The TV-Advisor makes use of explicit techniques to generate recommendations for a TV viewer, extracting user preferences explicitly provided by them in order to get a high quality recommendation. Nevertheless, this system makes use of volatile data, therefore does not allow an evolution of the user profile over time.

The PTV enhanced the weak point of the TV-Advisor, allowing the system to improve the recommendations over

time storing the relevant data. However, the set of recommendations was stored in a different place of the main system, removing users from the main system experience.

One of the earliest commercially available TV recommenders comes from TiVO, generating recommendations directly displayed to the users. Additionally, the system learns by a tracking system combined with a explicit introduced feedback to indicate the user's feeling about TV content.

All of the systems described above share one common characteristic: the systems are developed as non cross-platform. Our N-Screen improves this aspect providing a fully compatible system, requiring to users just Internet access and they preferred browser. Furthermore, it presents an innovative feature, the Virtual TV, allowing faraway users to watch simultaneously the same selected programme, providing the experience of a '*virtual living room*'.

Recently, a slight number of new browser-based systems have been launched due to its advantages. See <http://peel.com/>, <https://www.fan.tv/>, <http://www.buddytv.com/> and <https://www.simultv.com/>.

3. REVIEW STUDY

A model for the platform is defined in this chapter. Initially, the first version of the N-Screen developed by Notube[5] is evaluated to obtain some guidelines and potential improvements facing our own. The final software implementation requirements and constraints are defined. Finally, a discussion and evaluation over different features is carried out, exposing different options and some final conclusions in order to face a potential deployment to final users.

3.1 Browser-Based Social N-Screen Platform Model

Essentially, the BBSNSP¹⁰ responds to a second screen application based on a recommendation system. However, a further review shows some general differences:

- *Browser-based*: instead of being developed as a mobile or computer app, the BBSNS is a web app. A *web app* refers to software that runs on a web browser. This way, not only the app can be updated and maintained without disturbing potential users by requiring them to re-download. Additionally, it provides implicit support for cross-platform[38]¹¹ compatibility.
- *Group decision recommendation system -Social-*. The recommendation feature is focused on 'how collaborating together might help people find something interesting to watch'¹². It is designed to be used within a small group of friends in a collaboratively way to reach together a successful programme to watch.

¹⁰Browser-Based Social N-Screen Platform

¹¹'Cross-platform' regards the capability of a software to run identically on different platforms.'

¹²<https://notube3.wordpress.com/2011/10/10/n-screen-a-second-screen-application-for-small-group-exploration-of-on-demand-content/>

- *Apart*¹³ group oriented: this BBSNS is mainly designed to watch together with other friends but being remotely located.
- *N-Screen*: It is not only oriented to be used as a secondary. It is considered that it might be used as a primary screen, secondary screen, or one of a screen devices collection.

3.2 First Browser-Based Social N-Screen Platform Review

The first BBSNSP was a project of Notube developed in 2011. It supposed a big step forward to get the Web and TV closer together using shared data models and content across multiple devices[33]. It is designed to help deciding and enabling to interact using drag and drop over screen devices. It allowed to investigate how helpful is group collaboration in order to find an interesting programme to watch, for limited group of users. It gave the strengths and weaknesses to establish the fundamentals for future developments.

While constituting a successful platform meeting most of its features, the Notube BBSNSP introduced some issues found after its evaluation. These issues are following listed.

I) As a recommender system, the platform is intended to be user based content oriented. User preferences and explicit interaction should provide to the recommendation strategies an on-real-time update to re-rank the displayed personal suggestions[27]. In Notube's platform, user interaction is treated as *volatile* data, each time that the session is closed, the information is lost. This implementation impedes to exploit all this relevant information. Figure5 shows the 5 tasks that are intended to be accomplished by the recommendation engines in the client-side. If the platform lacks tracking the user interaction and preferences, it would not be possible to realize properly the first *training* step due to a shortcoming information.

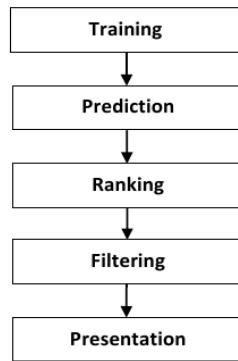


Figure 5: Recommender system tasks, obtained from [27]

II) Their own preliminary findings after the evaluation¹⁴ showed us a weak point. Notube results obtained after test-

¹³Different physical locations.

¹⁴<https://notube3.wordpress.com/2011/12/12/preliminary-findings-of-n-screen-user-testing/>

ing N-Screen with real users showed how some of them received a successful recommendation and indeed were wishing to watch later that specific selected programme. They received feedback such as "Not for watching something instantly, only for making suggestions for things that could choose to watch later if you wanted to" or "I do not think it is on to recommend things for others to watch instantly". This results revealed an interesting *sequential usage* behaviour. In this case, instead of passing from one device to another, the user is making use of the same device time later to accomplish a task. Therefore, not only the volatile activity of the user, but also a lack of option to save wished programmes for a future moment, makes unlikely the activity to watch *that programme later*.

III) It is very important to offer an attractive set of possible activities for the user to interact with the [35]. The only implicit offered interactions are the browsing and the suggestion part. For this reason, we found that Notube N-Screen slightly incomplete in terms of interactivity actions.

IV) The platform was designed to be not only a recommendation system, but also a place to watch a selected programme. There exist two different ways to realize this action: locally and remotely. The first one is performed when a user decides to watch a programme individually. By contrast, the second one is conducted when a group decides to watch together a selected programme and the members are located in remote locations. This last visualization mode involves the execution of a browser-based 'virtual TV' in which every person within the group can watch simultaneously the same. Unfortunately, this last feature was not working because the programme visualization part was missing. Making the virtual TV feature working is indeed necessary for a complete success of the platform.

V) As mentioned before in this section, issue I), the platform is designed to provide -future- recommendation strategies. For this purpose, its structure design needs to be flexible and scalable to allow future recommendation scripts compatible in terms of data, in this case, a wide set of programmes. Following a deep study of the source code, we found an important bottleneck. The implementation was not flexible to face data content migrations. The programmes displayed, and all the logic behind it, were designed to correctly work just locally and with a limited flexibility range. It is not possible to afford heavy data as a wide set of programmes running locally due to memory limitations.

VI) The inherit second screen behaviour of the platform makes strongly important to take into account that higher complex interaction in this type of environments is a determinative factor [12], since involves a multi-tasking activity. We found that the homepage was not simple while informative enough in order to not distract the user from the main screen attention. It lacked first sight relevant information, therefore it required more attention than actually needed.

4. IMPLEMENTATION STUDY

Once the first BBSNSP has been reviewed, it is moment to study how to settle every found issue and bottleneck exposed in Section 3.2 and start the implementation. The decisions regarding the implementation of new features are exposed.

4.0.1 Localhost Deployment

Before being able to start programming the platform, it was required preparing the environment.

On the one hand, it was needed to set up a local server to be able to run and test our web application. We used XAMPP on a Linux distribution for this purpose, due to its multiple advantages and intuitiveness. XAMPP is an open source independent server platform which consists mainly of a MySQL database, Apache Web server and required interpreters for scripting languages as PHP.

On the other hand, the set-up required an Ejabberd installation to manage instant messages in order to enable automatic non-typed communication between remote users and allow them to collaborate -suggest-. Ejabberd is a Jabber/XMPP[46]¹⁵ server [22] which is realized in Erlang¹⁶ language. Its main functionality is that it works as an instant messaging server that allows more than one people to communicate and participate in real time, based on typed text or not. Additionally, considering that is intended to be used by a web application as part of a communication tool, it was necessary to enable BOSH¹⁷ in our Ejabberd server configuration. HTTP is synchronous providing simple call and response methods, discordant to XMPP's asynchronous event based protocol. Therefore, BOSH is a protocol that provided us a method to use XMPP in our platform by making http requests with a long time-out.

After this preparation, the environment was therefore ready to start the implementation.

4.1 Registration & Login

The platform is intended to be used to test researches developed about recommendation strategies, therefore, it follows a user content based model. As explained in Section 3.2 issue I), user preferences and explicit interaction should provide to the recommendation strategies an on-real-time update to re-rank the displayed personal suggestions. In order to deal with the volatile data it was decided to implement a Registration & Login system. This way, it is possible to tack user preferences and provide relevant data to the recommendation side.

An important step before implementing the registration system was to study different types of registration we could offer. Due to the imminent growth of the social networks popularity such as Facebook¹⁸ [34], websites are currently offering two different options to accomplish a registration:

- *Good registration*: known as the one where a user fills in directly the registration form with their personal data.

¹⁵ 'Extensible Messaging and Presence Protocol, better known as XMPP (formerly Jabber), is an open and extensible XML-based protocol originally designed for instant messaging.'

¹⁶ Therefore, it was required also the Erlang packages installation for compilation

¹⁷ Bidirectional-streams Over Synchronous HTTP

¹⁸ <https://www.facebook.com/>

- *OpenID*: OpenID Registration is an extension to the OpenID[10]¹⁹ Authentication protocol that allows for very light-weight profile (mostly social networks profile, as Facebook or Twitter²⁰) exchange . It is designed to pass eight commonly requested pieces of information when an end user goes to register a new account with a web service.

The OpenID provides the fastest registration system. This '1-click' activity can definitely be very attractive to implement as unique registration for a second screen platform[3], where users distraction has a crucial importance. But despite its significance through the last years, not every user is willing to share their social networks' personal profile due to a lack of confidence in such websites[31]. For this reason, we decided to include both in our platform, selecting the OpenID registration provided by Facebook, since this social network can offer valuable information for the recommendation system.

The implementation for registration & login has been carried out making use of:

- *MySQL database*
- *Database handler scripts*:
 - HTML5 submit forms & PHP for the good registration
 - Javascript Facebook SDK[39]²¹ & PHP for the OpenID registration

4.1.1 Database

The structure of our database has been changing as the platform evolved. At the end, intending to match every needed requirement, we reached the following schema based on two tables:

Table **members**. Column fields:

- **member_id**: Primary key²²
- **firstname**: First Name
- **lastname**: Last Name
- **login**: Unique user-name
- **passwd**: MD5 encrypted[45]²³

¹⁹ OpenID is an interoperable authentication protocol designed to be safe, faster and easier way to log in to web sites.'

²⁰ <https://www.twitter.com/>

²¹ 'Software Development Kit (SDK) refers to a programming package that enables a programmer to develop applications for a specific platform.'

²² The *primary key* of a relational table uniquely identifies each record in the table.

²³ The *MD5* message-digest algorithm is a widely used cryptographic hash function producing a 128-bit (16-byte) hash value, typically expressed in text format as a 32 digit hexadecimal number.'

- `facebook_id`: unique ID extracted from Facebook OpenID.

Table content. Column fields:

- `member_id`: Primary key²⁴
- `recommendations`: Personal recommendations list, JSON²⁵ format.
- `recently_viewed`: Recently viewed or watched programmes personal list, JSON format.
- `watch_later`: Watch later personal list, JSON format.
- `like_dislike`: List containing personal likes and dislikes of the user, JSON format.
- `shared_by_friends`: List containing suggestions to the user made by members within his/her same group.

For further details in terms of database fields definition, the following code (`mysql.sql`) shows in SQL language our tables initialization:

```
CREATE TABLE IF NOT EXISTS 'members' (
  'member_id' int(11)
    unsigned NOT NULL AUTO_INCREMENT,
  'firstname' varchar(100) DEFAULT NULL,
  'lastname' varchar(100) DEFAULT NULL,
  'login' varchar(100) NOT NULL DEFAULT '',
  'passwd' varchar(32) NOT NULL DEFAULT '',
  'facebook_id' bigint(11) DEFAULT NULL,
  PRIMARY KEY ('member_id')
) ENGINE=MyISAM
  DEFAULT CHARSET=latin1 AUTO_INCREMENT=
  1 ;

CREATE TABLE IF NOT EXISTS 'content' (
  'member_id' int(11)
    NOT NULL AUTO_INCREMENT,
  'recommendations' longtext NOT NULL,
  'recently_viewed' longtext NOT NULL,
  'watch_later' longtext NOT NULL,
  'like_dislike' longtext NOT NULL,
  'shared_by_friends' longtext NOT NULL,
  PRIMARY KEY ('member_id')
) ENGINE=InnoDB
  DEFAULT CHARSET=latin1 AUTO_INCREMENT=
  1 ;
```

4.1.2 Login Security

An important implementation to mention is that, in order to access to the personal webpage after the login action, a security checking has been implemented. The access to the welcome page containing personal user-based content is only possible if the login has been correctly done, case

²⁴The *primary key* of a relational table uniquely identifies each record in the table.

²⁵JSON (JavaScript Object Notation) is a lightweight format that is used for data interchanging.

in which the authentication SESSION VARIABLES[1]²⁶ are set and authenticated.

The following script (`auth.php`) shows this implementation:²⁷

```
<?php
//Start session
session_start();

//Check whether the session variable
//SESS_MEMBER_ID is present or not
if (!isset($_SESSION['SESS_MEMBER_ID']))
  || (trim($_SESSION['SESS_MEMBER_ID']) == '')) {
  header("location:index.html");
  exit();
}
?>
```

In addition, for localhost testing purposes, it has been included a management of the browser cache memory to allow more than one sessions running simultaneously in the same browser.

4.2 Interaction Activities

4.2.1 Watch Later

It is severely important to understand how is the user behaviour when interacting with a web service. Developers and designers work together to deploy a final product, but sometimes users can present unpredictable conducts and wishes[30]. It is only after realizing tests on final users when the success or failure can be declared. Notube N-Screen, for example, was designed to be a second screen recommendation platform to watch immediately a selected programme. But after a evaluationwith real users, as explained in 3.2 issue II), they found out how some users where wishing to watch that successful recommended programme not immediately, but in another later moment. This result revealed a very interesting *sequential usage* behaviour in which users utilize the same platform -and sometimes the same device- but in separated moments to accomplish a task, in this case, watch the desired programme. The platform therefore showed a general successful feedback, but was lacking an important user conduct that was not taking into account at the beginning.

Our simplest and effective solution to this situation[23] has been the implementation of the possibility to add programmes to a personal 'watch later' list. This list is directly populated with the implicit user interaction clicking a 'watch later' button. The list can be edited by the addition or removal of a programme. It is important to mention that each time the user edits this personal list, it is directly updated in the database making use of the PHP script `set_channel.php`, which source code is as follows:

```
<?php
//Start session
```

²⁶A *Session Variable* is an associative array containing session variables available to the current script.'

²⁷SESS_MEMBER_ID is only initialized when the login authentication had been successful.

```

session_start();
$data = mysql_escape_string($_POST['data',
]);
$channel = $_POST['channel'];
ini_set('default_charset', 'UTF-8');

//Include database connection details
require_once('config.php');

//Connect to mysql server
$link = mysql_connect(DB_HOST, DB_USER,
DB_PASSWORD);
if(!$link) {
die('Failed to connect to server:'.
mysql_error());
}

//Selecting database for the user
$db = mysql_select_db(DB_DATABASE);
if(!$db) {
die('Unable to select database');
}
$member_id = $_SESSION['SESS_MEMBER_ID'];

mysql_query('UPDATE content SET $channel
=
'$data', WHERE member_id = '$member_id
');
?>

```

4.2.2 Like & Dislike

As mentioned in Section 3.2 issue III), we analysed Notube N-Screen and we found that the platform was missing interaction activities. The implementation of the Watch Later list explained in Section 4.2.1 is actually an addition that improves this issue. Nevertheless, after a deep study we came to the result that just adding that feature was not enough. Based on the recommendation system that is going to be included afterwards, we converged to an idea to include the possibility to elicit user preferences by ranking a programme with a simple Like or Dislike action.

The idea came from the project developed by Vista-TV Sibyl²⁸. Sibyl is a TV and radio programme recommender system designed for tablets and personal computers which uses a novel drag-and-drop system to extract user preferences. A user is able to express preferences by dragging individual programmes into 'like' and 'dislike' boxes. These preferences are immediately used by the client-side recommender to re-rank the programmes and refresh the recommendation list. Therefore, the implementation in N-Screen not only may improve the user interaction, but also can be used to upgrade the recommendation strategy using directly relevant information provided by the user.

As well as with the case of the Watch Later list, likes and dislikes are directly populated with the implicit user interaction of clicking a button; simultaneously updating the database with PHP script `set_channel.php`.

²⁸<http://sibyl.prototyping.bbc.co.uk/>

4.2.3 Hyperlink Metadata

In order to keep improving the platform without distracting the user from the main purpose[3] -watch a programme-, we decided to implement another more additional feature: Hyperlink[44]²⁹ Metadata³⁰. Inside each selected programme description, we included the possibility to click hyperlink metadata to browse further information of this selected concept. The first idea was to add the possibility to include clickable actions to every general metadata of a TV programme as actor, director or genre. Unfortunately, it has been only possible to implement the hyperlink with 'tags' due to content dataset restrictions - data explanation in Section 4.4-. For that reason it has been possible only to display a small part of the goal, but the implementation is developed to work successfully with other datasets that provide wider content extractions.

4.2.4 Random Selection

Nowadays, recommendation systems offer a manner to save time exploring for users between their preferences. This new service presents an almost universal acceptance due to its advantages[6]. Nevertheless, recommendation systems bound the user within his/her pre-defined preferences, not offering the opportunity to explore totally new content. For this reason, our last addition has been the implementation of the possibility to select a random selection of videos. The idea was motivated by <http://nscreen.notu.be/ted/>. This way, we can provide to final users a way to explore non-related content with them, and therefore, offering the possibility to find new preferences.

4.3 Remote TV

Social activities through the Web are becoming exponentially popular since the web encourages users to participate socially active without even moving from their rooms[33]. On the other hand, TV remains a largely passive experience that usually requires physical presence to become social in terms of simultaneous experience sharing, i.e. if you want to watch the same programme at the same time with a friend, you usually meet together in order to do it. For this reason, one of the most innovative and attractive features included in Notube N-Screen was the possibility to share a cross-platform 'virtual TV' in which every person within a group can watch simultaneously the same. Watching TV with faraway friends through a virtual living room.

Unfortunately, as explained in 3.2 issue IV), this last feature was not working because the programme visualization part was missing. We decided that it was necessary to resuscitate the virtual television in order to achieve a successful platform. After long time studying the source code of the script handling the remote TV `player.html`, the bug was found. The problem was mainly residing in data compatibility and how `player.html` handled this data to enable a visualization. Further details concerning data structure are explained in section 4.4. The following `player.html` section of code shows how we handled the issue, replacing the lo-

²⁹'Hyperlink' is a reference to data that the reader can directly follow either by clicking or by hovering or that is followed automatically.'

³⁰*Metadata*: data about data. It is descriptive information about a particular data set, object, or resource.

cal '*manifest*'³¹ extraction for a **http-request** in order to retrieve it and correctly parse it, and therefore, fixing the problem.

```
$document.bind('tv_changed', function (e
    ,item) {
    console.log(item);
    var programme = item.nowp;
    var id = item.nowp.id;
    me.nowp = item.nowp;
    $("#title").html(programme["title"]);

    var action = "Play";
    if(programme && programme["action"]){
        action = programme["action"];
    }
    show_message(action+'ing '+programme["title"]);

    if(action=="Play"){

$.ajax({
    url: "get_tedtalks_by_id.php",
    type: "POST",
    async: false,
    data: {id: id},
    dataType: "json",
    success: function (data) {
        item = changeData(data);
        //JSON with suggestions format
        var manifest = item.suggestions[0].manifest;
        process_manifest(manifest, programme)
        ;
    }
});
// ---- PREVIOUS CODE -----
//pretty much everything should have a
//manifest
//var manifest = programme["manifest"]
//;
//var manifest = item.manifest;
//if(manifest){
//    console.log("manifest is "+
//manifest);

//    $.ajax({
//        url: manifest,
//        dataType: "json",
//        success: function(data){
//            process_manifest(data,
//            programme);
//        }
//    });
//}else{
//    alert('no manifest');
//}
});
```

4.4 Content Data

³¹The *manifest* provides relevant metadata for a specific programme such as video-url and video-format

This project presents a functional platform that can be used, between others, to test future recommendation strategies. One of the possibilities that are currently being researched in our Web & Media Department ³² is a recommendation system based on BBC^[42]³³ programmes through the web-page <http://www.bbc.co.uk/programmes/>. As mentioned in section 3.2 issue V), the Notube N-Screen structure was designed to work with locally stored data. This approach was inefficient since facing future data migrations or including heavier data would follow not only memory but also functional issues. Consequently, we decided to change how the platform deals with this. We converted it to a platform structure designed to deal with remotely stored data based on programmes' IDs including metadata extraction. In order to make this happen, a set of scripts to handle **http-requests**³⁴ has been implemented. These scripts have been programmed making use of Javascript^[9]³⁵ AJAX in the client side, and PHP in the server side. This way, it is not needed to locally store testing datasets but to provide to the scripts a suitable URL to extract information. As a result, the functionality speed is maintained while the platform total weight is severely reduced, since it does not locally store any dataset.

In addition, it has been taking into account the possible data structure that the recommendation system may use as input. For this purpose, a deep study of data structure compatibility has been conducted to facilitate, as much as possible, future implementations carried out by recommendation engines researchers. Based on various data extraction APIs³⁶ such as the *BBC Developers API*³⁷ or the *TED Talks Lab API*³⁸ we decided to set up the following structure³⁹ in JSON format for every object contained in our N-Screen, as programmes or videos:

```
{
"pid":1000,
"title":"Gero Miesenboeck: Re-engineering
the brain",
"description":"In the quest to map the
brain, many scientists have attempted
the incredibly daunting task of
recording the activity of each neuron.
Gero Miesenboeck works backward --
manipulating specific neurons to
figure out exactly what they do,
through a series of stunning
experiments that reengineer the way
fruit flies perceive light.",
```

³²<http://wm.cs.vu.nl/>

³³'British Broadcasting Corporation (BBC) is a UK-based international public-service broadcaster head-quartered at Broadcasting House in London.'

³⁴*HTTP request/response* protocol, which means a client-side application sends a request for some file, and the web server sends back a response.

³⁵'Asynchronous JavaScript and XML (AJAX) is the method of exchanging data with a server, and updating parts of a web page without reloading the entire page.'

³⁶*Application-Programming Interface*

³⁷<https://developer.bbc.co.uk/>

³⁸http://developer.ted.com/API_Docs

³⁹Notice that it is a random example using a extracted TED Talks Video.

```

"date_time": "2010-11-03 22:44:00",
"url": "http://download.ted.com/talks/
    GeroMiesenboeck_2010G-950k.mp4",
"video": "http://download.ted.com/talks/
    GeroMiesenboeck_2010G-950k.mp4",
"speaker": [
{
"speaker": {
"id": 741,
"title": "",
"firstname": "Gero",
"middleinitial": "",
"lastname": "Miesenboeck",
"description": "Optogeneticist",
"whotheyare": "Using light and a little
    genetic engineering -- optogenetics
    -- Gero Miesenboeck has developed
    a way to control how living nerve
    cells work, and advanced
    understanding of how the brain
    controls behavior.",
"whylisten": "<p>Gero Miesenboeck is
    pioneering the field of
    optogenetics: genetically modifying
    nerve cells to respond to light.
    By flashing light at a modified
    neuron in a living nervous system,
    Miesenboeck and his collaborators
    can mimic a brain impulse -- and
    then study what happens next.
    Optogenetics will allow ever more
    precise experiments on living
    brains, allowing us to gather
    better evidence on how electrical
    impulses on tissue translate into
    actual behavior and thoughts...</p
    >",
"slug": "gero_miesenboeck",
"published_at": "2010-06-09 08:14:00",
"updated_at": "2010-11-04 15:11:51"
}
}
],
"image": "http://images.ted.com/images/ted/
    51f652b9ff6854867d1d7abb2683caf1d8dd22
    fb_240x180.jpg",
"manifest": {
"pid": 1000,
"id": 1000,
"title": "Gero Miesenboeck: Re-engineering
    the brain",
"image": "http://images.ted.com/images/ted/
    51f652b9ff6854867d1d7abb2683caf1d8dd22
    fb_240x180.jpg",
"provider": "ted",
"duration": 1750,
"media": {
"mp4": {
"uri": "http://download.ted.com/talks/
    GeroMiesenboeck_2010G-950k.mp4",
"is_live": "false"
}
}
},

```

```

"type": "video/mp4"
},
"tags": {
"biology": "biology",
"brain": "brain",
"neurology": "neurology",
"science": "science"
}
},
```

In order to parse every possible response provided by the API selected to extract videos and programmes collection, it has been implemented a JavaScript function to set up a total compatibility in our platform. This script is named `changeData(data)` which source code is as follows:

```

//Adapt any http request to our own data
//format

function changeData(data){

    var random_ted = {
        suggestions: []
    };

    if(data.talks == null){
        return random_ted;
    }

    for(var i = 0; i < data.talks.length; i++)
    {
        var item = data.talks[i];
        for(var j = 0; j < data.talks[i].talk.photo_urls.length; j++){
            if(data.talks[i].talk.photo_urls[j].size == "240x180"){
                var image = data.talks[i].talk.
                    photo_urls[j].url;
            }
        }

        if(item.talk.media_profile_uris["internal"]){
            random_ted.suggestions.push({
                "pid": item.talk.id,
                "title": item.talk.name,
                "description": item.talk.
                    description,
                "date_time": item.talk.
                    published_at,
                // "media_profile_uris": item.
                talk.media_profile_uris,
                "url": item.talk.
                    media_profile_uris["internal
                    "]["950k"].uri, //TODO
                    CHANGE THIS
                "video": item.talk.
                    media_profile_uris["internal
                    "]["950k"].uri,
                "speaker": item.talk.speakers,
                "image": image,
                "manifest": {
                    "pid": item.talk.id,

```

```

        "id" : item.talk.id,
        "title" : item.talk.name,
        "image" : image,
        "provider" : "ted",
        "duration" : 1750,
        "media": {
            "mp4": {
                // "type": "video/x-swf"
                ,
                "uri": item.talk.
                    media_profile_uris["internal"]["950k"].
                    uri,
                "is_live": "false"
            }
        },
        "type": "video/mp4"
    },
    "tags" : item.talk.tags
});

}

else{

    random_ted.suggestions.push({
        "pid" : item.talk.id,
        "title" : item.talk.name,
        "description" : item.talk.
            description,
        "date_time" : item.talk.
            published_at,
        // "media_profile_uris" : item.
            talk.media_profile_uris,
        "url" : "", //TODO CHANGE THIS
        "video" : "",
        "speaker" : item.talk.speakers,
        "image" : image,
        "manifest" : {
            "pid" : item.talk.id,
            "id" : item.talk.id,
            "title" : item.talk.name,
            "image" : image,
            "provider" : "ted",
            "duration" : 1750,
            "media": {
                "mp4": {
                    // "type": "video/x-swf"
                    ,
                    "uri": "",
                    "is_live": "false"
                }
            },
            "type": "video/mp4"
        },
        "tags" : item.talk.tags
    });
}

}

}return random_ted;
}

```

It is important to mention that in order to introduce an attractive demo of the platform, a complete data migration has been implemented. Due to its advantages and popularity we decided to implement the final demo making use of videos provided by TED Talks API[7].

4.5 Web Design

While building a web platform, it is important to design how to improve its functionality and also its graphical interface. A wide set of studies [3] show how a not only well-built website, but also well-designed can increase its user traffic, due to an improved user enjoyment. Nowadays a aesthetic design can be even more influential in affecting user preferences than traditional operational usability, since its effect seems to transcend the product and influence other judgements, known as the *halo effect*[14][40]⁴⁰. Concerning the halo effect, several studies [14] presented a correlation between the aesthetic factor of a graphical interface, its perceived usability and the final user satisfaction with that interactive system.

For this reason, an extensive part of this project has been focused in web design research and implementation in order to reach an improved user experience.

Through previous subsections included in our Implementation Study, a list of solutions for *functionality* issues have been exposed. In this subsection, we are going to introduce our implementations concerning *design* issues.

4.5.1 Home Page

Since the beginning of web pages, human-computer interaction has been an important factor concerning experience evaluations[26]. Usability considerations played an important role and influence the way interactive systems are designed and developed[19]. But determining user satisfaction, there have been a fluctuation from functional fulfilment to how is the provided global experience[14]. How intuitive an interface is and how it looks is influencing the capability to engage users more than ever[3]. Now users are demanding functionality, usability and aesthetics in order to generate affective responses.

For this reason, it is severely important trying to understand who are going to be the final users of an interactive service, where is it going to be used and how. Following this, we converge to a main aspect that the homepage demanded to accomplish, due to its inherit second screen conduct: It needed to be easy to use in order to not distract the user from the main viewing experience, in our case, mostly in front of a TV; and at the same time meet aesthetic design to boost users engagement. We found that the homepage was lacking first sight relevant information, therefore it required more attention than actually needed. Furthermore, its aesthetics could be improved. Figure 6 shows a screenshot of Notube N-Screen homepage. This homepage was showing, during first sight view, the set of different channels 'Recommendations for you', 'Recently Viewed', 'Search

⁴⁰The *halo effect* is a cognitive bias in which an observer's overall impression of a person, company, brand, or product influences the observer's feelings and thoughts about that entity's character or properties'

Results' and 'Shared by friends', but without providing any further details about them.

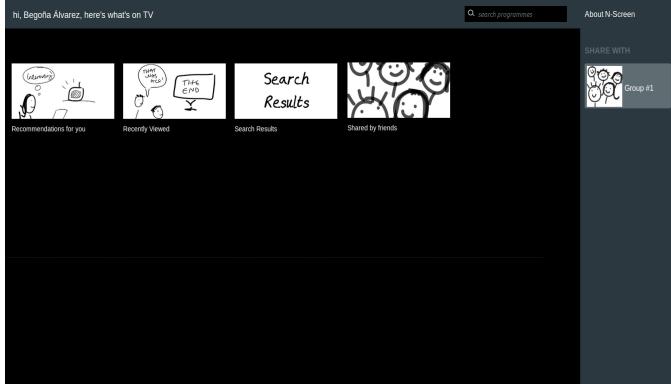


Figure 6: Notube N-Screen Homepage

Consequently, we decided to display the homepage providing further information meanwhile trying to not disturb the user[8][23][30]. We opted following the homepage design of <http://nscreen.notu.be/ted/> due to its simplicity and at the same time its further information provided [28]. Figure 7 shows the result of our implemented homepage.

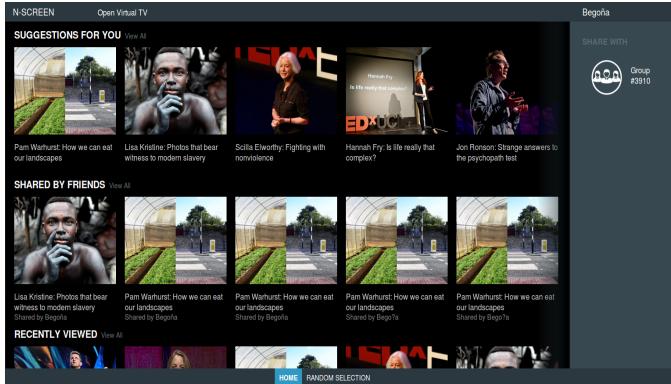


Figure 7: New N-Screen Homepage

Concerning channels replacement, the new design shows for every channel as 'Suggestions for you' or 'Shared by friends' a first sight view of five programmes -or less if the screen has a smaller size -. Furthermore, it has been added the possibility to view all the programmes contained with the addition of a clickable 'View All' next to the channel title. Figure 8 shows this addition and Figure 9 shows the result after clicking 'View All' for one of the channels.

Every channel contained in the new N-Screen homepage - Suggestions for You, Shared By Friends, Recently Viewed, Watch Later, Likes and Dislikes - present the same design approach.

In addition, it has been implemented more design improvements concerning the homepage aesthetics. Most of the websites are currently showing information related to the user profile in the header at the right side[8][23][30]. For this reason, the name of the user has been moved in the header

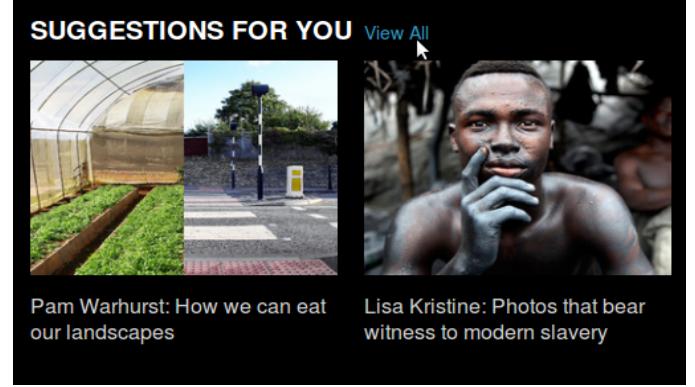


Figure 8: View All Addition next to a Channel Title, New N-Screen Homepage

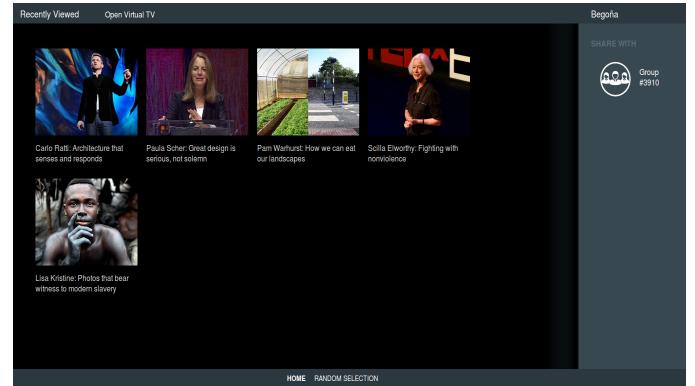


Figure 9: Programmes Visualization after 'View All' click, New N-Screen

from the left to the right side in order to maintain its placement customary. Moreover, the images places next to group number and members of the same group been redesigned, see Figure 10.



Figure 10: Images Redesign in Vertical-Right Bar, New N-Screen

4.5.2 Selected Programme Overlay

One of the most tedious parts during the design has been re-designing the visualization of a selected programme. During this phase, aesthetics and usability have been the most important factors. It has been included a vertical-right interactive bar next to the programme default image, see Figure 11. This bar contains a set of five icons: Watch Later, Like, Dislike, Shared by Friends and Recently Viewed. It is important to mention that three of this icons -Watch Later, Like and Dislike- are call-to-action icons, which means that

if the user clicks on one of them, the programme will be automatically added to the personal list which name is that precise icon. Moreover, if a programme is contained in one of the personal lists, the icon will be automatically rendered to be displayed in a different colour, as reminder for the user, see Figure ??.

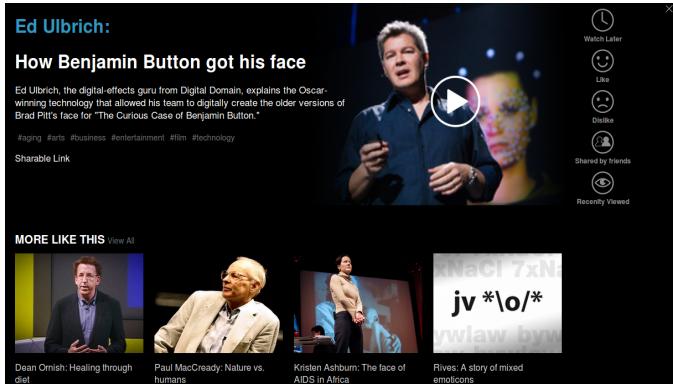


Figure 11: Select Programme Visualization, New N-Screen



Figure 12: Designed Icons

Additionally, it has been added below a programme description an inline set of hyperlinked tags extracted for the programme metadata, see Figure 13. A user can click to a desired tag to explore further related programmes. Figure 14 show the visualization of this action.

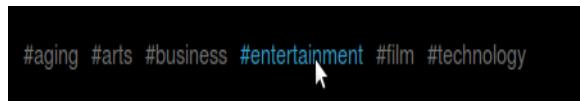


Figure 13: Hyperlinked Tags, New N-Screen



Figure 14: Visualization of related programmes after the selection of a tag, New N-Screen

At last, it has been included a clickable selection of related

programmes below its summary, placed on the 'More Like This' section.

5. EVALUATION AND RESULTS

Initially, some tests were applied to the final platform to prove its proper functionality. The main features that make the platform valuable such as registration, personal lists updating, sharing to a faraway user and remote TV have been tested. Afterwards, when the functionalities were demonstrated to work, an evaluation of the user experience has been carried out. The descriptions of the tests and corresponding results are exposed in this section.

5.1 Technical Tests

This tests tried to prove that every functional part included in the source code was working. The test was carried out by ourselves and we tested the following features:

- Registration
 - Username not already taken by another user
 - Double entering password
 - OpenID authorization
 - Database members table initialization
 - Database content table initialization
 - Cache
- Login
 - Username and corresponding password
 - OpenID authorization
 - Security
 - User personal row in database members table
 - User personal row in database content table
 - Cache
- Homepage
 - Content
 - Channels - Personal Lists
 - View All
 - Shared by in Shared by Friends
 - Random Selection
 - User name
 - Group number
 - Group member names
 - Drag&Drop
 - Virtual TV
- Personal Lists Update
 - Shared by Friends
 - Recently Viewed
 - Watch Later
 - Likes
 - Dislikes

- Call-to-Action icons
 - Watch Later
 - Like
 - Dislike
- Non-Call-to-Action icons
 - Shared by Friends
 - Recently Viewed
- Faraway Programme Sharing to a Single User
 - Unique notifications
 - Unique Shared by Friends channel
- Faraway Programme Sharing to a Group
 - Group Notifications
 - Group Shared by Friends channel
- Programme selection
 - Information displayed
 - Local play
 - Call-to-action icons
 - Non-call-to-action icons
 - Tags
 - More Like This
- Virtual TV
 - Sharing
 - Play

After the test, we ascertained that every part listed above was correctly working.

5.2 User Experience Evaluation

To accomplish the success of our platform, it was necessary to consider testing its interface as well. An interface is the intermediary between users and content. It guides them through different complexities found on an interactive web system. "The happy marriage of architecture and interface—of logical structure and visual meaning—creates a cohesive user experience" [18].

In order to test this important part of the platform, we carried out a user experience (UX) evaluation in order to extract how users feel during the interaction. For this purpose, we recruited 5 participants: three women and two man across a spread of ages between 20 and 31. All participants described themselves as screen devices enthusiasts, regularly spending at least 2 leisure hours a day in front of a screen.

Following some introductory context about our N-Screen, during each session we showed the participants our own version of N-Screen, containing a set of videos provided by TED Talks API, and we walked them through a group watching scenario -with the author of this report taking the role of the participant's N-Screen 'friend'—.

During the evaluation, we asked the participant to think out loud to extract their thoughts and feelings about our own N-Screen. The results of this evaluation are exposed in the following subsections.

5.2.1 Registration & Login

Each participant was required to sign up in our platform. Concerning the registration activity, all participants except one did not give importance to this step. This one participant required to be able to get into the platform without registration and sign up afterwards, if wanted. In addition, three participants selected the OpenID registration explaining that the one-click was actually much easier. Contrary, one of the participants selected the good registration due to lacking Facebook account. At last, the resting participant selected the good registration claiming a distrust sharing a personal social network profile.

After registration, we required to every participant to sign in in order to test how intuitive was this process, since the registration pop-up appears before the log in option. No one showed any trouble to login.

5.2.2 Homepage

Each participant in an N-Screen group starts with a different set of personalised programme recommendations, and a set of empty personal lists -since they interaction just started-. We had to ask our participants to imagine these were based on their user profile. Despite this, all the participants liked the concept of seeing programme suggestions based on their own preferences.

All participants showed an enthusiastic feedback about the homepage. The display of a short set of videos below each channel was for them very informative, easy and non-disturbing.

Additionally, tapping on a programme in our N-Screen displays an overlay with a brief programme synopsis with clickable tags, play button, a vertical bar containing call-to-action icons and a set of programmes related to the selected one. All participants showed a positive reaction to this overlay, considering it with the precise information needed. We asked the participants to try to interact with the programme overlay, and all of them found out easily that 'Watch Later', 'Like' and 'Dislike' buttons were clickable and concerned an updating of their personal lists, and also all of them realised that 'Shared by Friends' and 'Recently Viewed' were static buttons automatically rendered by the platform. It is important to mention that one of the participants realised that the Like and Dislike buttons were not exclusive, being possible to have both at the same time active. Concerning the hyperlink metadata, all participants figured out that they were also clickable and were appreciative about them, showing videos related to a specific tag was very useful for everyone. In addition, the play button was intuitive for every participant.

It is important to mention that every participant except one exposed a comment without being asked about the random selection. They found this possibility definitely useful, since sometimes it is preferable to watch something totally non-related to own preferences and therefore find something new.

A special test that we carried out was to ask to every participant to go back to the homepage if they were out of it. Every participant found out by themselves that there was a clickable button placed in the footer with the word HOME that could drive them there.

At last, one of the participants showed disappointment with the navigation on the home page, preferring to be horizontally static and just allowing to scroll vertically.

5.2.3 Sharing & Virtual TV

During this phase of the test, we asked to all participants to share a program. One of the participants did not manage to accomplish it without a hint, three participants did it without trouble, and impressively the resting one starting sharing without even being asked to it, so for this last one was incredibly intuitive.

Additionally, any problem to open the Virtual TV and drag & drop something to it was showed, this last one since the previous phase provided a hint to accomplish the TV sharing.

All participants were very enthusiastic about the Virtual TV and found this featured extremely useful and innovative.

5.2.4 General Overview

At the end of the evaluation with every participant, we asked them how was their general feeling about the platform, how intuitive it was and also its aesthetic. Every participant shared a positive reaction after this questions, explaining that it was very intuitive and with a beautiful minimalistic interface.

5.2.5 Results

Overall, participants were complimentary about trying out our own version of N-Screen; they enjoyed it and found it fun and easy to use:

- The registration requirement was accepted for every participant but one.
- The login was easy to use for everyone.
- The homepage design was universally liked.
- The selected programme overlay was universally liked.
- The drag&drop was intuitive for most of the participants.
- The vertical bar with icons was universally liked and found very useful.
- The random selection was universally liked.
- The hyperlink metadata was universally liked and found very useful.

Moreover, some issues were found with a potential future improvement:

- It can be included the possibility to enter to the platform without being registered.
- Exclusive Like and Dislike needs to be implemented.
- A hint for just registered users in order to help them how to share a programme should be included.

- Horizontal scroll in homepage should be not allowed.

As a result from the evaluation, we can conclude that our approach in order to improve the Notube N-Screen platform has been successful. Therefore our main goal has been accomplished.

6. CONCLUSIONS

In this report, we are addressing the interactivity problem of recommender second screen platform. We developed an innovative browser-based platform based on Notube previous work and we tried to improve it including new features meanwhile providing a scalable software design to enable future recommendation strategies testing. The main thrust of this project was to adapt the platform including new features in order to improve five main issues identified: the volatile treat of the explicit relevant data provided by users, the sequential usage of the second screen, the lack of interactive activities, the possibility to play a video both locally and through a virtual TV and an scalable software to enable future data content migrations.

The volatile data was settled by including a registration system in order to track user preferences. To deal with the sequential usage behaviour, an editable watch later list has been implemented. To offer a more attractive set of possible activities to interact with, explicitly provided feedback of programmes by like and dislike actions, hyperlink metadata to browse further and a random selection have been included. Both the locally and the remote watching have been successfully fixed and at last the platform has been designed to be fully adaptable to enable future content data migrations.

Our results extracted from the evaluation showed how every goal have been pleasantly accomplished.

6.1 Future Lines

Regarding the future of the platform, it is important to pay attention to some points. These points have been considered as highly convenient in order to increase performance and obtaining a better experience.

- Include the possibility to enter to the platform without requiring a formal registration.
- Improvement of the 'More like this' section, since it is based only in one tag.
- Offer the possibility of user profile management.
- Include the possibility to like or dislike metadata.
- Include the possibility to select between different languages and subtitles when watching a programme.
- Include an instant messaging chat.
- Improvement of the responsive design in registration and selected programme overlays.
- Smart-TV synchronization by the development of a Smart-TV app.

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I would also like to express my gratitude to my supervisor Lora Aroyo and my co-supervisor Valentina Maccatrazzo for the useful comments, remarks and engagement through the learning process of this master thesis.

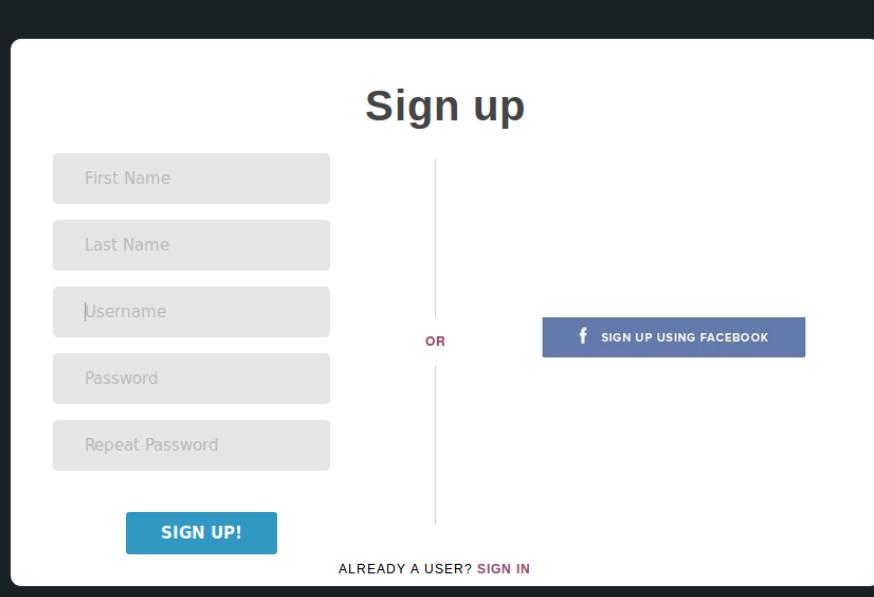
I would also like mention special thanks to my brother, mother and father for all the received affection and support. At last but not least, I would like to express my sincere thanks to Agustín Tena for his support and guidance during the process of this project.

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APPENDIX
A. SCREENSHOTS



The image shows a registration form titled "Sign up". It features five input fields: "First Name", "Last Name", "Username", "Password", and "Repeat Password". Below these fields is a blue "SIGN UP!" button. To the right of the input fields is a vertical line with the word "OR" in red capital letters. Next to "OR" is a blue button with the Facebook logo and the text "SIGN UP USING FACEBOOK". At the bottom of the form, there is a link "ALREADY A USER? SIGN IN" in red capital letters.

Figure 15: Registration Form

Login

YOU ARE JOINING GROUP 5850

[LOGIN!](#)

OR

 [CONNECT](#)

NOT A MEMBER? [SIGN UP](#)

Figure 16: Login Form

N-SCREEN
Open Virtual TV
Begoña

SUGGESTIONS FOR YOU [View All](#)

Pam Warhurst: How we can eat our landscapes

Lisa Kristine: Photos that bear witness to modern slavery

Scilla Elworthy: Fighting with nonviolence

Hannah Fry: Is life really that complex?

Jon Ronson: Strange answers to the psychopath test

SHARED BY FRIENDS [View All](#)

Dan Dennett: Dangerous memes
Shared by Javier

Ruby Wax: What's so funny about mental illness?
Shared by Javier

Aris Venetikidis: Making sense of maps
Shared by Javier

Ryan Merkley: Online video -- annotated, remixed and popped
Shared by Javier

Sebastian Thrun: Google's driverless car
Shared by Jordan

RECENTLY VIEWED [View All](#)

[HOME](#)
[RANDOM SELECTION](#)

SHARE WITH

Group #5850

Agustín

Figure 17: Homepage - Suggestions for you, Shared by friends

N-SCREEN Open Virtual TV

brain against concussion Shared by Agustin

RECENTLY VIEWED View All

Photographing the hidden story

Pop culture in the Arab world

A new way to fight corruption

Dragonflies that fly across oceans

Making sense of maps

WATCH LATER View All

Photographing the hidden story

Making sense of maps

Great design is serious, not solemn

Scilla Elworthy: Fighting with nonviolence

LIKES View All

HOME RANDOM SELECTION

The screenshot shows a dark-themed user interface for a video platform. At the top, there are five video thumbnails under the heading 'RECENTLY VIEWED'. Below them is another row of five thumbnails under 'WATCH LATER'. On the right side, there are two sections: 'SHARE WITH' (Group #5850 and Agustin) and a 'LIKES' section with five more video thumbnails. A navigation bar at the bottom includes 'HOME' and 'RANDOM SELECTION'.

Figure 18: Homepage - Recently Viewed, Watch Later

N-SCREEN Open Virtual TV

Photographing the hidden story

Making sense of maps

Great design is serious, not solemn

Scilla Elworthy: Fighting with nonviolence

LIKES View All

Photographing the hidden story

Dragonflies that fly across oceans

Making sense of maps

Google's driverless car

How we can eat our landscapes

DISLIKES View All

Pop culture in the Arab world

A new way to fight corruption

HOME RANDOM SELECTION

This screenshot shows the same dark-themed interface as Figure 18. It features a 'LIKES' section with five video thumbnails and a 'DISLIKES' section with two video thumbnails. The layout is identical to the 'Recently Viewed' and 'Watch Later' sections, with a 'SHARE WITH' section on the right. The navigation bar at the bottom remains the same.

Figure 19: Homepage - Likes, Dislikes

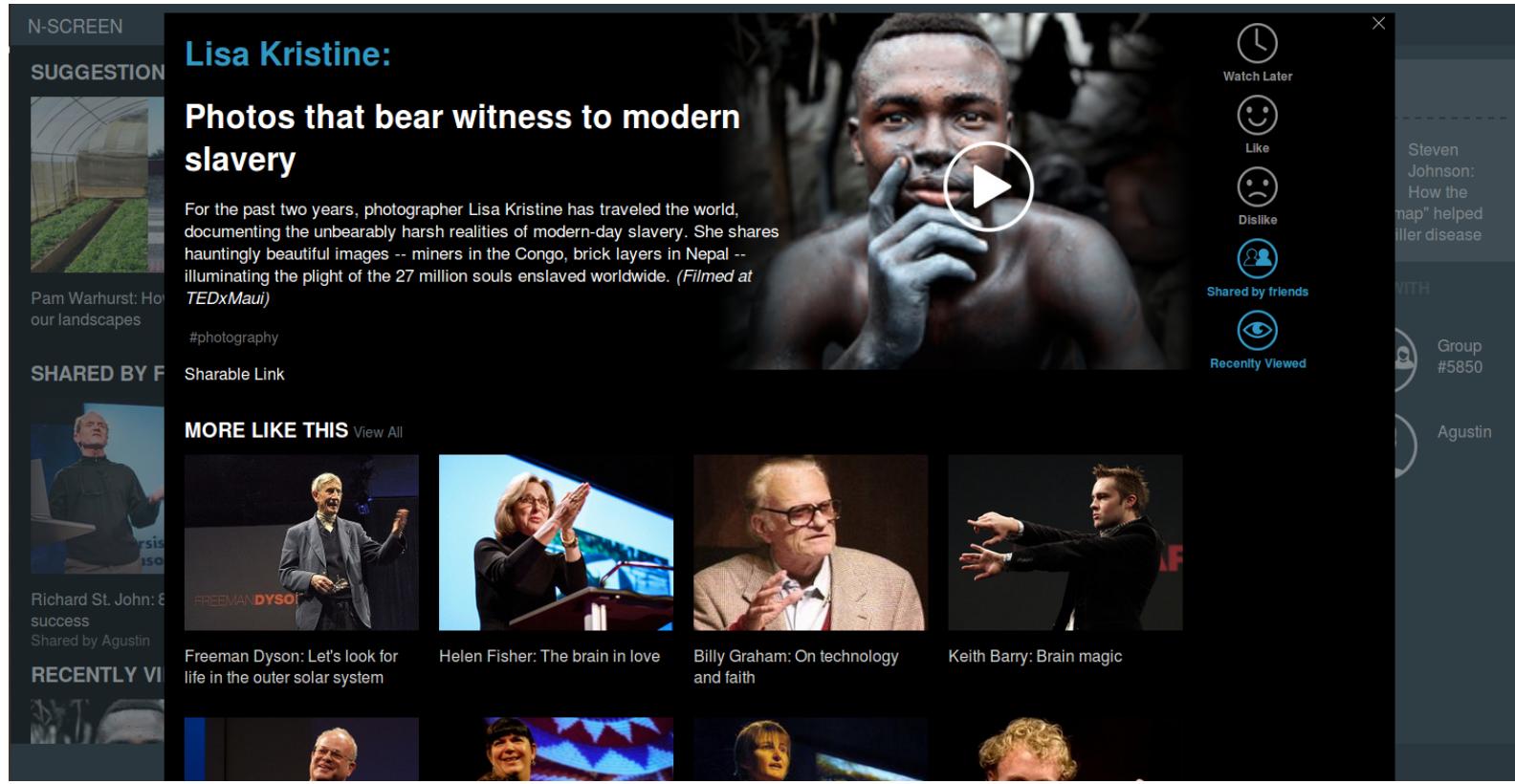


Figure 20: Programme overlay



Figure 21: Local play of a programme

N-SCREEN

SUGGESTION



Pam Warhurst: How
our landscapes



Emiliano Salinas: A civil
response to violence



Rory Stewart: Time to end the
war in Afghanistan



Josette Sheeran: Ending hunger
now



Jeremy Gilley: One day of peace

SHARED BY F



Richard St. John: 8
success
Shared by Agustin



Julia Bacha: Pay attention to
nonviolence



Peter van Uhm: Why I chose a
gun



Leymah Gbowee: Unlock the
intelligence, passion, greatness
of girls



James Stavridis: A Navy
Admiral's thoughts on global
security

RECENTLY VI



I SAW



Figure 22: Hyperlink tag overlay

Related to Photos that bear witness to modern slavery

Begoña



James Nachtwey: Moving
photos of extreme drug-resistant
TB



David Perry: Are games better
than life?



Steven Johnson: The Web as a
city



Doris Kearns Goodwin: Lessons
from past presidents



Group
#5850



Agustin



James Burchfield: Playing
invisible turntables



Jared Diamond: Why do
societies collapse?



Mihaly Csikszentmihalyi: Flow,
the secret to happiness



Garrett Lisi: An 8-dimensional
model of the universe



HOME RANDOM SELECTION

Figure 23: More like this



Hannah Fry: Is life really that complex?

Lisa Kristine: Photos that bear witness to modern slavery

Pam Warhurst: How we can eat our landscapes

Scilla Elworthy: Fighting with nonviolence



Jon Ronson: Strange answers to the psychopath test

SHARE WITH



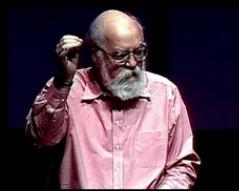
Group #5850



Agustin

HOME RANDOM SELECTION

Figure 24: View All - Suggestions for you

Kim Gorgens: Protecting the brain against concussion
Shared by AgustinKristina Gjerde: Making law on the high seas
Shared by AgustinJohn Hardy: My green school dream
Shared by AgustinShimon Schocken: What a bike ride can teach you
Shared by AgustinDenis Dutton: A Darwinian theory of beauty
Shared by AgustinDan Dennett: Dangerous memes
Shared by JavierRuby Wax: What's so funny about mental illness?
Shared by JavierAris Venetikidis: Making sense of maps
Shared by Javier

SHARE WITH



Group #5850



Agustin

HOME RANDOM SELECTION

Figure 25: View All - Shared by friends

Recently Viewed

Open Virtual TV

Begoña



Photographing the hidden story



Pop culture in the Arab world



A new way to fight corruption



Dragonflies that fly across oceans



Making sense of maps



Google's driverless car



How we can eat our landscapes



Great design is serious, not solemn



HOME RANDOM SELECTION

Figure 26: View All - Recently Viewed

Watch Later List

Open Virtual TV

Begoña



Photographing the hidden story



Making sense of maps



Great design is serious, not solemn



Scilla Elworthy: Fighting with nonviolence

HOME RANDOM SELECTION

Figure 27: View All - Watch Later

Likes List

Open Virtual TV

Begoña



Photographing the hidden story



Dragonflies that fly across oceans



Making sense of maps



Google's driverless car



How we can eat our landscapes



Great design is serious, not solemn



Scilla Elworthy: Fighting with nonviolence

SHARE WITH



Group
#5850



Agustin

HOME RANDOM SELECTION

Figure 28: View All - Likes

Dislikes List

Open Virtual TV

Begoña



Pop culture in the Arab world



A new way to fight corruption

SHARE WITH



Group
#5850



Agustin

HOME RANDOM SELECTION

Figure 29: View All - Dislikes

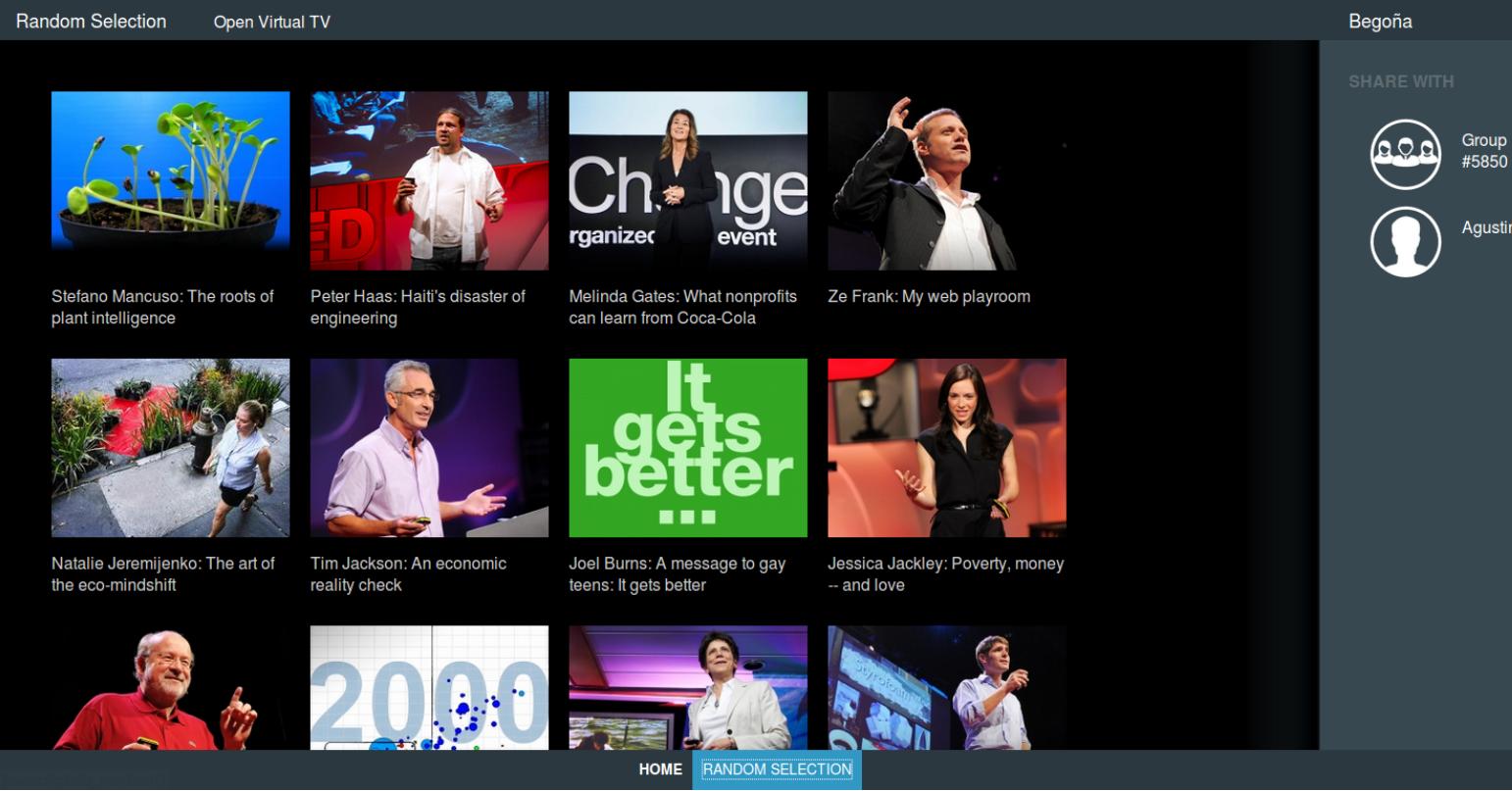


Figure 30: Random Selection

The screenshot shows a user interface for a virtual television channel. At the top, there are navigation links: 'N-SCREEN' and 'Open Virtual TV' on the left, and 'Begoña' on the right. Below these are sections for recommendations and sharing:

SUGGESTIONS FOR YOU [View All](#)

- Pam Warhurst: How we can eat our landscapes**
- Lisa Kristine: Photos that bear witness to modern slavery**
- Scilla Elworthy: Fighting with nonviolence**
- Hannah Fry: Is life really that complex?**
- Jon Ronson: Strange answers to the psychopath test**

SHARED BY FRIENDS [View All](#)

- Kim Gorgens: Protecting the brain against concussion**
Shared by Agustin
- Kristina Gjerde: Making law on the high seas**
Shared by Agustin
- John Hardy: My green school dream**
Shared by Agustin
- Shimon Schocken: What a bike ride can teach you**
Shared by Agustin
- Denis Dutton: A Darwinian theory of beauty**
Shared by Agustin

RECENTLY VIEWED [View All](#)

Below these sections are five small video thumbnails, likely representing recently viewed content. At the bottom of the screen are 'HOME' and 'RANDOM SELECTION' buttons.

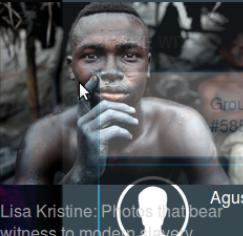
Figure 31: Drag&Drop - Sharing to a single person

N-SCREEN

Open Virtual TV

Begoña

SUGGESTIONS FOR YOU [View All](#)



Pam Warhurst: How we can eat our landscapes

Lisa Kristine: Photos that bear witness to modern slavery

Scilla Elworthy: Fighting with nonviolence

Hannah Fry: Is life really that complex?

Jon Ronson: Strange answers to the psychopath test

Lisa Kristine: Photos that bear witness to modern slavery

Group #5850

Agustin

SHARED BY FRIENDS [View All](#)



Kim Gorgens: Protecting the brain against concussion

Kristina Gjerde: Making law on the high seas

John Hardy: My green school dream

Shimon Schocken: What a bike ride can teach you

Denis Dutton: A Darwinian theory of beauty

Shared by Agustin

RECENTLY VIEWED [View All](#)



HOME

RANDOM SELECTION

Figure 32: Drag&Drop - Sharing to a group

N-SCREEN

Open Virtual TV

Begoña

SUGGESTIONS FOR YOU [View All](#)



Pam Warhurst: How we can eat our landscapes

Lisa Kristine: Photos that bear witness to modern slavery

Scilla Elworthy: Fighting with nonviolence

Hannah Fry: Is life really that complex?

Jon Ronson: Strange answers to the psychopath test

Agustin shared Richard St. John: 8 secrets of success with you

Agustin shared Steven Johnson: How the "ghost map" helped end a killer disease with you

Begoña shared Scilla Elworthy: Fighting with nonviolence with the group

Begoña shared Lisa Kristine: Photos that bear witness to modern slavery with the group

SHARED BY FRIENDS [View All](#)



Richard St. John: 8 secrets of success

Steven Johnson: How the "ghost map" helped end a killer disease

Scilla Elworthy: Fighting with nonviolence

Lisa Kristine: Photos that bear witness to modern slavery

Kim Gorgens: Protecting the brain against concussion

Shared by Agustin

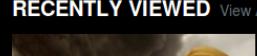
Shared by Agustin

Shared by Begoña

Shared by Begoña

Shared by Agustin

RECENTLY VIEWED [View All](#)



HOME

RANDOM SELECTION

Figure 33: Homepage - Notifications - Programme shared

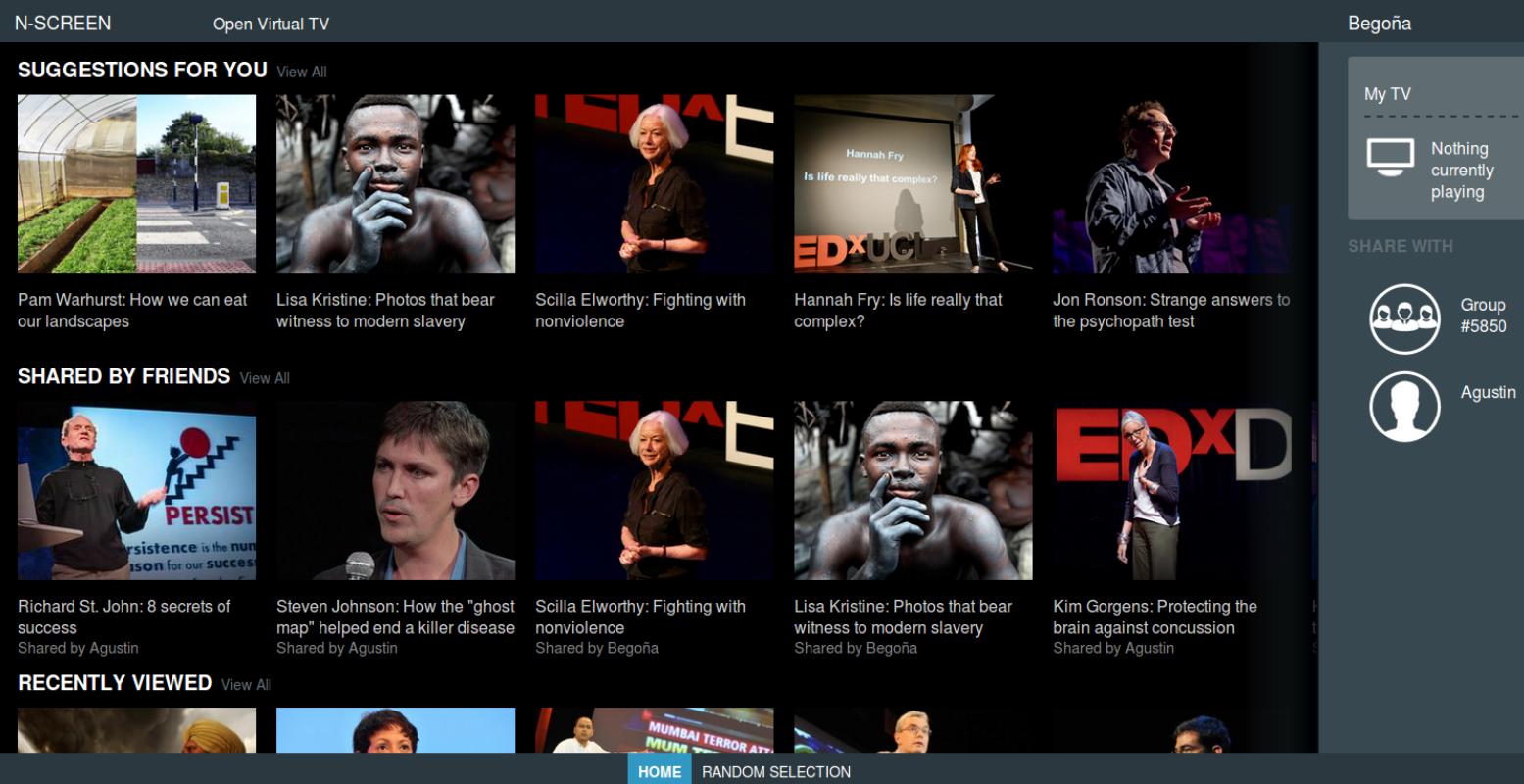


Figure 34: Homepage - Virtual TV ON

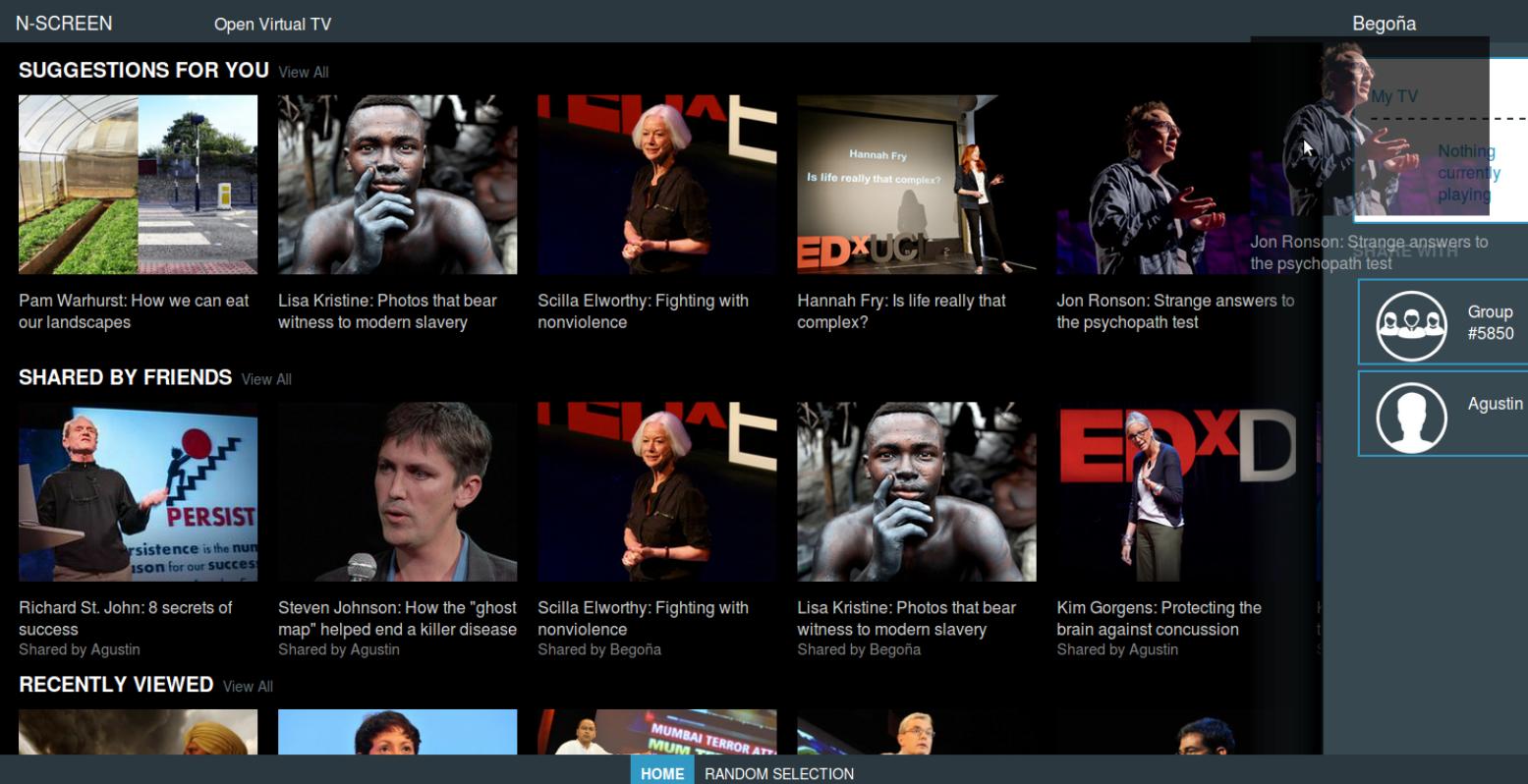


Figure 35: Drag&Drop - Virtual TV

Welcome to Simple TV

Group is 5850

Figure 36: Virtual TV - Nothing playing

Playing Steven Johnson: How the "ghost map" helped end a killer disease

Figure 37: Virtual TV - Programme starting



Figure 38: Virtual TV - Programme playing

N-SCREEN
Open Virtual TV
Begoña

SUGGESTIONS FOR YOU [View All](#)
My TV

Pam Warhurst: How we can eat our landscapes
Shared by Agustin

Lisa Kristine: Photos that bear witness to modern slavery
Shared by Agustin

Scilla Elworthy: Fighting with nonviolence
Shared by Begoña

Hannah Fry: Is life really that complex?
Shared by Begoña

Jon Ronson: Strange answers to the psychopath test
Shared by Agustin

SHARED BY FRIENDS [View All](#)
SHARE WITH

Richard St. John: 8 secrets of success
Shared by Agustin

Steven Johnson: How the "ghost map" helped end a killer disease
Shared by Agustin

Scilla Elworthy: Fighting with nonviolence
Shared by Begoña

Lisa Kristine: Photos that bear witness to modern slavery
Shared by Begoña

Kim Gorgens: Protecting the brain against concussion
Shared by Agustin

RECENTLY VIEWED [View All](#)

[HOME](#) [RANDOM SELECTION](#)

Figure 39: Homepage - Video currently playing in Virtual TV

N-SCREEN Open Virtual TV Begoña

SUGGESTIONS FOR YOU [View All](#)

Pam Warhurst: How we can eat our landscapes

Lisa Kristine: Photos that bear witness to modern slavery

Scilla Elworthy: Fighting with nonviolence

Hannah Fry: Is life really that complex?

Jon Ronson: Strange answers to the psychopath test

SHARED BY FRIENDS [View All](#)

Richard St. John: 8 secrets of success
Shared by Agustin

Steven Johnson: How the "ghost map" helped end a killer disease
Shared by Agustin

Scilla Elworthy: Fighting with nonviolence
Shared by Begoña

Lisa Kristine: Photos that bear witness to modern slavery
Shared by Begoña

Kim Gorgens: Protecting the brain against concussion
Shared by Agustin

RECENTLY VIEWED [View All](#)

[HOME](#) [RANDOM SELECTION](#)

My TV

Steven Johnson: How the "ghost map" helped end a killer disease

SHARE WITH

Group #5850
 Agustin

Figure 40: Homepage - Programme currently playing in Virtual TV

N-SCREEN Open Virtual TV Begoña

SUGGESTIONS FOR YOU [View All](#)

Pam Warhurst: How we can eat our landscapes

Lisa Kristine: Photos that bear witness to modern slavery

Scilla Elworthy: Fighting with nonviolence

Hannah Fry: Is life really that complex?

Jon Ronson: Strange answers to the psychopath test

SHARED BY FRIENDS [View All](#)

Richard St. John: 8 secrets of success
Shared by Agustin

Steven Johnson: How the "ghost map" helped end a killer disease
Shared by Agustin

Scilla Elworthy: Fighting with nonviolence
Shared by Begoña

Lisa Kristine: Photos that bear witness to modern slavery
Shared by Begoña

Kim Gorgens: Protecting the brain against concussion
Shared by Agustin

RECENTLY VIEWED [View All](#)

[HOME](#) [RANDOM SELECTION](#)

TV started playing Steven Johnson: How the "ghost map" helped end a killer disease

Steven Johnson: How the "ghost map" helped end a killer disease

SHARE WITH

Group #5850
 Agustin

Figure 41: Homepage - Notification programme currently playing in Virtual TV

B. SOURCE CODE

All the source files used to implement this platform can be accessed at the public repository:
<https://github.com/begonaalvarezd/begona-nscreen>